OSA Imaging and Applied Optics Congress

25–28 June 2018

Wyndham Orlando Resort

Orlando, Florida

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Network: Wyndham Conference HSIA

Password: 2018jun

Online Access to Technical Digest

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1. Visit the conference website at www.osa.org/imagingOPC
2. Select the "Access digest papers" link on the right hand navigation.
3. Log in using your email address and password used for registration. You will be directed to the conference page where you will see the .zip file link at the top of this page.

[Note: if you are logged in successfully, you will see your name in the upper right-hand corner.]

Poster Presentation PDFs

Authors presenting posters have the option to submit the PDF of their poster, which will be attached to their papers in OSA Publishing's Digital Library. If submitted, poster PDFs will be available about two weeks after the meeting. While accessing the papers in OSA Publishing's Digital Library look for the multimedia symbol shown above.

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Student Grand Challenge: The Optical Systems of the Future

The challenge was open to OSA student members and their advisors interested in presenting concepts for enhanced machine visioning or systems that enhance the human vision system by augmenting or extending another human sense.

Passive Optical System Challenge Problem

The image processing community strives to duplicate human vision. For certain specific and well defined tasks we have succeeded or surpassed human capability, but still struggle with poorly defined and dynamic environments. The category comparison between machine vision and human vision include:

- Spectrum: Machine vision is superior as human vision is limited to the visible spectrum. Machine vision is also more capable of seeing narrower spectrum steps and larger dynamic ranges than our eyes.
- Resolution: Human vision is superior. Current machine vision systems that are approaching 8K x 8K formats are starting to get there but, only with visible systems.
- Focus: Human vision is superior being able to focus from very close to very far with a single lens element. The eye aperture is limited by the size of the pupil for objects far away. Machine vision systems are specifically designed for very close or very far away and do not suffer from being aperture limited, but utilize many lens elements to accomplish the same human eye tasks.
- Optical Processing: Human vision + brain is superior to machine vision on pattern recognition and decision making.

The passive optical systems challenge was to create a novel concept, technology or system for improving results in one of the 8 categories below:

- Image Processing: Ideas focused on detection and categorization of objects in the view field.
- Lens Technology: Ideas that are focused on optical sensors.
- High Speed Data Transport: Ideas that are focused on fast and efficient transport of high resolution image data and streams.
- Adaptable Lens Technology: Ideas that are focused on adaptable optical sensors.
- Liquid Lens Optical Sensors: Ideas focused on liquid lens.
- Artificial Intelligence: Ideas that focus on image based cognition
- AV/VR Technology: Ideas that are focused on Augmented and Virtual Reality technologies.
- Other: Ideas that do not fall into one of the existing categories.

Active Optical System Challenge

Given you have a human vision system, which is intrinsically passive, how would you use active sensing techniques to augment that vision system to mimic or extend the human senses? Augmentation could mean adding higher precision 3D vision, active foveae imaging, active IR assisted sensing, vibrometry, polarimetry, sensing motion in the FOV, chemical/biological sensing, looking through fog/turbulence, etc. Many such systems have been demonstrated, but they are often large, heavy, and costly.

The active optical system challenge is to come up with novel sensor concepts that mimic at least two of the human senses at a distance of at least 10 m, with the sensor fitting into one third of the human brain (roughly 0.5 liters). More sensing modalities are encouraged, especially those that extend what humans can do.

1. Sight (e.g., producing 2D or 3D images)
2. Hearing (e.g., measuring object vibrations through optical means)
3. Smell (e.g., chemical/biological sensing)
4. Taste (e.g., chemical/biological sensing)
5. Touch (e.g., characterization of surface texture and/or temperature)

Finalists

All-passive, Transformable Optical Mapping (ATOM) Wearable Display, **Wei Cui**, *University of Illinois Urbana-Champaign, USA*

ARCADE: Accurate and Rapid Camera for Depth Estimation, **Shay Elmalem**, *Tel-Aviv University, Israel*

Low-Cost/High-Yield Fabrication of Microlens Array for Light-Field Imaging, **Hyun Myung Kim**, *Gwangju Institute of Science and Technology, South Korea*

Extraction of Phase Information from Intensity-only Images using Deep Learning, **Shuai Li**, *Massachusetts Institute of Technology, USA*

Challenge Judging and Winner Announcement

During the conference, attendees will have a chance to review the finalists' concepts by visiting their poster during the Monday and Tuesday poster sessions. Also, during the Tuesday plenary session hear a rapid fire explanation. Each attendee will be asked to vote for the best concept via the Imaging Congress Mobile App.

Winners will be announced during the Wednesday Plenary session and will receive a recognition plaque and a $250 prize.

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Special Events

Poster Sessions

Monday, 25 June – Wednesday 27 June
Palms Ballroom FGHI

The congress will feature three different poster sessions. The poster presenters should display their poster during the morning break and stand by their poster during the afternoon break to answer questions. Attendee may view the posters all day starting with the morning break and concluding with the afternoon break/poster session. This allows attendees a chance to preview posters at their leisure during the day.

All posters must be removed by 17:00 on the day they are displayed. Posters not removed may be disposed.

AIO Technology Demonstrations

The Applied Industrial Optics meeting highlights emerging technologies, with talks focusing on technical challenges and the path from lab to prototype and beyond. This year emerging technologies will be showcased in Technology Demos following selected Invited Talks. Look for the DEMO icon in the abstract section to learn about the demos for the selected invited talks. Each demonstration will take place during the last 15 minutes of the invited talk.

Digital Holographic Microscopy: Present and Future Panel Discussion

Monday, 25 June, 12:30–14:00
Salon C

Join the OSA Holography and Diffractive Optics Technical Group for a panel discussion exploring potential breakthroughs in digital holographic microscopy. Brief presentations from our featured panelists will be followed by a moderated question and answer session, helping facilitate the exchange of information with our community. Contact TGactivities@osa.org to register, pending availability.

Hosted by: OSA Holography and Diffractive Optics Technical Group

Congress Reception

Monday, 25 June; 18:30–20:00
Palms Ballroom E

Come join your colleagues for drinks, networking and thoughtful discussion. Enjoy light fare while networking. The reception is open to all full conference attendees. Conference attendees may purchase extra tickets for their guest.

OSA Light the Future Speakers Series

Tuesday, 26 June; 08:00–09:00
Citron

Imagine self-driving cars, 3D printing and a billion pixel camera. One hundred years ago these inventions were unthinkable. Yet today, researchers and industry leaders around the globe are perfecting such innovations that once were the realm of science fiction. To celebrate The Optical Society's 100th anniversary, OSA established the Light The Future speaker series at eight international events in 2016 for conference attendees, invited guests and the local community. The program which features visionaries, futurists and Nobel Prize winners who will bring an illuminating topic alive will continue in 2018.

During the Imaging and Applied Optics Congress, Jason Eichenholz, CTO and Co-Founder of Luminar Technologies, will present a talk as part of the Light the Future series.

Join us for at 12:30 on Tuesday in the Palms Foyer as the OSA Light the Future program sponsors lunch in celebration of the illuminating topics discussed during the conference.

For more information on the Light the Future program visit www.osa.org/get_involved/light_the_future/

Student & Early Career Professional Development & Networking Lunch and Learn

Tuesday, 26 June; 12:30–14:00
Jasmine

This program will provide a unique opportunity for students and early career professionals, who are close to finishing or who have recently finished their doctorate degree, to interact with experienced researchers. Key industry and academic leaders in the community will be matched for each student based on the student's preference or similarity of research interests. Students will have an opportunity to discuss their ongoing research and career plans with their mentor, while mentors will share their professional journey and provide useful tips to those who attend.

This Workshop is complimentary for OSA Members and there was an application process to be chosen to attend. Not all who apply will be able to attend due to space limitations and priority will be given to those who have most recently or are close to graduation.

50th Anniversary of Introduction to Fourier Optics by Joseph Goodman

Tuesday, 26 June; 13:30–19:30
Orange/Lemon/Lime

This year marks the 50th anniversary of the publishing of *Introduction to Fourier Optics* by Joseph Goodman, a book that has fundamental influence in the field of optical imaging. To commemorate this anniversary a special series of talks will be presented covering Fourier optics in the classroom to the evolvement of the field.

Join the Image Sensing and Pattern Recognition Technical Group for a small reception immediately following the conclusion of the program.

Reception Hosted By OSA Image Sensing and Pattern Recognition Technical Group

Illumicon II

Tuesday, 26 June 2018, 19:00–21:00
A secret location

You are invited to join the OSA Display Technology Technical Group for Illumicon II, an exclusive members-only event. Building on the declarations established at the inaugural Illumicon, which was convened in 2016, attendees will come together to discuss and debate emerging trends, technologies and opportunities in advanced 3D displays. Our discussions will also seek input on how the Display Technology Technical Group can further engage the 3D community in the years ahead. Illumicon II attendees will converge over drinks and appetizers at the confidential location. Entrance will be granted to those able to provide the secret Illumicon II event password. RSVP to tgactivities@osa.org to receive the event location and password.

Hosted by: OSA Display Technology Technical Group

Applications of Visual Science Technical Group Networking Lunch

Wednesday, 27 June 2018, 12:00–13:00
Salon C

Members of the OSA Applications of Visual Science Technical Group are invited to join us for a networking lunch on Wednesday. The event will provide an opportunity to connect with fellow attendees who share an interest in this field and to learn more about this technical group. Contact TGactivities@osa.org to register, pending availability.

Hosted by: OSA Applications of Visual Science Technical Group

Tour of Laser Propagation Facilities at Kennedy Space Center

Thursday, 28 June (13:00–18:00) and
Friday, 29 June (07:00–12:00)

During this tour at Kennedy Space Center (KSC), you will see various facilities used for outside field experiments such as laser propagation measurements. The tour will include UCF's Townes Institute Science and Technology Experimentation Facility (TISTEF), the Shuttle Landing Facility (SLF), and Vehicle Assembly Building (VAB). TISTEF is a site for experiments that require deployment in a fielded setting and consists of a 1 km grass range equipped with atmospheric monitoring instruments and multiple scintillometers as well as capabilities for optical tracking and remote sensing. From this site, slant path measurements can be made over the 13 km path to the top of the VAB. The 5 km long SLF is ideal for longer path measurements because of its homogeneity and flatness (earth's curvature has been removed). This tour is possible because of the pcAOP committee and University of Central Florida.

To patriciate in this tour advanced registration is required and there is an additional fee of $25 per person.

Plenary Speakers

Paul Debevec, *Google VR, USA*

Light Fields and Light Stages for Photoreal Movies, Games, and Virtual Reality

Monday, 25 June, 08:00–09:30

Paul Debevec is a research professor at the University of Southern California and the associate director of graphics research at USC's Institute for Creative Technologies. Debevec's Ph.D. thesis (UC Berkeley, 1996) presented Façade, an image-based modeling and rendering system for creating photoreal architectural models from photographs. Using Façade he led the creation of virtual cinematography of the Berkeley campus for his 1997 film The Campanile Movie whose techniques were used to create virtual backgrounds in The Matrix. Subsequently, Debevec pioneered high dynamic range image-based lighting techniques in his films Rendering with Natural Light (1998), Fiat Lux (1999), and The Parthenon (2004); he also leads the design of HDR Shop, the first high dynamic range image editing program. At USC ICT, Debevec has led the development of a series of Light Stage devices for capturing and simulating how objects and people reflect light, used to create photoreal digital actors in films such as Spider Man 2, Superman Returns, and The Curious Case of Benjamin Button, and Avatar, as well as 3D Display devices for telepresence and teleconferencing. He received ACM SIGGRAPH's first Significant New Researcher Award in 2001, co-authored the 2005 book High Dynamic Range Imaging from Morgan Kaufmann, and chaired the SIGGRAPH 2007 Computer Animation Festival. He serves as Vice President of ACM SIGGRAPH and is a member of the Visual Effects Society, the Academy of Motion Picture Arts and Sciences, and the Academy's Science and Technology Council.

Jason Eichenholz, *Luminar Technologies, USA*

The Role of Optics and Photonics in the Vehicles of Tomorrow

Tuesday, 26 June, 08:00–09:00

Jason Eichenholz is a serial entrepreneur and pioneer in laser, optics and photonics product development and commercialization. Over the course of his twenty-five year career, his unique blend of business and technical leadership has resulted in hundreds of millions of dollars of new photonics products being brought to market. Eichenholz is an inventor on ten U.S. patents on new types of solid-state lasers, displays and photonic devices.

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LIGHT THE FUTURE
SPEAKER SERIES

Laurent Pueyo, *Space Telescope Science Institute, USA*

Exoplanet Imaging: From Precision Optics to Precision Measurements

Wednesday, 27 June, 08:00–09:00

Laurent Pueyo is an astronomer at the Space Telescope Science Institute, in Baltimore, Maryland. He earned his doctorate from Princeton University in 2008 and conducted his post-doctoral work as a NASA Fellow at the Jet Propulsion Laboratory and as a Sagan Fellow at the Johns Hopkins University. His research focuses on imaging faint planets around nearby stars. He has pioneered advanced data analysis methods that are now standard tools used to study extrasolar planets, and invented an optical technique that is now baselined for future NASA missions. At STScI his duties include optimizing the extrasolar-planet imaging capabilities of NASA's James Webb Space Telescope (JWST), scheduled to launch in late 2019. He is also a member of the Science and Technology Definition Team for the Large Ultraviolet Optical and Infrared telescope, a future observatory that will identify Earth-sized planets and assess their habitability.

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Explanation of Session Codes

CM2E.4

Meeting Name
3 = 3D
A = AIO
C = COSI
D= DH
J = Joint Session
I = IS
L = LACSEA
M = Math
P = pcAOP
O= AO
S = LS&C

Day of the Week
M=Monday
Tu=Tuesday
W=Wednesday
Th=Thursday

Series Number
1=First Series of Sessions
2=Second Series of Sessions

Session

Designation
(alphabetically)

Number
(Presentation order within the session)

The first letter of the code designates the meeting (3 = 3D, A=AIO, C=COSI, D=DH, J=Joint, I=IS, L=LACSEA, M=MATH, P=pcAOP, O=AO, S= S&C). The second element denotes the day of the week (Monday=M, Tuesday=T, Wednesday=W, Thursday=Th). The third element indicates the session series in that day (for instance, 1 would denote the first parallel sessions in that day). Each day begins with the letter A in the fourth element and continues alphabetically through a series of parallel sessions. The lettering then restarts with each new series. The number on the end of the code (separated from the session code with a period) signals the position of the talk within the session (first, second, third, etc.). For example, a presentation coded CM2E.4 indicates that this paper is part of COSI (C) and is being presented on Monday (M) in the first series of sessions (2), and is the fifth parallel session (E) in that series and the fourth paper (4) presented in that session.

Plenaries are noted with Plenary

Keynote talks are noted with Keynote

Tutorials are noted with Tutorial

Invited talks are noted with Invited

AIO Technology Demonstration DEMO

Key to Conference Abbreviations

3D	3D Image Acquisition and Display: Technology, Perception and Applications
AIO	Applied Industrial Optics
AO	Adaptive Optics: Methods, Analysis and Applications
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IS	Imaging Systems and Applications
LACSEA	Laser Applications to Chemical, Security and Environmental Analysis
LS&C	Application of Lasers for Sensing & Free Space Communication
MATH	Mathematics in Imaging
pcAOP	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

Agenda of Sessions — Sunday, 24 June

15:00–18:00	**Registration,** *Palms Foyer*

Monday, 25 June

	Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon/ Lime	Citron	Clementine	Mandarin
	AIO	IS	LACSEA	MATH	COSI	DH	3D	LS&C
07:00–18:30	**Registration,** *Palms Foyer*							
08:00–09:30	**JM1A • Plenary Session I,** *Citron*							
09:30–10:30	**Coffee Break with Exhibitors,** *Palms Foyer*							
10:30–12:30	**AM2A • You Say LIDAR, I Say LADAR**	**IM2B • Thin Optics and Optical Design**	**LM2C • Ultra-fast techniques & high-speed imaging**	**MM2D • Tomography**	**CM2E • Indirect and non-line-of-sight imaging**	**DM2F • Advances in DH Techniques I**	**3M2G • Holographic Display**	**SM2H • Free Space Communications** (ends at 12:00)
12:30–14:00	**Lunch on your Own**							
12:30–14:00	**Digital Holographic Microscopy: Present and Future Panel Discussion,** *Salon C*							
14:00–16:00	**AM3A • Spectroscopy, Microscopy, and Fiberoscopy**	**IM3B • Biomedical Imaging I**	**LM3C • Novel techniques & special applications**	**MM3D • Imaging in complex media**	**JM3E • Not Your Dentist's X-ray (COSI/ AIO)**	**DM3F • Incoherent Holography**	**3M3G • Measurement I**	**SM3H • Sensing I**
16:00–17:00	**JM4A • Poster Session I and Coffee Break with Exhibitors,** *Palms Foyer and Ballroom FGHI*							
17:00–18:30	**AM5A • Look To The Stars**	**IM5B • Biomedical Imaging II**	**LM5C • Atmospheric & environmental monitoring I**	**MM5D • Inverse scattering**	**CM5E • Depth-resolved and turbid imaging**	**DM5F • Applications of DH**	**3M5G • HMD & Aerial Display**	**SM5H • Sensing II**
18:30–20:00	**Congress Reception,** *Palms Ballroom E*							

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Agenda of Sessions — Tuesday, 26 June

	Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon/ Lime	Citron	Clementine	Mandarin	Tangerine
	AIO	IS	LACSEA	MATH/COSI	COSI	DH	3D	LS&C	pcAOP
07:00–18:30	**Registration,** *Palms Foyer*								
08:00–09:00	**JTu1A • Plenary Session II with the Light the Future Speaker Series,** *Citron*								
09:00–10:00	**Coffee Break with Exhibitors,** *Palms Foyer*								
10:00–12:00	**ATu2A • Keynote and Laser Sorcery**	**ITu2B • Microscopy I: Super-resolution & Illumination Techniques**	**LTu2C • Combustion Diagnostics I**	**MTu2D • High-dimentional imaging**	**CTu2E • Compressive sensing 1**	**DTu2F • Contemporary Topics in DH**	**3Tu2G • HMD & VAC Solution**	**STu2H • Components I**	**PTu2I • Propagation Simulations**
12:00–13:30	**Light the Future Lunch,** *Palm Foyer*								
12:30–14:00	**Student & Early Career Professional Development & Networking Lunch and Learn,** *Jasmine*								
13:30–15:30	**ATu3A • Fiber Sensory Overload**	**ITu3B • Microscopy II: 3D & High Speed Techniques** (starts at 14:00)	**LTu3C • Combustion diagnostics II**		**JTu3D • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman**		**3Tu3E • Compressing & Integral imaging sensing (Light Field)**	**STu3F • Quantum Protocols I** (starts at 14:30)	**PTu3G • Underwater Propagation** (starts at 14:15)
15:30–16:30	**JTu4A • Poster Session II** **Coffee Break with Exhibitors,** *Palms Foyer and Ballroom FGHI*								
16:30–18:30	**ATu5A • Bridging Two Worlds - Academics and Industry**	**JTu5B • Microscopy & Imaging (IS/AO)**	**LTu5C • Atmospheric & environmental monitoring II**	**CTu5D • Compressive sensing 2: spectral imaging**	**JTu5E • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman**	**DTu5F • Computer-Generated Holograms**	**3Tu5G • 360-degree display and perception**	**STu5H • Quantum Protocols II**	**PTu5I • Propagation In Scattering Media**
18:30–19:30	**50th Anniversary of Introduction to Fourier Optics by Joseph Goodman Reception,** *Orange/Lemon/Lime*								
19:00–21:00	**Illumicon II,** *A secret location*								

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Agenda of Sessions — Wednesday, 27 June

	Sunset/Fleming	Siesta/Biscayne	Largo/ Longboat	Cedar/ Marathon	Orange/Lemon	Citron	Clementine	Mandarin	Tangerine	Lime
	AIO	IS/COSI	LACSEA	MATH	COSI	DH	3D	LS&C	pcAOP	AO
07:30–18:30	**Registration,** *Palms Foyer*									
08:00–09:00	**JW1A • Plenary Session III,** *Citron*									
09:00–10:00	**Coffee Break with Exhibitors,** *Palms Foyer*									
10:00–12:00	**AW2A • You Down With OCT (Yeah You Know Me)**	**IW2B • Computer Vision & Image Processing**	**LW2C • Velocimetry, films & fundamentals**	**MW2D • Sparsity based priors**	**CW2E • Computational microscopy**	**DW2F • Deep Learning in DH**	**3W2G • Measurement II**	**SW2H • Quantum Protocols III**	**PW2I • Atmospheric Propagation**	**OW2J • Wavefront/ Beam Control & Sensing I**
12:00–13:00	**Applications of Visual Science Technical Group Networking Lunch,** *Salon C*									
12:00–13:30	**Lunch on your Own**									
13:30–15:30	**AW3A • Animal Optics: The Facts of Light**	**CW3B • Machine Learning in Computational Sensing and Imaging I**	**LW3C • Techniques for reactors, shock tubes & cells**	**MW3D • Application in 3D Microscopy**	**JW3E • Aerospace Imaging (COSI/IS)**	**DW3F • Multi-wavelength Digital Holography**	**3W3G • Light Field Display**	**SW3H • Components II** (ends at 14:30)	**PW3H • Environmental Propagation**	**OW3J • Wavefront/ Beam Control & Sensing II** (ends at 15:00)
15:30–16:30	**JW4A • Poster Session III** **Coffee Break with Exhibitors,** *Palms Foyer and Ballroom FGHI*									
16:30–18:30	**AW5A • Orlando: The New Silicon Valley?**	**CW5B • Machine Learning in Computational Sensing and Imaging II**	**LW5C • Ultra-fast techniques & high-speed imaging II**	**MW5D • Model-based imaging**	**JW5E • Spectral Imaging (COSI/IS)**	**DW5F • OptoFluidic and Life Applications of DH**	**3W5G • Interferometry & OCT**			**JW5I • Turbulence & Propagation (pcAOP/AO)**

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Agenda of Sessions — Thursday, 28 June

	Sunset/Fleming	Siesta/Biscayne	Cedar/Marathon	Orange/Lemon/ Lime	Citron	Clementine
	AIO	Joint	DH	COSI	DH	AO
07:30–16:00	**Registration,** *Palms Foyer*					
08:00–09:00	**Postdeadline Papers** *(schedule and location listed in the congress update sheet)*					
09:00–09:45	**Coffee Break with Exhibitors,** *Palms Foyer*					
09:45–11:45	**ATh2A • Another Day, Another Detector**	**ITh2B • Sensors & Optics**	**DTh2C • Digital Holographic Microscopy**	**CTh2D • Phase retrieval**	**DTh2E • Advances in DH Techniques 2**	**OTh2F • AO Systems II**
11:45–13:30	**Lunch on your Own**					
13:00–18:00	**Tour of Laser Propagation Facilities at Kennedy Space Center** *(Extra fee and advanced registration required.)*					
13:30–15:30	**JTh3A • Ptychography, It's Complex (AIO/COSI)**	**JTh3B • Holographic Microscopy (COSI/DH)**		**CTh3C • Imaging through aberrations, Structured illumination & super resolution**	**DTh3D • Integral Imaging and Holographic Displays**	**OTh3E • Control & Simulations**
15:30–16:00	**Coffee Break with Exhibitors,** *Palms Foyer*					
16:00–18:00				**CTh4A • Quantum computational imaging**	**DTh4B • System Design and Data Processing in DH**	**OTh4C • Adaptive Optics Systems for the Eye**

Key to Conference Abbreviations

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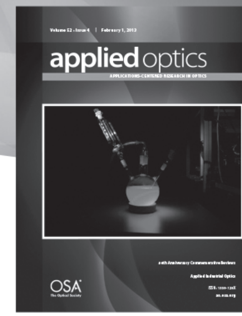

CALL FOR PAPERS:

LACSEA 2018

Submission Opens: 1 October 2018
Submission Deadline: 1 November 2018

This Feature Issue in *Applied Optics* is based on the Laser Applications to Chemical, Security, and Environmental Analysis (LACSEA) Topical Meeting. While meeting participants are encouraged to submit their work, this Feature Issue is open to all contributions.

<u>FEATURE ISSUE EDITORS</u>
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Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:00–18:30 Registration, *Palms Foyer*

Citron

08:00–09:30
JM1A • Plenary Session I

JM1A.1• 08:00 Plenary
Light Fields and Light Stages for Photoreal Movies, Games, and Virtual Reality, Paul Debevec, *Google VR, USA*. This talk will present work from USC ICT and Google VR in creating actors and environments for movies, games, and virtual reality. The Light Stage computational illumination and facial scanning systems are geodesic spheres of inward-pointing LED lights which have been used to create digital actor effects in movies such as Avatar, Benjamin Button, and Gravity, and have recently been used to create photoreal digital actors based on real people in movies such as Furious 7, Blade Runner: 2049, and Ready Player One. The lighting reproduction process of light stages allows omnidirectional lighting environments captured from the real world to be accurately reproduced in a studio, and has recently be extended with multispectral capabilities to enable LED lighting to accurately mimic the color rendition properties of daylight, incandescent, and mixed lighting environments. They have also recently used their full-body light stage in conjuction with natural language processing and automultiscopic projection to record and project interactive conversations with survivors of the World War II Holocaust. Debevec will conclude by discussing the technology and production processes behind "Welcome to Light Fields", the first downloadable virtual reality experience based on light field capture techniques which allow the visual appearance of an explorable volume of space to be recorded and reprojected photorealistically in VR enabling full 6DOF head movement.

09:30–10:30 Coffee Break with Exhibitors, *Palms Foyer*

10:30–12:30
AM2A • You Say LIDAR, I Say LADAR
Presider: Mark Itzler; Princeton Lightwave Inc., USA

AM2A. 1 • 10:30 Invited
Qualifying active components for Space and LIDAR applications, Thomas Laurent[1], Herwig Stange[1], Michael Kneier[1]; [1]*eagleyard Photonics GmbH, Germany*. Nowadays Single Frequency Laser Diodes are challenged again, as they are supposed to add more functionalities prior rather realized on module or system level. Latest requirements have significant impact in defining, selecting, and qualifying components successfully with respect to their use in various applications.

10:30–12:30
IM2B • Thin Optics and Optical Design
Presider: Michael Groenert; US Army RDECOM CERDEC, USA

IM2B.1 • 10:30 Invited
Electrically switchable large, thin, and fast optics, Nelson V. Tabiryan[1], Jeougyeon Hwang[1], Haiqing Xianyu[1], Svetlana Serak[1], Sarik Nersisyan[1], Brian Kimball[2], Diane Steeves[2], Michael McConney[3], Timothy Bunning[3]; [1]*Beam Enginering for Adv Measurements Co, USA;* [2]*US Army Natick Soldier Research, Development & Engineering Center, USA;* [3]*Air Force Research Labs, USA*. Diffractive waveplates enable stackable ultrathin light-weight large area optics fast-switchable with low-voltage/low power fields. State-of-the-art systems and low-cost manufacturing opportunities will be presented aimed at next generation augmented, virtual reality, flexible, polarizer-free displays, LiDARs, etc.

10:30–12:30
LM2C • Ultra-fast Techniques & High-speed Imaging
Presider: Thomas Dreier; Universität Duisburg-Essen, Germany

LM2C.1 • 10:30 Invited
Ultrashort Pulse Laser Imaging of Molecular Species, Waruna Kulatilaka[1]; [1]*Texas A&M Univ., USA*. Broadband, femtosecond-duration laser pulses provide numerous opportunities as well as challenges in high-temperature gas-phase spectroscopy of molecular species. Several recent advances in combustion diagnostic applications along with future perspectives are discussed.

10:30–12:00
MM2D • Tomography
Presider: Bettina Heise; RECENDT, Austria

MM2D.1 • 10:30 Invited
Quantitative Imaging with Photoacoustic and Optical Coherence Tomography, Peter Elbau[1], Leonidas Mindrinos[1], Otmar Scherzer[1,2]; [1]*Univ. of Vienna, Austria;* [2]*Johann Radon Inst. for Computational and Applied Mathematics, Austria*. We discuss a multi-modal imaging system consisting of an optical coherence tomography measurement, which we want to model as an inverse electromagnetic scattering problem, and a photoacoustic setup, where the acoustic response induced by a short laser pulse is measured and which provides us, after tracing back the pressure wave, with internal data describing the absorbed energy inside the medium. We want to show that this combination allows us to obtain a quantitative reconstruction for all the involved physical parameters.

Orange/Lemon/Lime	Citron	Clementine	Mandarin
Computational Optical Sensing and Imaging	Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:00–18:30 Registration, *Palms Foyer*

Citron

08:00–09:30
JM1A • Plenary Session I

JM1A.1• 08:00 Plenary
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09:30–10:30 Coffee Break with Exhibitors, *Palms Foyer*

10:30–12:30
CM2E • Indirect and non-line-of-sight imaging
Presider: Oliver Cossairt; Northwestern University, USA

CM2E.1 • 10:30
Non-Line-of-Sight Imaging using Superheterodyne Interferometry, Florian Willomitzer[1], Fengqiang Li[1], Prasanna V. Rangarajan[2], Oliver S. Cossairt[1]; [1]*Northwestern Univ., USA;* [2]*Southern Methodist Univ., USA.* The paper describes an interferometric imager concept capable of recovering the shape and geometry of objects hidden from view, with a resolution that exceeds the state-of-the-art.

CM2E.2 • 10:45
Resolving Non Line-of-Sight (NLoS) motion using Speckle, Muralidhar Madabhushi Balaji[1], Aparna Viswanath[1], Prasanna V. Rangarajan[1], Duncan MacFarlane[1], Marc Christensen[1]; [1]*Southern Methodist Univ., USA.* Motion of objects hidden from view is recovered by tracking displacements in speckle patterns produced by the coherently illuminated object. A latent image may additionally be recovered by examining spatial correlations in the speckle pattern.

10:30–12:30
DM2F • Advances in DH Techniques I
Presider: Tomasz Kozacki; Warsaw Univ. of Tech., Poland

DM2F.1 • 10:30 Tutorial
Computational Microscopy for 3D Imaging, Laura Waller[1]; [1]*Univ. of California Berkeley, USA.* This tutorial will describe new computational imaging systems that jointly design optical systems and inverse algorithms to enable 3D imaging. We will discuss microscopy and photography examples of single-shot lensless imagers consisting of only a scattering element (a diffuser) placed in front of a 2D image sensor.

10:30–12:30
3M2G • Holographic Display
Presider: Hong Hua; Univ. of Arizona, USA

3M2G.1 • 10:30 Invited
Optical see-through three-dimensional near-to-eye display with depth of field control, Jae-Hyeung Park[1]; [1]*Inha Univ., South Korea.* Three-dimensional near-to-eye display using holographic optical element (HOE) is presented. The proposed system expands the eyebox using multiplexed HOE, achieves per-pixel depth of field control using computer generated hologram (CGH), and reduces the computation time by foveated CGH.

10:30–12:00
SM2H • Free Space Communications
Presider: Claudine Besson; Office Natl. d'Etudes Rech Aerospatiales, France

SM2H.1 • 10:30 Invited
Correction of Atmospheric Effects on Laser Beams for sensing and communication, Karin Stein[1]; [1]*Fraunhofer IOSB, Germany.* Environmental effects limit the performance of any electro-optical (EO) system. Tasks such as delivery of directed energy and laser communications are significantly affected by atmospheric turbulence and refraction.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AM2A • You Say LIDAR, I Say LADAR—Continued

AM2A. 2 • 11:00 Invited

Title to be Determined, Carl Jackson[1]; [1]*SensL, Ireland.* Abstract not available

AM2A. 3 • 11:30 Invited

Advances in Doppler Lidar for Accurate 3D Wind Measurements, Simon Toft Sørensen[1], Matthew Warden[1], John Macarthur[1], Mark Silver[2], Theodore Holtom[3], Craig McDonald[4], Peter Clive[4], Henry Bookey[1]; [1]*Fraunhofer Centre for Applied Photonics, UK;* [2]*Thales UK, UK;* [3]*Wind Farm Analytics Ltd., UK;* [4]*Wood, UK.* We will present results from our recent development of a multi-beam Doppler lidar system for accurate 3-dimensional wind measurements. The eye-safe all-fibre system consists of a single seed laser that is amplified in multiple stages and shared between the three emitters. Steps towards wind turbine blade integration will be outlined.

IM2B • Thin Optics and Optical Design—Continued

IM2B.2 • 11:00

Achromatic Test of Pancharatnam Phase Lens for VR/AR, Comrun Yousefzadeh[1], Afsoon Jamali[1], Colin McGinty[1], Philip Bos[1]; [1]*liquid crystal Inst., kent state Univ. , USA.* In this paper we provide intuitive "limits" for the power of Pancharatnam phase based lenses under which these types of devices can be considered for use with the eye and camera specifically for VR/AR applications.

IM2B.3 • 11:15

Non-local Control of a Metasurface Image, Ashley Lyons[1,2], Charles Altuzarra[3], Guanghui Yuan[4], Christy Simpson[1,2], Thomas Roger[1], Daniele Faccio[1,2]; [1]*Heriot-Watt Univ., UK;* [2]*Univ. of Glasgow, UK;* [3]*Texas A&M Univ., USA;* [4]*Nanyang Technological Univ., Singapore.* By using correlated photon pairs, we demonstrate the non-local control of single-photon images formed by a polarisation sensitive metasurface. Non-local polarisation selection of a control photon, changes the image recorded after the metasurface.

IM2B.4 • 11:30

Towards Random Metasurface based Devices, Matthieu Dupre[1], Junhee Park[1], Liyi Hsu[1], Abdoulaye Ndao[1], Boubacar Kante[1]; [1]*Univ. of California San Diego, USA.* Using full wave simulations and a transmission matrix approach, we design and then realize random metasurface lenses with anisotropic nanorods, and show that we can obtain a diffraction limited focal spot for all polarizations.

LM2C • Ultra-fast Techniques & High-speed Imaging—Continued

LM2C.2 • 11:00

High-speed, multi-species and multi-parameters combustion imaging, Naibo Jiang[1], Sukesh Roy[1], Paul S. Hsu[1], Mikhail Slipchenko[1], Josef Felver[1], Jordi Estevadeordal[2], James R. Gord[3]; [1]*Spectral Energies, LLC, USA;* [2]*North Dakota State Univ., USA;* [3]*Air Force Research Lab, USA.* Simultaneous 10-kHz OH-PLIF/CH_2O-PLIF/PIV (Rayleigh scattering) measurements in DRL-A non-premixed flames were demonstrated using a three-leg burst-mode laser system. High-speed multi-species concentrations, heat-release rate, and flow velocity field (temperature) were measured.

LM2C.3 • 11:15

Development of a Background-Free, Broadband Absorption Method using Ultrafast Lasers: Time-Resolved Optically Gated Absorption (TOGA) Spectroscopy, Patrick S. Walsh[1], Hans U. Stauffer[1], Sukesh Roy[1], James R. Gord[2]; [1]*Spectral Energies, LLC, USA;* [2]*Aerospace Systems Directorate, Air Force Research Lab, USA.* We demonstrate a robust ultrafast-laser technique, referred to as time-resolved optically gated absorption (TOGA) spectroscopy, for acquiring broadband, background-free, single-laser-shot absorption spectra for use in combustion diagnostics.

LM2C.4 • 11:30 Invited

The Application of Diagnostic Techniques Utilizing Ultra-high Repetition Rate Laser in Typical Industrial Reacting Flows, Yi Gao[1], Chen Fu[1], Xiaoyuan Yang[1], Fei Qi[1]; [1]*Shanghai Jiao Tong Univ., UK.* The paper focuses on the study of unsteady combustion phenomena such as combustion instability, fuel atomization and pollutant generation utilizing laser diagnostics, e.g. PIV, PLIF and LII based on ultra high repetition rate laser (10k-100kHz).

MM2D • Tomography—Continued

MM2D.2 • 11:00

Synthetic Schlieren Tomography of Focused Ultrasound Transducers, Aki Pulkkinen[1], Jarkko J. Leskinen[1], Aimo Tiihonen[1]; [1]*Univ. of Eastern Finland, Finland.* Synthetic schlieren tomography is a technique for imaging of ultrasound fields based on deflection of light due to acousto-optic effect. In this work, principal physics, and pressure field estimation are described and compared with measurements.

MM2D.3 • 11:15

Tomographic reconstruction of 3D atomic potentials from intensity-only TEM measurements, David Ren[1], Michael Chen[1], Colin Ophus[2], Laura Waller[1]; [1]*Univ. of California Berkeley, USA;* [2]*National Center for Electron Microscopy, USA.* We demonstrate a tomographic Transmission Electron Microscopy (TEM) imaging modality and reconstruction algorithm that determines 3D positions of strongly scattering atoms. Our simulation-only results show that atomic potentials can be quantitatively recovered at atomic resolution from intensity-only measurements.

MM2D.4 • 11:30 Invited

Tomography, Radar, Holography and Lightfield imaging - different sides of the same coin, Konrad Schöbel[1], Lars Omlor[1], Tanja Teuber[1]; [1]*Competencies Algorithms, Carl Zeiss AG, Germany.* We present a common mathematical concept underlying such diverse imaging problems as tomography, radar, holography or lightfield imaging. This allows to "translate" ideas between different communities and yields interesting future research directions.

Orange/Lemon/Lime	Citron	Clementine	Mandarin
Computational Optical Sensing and Imaging	Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

CM2E • Indirect and non-line-of-sight imaging—Continued

CM2E.3 • 11:00
Indirect Imaging Using Correlography, Aparna Viswanath[1], Prasanna V. Rangarajan[1], Duncan MacFarlane[1], Marc Christensen[1]; [1]*Southern Methodist Univ., USA.* A computational imager combining ideas from correlography and phase retrieval is used to recover images of non-line-of-sight (NLoS) objects. It exploits the intrinsic roughness of real-world surfaces to indirectly illuminate NLoS objects and intercept the return.

CM2E.4 • 11:15
Micro Resolution Time-of-Flight Imaging, Fengqiang Li[1], Florian Willomitzer[1], Prasanna V. Rangarajan[2], Andreas Velten[3], Mohit Gupta[3], Oliver S. Cossairt[1]; [1]*Northwestern Univ., USA;* [2]*Southern Methodist Univ., USA;* [3]*Univ. of Wisconsin Madison, USA.* We propose a time-of-flight imaging technique with modulation frequencies as high as 1 THz using optical superheterodyne interferometry. Our proposed system provides great flexibility in imaging range and resolution.

CM2E.5 • 11:30
Passive Non-line-of-sight Source Classification from Coherence Measurements, Andre Beckus[1], Alexandru Tamasan[1], Zhean Shen[1], Sergey Sukhov[1], Aristide Dogariu[1], George K. Atia[1]; [1]*Univ. of Central Florida, USA.* We demonstrate a passive imaging approach for identifying the shape and size of a secondary source using non-line-of-sight spatial coherence measurements.

DM2F • Advances in DH Techniques I—Continued

DM2F.2 • 11:15 Invited
Multiplexed Illumination Holographic Fluorescence Imaging, Yuan Luo[1], Chen-Yen Lin[1], Hsi-Hsun Chen[1], Wei-Tang Lin[1]; [1]*National Taiwan Univ., Taiwan.* Optical sectioning techniques offer three-dimensional information from oragan tissues, but require individual axial planes to be imaged consecutively. We introduce active illumination, utilizing speckle or Talbot effect, and multiplexed volume holography, demonstrating three-dimensional biopsy for microscopy as well as endoscopy, without scanning.

3M2G • Holographic Display—Continued

3M2G.2 • 11:00 Invited
Color dynamic holographic display by complex amplitude modulation, Juan Liu[1]; [1]*Beijing Inst. of Technology, China.* An improved method of complex amplitude modulation (CAM) is proposed for color dynamic holographic display with a wide viewing angle. Bandlimited random initial phase is introduced to enlarge the field of view for 3D dispaly.

3M2G.3 • 11:30 Invited
Holographic Goggles for Near Infrared Fluorescence Image Guided Surgery, Viktor Gruev[1]; [1]*Univ. of Illinois, USA.* Abstract not available

SM2H • Free Space Communications—Continued

SM2H.2 • 11:00
Atmospheric turbulence on pointing errors of free space optical communication link, Siyuan Yu[1,2], Lifang Li[3,4], Pengzhen Guo[1,2], Qingbo Yang[1,2], Liying Tan[1,2], Jing Ma[1,2]; [1]*National Key Lab of Tunable Laser Tech., China;* [2]*Aerospace, Harbin Inst. of Tech., China;* [3]*Electrical and Mechanical College, Lab for Space Environment and Physical Sciences, China;* [4]*Electrical and Mechanical College, Harbin Inst. of Tech., China.* We have established a compensation model between atmospheric turbulence and pointing errors, which can provide quantitative analysis of atmosphere turbulence on pointing angle errors of PAT system.

SM2H.3 • 11:15
Free Space Optical Communication System through Turbid Media with Pointing Errors, Sunil Kumar K[1,2], Satheesh S K[1,3], Ilavazhagan G[4], Krishna Moorthy K[1]; [1]*Centre for Atmospheric and Oceanic Sciences, Indian Inst. of Science, India;* [2]*Electronics and Communication Engineering, Hindustan Inst. of Tech. & Science, India;* [3]*Divecha Centre for Climate Change, Indian Inst. of Science, India;* [4]*Centre for Photonics and LIDAR Research, Hindustan Inst. of Tech. & Science, India.* A seven channel Aethalometer measured Black carbon (BC) and Optical Properties of Aerosols and Clouds (OPAC) aerosol model based study shows a transmitter power penalty of 3dB for a DPSK Free Space Optical Communication System (FSOC).

SM2H.4 • 11:30
Increase Data Rate of OLED VLC System Using Pre-Emphasis Circuit and FBMC Modulation, Quang Thai Pham[1], François Rottenberg[2], Dat T. Pham[3], Shimamoto Shigeru[4]; [1]*HoChiMinh city Univ. of Technology, Viet Nam;* [2]*Université catholique de Louvain, ICTEAM Inst., Belgium;* [3]*National Inst. of Information and Communications Technology, Japan;* [4]*Dept. of Communications and Computer Inst., Waseda Univ., Japan.* Using a commercial organic light emitting diode (OLED) with 7 kHz modulation bandwidth, we was able to achieve 2 Mbps transmission data rate using a combination of active pre-equalizer and Filter Bank Multi-Carrier (FBMC) modulation.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AM2A • You Say LIDAR, I Say LADAR—Continued

AM2A. 4 • 12:00
Time-Domain Compressive FMCW LADAR, Bryan T. Bosworth[1], Charbel Rizk[1], Mark Foster[1]; [1]*Johns Hopkins Univ., USA.* We demonstrate a straightforward modification of FMCW LADAR to permit measurement of beat notes well beyond the receiver bandwidth using <0.5% of Nyquist sampling while achieving picowatt minimum sensitivity.

AM2A. 5 • 12:15
Compressive Time-of-Flight Imaging, Fengqiang Li[1], Huaijin Chen[2], Chia-Kai Yeh[1], Adithya Pediredla[2], Kuan He[1], Ashok Veeraghvan[1], Oliver S. Cossairt[1]; [1]*Northwestern Univ., USA;* [2]*Rice Univ., USA.* We propose an imaging architecture to achieve high spatial resolution ToF imaging via optical multiplexing and compressive sensing. We developed a prototype 1-megapixel compressive ToF camera that achieves as much as 4x improvement in spatial resolution.

IM2B • Thin Optics and Optical Design—Continued

IM2B.5 • 11:45
Reflective Microwave Ghost Imaging With Dynamic Metasurface Apertures, Aaron V. Diebold[1], Mohammadreza F. Imani[1], Timothy Sleasman[1], David Smith[1]; [1]*Duke Univ., USA.* We demonstrate phaseless, single-frequency ghost imaging at microwave frequencies using a dynamic metasurface aperture. This aperture comprises a simplified hardware architecture for generating diverse speckle patterns by tuning an array of resonant metamaterial elements.

IM2B.6 • 12:00
The Proton Beam Imaging System Design for the Spallation Neutron Source Tungsten Target, Abdurahim Rakhman[1], Willem Blokland[1], Slobodan Rajic[1], Mark Rennich[1]; [1]*Oak Ridge National Lab, USA.* A periscope based remote imaging system has been developed to for an in-situ viewing of high-energy proton beams on the rotating tungsten target in harsh radiation environment at the Spallation Neutron Source. The optical system design and the performance of a prototype system will be presented.

IM2B.7 • 12:15
Encoding Optical Architectures via Gene Expression Programming, Colin C. Olson[1]; [1]*Naval Research Lab, USA.* We introduce a methodology for encoding optical architectures (i.e., number, types, and order of optical elements) that enables automated design of optical systems when combined with ray tracing software, parameter optimizations, and a merit function.

LM2C • Ultra-fast Techniques & High-speed Imaging—Continued

LM2C.5 • 12:00
High-speed Tomo-PIV/OH-PLIF Measurements of a Transverse Turbulent Reacting Fuel Jet, Tongxun Yi[1]; [1]*Spectral Energies, LLC, USA.* High-speed tomographic PIV measurements synchronized with OH-PLIF imaging are used to fully resolve the nine-component velocity-gradient tensor upstream of a turbulent flame front, which is not possible with the traditional stereo-PIV/PLIF technique.

LM2C.6 • 12:15
Hydrogen Femtosecond Vibrational CARS Thermometry in Solid Propellant Flames, Daniel R. Richardson[1], Marley Kunzler[1], Daniel R. Guildenbecher[1]; [1]*Sandia National Labs, USA.* Femtosecond coherent anti-Stokes Raman scattering thermometry in a solid-fuel propellant flame is demonstrated by tuning the lasers to the rovibrational Raman transitions of diatomic hydrogen (H_2).

MM2D • Tomography—Continued

MM2D.5 • 12:00
CNN based Sinogram Denoising for Low-Dose CT, Muhammad Usman Ghani[1], Clem Karl[1]; [1]*Boston Univ., USA.* Reduction of source flux results in an increase of noise in data sinograms, which subsequently produces artifacts in the corresponded reconstructed images. We use deep-learning to denoise the original sinograms, resulting in higher quality images.

MM2D.6 • 12:15
Spectral Encoding using k-space/frequency Duality, Hichem Guerboukha[1], Kathirvel Nallappan[1], Maksim Skorobogatiy[1]; [1]*Ecole Polytechnique de Montreal, Canada.* Single-pixel imaging has recently attracted a lot of attention. Here, we propose to use spectral encoding in a single-pixel detection scheme. We demonstrate the reconstruction process for amplitude and phase masks and we study the resolution.

12:30–14:00 Lunch on your Own

12:30–14:00 Digital Holographic Microscopy: Present and Future Panel Discussion, *Salon C*

Orange/Lemon/Lime

Computational Optical Sensing and Imaging

CM2E • Indirect and non-line-of-sight imaging—Continued

CM2E.6 • 11:45
Diffuse Time-of-flight Imaging with a Single-Photon Camera, Ashley Lyons[1,2], Alessandro Boccolini[1], Audrey Repetti[1], Francesco Tonolini[1], Zhouye Chen[1], Jonathan Leach[1], Robert Henderson[3], Yves Wiaux[1], Daniele Faccio[1,2]; [1]*Heriot-Watt Univ., UK;* [2]*School of Physics and Astronomy, Univ. of Glasgow, UK;* [3]*Univ. of Edinburgh, UK.* The spatial and temporal photon arrival time information is used to perform imaging through diffusive media. Increasing the spatial and/or temporal resolution increases the final image resolution.

CM2E.7 • 12:00
Imaging with Phasor Fields for Non-Line-of Sight Applications, Syed A. Reza[1], Marco A. La Manna[1], Andreas Velten[1]; [1]*Univ. of Wisconsin-Madison, USA.* A mathematical construct 'Phasor Fields' (P-Fields) is used to develop a light transport mathematical model for non-line-of-sight (NLOS) imaging applications. We show that NLOS imaging can be treated as conventional line-of-sight (LOS) imaging using P-Fields.

CM2E.8 • 12:15
Indirect Imaging Using Virtualized Pattern Projection, Aparna Viswanath[1], Muralidhar Madabhushi Balaji[1], Prasanna V. Rangarajan[1], Duncan MacFarlane[1], Marc Christensen[1]; [1]*Southern Methodist Univ., USA.* The submission examines the role of illumination diversity in recovering shape, texture and motion of objects hidden from view. Focused spots incident on a scattering wall are used to spatially pattern the illumination within the hidden volume.

Citron

Digital Holography & 3-D Imaging

DM2F • Advances in DH Techniques I—Continued

DM2F.3 • 11:45
Simultaneous Angular Acquisition in Quantitative Phase Microscopy Using Off-Axis Hologram Multiplexing, Natan T. Shaked[1], Gyanendra Singh[1]; [1]*Tel-Aviv Univ., Israel.* We present a new technique for multiplexing multiple angular perspectives into a single off-axis hologram, which is useful for tomography, super resolution, and stereoscopy.

DM2F.4 • 12:00
Achieving Fast 3D Label-free Microscopy for Optical Tweezers Experiments, Juan M. Soto[1], Jose A. Rodrigo[1], Tatiana Alieva[1]; [1]*Dept. of Optics, Complutense Univ. of Madrid, Spain.* We present a technique exploiting partially coherent light and a system compatible with widefield microscopes that allows achieving label-free dynamic 3D quantitative imaging of live cells simultaneously manipulated by optical tweezers.

DM2F.5 • 12:15
Digital Plasmonic Holography, Joseph Nelson[1], Greta Knefelkamp[1], Alexandre Brolo[2], Nathan Lindquist[1]; [1]*Bethel Univ., USA;* [2]*Univ. of Victoria, Canada.* Direct two-dimensional imaging with surface plasmons suffers from the lack of simple two-dimensional lenses. Here we show that digital holographic microscopy techniques can be used for lens-less in-plane surface imaging with propagating plasmons.

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

3M2G • Holographic Display—Continued

3M2G.4 • 12:00
Near-eye foveated holographic display, Jisoo Hong[1], Youngmin Kim[1], Sunghee Hong[1], Choonsung Shin[1], Hoonjong Kang[1]; [1]*VR/AR research center, Korea Electronics Technology Inst., South Korea.* Holographic and two-dimensional displays can be combined at the angular spectrum domain to provide three-dimensional image near fovea and two-dimensional image for periphery. This scheme can resolve vergence-accommodation conflict of the near-eye display.

3M2G.5 • 12:15
Numerical correction of image distortion in CGH display based on automatic calibration algorithm, Liangcai Cao[1], Zehao He[1], Guofan Jin[1]; [1]*Tsinghua Univ., China.* A numerical correction method of image distortion for computer generated holography (CGH) display is proposed. A camera-based wavefront sensing system is proposed with the designed CGH testing images. The automatic pre-calibration algorithm is developed.

Mandarin

Application of Lasers for Sensing & Free Space Communication

SM2H • Free Space Communications—Continued

SM2H.5 • 11:45
Applications of Lasers for Sensing and Free Space Communication, Mohammed S. S.[1]; [1]*St. Joseph's College of Engineering, India.* This article gives an overview of the challenges a designer has to consider while implementing the Free Space Communication System using laser and how it's applied in various fields and the modulations schemes used in detail.Advantages of FSO result from the basic characteristics of laser beam, especially from its high frequency,coherency and low divergence, which lead to efficient delivery of power to a receiver and a high information carrying capacity.

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

12:30–14:00 Lunch on your Own

12:30–14:00 Digital Holographic Microscopy: Present and Future Panel Discussion, *Salon C*

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

14:00–16:00
AM3A • Spectroscopy, Microscopy, and Fiberoscopy
Presider: Brandon Redding; US Naval Research Lab, USA

AM3A.1 • 14:00 Invited
A Spectroscopic Method to Determine Color of Petroleum Products, John D. Rodriguez[2], Matthew Comstock[2], Dieter Bingemann[1], Ty Olmstead[2]; [1]*Ocean Optics BV, Germany;* [2]*Ocean Optics Inc, USA.* Color is an important metric for determining the quality of petroleum products. The spectroscopic method described in this paper yields results on actual gasoline samples that are accurate and repeatable

AM3A.2 • 14:30
High-precision wavelength modulation - direction absorption spectroscopy, Yanjun Du[1], Yanjun Ding[1], Zhimin Peng[1]; [1]*Tsinghua Univ., China.* Wavelength modulation - direct absorption spectroscopy (WM-DAS) is proposed by extracting the characteristic spectrum. This method improves the accuracy of the absorbance profile measurement by one order of magnitude and is verified by experiments.

AM3A.3 • 14:45
Handheld, Quantitative, Standoff Methane Detector and Imager, Richard T. Wainner[1], Nicholas F. Aubut[1], Matthew Laderer[1], Shin-Juh Chen[1], Mickey B. Frish[1]; [1]*Physical Sciences Inc., USA.* Addressing the needs of upstream natural gas infrastructure, using an adaptation of handheld remote laser sensing tools, we demonstrate sensitive quantified methane leak imaging and flux estimation.

14:00–16:00
IM3B • Biomedical Imaging I
Presider: Kevin Gemp; The MITRE Corporation, USA

IM3B.1 • 14:00 Invited
Ultra-High Resolution Full-Field OCT (FFOCT) for Cornea and Retina, Claude A. Boccara[1], Viacheslav C. Mazlin[1], Peng C. Xiao[1], Jules C. Scholler[1], Kate C. Grieve[2], Kristina Irsch[2], José-Alain Sahel[2], Mathias Fink[1]; [1]*Institut Langevin, France;* [2]*HOPITAL 15_20, France.* Full-field Optical Coherence Tomography (FFOCT) offers aberration independent resolution. This property is particularly useful for eye imaging, as micrometer features are visible without adaptive optics (AO). Diffraction-limited *in vivo* corneal and retinal images are demonstrated.

IM3B.2 • 14:30
Rapid full-field optical coherence tomography using geometric phase ferroelectric liquid crystal technology, Maitreyee . Roy[1], Zheng Wei[2], Colin Sheppard[3]; [1]*Univ. of New South Wales, Australia;* [2]*Dept. of Biomedical Engineering, National Univ. of Singapore, Singapore;* [3]*Dept. of Nanophysics, Istituto Italiano di Tecnologia, Italy.* We demonstrate a fast, switchable achromatic phase shifter operating on the geometric phase principle, using ferroelectric liquid crystal technology for rapid 3D biological imaging in a full field optical coherence tomography system.

IM3B.3 • 14:45
Automated Image Processing Algorithm for Infrared Meibography, Clara Llorens Quintana[1], Piotr Syga[2], D. Robert Iskander[1]; [1]*Biomedical Engineering, Wroclaw Univ. of Science and Technology., Poland;* [2]*Computer Science, Wroclaw Univ. of Science and Technology., Poland.* Infrared meibography is a technique for imaging meibomian glands that are located in the rim of the eyelids. An automated methodology for analysing these images was proposed to assess meibomian glands structure and health.

14:00–16:00
LM3C • Novel Techniques & Special Applications
Presider: Paul Hsu; Spectral Energies LLC, USA

LM3C.1 • 14:00 Invited
Towards an all-purpose laser excitation tool for multimodal nonlinear microscopy, Niklas Müller[1], Lukas Brückner[1], Marcus . Motzkus[1]; [1]*Ruprecht-Karls-Universitat Heidelberg, Germany.* We present combined mid-infrared and nonlinear Raman spectroscopy in a single beam setup exploiting spectral focussing and sub 10 fs pulse shaping.

LM3C.2 • 14:30
Four-Dimensional X-ray Imaging of Multiphase Flows, Benjamin R. Halls[1], Naveed Rahman[2], Terrence Meyer[2], Malissa Lightfoot[3], Mikhail Slipchenko[2,4], Sukesh Roy[4], James R. Gord[1]; [1]*Air Force Research Lab, USA;* [2]*Purdue Univ., USA;* [3]*Air Force Research Lab, USA;* [4]*Spectral Energies, LLC, USA.* Four-dimensional x-ray measurements are demonstrated in an optically complex spray using three x-ray sources and three high-speed imaging systems. Time-evolving volumes are reconstructed from the quantitative two-dimensional path length data.

LM3C.3 • 14:45
Diode Laser Based Film Thickness Measurement of DEF, Anna K. Schmidt[1,2], Benjamin Kühnreich[1,2], Hannah Kittel[3], Cameron Tropea[3], Ilia Roisman[3], Andreas Dreizler[2], Steven Wagner[1,2]; [1]*High Temperature Process Diagnostics, Germany;* [2]*Reactive Flows and diagnostics, Germany;* [3]*Fluid Mechanics and Aerodynamics, Germany.* An absorption based laser sensor for the investigation of liquid film thicknesses of DEF is presented. A wavelength pre-selection ensures that film thicknesses could be measured without cross sensitivity to temperature or concentration.

14:00–15:45
MM3D • Imaging In Complex Media
Presider: John Schotland; Univ. of Michigan, USA

MM3D.1 • 14:00 Invited
Correlation-based imaging in random media, Josselin Garnier[1]; [1]*Ecole Polytechnique, France.* In the white-noise paraxial regime wave propagation in random media can be modeled by a Schrodinger-type equation driven by a Brownian field. Correlation-based imaging methods can then be characterized in terms of resolution and stability.

MM3D.2 • 14:30
First Born Model for Reflection-Mode Fourier Ptychographic Microscopy, Alex C. Matlock[1], Anne Sentenac[2], Ji Yi[3], Lei Tian[1]; [1]*Boston Univ., USA;* [2]*Institut Fresnel - CNRS, France;* [3]*Medicine, Boston Univ. School of Medicine, USA.* We validate a first Born approximation based model for Reflection-mode Fourier ptychography under the semi-infinite boundary condition. Our model enables optical thickness and absorption recovery with enhanced resolution from thin samples.

MM3D.3 • 14:45
Withdrawn

Orange/Lemon/Lime

Joint Computational Optical Sensing and Imaging/Applied Industrial Optics

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

14:00–16:00
JM3E • Not Your Dentist's X-ray (COSI/AIO)
Presider: Andrew Harvey; Univ. of Glasgow, UK

JM3E.1 • 14:00 Invited
X-ray imaging based on coherence engineering as a multi-scale material characterization tool, Yunhui Zhu[1]; [1]*Virginia Tech, USA*. Quantitative X-ray imaging based on phase-space engineering has significantly extended the data acquisition space, which enables enhanced contrast, higher sensitivity, and simultaneous characterization of complex material structures across multiple length scales.

JM3E.2 • 14:30 Invited
Recent Developments in X-ray Computed Tomography, Philipp Hoelzer[1]; [1]*Siemens Medical Solutions, Inc., USA*. This talk presents concepts of computed tomography in terms of image acquisition, reconstruction and analysis, and outlines some recent technology developments.

Citron

Digital Holography & 3-D Imaging

14:00–16:00
DM3F • Incoherent Holography
Presider: Konstantinos Falaggis; Univ. of North Carolina at Charlotte, USA

DM3F.1 • 14:00 Invited
Switchable, broadband, polarization-independent diffractive optical components and systems, David E. Roberts[1], Nelson V. Tabiryan[1], Michael McConney[2], Timothy Bunning[2]; [1]*BEAM Engineering for Adv. Measurements, USA;* [2]*Air Force Research Labs, USA*. Devices based on diffractive waveplates exhibit diffraction characteristics that are dependent on the polarization and wavelength of light. In applications, switchability, polarization independence, and wavelength independence are often desirable. Here we report on recent developments of diffractive optical elements that have various combinations of switchability, polarization independence, and broad wavelength coverage.

DM3F.2 • 14:30 Invited
Adaptive Fluorescence Digital Holographic Imaging, Yuhong Wan[1], Tianlong Man[1], Hongqiang Zhou[1], Dayong Wang[1]; [1]*Beijing Univ. of Technology, China*. Fluorescence self-interference holographic microscopy combined with computational adaptive optics are demonstrated, thus the imaging performances of the technology are improved with less recording time, anisotropic aberration correction and improved imaging resolution.

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

14:00–16:00
3M3G • Measurement I
Presider: Osamu Matoba; Kobe Univ., Japan

3M3G.1 • 14:00 Invited
Single-Shot Phase Imaging with Coded Diffraction and Its Applications, Ryoichi Horisaki[1,2]; [1]*Osaka Univ., Japan;* [2]*JST, PRESTO, Japan*. We have presented single-shot quantitative phase imaging with a coded aperture or structured illumination based on compressive sensing. It enables to remove the reference light and increase the field-of-view which are fundamental issues in digital holography and phase retrieval.

3M3G.2 • 14:30
High Resolution Single-Shot 3D Imaging with the "3D movie camera", Florian Willomitzer[1], Gerd Häusler[2]; [1]*Northwestern Univ., USA;* [2]*Univ. Erlangen-Nuremberg, Germany*. We introduce a novel sensor for the 3D acquisition of macroscopic live scenes. The sensor combines single-shot acquisition with a precision and point cloud density close to the theoretical maximum.

3M3G.3 • 14:45
Structured Light Imaging under Sunlight Conditions, Jostein Thorstensen[1], Jon Tschudi[1], Karl Henrik Haugholt[1], Gregory Bouquet[1], Trine Kirkhus[1]; [1]*Smart Sensor Systems, SINTEF, Norway*. We demonstrate a Structured Light Imaging system that provides Mpix resolution images with sub-mm depth precision at 1 m distance, when operating in direct sunlight. This is achieved through spectral filtering of the camera and the use of a high power VCSEL. We discuss predicted and observed precision.

Mandarin

Application of Lasers for Sensing & Free Space Communication

14:00–16:00
SM3H • Sensing I
Presider: Karin Stein; Fraunhofer IOSB, Germany

SM3H.1 • 14:00 Invited
New developments in active sensing at ONERA, Claudine Besson[1]; [1]*ONERA, France*. The paper presents some of the technology maturing activity on gas sensing and active imaging at ONERA along with the development of tools and methods for optical sensors performance assessment.

SM3H.2 • 14:30 Invited
Novel Development for FMCW Lidar, Patrick Feneyrou[1], Luc Leviandier[1], Jean Minet[2], Grégoire Pillet[3], Aude Martin[1], Daniel Dolfi[1], Jean-Pierre Schlotterbeck[4], Philippe Rondeau[4], Xavier Lacondemine[4], Alain Rieu[5], Thierry Midavaine[5]; [1]*Thales Research and Technology France, France;* [2]*Koheron, France;* [3]*Thales DMS France, France;* [4]*Thales AVS France, France;* [5]*Thales LAS France, France*. Frequency-modulated continuous-wave lidar is evaluated for laser anemometry for helicopter, range finding and velocimetry at long range. Optimized signal processing is described as well as demonstration of range-finding/velocimetry from a few meters up to 10 km.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AM3A • Spectroscopy, Microscopy, and Fiberoscopy—Continued

AM3A.4 • 15:00
Uniform Angular Illumination in Optical Microscopes, Ravikiran Attota[1], Emil Agocs[1]; [1]*Nanoscale Metrology, NIST, USA.* Angular illumination asymmetry (ANILAS) at the sample plane depends on illumination wavelength, objective type and the location of aperture stop. To extract consistent and accurate quantitative values, all the three parameters must be aligned.

AM3A.5 • 15:15 Invited
Path to new optical components using CO2 splicing technologies, Erik Bottcher[1]; [1]*NYFORS, Sweden.* CO2 lasers are becoming increasingly popular for fiber processing. Due to the short absorption length of 10,6 um light in glass, a very localized heating in the component can be achieved. But this localized heating is not only advantageous in traditional fiber splicing. By controlling the shape and angle of the light new fiber components can be manufactured.

IM3B • Biomedical Imaging I—Continued

IM3B.4 • 15:00 Invited
Integrating Retinal Birefringence Scanning and Optical Coherence Tomography for Pediatric Retinal Imaging, Boris I. Gramatikov[1], Kristina Irsch[1], David L. Guyton[1]; [1]*Wilmer Eye Inst., Johns Hopkins Univ., USA.* A hybrid system integrating Optical Coherence Tomography and Retinal Birefringence Scanning acquires and/or analyzes data only during central fixation. This can lead to significant acceleration of the image processing phase, and shorten the exam duration.

IM3B.5 • 15:30 Invited
Adaptive electrowetting optical devices for imaging, Juliet T. Gopinath[1], Robert H. Cormack[1], Gregory L. Futia[2], Connor McCullough[2], Philip D. Nystrom[3], Baris N. Ozbay[2], Wei Y. Lim[3], Omkar D. Supekar[3], Mo Zohrabi[1], Emily A. Gibson[2], Diego Restrepo[4], Victor M. Bright[3]; [1]*Electrical, Computer and Energy Engineering, Univ. of Colorado Boulder, USA;* [2]*Bioengineering, Univ. of Colorado Denver Anschutz Medical Campus, USA;* [3]*Mechanical Engineering, Univ. of Colorado Boulder, USA;* [4]*Developmental and Cell Biology, Univ. of Colorado Denver Anschutz Medical Campus, USA.* Electrowetting adaptive optical devices are compact, high quality, versatile, and consume very low amounts of power. We demonstrate these elements for non-mechanical beam scanning in a two-photon microscope and show imaging of mouse hippocampal neurons.

LM3C • Novel Techniques & Special Applications—Continued

LM3C.4 • 15:00 Invited
PIVOTS: A novel method of performing time gated particle image velocimetry, Megan Paciaroni[1], Yi Chen[2], Daniel R. Guildenbecher[2], Kyle Lynch[2]; [1]*Physics & Engineering, Fort Lewis College, USA;* [2]*Sandia National Labs, USA.* Backscatter Particle Image Velocimetry via Optical Time-of-flight Sectioning (PIVOTS) is a novel method of performing PIV in situations where conventional PIV presents difficulties. The PIVOTS technique is introduced along with recent applications and results.

LM3C.5 • 15:30
Analysis of the Laser-Induced Ignition Spark for Cryogenic Rocket Combustion, Robert G. Stützer[1], Michael Börner[1], Michael Oschwald[1]; [1]*Inst. of Space Propulsion, German Aerospace Center (DLR), Germany.* Laser ignition was applied on a cryogenic rocket combustor. The induced plasma breakdown was analyzed using spectroscopic (LIBS) and other optical methods. Hence, plasma temperature, localized equivalence ratio and the exact ignition time were determined.

MM3D • Imaging In Complex Media—Continued

MM3D.4 • 15:00 Invited
Seeing Inside and Beyond: Challenges and Trends in (Low) Coherent Imaging, Bettina Heise[1,2]; [1]*Optics, Research Center for Nondestructive Testing (RECENDT), Austria;* [2]*Engineering and Natural Sciences Fac., Johannes Kepler Univ. (JKU), Austria.* In this paper we review developments in (low) coherent imaging with respect to optical and mathematical concepts and realizations. In particular novel light sources, SLM-based controlling of wavefronts, and advanced reconstruction point towards future solutions.

MM3D.5 • 15:30
Simultaneous Measurement and Reconstruction Tailoring for Phase Imaging, Zhengyun Zhang[1], Wei-Na Li[1], Anand Asundi[2], George Barbastathis[1,3]; [1]*Singapore-MIT Alliance for Res & Tech Ct, Singapore;* [2]*School of Mechanical and Aerospace Engineering, Nanyang Technological Univ., Singapore;* [3]*Dept. of Mechanical Engineering, MIT, USA.* We propose a joint optimization approach to phase imaging, wherein instead of separately designing the measurement process and reconstruction method, we use convex optimization to find an optimal measurement-reconstruction pair minimizing expected reconstruction error.

Orange/Lemon/Lime	Citron	Clementine	Mandarin
Joint Computational Optical Sensing and Imaging/Applied Industrial Optics	Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

JM3E • Not Your Dentist's X-ray (COSI/AIO)—Continued

JM3E.3 • 15:00 Invited

3D Imaging on the Nanoscale via X-ray Ptychography, Esther H. Tsai[1], Mirko Holler[1], Manuel Guizar-Sicairos[1]; *[1]Paul Scherrer Inst., Switzerland.* From the discovery of physiological-relevant features in bulk frozen-hydrated tissues to tracking morphological changes in energy materials, ptychographic tomography has enabled the 3D characterization of various materials with an unparalleled resolution in hard X-ray imaging. Current status and challenges will be discussed.

JM3E.4 • 15:30

High Resolution Ptychographic Coherent Diffractive Imaging using Table-top XUV Sources, Wilhelm Eschen[2], Getnet K. Tadesse[1,2], Robert Klas[1,2], Maxim Tschernajew[2], Frederik Tuitje[1,3], Christian Spielmann[1,3], Andreas Tünnermann[2,4], Jens Limpert[1,2], Jan Rothhardt[1,2]; *[1]Helmholtz Inst. Jena, Germany; [2]Inst. of Applied Physics, Friedrich-Schiller-Univ. Jena, Germany; [3]Inst. of Optics and Quantum Electronics, Friedrich-Schiller-Univ. Jena, Germany; [4]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We present a coherent imaging setup for extended samples achieving record-high resolution for non-periodic samples. A Siemens star pattern is imaged and the Rayleigh criterion is used to provide a reliable sub-50 nm resolution claim.

DM3F • Incoherent Holography—Continued

DM3F.3 • 15:00

Far-Field Imaging by Annular Phase Coded Apertures, Angika Bulbul[1], Vijayakumar A[1], Joseph Rosen[1]; *[1]Ben Gurion Univ. of the Negev, Israel.* We present a partial aperture imaging system with annular phase coded masks. The principle of interferenceless coded aperture correlation holography for 3D imaging is applied using only a small fraction of the aperture area.

DM3F.4 • 15:15

Interferenceless Coded Aperture Correlation Holography with Single Shot Recording and Non-Linear Reconstructing, Mani R. Rai[1], Vijayakumar A[1], Joseph Rosen[1]; *[1]Ben Gurion Univ., Israel.* A non-linear computer reconstruction technique is developed for reconstructing 3D images from a single camera shot. The technique is demonstrated on a recently developed digital holography technique called interferenceless coded aperture correlation holography.

DM3F.5 • 15:30

Extending the Field of View by a Scattering Window, Mani R. Rai[1], Vijayakumar A[1], Joseph Rosen[1]; *[1]Ben Gurion Univ., Israel.* We demonstrate a technique to extend the field of view of the interferenceless coded aperture correlation holography (I-COACH) system beyond the limit imposed by the finite area of the image sensor.

3M3G • Measurement I—Continued

3M3G.4 • 15:00

Grid-based oneshot scan using dot-line pattern, Hiroshi Kawasaki[1], Ryo Furukawa[2]; *[1]Kyushu Univ., Japan; [2]Hiroshima City Univ., Japan.* Grid-based Oneshot scanning technique which is robust to subsurface scattering is proposed. The pattern consists of parallel lines, where dotted lines and solid lines are alternatively aligned. Real objects are scanned to prove the effectiveness.

3M3G.5 • 15:15

Evaluating the Influence of Camera and Projector Lens Distortion in 3D Reconstruction Quality for Fringe Projection Profilometry, Andres G. Marrugo[1], Raul Vargas[1], Jesus Pineda[1], Jaime Meneses[2], Lenny A. Romero[3]; *[1]Facultad de Ingenieria, Universidad Tecnologica de Bolivar, Colombia; [2]Grupo de Óptica y Tratamiento de Señales, Universidad Industrial de Santander, Colombia; [3]Facultad de Ciencias Basicas, Universidad Tecnologica de Bolivar, Colombia.* We study the influence of geometric distortions of the camera and projector lenses on 3D reconstruction quality for fringe projection profilometry. Experimental results on real objects and their 3D models show the accuracy is improved.

3M3G.6 • 15:30

Hyperspectral + Depth Imaging Using Compressive Sensing and Structured Light, Elkin D. Diaz[1], Jaime Meneses[1], Henry Arguello[1]; *[1]Universidad Industrial de Santander, Colombia.* This works presents a new CASSI setup to capture the depth and spectral information of a scene using structured light and compressive sensing. The traditional sensor in structured light acquisition is replaced by a CASSI camera.

SM3H • Sensing I—Continued

SM3H.3 • 15:00 Invited

Automotive LiDAR with short-wave infrared Geiger-mode detectors, Mark A. Itzler[2]; *[2]Argo AI, LLC, USA.* We describe potentially disruptive automotive LiDAR performance essential to future autonomous vehicle navigation enabled by the combination of two factors: single-photon sensitivity and greater eye-safety of lasers at wavelengths beyond 1400 nm.

SM3H.4 • 15:30

Photon Counting Panoramic 3D-imaging, Markus N. Henriksson[1], Lars Allard[1], per jonsson[1]; *[1]Swedish Defence Research Agency, Sweden.* Panoramic 3D imaging with a Gm-APD array detector over 300 m distance in daylight conditions is demonstrated. Panorama acquisition of 128 rows×350 columns/second is achieved limited by laser pulse energy and background light.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AM3A • Spectroscopy, Microscopy, and Fiberoscopy—Continued

IM3B • Biomedical Imaging I—Continued

LM3C • Novel Techniques & Special Applications—Continued

LM3C.6 • 15:45
Two Dimensional Scanning System for Surface Analysis of Solids Based on Laser-induced Charge Effect, Ognyan Ivanov[1], Viktor Pulis[1], Stefan I. Karatodorov[1], José Luis Pérez Díaz[2]; [1]*Inst. of Solid State Physics, Bulgaria;* [2]*Escuela Politécnica Superior, Universidad de Alcalá, Spain.* An automated two-dimensional scanning system for express, contactless and non-destructing analysis of nonhomogeneous points on solid surfaces is presented. The system performance, based on a sensor for laser-induced surface photo charge effect, is demonstrated.

MM3D • Imaging In Complex Media—Continued

16:00–17:00 Coffee Break with Exhibitors, *Palms Foyer*

Salon FGHI

16:00–17:00
JM4A • Poster Session I

JM4A.1
Optofluidic Microscopy by Wavefront Division Holographic Interferometer on Chip, Biagio Mandracchia[1], Vittorio Bianco[1], Melania Paturzo[1], Pietro Ferraro[1]; [1]*Inst. of Applied Sciences and Intelligent Systems, Italy.* We embed coherent imaging functionalities onboard a pocket Lab-on-a-Chip device. A pocket module that allows performing off-axis Digital Holography microscopy with no need for an interferometer setup is designed and tested for the scope.

JM4A.2
Detection of Blood Glucose Level in Mice using Ultrasonic-assisted Mid-infrared Fourier Spectroscopy for realizing Earring-type Non-invasive Blood Glucose Sensors, Natsumi Kawashima[1], Tomoya Kitazaki[1], Hiroyuki NOMURA[1], Akira NISHIYAMA[1], Kenji WADA[1], Ichiro ISHIMARU[1]; [1]*Kagawa Univ., Japan.* A non-invasive, ultrasonic-assisted mid-infrared Fourier spectroscopy method to determine blood glucose levels in mice is proposed, which can be installed into smartphones. This technique is shown to depend on the time when measurements are recorded.

JM4A.3
Quantum Cascade Laser-based Optical Monitoring of N_2O_5 in a Nocturnal Tropospheric Chemical Reaction Process in an Atmospheric Simulation Chamber, Weidong Chen[1]; [1]*Universite du Littoral, France.* A spectroscopic instrument based on an external cavity quantum cascade laser was developed for optical monitoring of dinitrogen pentoxide (N_2O_5) at the ppbv-level in a nocturnal tropospheric chemical reaction process in an atmospheric simulation chamber.

JM4A.4
Design of 3D Stochastic Electromagnetic Sources, Olga . Korotkova[1]; [1]*Univ. of Miami, USA.* The possibilities for mathematical modeling of various classes of 3D EM stationary sources are elucidated. The special cases of uniform and non-uniform correlations, twisting, electromagnetic isotropy/anisotropy are presented.

JM4A.5
Fast and Precise Method for Measurement and Compensation of Aberrations in Spatial Light Modulator Based Holographic Projection, Jan Bolek[1], Michal Makowski[1]; [1]*Faculty of Physics, Warsaw Univ. of Technology, Poland.* We present a new method for correcting aberrations in spatial light modulator based holographic projection systems. The proposed method provides precise retrieval of aberration mask. Results showing significant impact on hologram reconstruction quality are presented.

JM4A.6
Polarization-Interference 3D Holographic Tomography of Optical Anisotropy of Biological Fluids Polycrystalline Films, Igor Panko[1]; [1]*Chernivtsi National Univ., Ukraine.* Our work is aimed at the development and experimental testing of Mueller-matrix digital holographic mapping method for reconstruction of the distribution of optical anisotropy parameters of partially depolarizing films of various biological fluids and the determination of objective criteria for the differentiation of polycrystalline blood films of healthy donors and patients with prostate cancer.

JM4A.7
HD Image Quality Light-field Display Architecture for Interactive-Tabletop Display Systems, Wongun Jang[1]; [1]*Korea Photonics Technology Inst., South Korea.* We employed multiple number of micro-projectors with HD (1280 by 720) display resolution for light-field technology based-tabletop display systems. Display system is developed for the final target specifications that exhibits 35 inches diagonal with 720p (number of hogels) 3-dimensional image resolution, 5° angular resolution, ±25° viewing angle, and user-display interactive display system

JM4A.8
Advancing Deep Ocean Sensing through Laser Spectroscopy, Anna P. Michel[1], Scott Wankel[1], Jason Kapit[1], Charles Harb[2], Beckett Colson[1]; [1]*WHOI, USA;* [2]*Ring-IR, USA.* To advance our understanding of ocean chemistry, new in situ sensors are needed. By coupling gas extraction techniques to laser-based sensors, we can measure key gases such as methane and carbon dioxide in ocean environments.

Orange/Lemon/Lime	Citron	Clementine	Mandarin
Joint Computational Optical Sensing and Imaging/Applied Industrial Optics	Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

JM3E • Not Your Dentist's X-ray (COSI/AIO)—Continued

JM3E.5 • 15:45
Computational X-ray Imaging using Document Scanners, Achuta Kadambi[1], Avilash Cramer[1], Richard Lanza[1], Ramesh Raskar[1], Rajiv Gupta[2,1]; [1]*MIT, USA;* [2]*Harvard Medical School, USA.* We propose a computational imaging approach enabling document scanners to be used as frugal, high-resolution X-ray imagers. We modify the document scanner optics for X-ray sensitivity and design a post-processing algorithm to denoise images.

DM3F • Incoherent Holography—Continued

DM3F.6 • 15:45
Self-referencing interference incoherent digital holography using geometrical phase lens and linear polarizer, KiHong Choi[1], Sungwon Choi[1], Junkyu Yim[1], Sung-Wook Min[1]; [1]*Kyung Hee Univ., South Korea.* The self-referencing interference incoherent digital holography system is presented. To capture the hologram, the geometrical phase lens is implemented inside the system, functioning as a common-path polarization dependent wavefront splitter and modulator.

3M3G • Measurement I—Continued

3M3G.7 • 15:45
Ultrafast, sensitive, and inexpensive 3 dimensional MMW/THz imaging system using Glow Discharge Detector Array and CCD camera based on upconversion to visual band, Amir Abramovich[1], Daniel Rozban[1], Avihai Aharon[1], Yitzhak Yitzhaky[2], Natan Kopeika[2]; [1]*Ariel Univ., Israel;* [2]*Ben Gurion Univ., Israel.* A 3 dimensional MMW/THz imaging system using the upconversion mechanism of glow discharge detectors is demonstrated. The MMW/THz radiation is converted to the visual band using an inexpensive glow discharge detector array and basic optical CCD camera to yield the MMW/THz image.

SM3H • Sensing I—Continued

SM3H.5 • 15:45
Fast and Calibration-Free Trace-Gas Monitoring Based On Beat Frequency Quartz-Enhanced Photoacoustic Spectroscopy, Hongpeng Wu[1], Lei Dong[1], Huadan Zheng[1], Xukun Yin[1], Suotang Jia[1], Frank Tittel[2]; [1]*Shanxi Univ., China;* [2]*Rice Univ., USA.* Beat frequency QEPAS sensor for ultra-sensitive calibration-free trace gas detection was developed. The resonance frequency and *Q*-factor of the quartz tuning fork as well as the trace gas concentration can be obtained simultaneously.

16:00–17:00 Coffee Break with Exhibitors, *Palms Foyer*

Salon FGHI

16:00–17:00
JM4A • Poster Session I

JM4A.9
Ultrasonic-Assisted Blood Glucose Monitoring using Mid-Infrared Spectroscopy, Hiroyuki Nomura[1], Keita Mori[1], Natsumi Kawashima[1], Tomoya Kitazaki[1], Akira Nishiyama[1], Kenji Wada[1], Ichiro Ishimaru[1]; [1]*Kagawa Univ., Japan.* We propose to monitor blood glucose concentrations using mid-infrared spectroscopy in an ultrasonic-assisted liquid cell that can be attached to a dialyzer. This method can measure the transmitted light through whole blood during dialysis.

JM4A.10
Bandwidth Dependent Blurring Reduction Technique in Holographic Display, Mehdi Askari[1], Jae-Hyeung Park[1]; [1]*Inha Univ., South Korea.* In this paper, we propose a method to deal with the image blurring problem that arises due to the use of an extended linewidth light source in holographic displays. Our proposed method pre-compensates the target image with the point spread function of the optical system calculated for the finite linewidth of the source.

JM4A.11
Solving the Transport-of-Intensity Equation without the Usual Intensity Restrictions, Soheil Mehrabkhani[1], Lennart Wefelnberg[1], Thomas Schneider[1]; [1]*Technische Universität Braunschweig, Germany.* Solving the Transport-of-intensity equation (TIE) by a Fourier-Transform (FT) requires some assumptions related to the intensity distribution. In this paper, we present an iterative approach, which removes all these restrictions and provides very accurate results.

JM4A.12
Higher harmonic detection and sensitivity to drifts in trace-gas sensors– Novel schemes for precision measurements, Mohammad A. Khan[1], Caio Azavedo[1], Joseph Jefferey[1], May Hliang[1]; [1]*Delaware State Univ., USA.* We show the advantages of wavelength modulation spectroscopy for improving sensitivity in trace-gas detection. This is achieved using higher harmonic detection to probe spectral features of the absorption signal around linecenter and in line-wing region.

JM4A.13
Real-Time Gaze Optimization of Multi-Layer Stereoscopes Using GPU Parallel Computing, Youngjin Jo[1], Seungjae Lee[1], Jaebum Cho[1], Byoungho . Lee[1]; [1]*Seoul National Univ., South Korea.* We present a real-time optimization method using GPU parallel processing for the image misalignment problems caused by the pupil swim in multi-layer stereoscopes. The simulation results show that this resolves the misalignment of the image and enables real-time operation.

JM4A.14
A large-angle solar concentrator using volume holograms, Yao Cui[1], Jianshe Ma[2], Ping Su[2], Tianfeng WU[1]; [1]*Dept. of Precision Instrument, Tsinghua Univ., China;* [2]*Graduate School at Shenzhen, Tsinghua Univ., China.* We design a large-angle (16°) solar concentrator using three cascaded volume holographic elements (two gratings and one lens). By overlapping the working angle-range of each element, we get relatively stable light intensity on the solar cell.

JM4A.15
Compensation of reconstructed depth distortion caused by optical misalignment on holographic projection system, Hayan Kim[1], Keehoon Hong[1], Minsik Park[1], Jinwoong Kim[1]; [1]*ETRI, South Korea.* We propose a numerical compensation method for reconstructed depth distortions caused by inaccurate optical alignment on a holographic projection system. The feasibility of the proposed compensation method is verified by experiments.

JM4A.16
Sub-surface Thermal Imaging of Microelectronic Devices using Confocal Laser Scanning Thermoreflectance Microscopy, Dong Uk Kim[1], Chan Bae Jeong[1], Jung Dae Kim[1], Ki Soo Chang[1]; [1]*Korea Basic Science Inst., South Korea.* We report on a confocal thermoreflectance imaging system, which provides the elimination of out-of-focus reflections, and demonstrate the improvement of ~23 times in the sensitivity due to the confocality during the sub-surface thermoreflectance measurement.

16:00–17:00
JM4A • Poster Session I

JM4A.17
An Experimental and Theoretical Investigation of CO-QEPAS Sensor Based on a High Power DFB Diode Laser, Yao Tong[1], Yufei Ma[1], Ying He[1], Xin Yu[1]; [1]*Harbin Inst. of Technology, China.* A high sensitive CO-QEPAS sensor with a high power 2.33 μm diode laser was demonstrated. A 11.2 ppm detection limit was obtained and the pressure and temperature sensitivities of the reported sensor were analyzed.

JM4A.18
Analysis of mean thickness of a phase objects using one-shot phase shifting interferometry, Angel Monzalvo Hernandez[1], German Resendiz-Lopez[1,3], Rigoberto Garcia Garcia[1], Juan M. Islas-Islas[1], Luis Garcia Lechuga[1], Jaime Garnica Gonzalez[2], Victor Flores-Muñoz[4], Oscar Lira Uribe[1], Noel-Ivan Toto-Arellano[1]; [1]*Universidad Tecnológica de Tulancingo, Mexico;* [2]*Universidad Autónoma del Estado de Hidalgo, Mexico;* [3]*Instituto de Ciencias Básicas e Ingeniería (ICBI) de la Universidad Autónoma del Estado de Hidalgo, Mexico;* [4]*Departamento de Ingeniería Robótica, Universidad Politécnica del Bicentenario, Mexico.* In this research a novel interferometric system is reported, which allows the generation of four simultaneous interferograms with phase shifts, the system consists of three coupled interferometers: The optical phase is calculated using the four-step algorithm. The results obtained for static transparent samples are presented.

JM4A.19
Withdrawn

JM4A.20
On the Rotation Angle of Reconstruction Plane in Optical Phase-only Image Encryption and Multiplexing, Hsuan-Ting Chang[1], Yao-Ting Wang[1], Yu-Hsuan Chou[1]; [1]*National Yunlin Univ. of Science and Tech, Taiwan.* We investigate the effects on rotation angle arrangement in the proposed angle multiplexing method for optical image encryption using the phase-only function in the Fresnel transform domain. The computer simulation results show that the images reconstructed with the asymmetric rotation angles can be more secure than that with symmetric arrangements.

JM4A.21
Holographic 3D particle tracking based on numerical diffraction propagation and correlation recognition, Zhe Wang[1,2], Biagio Mandracchia[2], Vittorio Bianco[2], Pascale Memmolo[2], Zhuqing Jiang[1], Pietro Ferraro[2]; [1]*College of Applied Sciences, Beijing Univ. of Technology, China;* [2]*CNR-ISASI, Italy.* A holographic 3D particle tracking method based on numerical diffraction propagation and correlation recognition is applied on film drainage analysis and red blood cells counting. Location of particles in different depth layers are revealed accurately.

JM4A.22
Special non-diffracting beams analysis by digital holography, Marcos R. Gesualdi[1], Indira S. V. Yepes[1], Rafael A. B. Suarez[1], Santiago R. C. Fernadez[1]; [1]*Universidade Federal do ABC, Brazil.* In this work, we present the experimental realizations of phase and intensity analysis of the non-diffracting beams (Bessel, Mathieus and superposition of co-propagating Bessel beams - Frozen Waves) are made through computer-generated holograms reproduced in spatial light modulators and digital holography. The results are in agreement with the theoretical predictions and are presenting excellent prospects for the beam type analysis with potential applications in optical micromanipulation and optics communications.

JM4A.23
Using digital Zernike phase-contrast for the focus-plane detection of pure phase objects analyzed with DHM., Maria L. Cruz[1]; [1]*Facultad de Ingeniería, Universidad Panamericana, Mexico.* We propose to use digital Zernike phase-contrast and two criteria to find the focus plane of pure phase objects. We present the simulation results of the method where the focus is well detected.

JM4A.24
Thickness and refractive index analysis of ellipsometry data of ultra-thin semi-transparent films, Poul-Erik Hansen[2,1], Jonas S. Madsen[2,1]; [1]*Danish national metrology Inst. (DFM), Denmark;* [2]*Nanometrology, Danish Fundamental Metrology, Denmark.* Ellipsometry measurement of both the refractive index and the thickness of ultra-thin semi-transparent film are a great challenge in optical metrology today. Here we present a new method making this possible.

JM4A.25
Thin-film drainage study based on holographic 3D particle tracking, Zhe Wang[1,2], Biagio Mandracchia[2], Vincenzo Ferraro[3], Ernesto Di Maio[3], Pier Luca Maffettone[3], Zhuqing Jiang[1], Pietro Ferrarro[2]; [1]*College of Applied Sciences, Beijing Univ. of Technology, China;* [2]*CNR-ISASI, Italy;* [3]*Dipartimento di Ingegneria Chimica, dei Materiali e della Produzione Industriale, Università di Napoli Federico II, Italy.* Thin-film drainage process has been studied by a digital holographic recording system. In this study, trajectories of three particles inside a bubble film are revealed by holographic 3D tracking during the bubble growth.

JM4A.26
Towards sub-mm-size Helmholtz Photoacoustic Cells for Atmospheric Gas Sensing: simulation and developments, Virginie Zeninari[1], Chehem Mohamed Ibrahim[1], Raphael Vallon[1], Bertrand Parvitte[1]; [1]*Universite de Reims Champagne-Ardenne, France.* In the framework of research program called MIRIADE, GSMA reports simulations and developments of mm-size Helmholtz resonant photoacoustic cells for the optical sensing of the atmosphere when associated with mid-infrared sources such as QCLs.

JM4A.27
Statistical Analysis of 3D Digital Holographic Images of Phase-Inhomogeneous Objects, Igor Panko[1]; [1]*Chernivtsi National Univ., Ukraine.* A new principle for recording information on the structure of optically inhomogeneous layers is proposed. Principles of variations of the polarization state of illuminating laser radiation using a reference wave are used. A digital holographic algorithm for obtaining three-dimensional Muller-matrix images of phase-inhomogeneous layers is presented. The statistical moments of the first and fourth orders are determined, which characterize the layered anisotropy of biological layers.

JM4A.28
Development of bifocal holographic lens using a photopolymer, Hui-Ying Wu[1], Chang-Won Shin[1], Sang-Keun Gil[2], Nam Kim[1]; [1]*Chungbuk National Univ., South Korea;* [2]*Suwon Univ., South Korea.* A bifocal holographic lens using a photopolymer is presented in this paper. We used monochromatic light to evaluate the holographic optical element (HOE) by measuring the diffraction efficiencies of holographic gratings. The experimental results confirm that the bifocal holographic lens can focus on two different points.

JM4A.29
Withdrawn

JM4A.30
Noise Reduction for Projection of Cone Beam Computed Tomography Based on Prior Knowledge, Fuqiang Yang[1], Dinghua Zhang[1], Kuidong Huang[1], Yafei Yang[1]; [1]*NWPU, China.* The study aims to investigate a new algorithm applying to the projection to generate high quality images by reducing the noise in cone-beam computed tomography (CBCT). A single sampling without object is first employed in scanning to obtain the noise as the knowledge, then a random Gaussian Matrix (GM) is used to get a new noise map. Study results demonstrated significant improvement in SNRs of the images by overlapping the noise map on the projection for average. Since the noise is reduced, it has the potential to improve projection quality.

JM4A.31
Fresnel Holograms Generation Using Partitioned Holograms and Fast Cosine Transform, Fabriciu A. Benini[1], Ben-Hur V. Borges[1], Luiz G. Neto[1]; [1]*Universidade de Sao Paulo, Brazil.* We suggest the use of partitioned holograms to decrease the time calculation of Fresnel holograms. We show that the time calculation can be decreased about 3 times partitioning the desired Fresnel hologram into 16 or more sub holograms.

JM4A.32
A phase-space approach to optical resolution, Cagatay Isil[1], Figen S. Oktem[1]; [1]*Middle East Technical Univ., Turkey.* We show, using a phase-space approach, how to determine the diffraction-limited resolution for imaging systems with multiple diffracting apertures. A microscope objective is analyzed using the developed approach, and results are compared with the known technical specifications.

JM4A.33
Multiplexing Multiple Digital Holograms for Efficient Transmission and Recovery, Ravi Shekhar[2], Gopinathan Unnikrishnan[2], Naveen K. Nishchal[1]; [1]*Indian Inst. of Technology Patna, India;* [2]*Applied Physics, Defence Inst. of Advanced Technology, India.* For efficient transmission of multiple digital holograms simultaneously, we multiplex them into a single package. An encoding mechanism and orthogonal random binary masks are employed to recover better quality and cross-talk free images.

16:00–17:00
JM4A • Poster Session I

JM4A.34
Accommodometer for Light Field display, Kwang-Hoon Lee[1]; [1]*Korea Photonics Technology Inst., South Korea*. We had study that verifying whether the LF display provides accommodative function, and quantifying the focusable range at the reconstruction image space in which permitted by the focusable power served by the display

JM4A.35
Surface roughness sensing with singular vortex beams, Bohdan V. Sokolenko[1]; [1]*V I Vernadsky Crimean Federal Univ, Russia*. In the present research we discuss the results of analysis of coherent light beams carrying optical vortex. Vertical resolution of vortex roughness probing can be achieved down to 5,27 nm for He-Ne laser source.

JM4A.36
Parallel phase-shifting interferometer with four interferograms using a modified Michelson configuration, Luis Garcia Lechuga[1], Gustavo Rodriguez Zurita[3], David Serrano Garcia[2], German Resendiz-Lopez[1,5], Angel Monzalvo Hernandez[1], Rigoberto Garcia Garcia[1], Jaime Garnica Gonzalez[4], Salvador Hernandez Mendoza[1], Juan M. Islas-Islas[1], Noel-Ivan Toto-Arellano[1]; [1]*Universidad Tecnológica de Tulancingo, Mexico;* [2]*Centro Universitario de Ciencias Exactas e Ingenierías, Universidad de Guadalajara, Mexico;* [3]*Benemerita Universidad Autonoma de Puebla, Mexico;* [4]*Instituto de Ciencias Básicas e Ingeniería, Universidad Autónoma del Estado de Hidalgo, Mexico;* [5]*Doctorado en Ciencias en Ingenieria Industrial, Instituto de Ciencias Básicas e Ingeniería (ICBI), Universidad Autónoma del Estado de Hidalgo, Mexico*. In this paper, we report an optical implementation of a parallel-phase-shifting-interferometer that uses two Michelson interferometers for generate two-interferograms, to present the capabilities of the system, phase measurements results obtained from transparent structures are presented.

JM4A.37
Relevance analysis for texture descriptors in studies of dynamic photoelasticity, Hermes Fandiño[1,2], Juan C. Briñez de León[1], Alejandro Restrepo Martínez[1], John W. Branch Bedoya[1]; [1]*Universidad Nacional de Colombia, Colombia;* [2]*ITM, Colombia*. Analyzing fringe patterns in photoelasticity images is a common process for describing stress concentration zones. Notwithstanding, we show that an unique texture descriptor could be insufficient for describing the ROI texture in dynamic photoelasticity.

JM4A.38
Withdrawn

JM4A.39
Nonlinear optical single-molecular image technique and its applications, Xiaoming Wang[1]; [1]*Hubei Univ. of Chinese Medicine, China*. Nonlinear optical single-molecular image technique is our patented new optical microscopy technique(Chinese patent 200910060951.7, PCT /CN2010/000138). It has broad applications in many areas. In the paper, we presented the principle of single molecular profile image magnifying technique and its lot of application.

JM4A.40
Experimental demonstration of superresolution using signum phase mask, Bohumil Stoklasa[1], Martin Paur[1], Jaroslav Rehacek[1], Zdenek Hradil[1], Jai Grover[2], Andrej Krzic[2], Luis L. Sanchez-Soto[3,4]; [1]*Univerzita Palackeho v Olomouci, Czechia;* [2]*ESA-ESTEC, Netherlands;* [3]*Universidad Complutense, Spain;* [4]*Max-Planck Inst., Germany*. We experimentally show, how an imaging system incorporating phase signum mask can improve the resolution of two incoherent points. Mean squared error of two points separation estimator for standard and modified detection is discussed.

JM4A.41
HBT Telescope based on self-Correlation in Spatial Domain, Zhentao Liu[1,2], Xia Shen[1,2], Jianrong Wu[1,2], Enrong Li[1,2]; [1]*SIOM, CAS, China;* [2]*Univ. of Chinese Academy of Sciences, China*. HBT telescope based on self-correlation in spatial domain can realize lensless imaging in a single measurement, which overcomes the measurement limitations of HBT interferometry. The simulation and discussion verify its correctness and feasibility.

JM4A.42
Detecting the Presence of a Transparent Object in Off-axis Digital Holograms, Tomi Pitkaaho[1], Aki Manninen[2], Thomas J. Naughton[1]; [1]*Maynooth Univ., Ireland;* [2]*Biocenter Oulu, Univ. of Oulu, Finland*. Detecting presence of an object in digital holograms is an important consideration in many applications. We propose a novel method that works directly in the hologram plane to determine the presence or absence of an object.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

17:00–18:30
AM5A • Look to the Stars
Presider: Ivan Capraro; Adaptica Srl, Italy

AM5A.1 • 17:00 Invited

Fast Aberration Correction with Multi-Actuator Adaptive Lenses in Medium Size Telescopes and Complex Laser Systems, Stefano Bonora[1]; [1]*CNR-INFM, Italy.* Fast adaptive optics systems with deformable mirrors have been used to correct for time variant aberrations induced by air turbulence. We will show that the multi actuator adaptive lenses can replace deformable mirrors in such applications with the advantage of a simpler and more compact optical setup. We will show the results obtained on medium size telescopes and to improve the stability of complex laser systems.

DEMO

The demonstrative system that includes a Multi actuator Adaptive Lens in closed loop control with a Shack Hartmann wavefront sensor working at 400Hz. We will show wavefront correction and far field beam shaping with the adaptive lens.

17:00–18:00
IM5B • Biomedical II
Presider: Maitreyee Roy; Univ. of New South Wales, Australia

IM5B.1 • 17:00 Invited

Angiography, Lymphangiography, Elastography and Polarisation Contrast Extensions of Optical Coherence Tomography, David D. Sampson[2,1]; [1]*Univ. of Western Australia, Australia;* [2]*Univ. of Surrey, UK.* Optical coherence tomography is being extended beyond native scattering contrast to probe features of biological tissues, such as motion to detect vessels, stress response to detect stiffness, and polarized light response to detect sub-wavelength-resolution structural order. Many applications of tissue characterization will be presented.

IM5B.2 • 17:30 Invited

Integrated Tissue Analytics for Clinical Imaging Systems, Dmitry V. Dylov[1]; [1]*Skolkovo Inst. of Science and Technology, Russia.* We will overview some recent advancements in the in-situ evaluation of tissues using imaging systems that rely on optical spectroscopy, fluorescence imaging, and multiplexed microscopy. Computational and analytical methods of real-time tissue differentiation will be considered.

17:00–18:30
LM5C • Atmospheric & Environmental Monitoring I
Presider: Virginie Zeninari; Universite de Reims Champagne-Ardenne, France

LM5C.1 • 17:00 Invited

Multi-Parameter IC Engine Exhaust Gas Diagnostics - From Manifold, Via Aftertreatment to the Tail Pipe End, Steven Wagner[1], Luigi Biondo[1], Niels Göran Blume[1], Oliver Diemel[1], Johannes Emmert[1], Lisa Engel[1], Anna K. Schmidt[1], Felix Stritzke[1]; [1]*High Temperature Process Diagnostics, Inst. of Reactive Flows and Diagnostics, Technische Universität Darmstadt, Germany.* More stringent exhaust emissions regulation of IC engines requires more detailed investigation of the after treatment and conversion processes of the exhaust flow. Here, we present three independent laser absorption spectrometers for the measurement of mole fractions and temperature during EGR, SCR after treatment and at the tail pipe end.

LM5C.2 • 17:30

Gas Mixtures Characterization Using a Field Programmable Gate Array (FPGA): CO_2/O_2 Case Study, Herve Tatenguem Fankem[1], Tobias Milde[1], Morten Hoppe[1], Andreas Sacher[1], Joachim Sacher[1]; [1]*Sacher Lasertechnik GmbH, Germany.* We report on the development and validation of an FPGA-based algorithm, for studying and characterizing gas mixtures. The proposed algorithm is successfully used to analyze a mixture of CO_2/O_2 in different proportions.

17:00–18:30
MM5D • Inverse Scattering
Presider: Josselin Garnier; Ecole Polytechnique, France

MM5D.1 • 17:00 Invited

Inverse Problems in Acoustic-Optic Imaging, John C. Schotland[1]; [1]*Univ. of Michigan, USA.* Abstract to be determined.

MM5D.2 • 17:30

Imaging Through Volumetric Scattering with a Single Photon Sensitive Camera, Guy Satat[1], Matthew Tancik[1], Ramesh Raskar[1]; [1]*MIT Media Lab, USA.* Imaging through highly scattering media holds many opportunities in underwater and biomedical imaging. Here we leverage a single photon avalanche diode (SPAD) camera, and experimentally demonstrate an imaging pipeline to see through turbid water in optical reflection mode.

Orange/Lemon/Lime

Computational Optical Sensing and Imaging

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

17:00–18:15
CM5E • Depth-Resolved and Turbid Imaging
Presider: Rajesh Menon; Univ. of Utah, USA

CM5E.1 • 17:00
Multi-layered Born Scattering Model for 3D Phase Imaging with Multiple Scattering Objects, Michael Chen[1], Hsiou-Yuan Liu[1], David Ren[1], Laura Waller[1]; *[1]UC Berkeley, USA.* We demonstrate a 3D phase imaging model for scattering objects with intensity-only measurements taken with patterned illumination in an LED array microscope. 3D refractive index (RI) of polystyrene beads is recovered, and the preliminary results indicate that the proposed model outperforms existing methods in terms of quantitative accuracy of RI.

CM5E.2 • 17:15
Depth-resolved Lensless Imaging, Mengqi Du[1], Kjeld Eikema[1], Stefan Witte[1]; *[1]ARCNL, Netherlands.* A numerical approach is developed to reconstruct 3D images from a set of wavelength- and phase-resolved diffraction patterns, resulting in a computational depth-resolved imaging method.

CM5E.3 • 17:30
3D Fluorescence Microscopy with DiffuserCam, Grace Kuo[1], Nick Antipa[1], Ren Ng[1], Laura Waller[1]; *[1]Univ. of California Berkeley, USA.* We propose a lensless diffuser-based microscope for 3D fluorescence microscopy from a single exposure. We use compressed sensing and a local convolution model to account for the system's spatially-varying point spread functions in a computationally efficient manner.

17:00–18:15
DM5F • Applications of DH
Presider: Peter Schelkens; Vrije Universiteit Brussel, Belgium

DM5F.1 • 17:00 Invited
Interferometric out-of-focus imaging of ice particles for airborne instrumentation, Marc . Brunel[1], Mohamed Talbi[1], Sébastien Coëtmellec[1], Denis Lebrun[1], Gérard Gréhan[1], Michael Fromager[2], Kamel Aït Ameur[2], Yingchun Wu[3], Justin Jacquot-Kielar[4]; *[1]CNRS UMR 6614 CORIA, France; [2]ENSICAEN, France; [3]Zhejiang Univ., China; [4]Mc Gill Univ., Canada.* The set of experimental and numerical tools that have been developed to perform interferometric out-of-focus images of ice particles is presented. The different experimental results that have been obtained and that validate the measurement method are presented, analyzed and discussed.

DM5F.2 • 17:30
Vibration retrieval from time sequences of digital on-line Fresnel holograms, Laure Lagny[1], Carlos Alejandro Trujillo Anaya[2], Julien Le Meur[3], Silvio Montresor[1], Jorge Garcia-Sucerquia[2], Kevin Heggarty[3], Charles Pezerat[1], Pascal Picart[1]; *[1]LAUM CNRS Université du Maine, France; [2]Universidad Nacional de Colombia-Sede Medellin, Colombia; [3]Telecom Bretagne, France.* This paper proposes an on-line holographic configuration for full-field vibration retrieval at 100kHz. Negative zoom and DOE are combined to yield the best photometric efficiency. Experimental results demonstrate the suitability of the proposed approach.

17:00–18:30
3M5G • HMD & Aerial Display
Presider: Bahram Javidi; Univ. of Connecticut, USA

3M5G.1 • 17:00 Invited
Fundamental Limitations for Augmented Reality Displays with Visors, Waveguides, or Other Passive Optics, Barmak Heshmat[1,2]; *[1]Meta Company, USA; [2]Media Lab, MIT, USA.* This study identifies fundamental limitations and trade-offs enforced by laws of optics for any augmented reality display that uses passive optical elements such as visors, waveguides, and meta-surfaces to deliver the image to the eye.

3M5G.2 • 17:30 Invited
How Recent Optical Technology Breakthroughs Enable Next Generation Head Mounted Displays, Bernard Kress[1]; *[1]Microsoft Corp, USA.* Virtually all HMDs currently available on the market, in either VR, AR or MR form, lack both wearable and visual confort, two major experience pillars required to enable the analyst's impressive digital reality markets. Conventional optical designs limit today cruelly all HMD architectures. However, recent optical breakthroughs might provide alternate architectures to counter such dire hardware limitations.

17:00–18:30
SM5H • Sensing II
Presider: David Rabb; US Air Force Research Lab, USA

SM5H.1 • 17:00 Invited
A Bayesian Framework for Imaging and Atmospheric Sensing using Coherent Laser Radar, Charles A. Bouman[1]; *[1]Purdue Univ., USA.* Optically-coherent imaging systems offer significant improvements in sensitivity, resolution, and atmosphericturbulence sensing and mitigation compared to non-coherent systems. Conventional approaches for processingoptically-coherent data are based on realatively-simple inversion techniques which produce speckled images and poor turbulence estimates.

SM5H.2 • 17:30
Application of the correlation transport equation to photon Doppler velocimetry of ejecta from shock-loaded samples, Arseniy N. Kondratyev[1]; *[1]Dukhov Research Inst. of Automatics, Russia.* The report addresses the actual problem of photon Doppler velocimetry of ejecta from shock-loaded metal samples. It is shown that, for modeling the Doppler spectrum from an expanding cloud of ejected particles, the correlation transport equation can be applied.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AM5A • Look to the Stars—Continued

AM5A.2 • 17:45 Invited
Quantum Communication in Space - Challenges and Opportunities, Imran Khan[1,2]; [1]*Division Leuchs - Quantum Information Processing Group, Max Planck Inst. for the Science of Light, Germany;* [2]*InfiniQuant, Germany.* In this talk we present the challenges and opportunities associated with bringing economically feasible quantum key distribution to space, which is currently the only viable alternative to bridge global distances for quantum communication.

DEMO
We show a proof-of-principle experiment on quantum random number generation. The experiment is based on homodyne (coherent) detection of the quantum vacuum state of light. This can be done using off-the-shelf telecom components.

IM5B • Biomedical II—Continued

LM5C • Atmospheric & Environmental Monitoring I—Continued

LM5C.3 • 17:45
Fast and Widely-tunable, VBG Spectrally Narrowed, Picosecond Optical Parametric Oscillator for Backscatter Absorption Gas Imaging, Guillaume Walter[1], Jean-Baptiste Dherbecourt[1], Jean-Michel Melkonian[1], Myriam Raybaut[1], Antoine Godard[1], Didier Henry[1], Cyril Drag[2]; [1]*Onera, The French Aerospace Lab, France;* [2]*Laboratoire de Physique des Plasma, Ecole Polytechnique-CNRS-Univ Paris-Sud-UPMC, Université Paris-Saclay, France.* We implement a fast and widely tunable picosecond OPO, based on an aperiodically-poled nonlinear crystal, tuned and spectrally narrowed by a chirped VBG, for backscatter absorption gas imaging of N_2O around 3.82 µm.

LM5C.4 • 18:00
Development of broadband cavity enhanced spectroscopy and its application in trace gases, peroxy radicals and aerosol optical detection, Weixiong Zhao[1], Xuezhe Xu[1], Bo Fang[1], Yang Zhang[1], Weijun Zhang[1], Weidong Chen[2]; [1]*AIOFM, CAS, China;* [2]*LPCA, ULCO, France.* We report the development of broadband cavity enhanced spectroscopy for trace gases, its combination with chemical amplification for peroxy radicals measurement, and with integrating sphere for simultaneous in situ measurements of aerosol scattering and extinction.

LM5C.5 • 18:15
Detectorless Intracavity Technique with an EC-QCL for Atmospheric Gas Detection, Raphael Vallon[1], Laurent Bizet[1], Bertrand Parvitte[1], Gregory Maisons[2], Mathieu Carras[2], Virginie Zeninari[1]; [1]*Universite de Reims Champagne-Ardenne, France;* [2]*MirSense, France.* We report the development of an external-cavity quantum cascade laser emitting in the mid-infrared region and its application to the detectorless intracavity detection of atmospheric molecules such as methane and water vapor.

MM5D • Inverse Scattering—Continued

MM5D.3 • 17:45
Optimizing Defect Detectability across Multiple UltravioletWavelengths, Mark-Alexander Henn[1], Bryan M. Barnes[1], Hui Zhou[1], Richard M. Silver[1]; [1]*NIST, USA.* We investigate defect detectability using simulated deep-, vacuum-, and extremeultraviolet wavelengths. Improvements to a signal-to-noise ratio defect metric appear achievable down to λ = 47 nm.

MM5D.4 • 18:00 Invited
Computational 4D imaging in widefield microscopy with partially coherent illumination, Jose A. Rodrigo[1], Juan M. Soto[1], Tatiana Alieva[1]; [1]*Complutense Univ. of Madrid, Spain.* We present a system and computational technique exploiting the advantages of partially coherent illumination paving the way for 4D label-free imaging in conventional widefield microscopy. The experimental demonstrations include video-rate speckle-noise-free 3D imaging of biological cells.

18:30–20:00 Congress Reception, *Palms Ballroom E*

Orange/Lemon/Lime	Citron	Clementine	Mandarin
Computational Optical Sensing and Imaging	Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

CM5E • Depth-Resolved and Turbid Imaging—Continued

CM5E.4 • 17:45
Double-Cubic Point Spread Function for 3D Extended-Depth Localization Microscopy, Yongzhuang Zhou[1], Vytautas Zickus[1], Andrew R. Harvey[1], Paul Zammit[1]; [1]*Univ. of Glasgow, UK.* We report the design and implementation of a new pupil-engineered phase function that enables simple and robust 3D localization microscopy with a ten-fold extension in depth-of-field. Applications include single-particle tracking, super resolution microscopy and lab-on-chip. We demonstrate its application to in-vivo mapping of blood flow in zebrafish.

CM5E.5 • 18:00
Depth Sensitivity Improvement of Region-of-Interest Diffuse Optical Tomography from Superficial Signal Regression, Manob Jyoti Saikia[1,2], Rakesh Manjappa[1], Kunal Mankodiya[2], Rajan Kanhirodan[1]; [1]*Physics, Indian Inst. of Science, India;* [2]*Electrical, Computer and Biomedical Engineering, Univ. of Rhode Island, USA.* We report depth sensitivity enhancement of a region-of-interest optical tomographic system. Two optode configurations, 25 and 50 mm separations are used to construct a noise model. A regression technique isolates the functional activity of deep tissue layer.

DM5F • Applications of DH—Continued

DM5F.3 • 17:45
Digital Holographic Interferometry Application On Objects With Heterogeneous Reflecting Properties, Jean-François Vandenrijt[1], Yuchen Zhao[1], Fabian Languy[1], Cédric Thizy[1], Marc P. Georges[1]; [1]*Centre Spatial de Liège - STAR Research Unit, Liège Université, Belgium.* Some objects of industrial interest show zones which can be either scattering or specular. We present experimental digital holographic interferometry results obtained in a setup dealing with both at the same time.

DM5F.4 • 18:00
Ultrahigh-throughput rendering of digital holograms, Michael Atlan[1]; [1]*CNRS, France.* The advent of commodity computer graphics processing units has made video-rate and ultrafast holographic image rendering possible by streamline processing of optically-acquired interferograms. We present holovibes, a software designed to perform sustained ultrahigh-throughput digital hologram rendering with real-time visualization.

3M5G • HMD & Aerial Display—Continued

3M5G.3 • 18:00
Curved screen virtual reality headsets, Ginni Grover[1], Basel Salahieh[1], Oscar Nestares[1]; [1]*Intel Corporation, USA.* With the flexible displays on market horizon, we can now design VR systems with an additional degree of freedom. We show curved screen designs can improve the field of view or optical resolution in VR.

3M5G.4 • 18:15
Forming Underwater Information Display with Aerial Imaging by Retro-Reflection (AIRR), Hirotsugu Yamamoto[1,2], Kenta Onuki[1], Sho Onose[1]; [1]*Utsunomiya Univ., Japan;* [2]*ACCEL, JST, Japan.* This paper proposes a new technique to form a real image in the water. The underwater image is formed by use of a retro-reflector. We have succeeded in forming an underwater information display.

SM5H • Sensing II—Continued

SM5H.3 • 17:45 Tutorial
Experiences as an Expert Witness in the Uber vs Google/Waymo Lidar for Driverless Car Case, Paul McManamon[1]; [1]*Exciting Technology LLC, USA.* Paul McManamon will discuss his experiences as an expert witness in Uber vs Google/Waymo Lidar for Driverless Car trial. This was a very high profile case, and McManamon's first experience as an expert witness.

18:30–20:00 Congress Reception, *Palms Ballroom E*

Sunset/Fleming — Applied Industrial Optics

Siesta/Biscayne — Imaging Systems and Applications

Largo/Longboat — Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon — Mathematics in Imaging

Orange/Lemon/Lime — Computational Optical Sensing and Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:00–18:30 Registration, *Palms Foyer*

Citron

08:00–09:00
JTu1A • Plenary Session II with OSA Light the Future Speakers Series

JTu1A.1 • 08:00 Plenary
The Role of Optics and Photonics in the Vehicles of Tomorrow, Jason Eichenholz, *Luminar Technologies, USA.* This presentation will take a high level look at the future of optics and photonics technologies in autonomous vehicles. Optics are a crucial component in an industry headed for extreme disruption over the next few decades and will play a critical role in shaping the future of navigation, passenger experience and the ultimate safety of the autonomous trip. The key components of all-things-optic, including LiDAR, laser headlights, passenger monitoring and interior lighting and displays, the role each plays inside a future automobile and its impact on the transportation industry will be discussed.

09:00–10:00 Coffee Break with Exhibitors, *Palms Foyer*

10:00–12:00
ATu2A • Keynote and Laser Sorcery
Presider: Joseph Dallas; Avo Photonics Inc, USA

ATu2A.1 • 10:00 Keynote
Risks of Comfort Zone, and Benefits of Leaving it: An Entrepreneurial Roller Coaster Story, E Hooman Banaei, *Everix Optical Filters, USA.* Banaei will share the ups and downs of his entrepreneurial journey of starting in a garage and moving towards making a photonic component a new household name by touching lives of potentially billions.

10:00–11:45
ITu2B • Microscopy I: Super-resolution & Illumination Techniques
Presider: Kristina Irsch; Johns Hopkins University, USA

ITu2B.1 • 10:00 Invited
Super-resolution confocal microscopy using optical nonlinearity, Katsumasa Fujita[1]; [1]*Osaka Univ., Japan.* Utilizing the nonlinear optical effect is key to break the diffraction limit. I present the techniques to induce the higher-order nonlinearity in light excitation and scattering that improve the spatial resolution in confocal microscopy.

ITu2B.2 • 10:30
Improved Lateral Resolution of Continuous Wave STED Microscopy using Standing Wave in focus, Geon Lim[1], Wan-Chin Kim[2], Han-wook Yi[1], No-Cheol Park[1]; [1]*Yonsei Univ., South Korea;* [2]*Honam Univ., South Korea.* To improve lateral resolution of CW STED microscopy, interference generated standing wave by apodization aperture in excitation beam is introduced. Theoretical calculation and experiments are fulfilled, and the results show enhanced resolution than conventional case.

10:00–12:00
LTu2C • Combustion Diagnostics I
Presider: Daniel Richardson; Sandia National Labs, USA

LTu2C.1 • 10:00 Invited
1D single-shot thermography by Spontaneous Raman Scattering in turbulent, spray or oxyfuel flames, Armelle Cessou[1,2], Florestan Guichard[1], hassan Ajrouche[1], Amath Lo[1]; [1]*Université de Rouen, France;* [2]*CNRS, France.* Spontaneous Raman scattering noise, limited for thermography in turbulent flames where high spatial and time resolutions are required, is revisited for simultaneous temperature and multispecies concentration single-shot linewise measurements, offering new applications.

LTu2C.2 • 10:30
Backward lasing for range-resolved detection of atomic hydrogen in a methane-oxygen flame, Maria Ruchkina[1], Pengji Ding[1], Andreas Ehn[1], Marcus Aldén[1], Joakim Bood[1]; [1]*Lund Univ., Sweden.* We demonstrate range-resolved detection of atomic hydrogen in methane/oxygen flames based on 2-photon excited backward lasing using 205-nm femtosecond laser pulses. Range resolution is achieved by temporally resolving the backward emission with a streak camera.

10:00–12:00
MTu2D • High-Dimentional Imaging
Presider: Laure Blanc-Féraud; CNRS, USA

MTu2D.1 • 10:00 Invited
Accidental Cameras: using naturally occurring apertures and occluders to form images, Bill Freeman[1]; [1]*MIT, USA.* We study cameras that are accidentally formed in scenes, from pinhole, pinspeck, and single-edge occluders that we call "corner cameras". These cameras can reveal details about a scene that are otherwise invisible.

MTu2D.2 • 10:30
Surface Estimation of Small Animals from Orbital Plenoptic Projections, Jörg Peter[1], Mark E. Ladd[1]; [1]*German Cancer Research Center, Germany.* Normalized cross correlation weighted by spatial resolution characteristics of plenoptic cameras is presented, yielding more unique photo-consistency maps from which complex anatomical surfaces can be estimated more accurately at lesser computational cost.

10:00–12:00
CTu2E • Compressive Sensing 1
Presider: Jun Ke; Beijing Inst. of Technology, China

CTu2E.1 • 10:00 Invited
Single-shot 10 THz Compressed Ultrafast Photography, Lihong V. Wang[1], Jinyang Liang[1], Liren Zhu[1]; [1]*California Inst. of Technology, USA.* We have developed single-shot 10-trillion-frame-per-second compressed ultrafast photography (T-CUP), which can passively capture dynamic events with 100-fs frame intervals in a single camera exposure. This upgrade is 100 times faster than our original version.

CTu2E.2 • 10:30
Compressive Ultrafast Single Pixel Camera, Guy Satat[1], Gabriella Musarra[2], Ashley Lyons[2], Barmak Heshmat[1], Ramesh Raskar[1], Daniele Faccio[2]; [1]*MIT Media Lab, USA;* [2]*School of Physics & Astronomy, Univ. of Glasgow, UK.* We experimentally demonstrate a single-pixel, time-resolved camera that, by using the temporal information, produces improved reconstruction quality and shorter acquisition times, compared to traditional, non-time-resolved, single-pixel approaches.

Citron	Clementine	Mandarin	Tangerine
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:00–18:30 Registration, *Palms Foyer*

Citron

08:00–09:00
JTu1A • Plenary Session II with OSA Light the Future Speakers Series

JTu1A.1 • 08:00 Plenary
The Role of Optics and Photonics in the Vehicles of Tomorrow,Jason Eichenholz, Luminar Technologies, USA. This presentation will take a high level look at the future of optics and photonics technologies in autonomous vehicles. Optics are a crucial component in an industry headed for extreme disruption over the next few decades and will play a critical role in shaping the future of navigation, passenger experience and the ultimate safety of the autonomous trip. The key components of all-things-optic, including LiDAR, laser headlights, passenger monitoring and interior lighting and displays, the role each plays inside a future automobile and its impact on the transportation industry will be discussed.

09:00–10:00 Coffee Break with Exhibitors, *Palms Foyer*

10:00–11:45
DTu2F • Contemporary Topics in DH
Presider: Marc Georges; Universite de Liege, Belgium

DTu2F.1 • 10:00 Invited
Advances and Challenges in Synthetic Aperture Interferometry, Pablo D. Ruiz[1]; [1]*Loughborough Univ., UK*. Past and recent approaches to SAI will be discussed, focusing on the main challenges towards designing optical systems with a large space-bandwidth product, i.e. large fields of view and high spatial resolution.

DTu2F.2 • 10:30
Compressive holography for imaging behind a diffuser, Liangcai Cao[1], Hua Zhang[1], Wenhui Zhang[1], Hao Zhang[1], Guofan Jin[1]; [1]*Tsinghua Univ., China*. Compressive holography based on sparsity constraint is employed to reconstruct the object behind a weak diffuser. The experimental results demonstrate the effectiveness of the proposed model and the object was extracted from the perturbed hologram.

10:00–12:00
3Tu2G • HMD & VAC Solution
Presider: Adrian Stern; Ben Gurion Univ. of the Negev, Israel

3Tu2G.1 • 10:00 Invited
Computational Near-eye Displays: Engineering the Interface between our Visual System and the Digital World, Gordon Wetzstein[1]; [1]*Stanford Univ., USA*. Immersive visual and experiential computing systems, i.e. virtual and augmented reality (VR/AR), are entering the consumer market and have the potential to profoundly impact our society. Applications of these systems range from communication, entertainment, education, collaborative work, simulation and training to telesurgery, phobia treatment, and basic vision research.

3Tu2G.2 • 10:30 Invited
Mixed Reality Near-eye Display with Focus Cue, Byoungho . Lee[1], Changwon Jang[1], Seungjae Lee[1]; [1]*Seoul National Univ., South Korea*. Mixed reality (MR) has received great attention for past few years. Supporting focus cue is regarded as an important factor because it can mitigate the visual fatigue. This paper will overview two main issues in MR technique: realization of see-through displays and supporting focus cue. These two issues are explained with specific experimental setups and results.

10:00–11:45
STu2H • Components I
Presider: Paul McManamon; Exciting Technology LLC, USA

STu2H.1 • 10:00 Invited
Reimagine, Whitney Mason; *DARPA, USA*. Abstract not available.

STu2H.2 • 10:30 Invited
Opportunities for LIDAR and Free-Space Optical Communications Using Micro-Scale Photonics Technologies, Gordon A. Keeler[1]; [1]*DARPA, USA*. The increasing sophistication and availability of integrated photonics and optical microsystems will enable revolutionary chip-scale solutions for traditionally macroscopic systems. This talk describes DARPA efforts to advance LIDAR and FSOC hardware with innovative microsystem technologies.

10:00–12:00
PTu2I • Propagation Simulations
Presider: Daniel LeMaster; US Air Force Research Lab, USA

PTu2I.1 • 10:00 Invited
Physics and Modeling of Optical Waves Propagating Through Atmospheric Turbulence, Ronald L. Phillips[1]; [1]*CREOL College of Optics and Photonics, Univ. of Central Florida, USA*. The turbulence in the atmosphere can strongly affect propagation optical waves. The turbulence is created by a variety of atmospheric conditions. Using a mathematical model the fluctuations of the statistical fluctuations and wave parameters are computed.

PTu2I.2 • 10:30
Wave and Ray Optics Simulations of Short Exposure Incoherent Imaging in Atmospheric Turbulence, David Voelz[1], Hanyu Zhan[1], Erandi A. Wijerathna[1]; [1]*Klipsch School of Electrical and Computer Engineering, New Mexico State Univ., USA*. Wave optics and ray tracing simulation results are presented for short exposure incoherent imaging through atmospheric turbulence ranging from weak to strong scintillation regimes. The ray tracing results provide a recognizable approximation to the wave optics results even in the saturation regime, although some loss of high spatial frequency fidelity is apparent.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon/Lime
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging	Computational Optical Sensing and Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

ATu2A • Keynote and Laser Sorcery—Continued

ATu2A.2 • 10:45 Invited
Advanced Optical Filters based on a New Generation of Volume Bragg Gratings in Photo-thermo-refractive Glass, Vadim Smirnov[1], Oleksiy Mokhun[1], Leonid Glebov[1]; *[1]OptiGrate, USA.* Nowadays volume Bragg gratings (VBGs) in PTR glass are used in a wide variety of laser systems and applications. In this presentation we discuss VBGs with enhanced parameters developed for spectral sensing and hyperspectral imaging.

ATu2A.3 • 11:15 Invited
Mode Control in T-Cavity Vertical External Cavity surface emitting Lasers (VECSEL), Mahmoud Fallahi[1,2], Chris Hessenius[1,2]; *[1]Univ. of Arizona, USA; [2]TPhotonics Inc., USA.* T-Cavity VECSELs allow for the generation of tunable two-color emission as well as Sum and difference frequency generation. By using intracavity mode control, a range of high power orbital angular momentum beams are demonstrated.

ITu2B • Microscopy I: Super-resolution & Illumination Techniques—Continued

ITu2B.3 • 10:45
Tunable structured illumination system based on a Wollaston prism, Sebastian Bedoya[1], Ana Doblas[1], Genaro Saavedra[2], Chrysanthe Preza[1]; *[1]Univ. of Memphis, USA; [2]Dept. of Optics, Univ. of Valencia, Spain.* Experimental verification of a simple illumination system to generate a 1D structured pattern with tunable modulation frequency is shown based on a Wollaston prism illuminated by the diffracted field of an incoherent linear source.

ITu2B.4 • 11:00
Optimal Path and Illumination Design for Multiframe Motion Deblurring, Sarah Dean[1], Zachary Phillips[2], Laura Waller[1,2], Ben Recht[1]; *[1]Electrical Engineering and Computer Science, Univ. of California, Berkeley, USA; [2]Graduate Group in Applied Science and Technology, Univ. of California, Berkeley, USA.* We propose an extension of coded illumination design for motion deblurring to multiframe imaging, where a large field-of-view sample is recovered from many motion-blurred measurements captured while scanning the sample continuously under coded illumination.

ITu2B.5 • 11:15
Speckle-Free Imaging with Nanosecond-Scale Acquisition Using Micro-lens-Stabilized Laser Arrays, Austin W. Steinforth[1], José A. Rivera[1], J. G. Eden[1]; *[1]Univ of Illinois at Urbana-Champaign, USA.* A novel light source comprising as many as 4,000 independent lasers has been developed for speckle-free illumination. Visible-light and near-infrared imaging with exposure time as short as five nanoseconds has been demonstrated.

LTu2C • Combustion Diagnostics I—Continued

LTu2C.3 • 10:45
Quantitative OH Measurements in Turbulent Flames using Laser-Diagnostics with High Spatio-Temporal Resolution, Christoph Arndt[1], Wolfgang Meier[1]; *[1]German Aerospace Center (DLR), Germany.* For time-resolved numerical simulations, quantitative, time-resolved validation data with well-defined boundary conditions are crucial. Here, we present a strategy for quantitative measurements of the OH concentration in turbulent flames and assess the measurement uncertainties.

LTu2C.4 • 11:00
Mid-infrared laser absorption tomography for quantitative temperature, CO, and CO_2 in turbulent flames, Chuyu Wei[1], Daniel I. Pineda[1], Raymond M. Spearrin[1]; *[1]Dept. of Mechanical and Aerospace Engineering, Univ. of California, Los Angeles, USA.* Mid-infrared laser absorption tomography is presented as a quantitative method to spatially-resolve species and temperature profiles in small-diameter flames relevant to practical combustion systems. Example measurements in a canonical turbulent flame are discussed.

LTu2C.5 • 11:15 Invited
Non-linear mid-infrared laser techniques for combustion diagnostics, Anna-Lena Sahlberg[1]; *[1]Lunds Universitet, Sweden.* In the past decades, non-linear laser techniques have become an important part of combustion research. The major advantages of non-linear laser techniques are their high temporal and spatial resolution and high sensitivity, the main disadvantages being the more complex setup involved and the more complex data analysis required. Employing non-linear laser techniques in the mid-infrared spectral region has several advantages.

MTu2D • High-Dimentional Imaging—Continued

MTu2D.3 • 10:45
On Scene Reconstruction from Spatial Coherence Measurements, Andre Beckus[1], Alexandru Tamasan[1], Aristide Dogariu[1], Ayman F. Abouraddy[1], George K. Atia[1]; *[1]Univ. of Central Florida, USA.* We determine the positions and dimensions of obscurants and apertures from coherence measurements of partially coherent light by leveraging the authors' recent closed-form approximation formula for the coherence of propagated fields in the Fresnel regime.

MTu2D.4 • 11:00 Invited
Learning and Exploiting Physics of Degradations, Paul Escande[1], Valentin Debarnot[2], Mauro Maggioni[1], Thomas Mangeat[3], Pierre Weiss[2]; *[1]Applied Mathematics and Statistics, Johns Hopkins Univ. , USA; [2]Institut des Technologies Avancees en Science du Vivant, France; [3]Lab of Molecular and Cellular Biology of the Proliferation Control, Falkland Islands [Malvinas].* Even though physics of degradations of an acquisition system might be complex, it often relies on a small number of parameters. We present a methodology to learn this physics and exploit it for restoration purposes.

CTu2E • Compressive Sensing 1—Continued

CTu2E.3 • 10:45
Encrypted Single Pixel Imaging with Basis Illumination Patterns, Zibang Zhang[2], Shuming Jiao[1], Manhong Yao[2], Xiang Li[2], Jingang Zhong[2]; *[1]Shenzhen Univ., China; [2]Jinan Univ., China.* In previous works, encrypted single pixel imaging (SPI) systems are usually implemented with random illumination patterns. We propose an encrypted SPI system using permutated Hadamard basis patterns, which enables high-quality and efficient encrypted single-pixel imaging.

CTu2E.4 • 11:00
Correlation Matrix Estimation from Compressed Measurements in a Pattern Recognition System, Kevin A. Arias[2], Tatiana Gelvez[1], Jonathan Arley Monsalve Salazar[2], Henry Arguello[2]; *[1]Dept. of Electrical Engineering, Universidad Industrial de Santander, Colombia; [2]Computer Science, Universidad Industrial de Santander, Colombia.* This paper uses compressive sensing theory to reduce the dimensionality of the correlation matrix estimation in a pattern recognition system. Results show that the correlation matrix can be effectively estimated from compressed measurements using a sparse-based reconstruction algorithm.

CTu2E.5 • 11:15
Exploiting Inter Voxel Correlation in Compressed Computational Imaging, Naren Viswanathan[1], Suresh Venkatesh[1], David Schurig[1]; *[1]ECE, Univ. of Utah, USA.* An ensemble of representative targets contains apriori correlation information, quantified by the intervoxel covariance matrix. Thresholding according to the eigenvalues of his matrix and reconstructing only those eigenmodes, a faster, more accurate reconstruction is obtained.

Citron	Clementine	Mandarin	Tangerine
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

DTu2F • Contemporary Topics in DH—Continued

DTu2F.3 • 10:45
Holographic see-through near-eye display using index-matched anisotropic crystal lens, Jong-Young Hong[1], Gang Li[1], Byoungho Lee[1]; [1]*Seoul National Univ., South Korea.* We propose the holographic display for see-through near-eye display using transmission type optical floater which is index-matched anisotropic crystal lens. By adopting transmission type optical floater, our system showed the possibility of the holographic display with large field of view.

DTu2F.4 • 11:00
Fast generation of holographic videos of a 3-D moving object based on a rotational-motion compensation method, Hongkun Cao[1], ShuFeng Lin[1], EunSoo Kim[1]; [1]*Kwangwoon Univ., South Korea. A curved-hologram-based rotational-motion compensation method is proposed for fast generation of holographic videos of a 3-D moving object. Experiments show the proposed method can dramatically enhance the computational speed of the conventional hologram-generation algorithms.*

DTu2F.6 • 11:15
Two-stage Autofocusing Methodology for Digital Lensless Holographic Microscopy, Carlos A. Trujillo[1], Jorge Garcia-Sucerquia[1]; [1]*Univ Nacional de Colombia Medellin, Colombia.* A two-stage methodology based on traditional techniques and the modified enclosed energy metric for autofocusing in digital lensless holographic microscopy is presented. The validation of the proposal has been performed with experimental holograms.

3Tu2G • HMD & VAC Solution—Continued

3Tu2G.3 • 11:00 Invited
An Adaptive Rendering for Microlens Array HMD based on Eye-Gaze Tracking, Hirokazu Kato[1], Alexander Plopski[1], Takafumi Taketomi[1], Christian Sandor[1]; [1]*Nara Inst. of Science and Technology, Japan.* Microlens Array HMDs require adaptive rendering based on eye-gaze tracking to show clear images to the user because of the small eye box. In this talk, we will explain our ideas about this issue.

STu2H • Components I—Continued

STu2H.3 • 11:00 Invited
Compact Steering Technologies for Automotive LiDAR: a Comparison Between Liquid Crystal Clad Waveguides and Optical MEMs, Scott R. Davis[1], Andrew W. Sparks[1], Laura Fegely[1], Kemiao Jia[1], Derek Gann[1]; [1]*Analog Devices, Inc., USA.* Compact, rugged, low power, and affordable laser beamsteering devices are desired to enable light detection and ranging (LiDAR) for advanced driver-assistance systems (ADAS). We have considered both MEMs and LC-clad waveguide technologies. The tradeoffs between the two will be presented.

PTu2I • Propagation Simulations—Continued

PTu2I.3 • 10:45
Image Reconstruction with Active Illumination in Strong Turbulence Scenarios, Venkata S. Gudimetla[1], Richard Homes[2]; [1]*US Air Force, USA;* [2]*Boeing LTS, USA.* Three fast-running reconstruction algorithms based on *single-frame* processing are compared up to Rytov variances of 0.4 over a 30 km range with an isoplanatic patch comparable to the diffraction angle, and many patches across the object.

PTu2I.4 • 11:00
Discrepancies between Simulation and Theory Results for Plane Wave Scintillation in Atmospheric Turbulence, Erandi A. Wijerathna[1], David Voelz[1], Hanyu Zhan[1]; [1]*New Mexico State Univ., USA.* The scintillation index for a plane wave in weak to deep turbulence is studied with wave optics simulations for several atmospheric spectrum models. The simulations generally predict peak scintillation values for $\sigma_R \approx 2$ and comparisons with analytical theory show the simulations predict significantly higher scintillation, particularly for small inner scale values.

PTu2I.5 • 11:15
Propagation Simulation of Higher Order Bessel Beams Integrated in Time (HOBBIT), Joseph Watkins[1], Keith Miller[1], Wenzhe Li[1], Kaitlyn Morgan[1], Eric G. Johnson[1]; [1]*Clemson Univ., USA.* The paper presents simulation results from the propagation of dynamic HOBBITs through a series of moving phase screens representing turbulence.

Sunset/Fleming — Applied Industrial Optics

Siesta/Biscayne — Imaging Systems and Applications

Largo/Longboat — Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon — Mathematics in Imaging

Orange/Lemon/Lime — Computational Optical Sensing and Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

ATu2A • Keynote and Laser Sorcery—Continued

DEMO

T-Cavity VECSELs developed by TPhotonics Inc. and the University of Arizona allow for the generation of tunable two-color emission, sum and difference frequency generation, and also orbital angular momentum beams. We will demo our first-generation VECSEL lasers which operating at room temperature with no water cooling.

ITu2B • Microscopy I: Super-resolution & Illumination Techniques—Continued

ITu2B.6 • 11:30
Imaging and Quantitating Abrasion Damage on Transparent Substrates Using Edge Light Illumination, Christine Cecala[1], Evan Bittner[1], Eric Null[1]; [1]*Corning Incorporated, USA.* A system was developed to characterize surface damage on samples subjected to abrasion testing. It is optimized to correlate directly with human visual rankings while providing repeatable quantitation of damage.

LTu2C • Combustion Diagnostics I—Continued

LTu2C.6 • 11:45
An improved TDLAS technique to measure residence time distributions in particle loaded combustion chambers, Sebastian Bürkle[1], Lukas G. Becker[1], Andreas Dreizler[1], Steven Wagner[1]; [1]*TU Darmstadt FG RSM, Germany.* A technique to measure residence time distributions in chemical reactors without the need of modelling by using pulse-injections of HCl with TDLAS-detection is presented and demonstrated under non-reacting and reacting conditions in an oxy-coal/oxy-gas combustor.

MTu2D • High-Dimentional Imaging—Continued

MTu2D.5 • 11:30
Using the Pupil-Difference Probability Density to Understand OTF, Kevin Liang[1,2], Miguel A. Alonso[1,2]; [1]*Inst. of Optics, USA;* [2]*Center for Freeform Optics, USA.* We provide an overview of the pupil-difference probability density (PDPD) and its connection to the OTF. We then illustrate its use in understanding the effects of mid-spatial frequency (MSF) structures and quadratic surface errors.

MTu2D.6 • 11:45
Spatial Intensity Averaging for Ghost Imaging With a Single-Port Dynamic Metasurface Aperture, Aaron V. Diebold[1], Mohammadreza F. Imani[1], Timothy Sleasman[1], David Smith[1]; [1]*Duke Univ., USA.* We present a method for achieving spatial intensity integration of temporally coherent microwave radiation. The approach consists of averaging the instantaneous intensity over an ensemble of random radiation patterns using a single-port metasurface aperture.

CTu2E • Compressive Sensing 1—Continued

CTu2E.6 • 11:30
Double-threshold Denoising for Single-pixel Camera, Chao Wang[1,2], Xuri Yao[1], Qing zhao[2]; [1]*National Space Science Center, Chinese Academy of Sciences, China;* [2]*Beijing Inst. of Technology, China.* Present a method that sets two thresholds to select the measurement data for image reconstruction of Single-pixel camera. The results show that the proposed double-threshold compressive imaging protocol provides better image quality than previous schemes.

CTu2E.7 • 11:45
Multi-object Recognition in Turbid Water Using Compressive Sensing, Changqing Dong[1,3], Xuemin Cheng[1,3], Hongsheng Bi[4,3], Qun Hao[2]; [1]*Tsinghua Univ., China;* [2]*School of Optics and Photonics, Beijing Inst. of Technology, China;* [3]*Graduate School at Shenzhen, Tsinghua Univ.,, China;* [4]*Chesapeake Biological Lab, Univ. of Maryland Center for Environmental Science, USA.* Recognizing and classifying plankton in low-contrast images is difficult. A clustering algorithm are proposed to classify plankton and counted them on a compressed sensing frame. The reasonable output is proved in the experiment.

12:00–13:30 Light the Future Lunch, *Palm Foyer*

12:30–14:00 Student & Early Career Professional Development & Networking Lunch and Learn, *Jasmine*

Citron	Clementine	Mandarin	Tangerine
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

DTu2F • Contemporary Topics in DH—Continued

DTu2F.7 • 11:30
Terahertz pulse time-domain holography for studying of broadband beams propagation dynamics, Nikolai V. Petrov[1], Victor G. Bespalov[1], Maksim S. Kulya[1]; [1]*ITMO Univ., Russia.* In given talk we consider the possibilities of terahertz pulse time-domain holography for the spatio-temporal and spatio-spectral analysis of arbitrary broadband beams basing on the spatio-temporal field distribution measured in one transversal plane.

3Tu2G • HMD & VAC Solution—Continued

3Tu2G.4 • 11:30
Super Multi-View Near-Eye Display Using Time-Multiplexing Technique, Takaaki Ueno[1], Yasuhiro Takaki[1]; [1]*Tokyo Univ. of Agri. & Tech., Japan.* A super multi-view near-eye display is proposed to solve the vergence-accommodation conflict. A ferroelectric liquid crystal display and an LED array were combined to generate viewpoints two-dimensionally in a time-multiplexing manner. The prototype was demonstrated.

3Tu2G.5 • 11:45
A Continuous Variable Lens System to Address the Accommodation Problem in VR and 3D Displays, Afsoon Jamali[1], Comrun Yousefzadeh[1], Colin McGinty[1], Douglas Bryant[1], Philip Bos[1]; [1]*Kent State Univ., USA.* We propose a hybrid system design comprised of refractive Fresnel and Pancharatnam-Berry LC lenses resulting in a compact, large aperture, fast and tunable optic that can be used in numerous applications including VR/3D systems.

STu2H • Components I—Continued

STu2H.4 • 11:30
High-speed pulse control and optimization of quantum cascade laser using all-optical modulation, Chen Peng[1], Haijun Zhou[2], Tao Chen[1], Biao Wei[2], Zeren Li[1]; [1]*Inst. of Fluid Physics, China Academy of Engineering Physics, China;* [2]*Chongqing Univ., China.* Pulse control and optimization are demonstrated in a standard middle-infrared quantum cascade laser via an all optical approach. It has the potential for application in free space optical communication and high speed frequency modulation spectroscopy.

PTu2I • Propagation Simulations—Continued

PTu2I.6 • 11:30
Investigating Polarization Singular Beams for Robust Propagation Through a Random Medium, Priyanka Lochab[1], Kedar Khare[1], Paramsivam Senthilkumaran[1]; [1]*Indian Inst. of Technology Delhi, India.* Beams carrying C-point polarization singularity (lemon and star) are experimentally shown to maintain robust intensity profile on passing through a random medium compared to beams carrying V-points polarization singularity (radially and azimuthally polarized).

PTu2I.7 • 11:45
High Energy Laser Propagation: Environmental Effects, Dana Morrill[1], Benjamin Akers[1]; [1]*Air Force Inst. of Technology, USA.* The environmental effects of high energy laser propagation are numerically simulated in a wave optics model coupled with direct simulation of the background fluid flow. The roles of fluid boundary conditions and scintillation are discussed.

12:00–13:30 Light the Future Lunch, *Palm Foyer*

12:30–14:00 Student & Early Career Professional Development & Networking Lunch and Learn, *Jasmine*

Tuesday, 26 June

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security and Environmental Analysis

Orange/Lemon/Lime

Joint

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

13:30–15:30
ATu3A • Fiber Sensory Overload
Presider: Denis Donlagic; Univerza v Mariboru, Slovenia

ATu3A.1 • 13:30 Invited
FOSS: Recent Development Efforts and Paths to Commercialization, Hon Man (Patrick) Chan[1]; [1]*NASA Armstrong Flight Research, USA.* An overview of FOSS technology developed at NASA based on OFDR is discussed in brief. Recent Deployments efforts, both in aerospace and beyond is demonstrated. Paths to commercialization with the public sector via NASA technology transfer office is also highlighted.

DEMO

Real Time Demonstration of NASA Armstrong Flight Research Center's next generation of Fiber Optics Sensing System (FOSS), based on Optical Frequency Domain Reflectrometry (OFDR), showcasing strain distribution of a test coupon where a single fiber optics cable can have multiple fiber sensors composed of fiber bragg gratings (FBG).

ATu3A.2 • 14:15 Invited
Smart metallic part manufacturing by laser-cladding based embedding of optical fiber sensors, Ander Zornoza[1], Tania Grandal[1,2]; [1]*AIMEN, Spain;* [2]*school of mathematics, Computer science and engineering, City Univ. of London, UK.* Laser based additive manufacturing of metal parts has opened the path to embedding fiber optic sensors that withstand the harshness of the process and applications, since the technique allows many degrees of freedom. As a promising solution laser cladding based embedding of metal coated fiber optics into which Fiber Bragg Grating (FBG) sensors have been written are presented in this paper.

14:00–15:15
ITu3B • Microscopy II: 3D & High Speed Techniques
Presider: Rajesh Menon; Univ. of Utah, USA

ITu3B.1 • 14:00 Invited
Compressive high-speed imaging in fluorescence microscopy and 3D photography, Shuo Pang[1]; [1]*Univ. of Central Florida, CREOL, USA.* We present the recent progress in compressive high-speed imaging systems based on spatiotemporal encoding. Specifically, the development in algorithms and new applications in fluorescence microscopy and 3D photography will be discussed.

ITu3B.2 • 14:30
Development of a coded exposure camera for high-speed 3D measurement using microscope, Toshihiko Yamashita[1], Hiroyuki Chiba[1], Kazuki Yamato[1], Hiromasa Oku[1]; [1]*Gunma Univ., Japan.* This paper propose a coded exposure camera for high-speed 3D measurement using microscope and a tunable acoustic gradient index lens.Experimental results showed the validity of the proposed camera.

13:30–15:30
LTu3C • Combustion Diagnostics II
Presider: Christoph Arndt; German Aerospace Center (DLR), Germany

LTu3C.1 • 13:30 Invited
Wavelength-Modulation Spectroscopy in the Near-GHz Regime for High-Speed Thermometry and Species Sensing, Garrett Mathews[1], Christopher S. Goldenstein[1]; [1]*Purdue Univ., USA.* This work presents the development and application of a novel wavelength-modulation spectroscopy technique for measuring gas temperature and H_2O concentration in combustion flows at rates approaching 1 MHz.

LTu3C.2 • 14:00
Two-line Kr PLIF technique for composition independent temperature imaging in gaseous combustion, Venkateswaran Narayanaswamy[1], Dominic Zelenak[1]; [1]*North Carolina State Univ., USA.* A two-line Kr PLIF based thermometry technique will be presented for application in gaseous combustion. The technique uses the spectral line broadening of the krypton seeded into the fuel stream to provide 2D temperature field.

LTu3C.3 • 14:15
Three-dimensional Temperature Measurements in Turbulent Reacting Flows, Paul S. Hsu[1], Benjamin R. Halls[2], Sukesh Roy[1], Terrence Meyer[3], James R. Gord[2]; [1]*Spectral Energies LLC, USA;* [2]*Air Force Research Lab, USA;* [3]*Purdue Univ., USA.* We demonstrated single-shot, three-dimensional temperature field measurements in a turbulent hydrogen-air flame using two-color hydroxyl radical volumetric laser-induced florescence (OH-VLIF). Four high-speed intensified cameras with shared quadscopes were used for tomographic temperature field imaging.

LTu3C.4 • 14:30 Invited
Thermometry and barometry in combustion using laser induced gratings, Paul Ewart[1]; [1]*Univ. of Oxford, UK.* Laser-induced grating spectroscopy for temperature and pressure measurements in combusting and non-combusting flows with time- and space-resolution are reviewed for applications in gasoline and diesel engines and other environments.

13:30–15:30
JTu3D • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman I
Presider: Edmund Lam; Univ. of Hong Kong, Hong Kong

JTu3D.1 • 13:30 Invited
Origins and Evolution of Introduction to Fourier Optics, Joseph W. Goodman[1]; [1]*Stanford Univ., USA.* In this talk I trace the history of Introduction to Fourier Optics, from inception to the 4th edition. Also discussed are foreign editions, numbers of books sold, citations, and other facts about the book.

JTu3D.2 • 14:00 Invited
What's the Problem? Insight and Inspiration Derived from Solving the Exercises in J. Goodman's Classic Book Introduction to Fourier Optics, James Leger[1]; [1]*Univ. of Minnesota Twin Cities, USA.* The exercises contained in Goodman's classic text have delighted students and researchers for 50 years. In this talk, we explore the impact of these elegant problems on pedagogy and research. We describe how these exercises have provided insight to beginning students and inspiration to practicing optical engineers.

JTu3D.3 • 14:30 Invited
The Transition of Fourier Optics Towards Computational Imaging and Digital Holography, Demetri Psaltis[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland.* I will trace the remarkable robustness of the Fourier Optics described in Goodman's book from the analog optical systems 50 years ago to the digital techniques that are widely used in optics today.

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free Space Communication

Tangerine

Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

13:30–15:30
3Tu3E • Compressing & Integral Imaging Sensing (Light Field)
Presider: Adrian Stern; Ben Gurion Univ. of the Negev, Israel

3Tu3E.1 • 13:30 Invited
Densely-sampled light field: reconstruction, compression and applications, Atanas Gotchev[1]; [1]*Tampere Univ. of Technology, Finland*. Densely-sampled Light Field is an attractive representation of scene visual content facilitating arbitrary ray interpolation and view synthesis. We discuss its effective reconstruction from sparse multi-perspective views, compression and applications in microscopy and full-parallax imaging.

3Tu3E.2 • 14:00 Invited
Smart optics for low-power computational sensing, David Stork[1]; [1]*Rambus Labs, USA*. Special diffraction gratings can structure incoming light so that fewer pixels need be read for a criterion sensor performance, thus reducing the power dissipation in some simple optical sensors.

3Tu3E.3 • 14:30 Invited
Light-field background de-cluttering for visual prostheses, Jae-Hyun Jung[1,2], Eli Peli[1,2]; [1]*Harvard Medical School, USA*; [2]*Ophthalmology, Schepens Eye Research Inst., USA*. Object recognition is challenging with current visual prostheses, especially with background clutter. We have developed an imaging system to remove the background clutter in the visual prostheses using the light-field camera and bipolar edge filtering.

14:30–15:30
STu3F • Quantum Protocols I
Presider: Robert Boyd; Univ. of Ottawa, Canada

STu3F.1 • 14:30 Invited
Weak Value Amplification: What is it and is it useful?, Jeff S. Lundeen[1]; [1]*Physics, Univ. of Ottawa, Canada*. Weak value amplification is a general technique that magnifies the effect of a measured parameter. It has enabled astounding sensitivity, for instance a 560 femtoradian mirror tilt. I will outline when WVA is useful.

14:15–15:30
PTu3G • Underwater Propagation
Presider: Olga Korotkova; University of Miami, USA

PTu3G.1 • 14:15 Invited
Airborne Lidar Characterization of Oceanic Phenomena, James H. Churnside[1]; [1]*Earth System Research Lab, NOAA, USA*. Airborne polarization lidar has been used to characterize a variety of oceanic phenomena. Physical phenomena, such as internal waves and turbulence, were observed by tracking scattering layers at density gradients in the upper ocean.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Orange/Lemon/Lime
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Joint

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

ATu3A • Fiber Sensory Overload—Continued

ATu3A.3 • 14:45 Invited
In-situ Continuous Measurement of Pressure Pulsations at 650C with Fiber Optic Sensor, John W. Berthold[1], Richard L. Lopushansky[1]; [1]*Davidson Instruments, Inc., USA.* We describe a system to measure combustion instabilities in gas turbine engines used for electrical power generation. The sensor is an extrinsic fiber optic Fabry-Perot interferometer packaged in a 6mm diameter probe that is permanently positioned within the engine near the combustor.

DEMO

The presentation will include a show-and-tell with one or more Davidson Instruments sensor probes that may be inspected by session attendees. The configuration of these typical probes that are used to monitor combustion dynamics in gas turbine combustors in the electric power generation industry will be described.

ITu3B • Microscopy II: 3D & High Speed Techniques—Continued

ITu3B.3 • 14:45
Depth of Focus Extension based on a Laser Frequency-shifted Feedback Imaging System, Yueyue Lu[1], Kaiyi Zhu[1], Shulian Zhang[1], Yidong Tan[1]; [1]*Dept. of Precision Instrument, Tsinghua Univ., The State Key Lab of Precision Measurement Technology and Instrument, China.* A laser frequency-shifted feedback imaging configuration is demonstrated whose depth of focus is extended to twice the focus length of the objective lens. Images on any planes can be refocused from one defocus image.

ITu3B.4 • 15:00
Temporal Study of Photonic Jet Formations under Ultrashort Laser Pulses Illumination for Different Geometries in Near-field Optical Microscopy, Charles Pichette[1], Michel Piché[1], Pierre Marquet[2,1], Simon Thibault[1]; [1]*Universite Laval, Canada;* [2]*Cervo Brain Research Center, Canada.* Near-field optical microscopy is a superresolution technique relying on photonic jets (PJs) with sub-diffraction limit focusing as illumination. The temporal and spectral characteristics of these PJs under ultrafast illumination is investigated here for different geometries.

LTu3C • Combustion Diagnostics II—Continued

LTu3C.5 • 15:00 Invited
Time-resolved digital in-line holography and pyrometry for aluminized solid rocket propellants, Yi Chen[1], Jeffery Heyborne[1], Daniel R. Guildenbecher[1]; [1]*Sandia National Labs, USA.* Combustion of aluminum droplets in solid rocket propellants is studied using laser diagnostic techniques. The time-resolved droplet velocity, temperature, and size are measured using high speed digital in-line holography and imaging pyrometry at 20kHz.

JTu3D • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman I—Continued

JTu3D.4 • 15:00 Invited
Linear-Algebra Optics, Bahaa Saleh[1]; [1]*Univ. of Central Florida, USA.* Fourier and linear systems methods are indispensable tools of optics. Matrix methods are necessary to describe discrete optical systems, such as polarization and ray optics. A more general approach based on linear algebra and vector spaces is necessary to address the full spectrum of topics in classical optics.

15:30–16:30 Coffee Break with Exhibitors, *Palms Foyer*

Clementine	Mandarin	Tangerine
3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

3Tu3E • Compressing & Integral Imaging Sensing (Light Field)—Continued

3Tu3E.4 • 15:00
Plenoptic Tomographic Imaging of Fluorescent Probes – Instrumentation Blueprint, Jörg Peter[1], Mark E. Ladd[1]; [1]*German Cancer Research Center, Germany.* We report on the development and simulation results of a plenoptic camera and tomography system designed for in vivo bioluminescence and multispectral fluorescence imaging. The system is intended for synchromodal use in secondary imaging modalities.

3Tu3E.5 • 15:15
Depth Estimation and Multi-view Spectral Image Based on Compressive Sensing Light Field Reconstruction, Xiaomin Liu[1], Qiancheng Wang[1], Zhibang Ma[1], Yuanye Niu[2], Shaoli Duan[3], Huaping Zang[1], Fengying Ma[1], Min Huang[4], Qunbo Lv[4], Erjun Liang[1]; [1]*Zhengzhou Univ., China;* [2]*Zhengzhou Xin da Inst. of Advanced Technology, China;* [3]*Kunming Inst. of Physics, China;* [4]*Academy of Opto-Electronics, Chinese Academy of Sciences, China.* Based on compressive sensing, multi-views light field images were reconstructed both simulating and physical implementing. LF-image depth estimation with multi-clue fusion was realized. And multi-view true color images were generated synthesized though spectral data.

STu3F • Quantum Protocols I—Continued

STu3F.2 • 15:00 Invited
Quantum Key Distribution (QKD) Using Full Laguerre-Gauss Encoding, Robert W. Boyd[1,2]; [1]*Univ. of Ottawa, Canada;* [2]*Inst. of Optics, Univ. of Rochester, USA.* We describe progress in developing a free-space QKD system that encodes information in both the radial and azimuthal degrees of freedom. Such a system makes optimum use of the sizes of sending and receiving telescopes.

PTu3G • Underwater Propagation—Continued

PTu3G.2 • 14:45
Mapping the Attenuation Coefficient in Yellowstone Lake, Yellowstone National Park, USA, Michael R. Roddewig[1,2], James H. Churnside[3], Joseph A. Shaw[1]; [1]*Montana State Univ., USA;* [2]*AdvR, Inc., USA;* [3]*Earth Systems Research Lab, NOAA, USA.* We introduce a spatial and temporal study of the lidar attenuation coefficient from a series of airborne lidar flights conducted in 2015 and 2016 over Yellowstone Lake, Yellowstone National Park, Wyoming, USA. We then relate these data to the Secchi disk depth, discuss the possible impact that local weather may have had on the attenuation coefficient, and compare these data to the modeled lidar attenuation coefficient.

PTu3G.3 • 15:00
Sensitivity Study on the Effect of the Optical and Physical Properties of Coated Spherical Particles on the Underwater Linear Polarization Pattern, Masada Tzabari[1], Carynelisa Haspel[1]; [1]*The Fredy and Nadine Herrmann Inst. of Earth Sciences, The Hebrew Univ. of Jerusalem, Israel.* The influence of coated spherical hydrosols on the polarization characteristics (e.g., the degree of linear polarization and E-vector angle) of light refracted at the air-water interface followed by single scattering is investigated.

PTu3G.4 • 15:15
Experiments with non-uniformly correlated laser beams propagating underwater, Svetlana Avramov-Zamurovic[1], Milo Hyde[2], Charles Nelson[1]; [1]*USNA, USA;* [2]*AFIT, USA.* Generation and underwater propagation of recently developed non-uniformly correlated laser beams is presented. The experimental set-up and initial observations of the beam intensity after a short underwater path are given.

15:30–16:30 Coffee Break with Exhibitors, *Palms Foyer*

15:30–16:30
JTu4A • Poster Session II

JTu4A.1
Interactive Multi-plane Display, Youngmin Kim[1], Jisoo Hong[1], Sunghee Hong[1], Choonsung Shin[1], Hyeong-Hak Ahn[1], Elena Stoykova[2,1], Hoonjong Kang[1]; [1]*Korea Electronics Technology Inst., South Korea;* [2]*Inst. of Optical Materials and Technologies, Bulgarian Academy of Science, Bulgaria*. Interactive multi-plane display by using plural high-definition panels and transmissive dihedral corner reflector array plate was proposed. The observer could interact with floated multiple image planes.

JTu4A.2
Rapid calculation of full-color holographic system with real objects using relocated point cloud gridding method, Yu Zhao[1], Md-Sifatul Islam[1], Shahinur Alam[1], Seok-Hee Jeon[2], Nam Kim[1]; [1]*Chungbuk National Univ., South Korea;* [2]*Incheon National Univ., South Korea.* We propose a relocated-point cloud gridding method to accelerate the full-color holographic system with real objects. The proposed method reduces the huge computational costs associated with full-color hologram generation and the reconstructed results are excellent.

JTu4A.3
Coded aperture structured illumination digital holographic microscopy, Yu-Chih Lin[1], Xin-Ji Lai[1], Han-Yen Tu[2], Chau-Jern Cheng[1]; [1]*National Taiwan Normal Univ., Taiwan;* [2]*Dept. of Electrical Engineering, Chinese Culture Univ., Taiwan.* This work proposes and experimentally demonstrates coded aperture structured illumination digital holographic microscopy for resolution enhancement. The binary codes are applied for spatial phase shifting along with compressive sensing for retrieving the missing data.

JTu4A.4
Reduction of Visual Discomfort in HMD using Image Refocusing linked to Depth Control, Gwangsoon Lee[1], Joonsoo Kim[1], Won-Sik Cheong[1], Jeonil Seo[1], Jae-Hyeung Park[2]; [1]*Electronics and Telecom Research Inst, South Korea;* [2]*Inha Univ., South Korea.* This paper proposes an image refocusing algorithm that can reduce the visual discomfort in stereoscopic HMD. Specifically, our image refocusing is optimized to emulate human vision and conducted by taking into consideration the control of perceived depth.

JTu4A.5
Measurement of angular dependence of emissivity through photothermal effect, Yaqi Zhang[1], Gerald Diebold[1]; [1]*Brown Univ., USA.* The angular dependence of emissivity is obtained indirectly by measuring absorption through photothermal effect. Absorption of light induces thermal deformation and then electric charge generation. Angular dependence of emissivity of graphite and copper are given.

JTu4A.6
LED based Off-axis Reflection Digital Holographic Microscopy using Holographic Optical Element, Byounghyo Lee[1], Dukho Lee[1], Byoungho . Lee[1]; [1]*Seoul National Univalsity, South Korea.* We present compact off-axis reflection digital holographic microscopy that can image specimens using LED. Reflection holographic optical element is implemented to replace classical interferometer and make signal and reference wave follow the common optical path length to obtain interference pattern.

JTu4A.7
High-Sensitivity Measurement of Environmental NO_2 by Laser Photoacoustic Spectroscopy, Weidong Chen[1]; [1]*Universite du Littoral, France.* A photoacoustic spectroscopy based NO_2 sensor was developed for measurement of ambient NO_2 with a sensitivity of about 0.4 ppb (SNR=1) in 1 min, which was validated with side-by-side measurements using a referenced NOx analyzer.

JTu4A.8
Evaluation of De-Noising Algorithms for Amplitude Image Restoration in Digital Holography, Silvio Montresor[1], Pascal Picart[1]; [1]*LAUM CNRS Le Mans Université, France.* This paper presents the analysis of de-noising algorithms for images from digital holography. A set of 20 experimental images with SNR diversity are processed by 34 de-noising algorithms. Algorithms are ranked using appropriate metrics.

JTu4A.9
Dynamic holographic video projection based on upconversion material screen and LCos-SLM, Wen Zhou[1]; [1]*Shanghai Univ., China.* A dynamic holographic three-dimensional (3D) projection based on liquid crystal on silicon spatial light modulator (LCos-SLM) and upconversion material is introduced. This work is to make the dynamic holographic video can be observed strightly on the upconversion material. And we also have done some work on the analysis of the image light field distribution in the upconversion material.

JTu4A.10
Performance Evaluation of Sparseness Significance Ranking Measure (SSRM) on Holographic Content, Ayyoub Ahar[1,2], Tobias Birnbaum[1,2], David Blinder[1,2], Athanasia Symeonidou[1,2], Peter Schelkens[1,2]; [1]*Vrije Univ. Brussel (VUB), Belgium;* [2]*imec, Belgium.* The Sparseness Significance Ranking Measure (SSRM) is a new quality measure for regular images. Here, we evaluate its performance on holographic content compared to MSE, PSNR and VSM. Results show a significant gain over the classical methods.

JTu4A.11
3D MTF for the Image Quality Assessment of Holographic Display System, Joongki Park[1], Eun-Young Chang[1], Hayan Kim[1], Jae-Han Kim[1], Jinwoong Kim[1], Minsik Park[1]; [1]*ETRI, South Korea.* We propose a 3D MTF measurement method as a quantitative evaluation method for image quality of holographic displays. We show the experimental result of our tabletop holographic display by exploiting the proposed method.

JTu4A.12
Integral image pick-up based dynamic control holographic display system, Yan-Ling Piao[1], Young-Tae Lim[1], Ki-Chul Kwon[1], Nam Kim[1]; [1]*Chungbuk National Univ., South Korea.* The real-existing scenes acquisition for hologram generation still have serious problem. In this research, an efficient CGH scheme that using Integral image pick-up system and dynamic control holographic display system is proposed.

JTu4A.13
A Novel Polarized Optical Flow Algorithm for Bionic Polarization Navigation Using in the Glimmer Light, Le Guan[1,2], Sheng Liu[1], Shiqi Li[1], Liyuan Zhai[1], Jinkui Chu[1], Yan Cui[1], Huikai Xie[2]; [1]*Key Lab for Micro/Nano Technology and System of Liaoning Province, Dalian Univ. of Technology, China;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Florida, USA.* A novel optical flow algorithm combining the polarization imaging technique is proposed to apply in the new type of polarization navigation sensor, which can output the velocity information around the clock.

JTu4A.14
Improvement of Signal and Contrast Ratio by Optimizing Spatially Offset Raman Spectroscopy System, Qiushi Liu[1], Xiaohua Zhang[1], Baozhen Zhao[1]; [1]*CIAE, China.* By optimizing SORS system, the signal intensity increased about 3 times and the contrast ratio enhancement was about 2 times. The detection of subsurface components under the opaque medium was successfully achieved.

JTu4A.15
Adaptive Multi-Frequency Phase Stepping for Optimal 3D Depth Reconstruction, Jostein Thorstensen[1], Jens Thielemann[1]; [1]*Smart Sensor Systems, SINTEF Digital, Norway.* We propose a 3D measurement algorithm based on Multi-Frequency Phase Stepping, using a single period pattern and a higher frequency pattern. An experimentally verified analytical expression for depth precision enables adaptive selection of the high frequency, ensuring optimal depth precision.

JTu4A.16
Recording Multiple Holographic Gratings in Nickel ion Doped Photopolymer Material Using Angle Multiplexing, Aswathy G[1], Rajesh C.S[1], Cheranelloor S. Kartha[1]; [1]*Physics, CUSAT, India.* Feasibility of recording multiple holographic gratings in the same volume of the nickel ion doped photopolymer material was checked. Fifteen gratings with different resolutions were recorded in the same location using angle multiplexing technique.

JTu4A.17
Quasi-1D High-Speed Raman/Filtered Rayleigh Scattering for Combustion Dynamics Applications, Gaetano Magnotti[1], Yedhu Krishna[1]; [1]*CCRC, KAUST, Saudi Arabia.* Raman/Rayleigh scattering is a powerful diagnostics technique to measure temperature, species and their gradients in non-sooting jet flames, but it is typically limited to repetition rates of 10 Hz or lower and to open jet configurations. Here we introduce a novel approach to extend sampling rates to 10 kHz, while maintaining the high accuracy and precision needed in experimental datasets intended for validation of numerical combustion models.

JTu4A.18
Measurement of glucose concentrations inside agar using parametric standing wave to realize non-invasive blood glucose sensor, Tomoya Kitazaki[1], Natsumi Kawashima[1], Naoyuki Yamamoto[1], Hiroyuki Nomura[1], Akira Nishiyama[1], Kenji Wada[1], Ichiro Ishimaru[1]; [1]*Kagawa Univ., Japan.* To realize a noninvasive blood glucose sensor, we propose a method to generate reflection planes inside agar using ultrasonic standing waves. This method allows measurement of the glucose concentrations inside agar samples using mid-infrared spectroscopy.

15:30–16:30
JTu4A • Poster Session II

JTu4A.19
Microscopic Shape from Focus using White Light Interferometric Fringes, Hernando Altamar-Mercado[1], Alberto Patiño-Vanegas[1], Andres G. Marrugo[2]; [1]*Facultad de Ciencias Basicas, Universidad Tecnologica de Bolivar, Colombia;* [2]*Facultad de Ingenieria, Universidad Tecnologica de Bolivar, Colombia.* In this work we study the use of a focus measure to improve the 3D reconstruction of low reflectivity microscopic samples using white light interference microscopy. Simulation and experimental results show the improved reconstruction.

JTu4A.20
IR Polarization for Natural Clutter Suppression, Francis P. Pantuso[1], Collin J. Bright[1], Richard W. Harr[1], Michael P. Polcha[1], Aaron S. LaPointe[1]; [1]*Night Vision and Electronics Sensors Dir, USA.* IR Polarization can help to find man-made objects in scenes primarily made up of the natural environment. A model was developed to predict and explain results in short range, on-the-move situations. Test results show that Polarization contrast nearly always exceeds radiance contrast and generally suppresses background clutter.

JTu4A.21
The first result of Compressed Channeled Imaging Spectropolarimeter, Wenyi Ren[1,2], Chen Fu[2], Gonzalo R. Arce[2]; [1]*Northwest Agriculture and forestry Univ., China;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Delaware, USA.* We presented a compressed channeled imaging spectropolarimeter, which was designed based on the channeled spectropolarimeter and coded aperture snapshot spectral imager. The 2-D spatial, 1-D spectral and 4-D full Stokes polarization information can be obtained simultaneously.

JTu4A.22
Security Enhancement of Double Random Phase Encryption against Ciphertext Only Attack, Shuming Jiao[1], Zhaoyong Zhuang[1], Wenbin zou[1], Xia Li[1]; [1]*Shenzhen Univ., China.* Recently several ciphertext only attack methods are proposed to crack double random phase encryption (DRPE), revealing severe system security flaws. A security enhancement scheme for DRPE against these attacks is proposed in this paper.

JTu4A.23
Optical Nonlinear Image Encryption System using Optically Generated Biometric Phase Mask, Gaurav Verma[1], Aloka Sinha[1]; [1]*Physics, IIT Delhi, India.* A new optical biometric phase mask generation process based on digital holography for nonlinear image encryption is presented for security and authentication. Computer simulations are performed to validate the effectiveness and feasibility of the proposed scheme.

JTu4A.24
Analysis of 3D Image Reconstruction for Spherical Object Using Convolutional Neural Network in Digital Holography, Wooyoung Jeong[1], Kyungchan Son[1], Wonseok Jeon[1], Hyunseok Yang[1]; [1]*Yonsei Univ., South Korea.* 3D depth measurement of object using digital holography is difficult to be realized because of the wavelength shorter than the depth of the object. In this paper, 3D image reconstruction of spherical object for digital holography is analyzed using convolutional neural network.

JTu4A.25
Single Shot Digital Holographic Imaging through a Scattering Layer, Bhargab Das[1], Nandan S. Bisht[3], R V. Vinu[2], Rakesh K. Singh[2]; [1]*Cen. Sci. Ins. Org. (CSIO), India;* [2]*Dept. of Physics, Indian Inst. of Space Science and Technology, India;* [3]*Dept. of Physics, Kumaun Univ., India.* We present our recent research studies on single-shot complex amplitude information retrieval through a visually opaque scattering layer realized using different architectures based on speckle interferometry, intensity correlation interferogram, phase-retrieval algorithm and digital holography.

JTu4A.26
An Infrared Dim Small Target Detection Algorithm Based on Adaptive Lateral Inhibition and SVD, Yong Song[1], Yun Li[1], Shaokun Han[1], Xu Li[1], Yurong Jiang[1], Yufei Zhao[1], Shangnan Zhao[1]; [1]*Beijing Institue of Technology, China.* This paper proposes an infrared dim small target detection algorithm based on adaptive lateral inhibition and singular value decomposition (SVD), which has relatively high detection rate and excellent abilities of background suppression and target enhancement.

JTu4A.27
An optical closure study of ethylene flame soot, Meng Wang[1], Yucun Liu[1], Arun Ramachandran[2], Ravi Varma[2], Huinan Yang[1], Mingxu Su[1], Jun Chen[1]; [1]*School of energy and power engineering, USST, China;* [2]*Physics, National Inst. of Technology, India.* An optical closure study of ethylene flame soot by combing Two-color laser-induced incandescence (LII) and cavity ring-down (CRD). Simulations and Lab measurements of the extinction coefficient showed good agreement with expected and reported values.

JTu4A.28
Measuring Flame Speeds with High Speed Imaging Diagnostics, Kenneth R. Bratton[1], Connor Woodruff[1], Loudon Campbell[1], Michelle Pantoya[1], Ronald Heaps[2]; [1]*Texas Tech Univ., USA;* [2]*Idaho National Labs, USA.* Comparison of flame speed measurements of slow (cm/s) and fast (m/s) reacting powders utilizing various filtration and laser illumination techniques. Imaging techniques provide unique observations of energy propagation but no difference in average flame speed.

JTu4A.29
Investigation of flowing liquid film by diode laser absorption spectroscopy and ultrasonic pulse-echo method, Huinan Yang[1], Yuexing Zhang[1], Yong Jiang[1], Jun Chen[1], Mingxu Su[1]; [1]*Univ. of Shanghai for Science and Technology, China.* Diode laser absorption spectroscopy (DLAS) and ultrasonic pulse-echo method (UPEM) were applied to investigate the flowing liquid film at different speeds, and it revealed that the parameters determined by both methods were in good agreement.

JTu4A.30
3D IC/Stacked Device Fault Isolation using Lock-in Infrared Microscopy, Hwan Hur[1], Kye-Sung Lee[1]; [1]*Korea Basic Science Inst., South Korea.* A lock-in infrared microscopy for 3D IC/Stacked device fault detection is developed. The fault is localized in 3-dimension by the thermal difference of an amplitude image and depth estimation from phase image considering the thermal diffusivity.

JTu4A.31
Speckle suppression in off-axis lensless Fourier transform digital holography by LCOS, Jie Zhao[1], Dayong Wang[1], Spozmai Panezai[1], Yunxin Wang[1], Lu Rong[1]; [1]*Beijing Univ. of Technology, China.* Speckle noise suppression in off-axis lensless Fourier transform digital holography by laterally shifting of object is analyzed quantitatively. LCOS spatial light modulator is used in object beam path to introduce the lateral shift in its position digitally without mechanical efforts.

JTu4A.32
Evaluation of phase shifting fringe patterns using iterative self-tuning demodulation method, Hubing Du[1]; [1]*Xi'an Technological Univ., China.* We presents a method an iterative self-tuning phase-shifting algorithm for extracting the phase of three frame phase shifting fringe patterns with unknown phase step. The proposed method can be implemented easily in many applications.

JTu4A.33
Focal plane detection via holographic autofocusing criterion applied on Terahertz Time-domain spectroscopy system, Yuchen Zhao[1], Dinh T. Nguyen[2], Yves Hermandez[2], Marc P. Georges[1]; [1]*Centre Spatial de Liège, STAR Research Unit, Liege Université, Belgium;* [2]*Multitel A.S.B.L, Belgium.* Holographic autofocusing technique is applied on a terahertz time-domain spectroscopy system to improve focus accuracy. We experimentally perform the focus plane detection with TDS measurement. Amplitude and phase information at different wavelengths are exacted.

JTu4A.34
3-D Surface Profilometry by Direct Color-Fringe Identification and an Orthogonal Setup, Nadia Tornero Martínez[1], Gerardo Trujillo-Schiaffino[1], Marcelino Anguiano-Morales[1], Didia Patricia Salas-Peimbert[1], Luis Francisco Corral-Martínez[1], Ismael Arturo Garduño-Wilches[1]; [1]*División de Estudios de Posgrado e Investigación, Instituto Tecnológico de Chihuahua, Mexico.* A new profilometry structured-light technique using an orthogonal system-setup is presented, based on color identification of a color-fringe pattern without employing mathematical-models, the topography of a surface is achieved with a precision of ±0.5766 mm.

JTu4A.35
Nondestructive Metrology of the Process of Holographic Recording by Ellipsometry, Hao Jiang[1], Zhao Ma[1], Yonggui Liao[1], Haiyan Peng[1], Shiyuan Liu[1]; [1]*Huazhong Univ. of Sci. and Tech, China.* Muller matrix ellipsometry is introduced as a nondestructive method to measure the fabrication process of grating upon holography, with which the exact widths and refractive indices, nanoparticle fractions of bright and dark regions are achieved.

JTu4A.36
Lensless holographic microscope of biological samples, Hanu Ram[1], Vaibhav B. Bansode[1], Renu John[1]; [1]*Biomedical Engineering, Indian Inst. of Technology Hyderabad, India.* Lensless holographic microscopy shows high potential to be a practical point of care diagnostic tool due to its unique features like compactness, simple prototype, and portability. In this work, a deep violet (370nm, 10 nm FWHM) LED at low power is used as a low coherent light source for lensless 3-D holographic imaging of live cells and microparticles. An on-chip Fresnel hologram of the sample is recorded on a high-resolution CMOS camera and 3-D phase reconstruction has been performed eliminating the twin images using an optimization approach.

15:30–16:30
JTu4A • Poster Session II

JTu4A.37
Enhancement of Low-light Images and Videos, Thangamani Veeramani[1]; [1]*Wipro Limited, India.* Enhancing Low-light Images is very important for further processing such as Sign Recognition, Lane Detection, Surround View Generation and many other problems in the Advanced Driver Assistance Systems. This is also crucial for Consumer Applications such as Digital Cameras and Smart-phone Cameras. The current enhancement algorithms mostly rely on a Space-Invariant approach where the Contrast Enhancement is done on the entire image. Hence we propose a Space-Variant approach that can restore the entire image in the low-light context.

JTu4A.38
Lifting Wavelet Transform based Ultrasound Image Fusion scheme, Jayant Bhardwaj[1]; [1]*Bhagwan Parshuram Inst of Tech, India.* A Wavelet transform(WT) called Lifting has been implemented for fusion of two ultrasound images. It is observed that this scheme has better performance over conventional scheme of Discrete Wavelet Transform (DWT).

JTu4A.39
Withdrawn

JTu4A.40
Defocused Image Formation Model for Plenoptic Imaging, Yanqin Chen[1], Xin Jin[1], Qionghai Dai[2]; [1]*Graduate School at Shenzhen, Tsinghua Univ., China;* [2]*Tsinghua Univ., China.* This paper proposes to extend the PSF matrix of plenoptic imaging systems at focused depth to desirable defocused depth by multiplying a defocus approximation matrix. This extension is beneficial for saving time and hardware memory.

JTu4A.41
Withdrawn

JTu4A.42
Towards Perception-Inspired Numerical Measures of Compression Error in Digital Holograms of Natural Three-Dimensional Scenes, Taina M. Lehtimaki[1], Ronan G. Reilly[1], Thomas J. Naughton[1]; [1]*Maynooth Univ., Ireland.* We report on a visual perception study to measure differences between numerical error in reconstructions from digital holograms of real-world objects that have undergone lossy compression, and the loss in quality perceived by human observers.

NOTES

Tuesday, 26 June

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon/Lime
Applied Industrial Optics	Joint Imaging Systems and Applications/ Adaptive Optics: Methods, Analysis and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Computational Optical Sensing and Imaging	Joint

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:30
ATu5A • Bridging Two Worlds - Academics and Industry
Presider: Gary Miller; NRL, USA

ATu5A.1 • 16:30 Invited

Definition of Boundary Conditions and Variables to Cross Borders, Dominik Rabus, *RABUS TECH, Germany.* Innovation today relies on the merger of technologies. I am convinced that novel break-through ideas can only be materialized using cross discipline thinking, understanding, in-depth knowledge, and expertise. Crossing borders from industry to academia or vice versa opens new paths, mind sets and thought processes which are vital for successful innovations.

Panel • 17:00

This panel discussion will explore the challenges and advantages of working concurrently in both academia and industry. While employment in each sector has its own merits, having access to both ecosystems can potentially have a greater impact on the success of a company. Here, we'll look at the issues surrounding this duality from panelists who currently have a foot in both worlds.

Panel

Dominik Rabus, *Rabus.Tech, Germany*

Cather Simpson, *The Photon Factory, University of Auckland, New Zealand*

Adam Wax, *Lumedica, USA*

16:30–18:30
JTu5B • Microscopy & Imaging (IS/AO)
Presider: John Girkin; University of Durham, UK

JTu5B.1 • 16:30 Invited

Wavefront Sensorless Aberration Correction with Multi Actuator Adaptive Lens in Microscopy and Retinal Imaging, Stefano Bonora[1]; [1]*CNR-INFM, Italy.* Multi actuator adaptive lenses can replace deformable mirrors in the correction of time variant aberrations. We will show the results obtained on medium size telescopes and to improve the stability of complex laser systems.

JTu5B.2 • 17:00

Intravital multi-photon imaging through intact highly scattering bone using binary wavefront optimization, Kayvan Forouhesh Tehrani[1], Peter Kner[1], Luke J. Mortensen[1]; [1]*Univ. of Georgia, USA.* Diffraction limited imaging of structures in a highly scattering heterogeneous tissue like bone is a non-trivial task. Here we show binary wavefront optimization using a genetic algorithm, for 2-photon imaging of bone endogenous cells.

16:30–18:30
LTu5C • Atmospheric & Environmental Monitoring II
Presider: Dennis Killinger; Univ. of South Florida, USA

LTu5C.1 • 16:30 Invited

Development of Highly Sensitive Quantitative Measurements of Nascent Soot Particles in Flames by Coupling Cavity-ring-down Extinction and Laser Induced Incandescence for Improving the Understanding of Soot Nucleation Process, Pascale Desgroux[1], Christopher Betrancourt[1], Xavier Mercier[1]; [1]*PC2A- Univ. of Lille - CNRS, France.* The presentation focuses on the recent advances obtained in quantitatively detecting soot nanoparticles of size 2-4 nm using Laser-induced incandescence. These particles are involved in the soot nucleation process in sooting flames.

LTu5C.2 • 17:00

Compact and Lightweight Laser Diagnostic System for Portable Emission Measurements of Passenger Cars, Luigi Biondo[1,2], Niels Göran Blume[1,2], Lisa Engel[1,2], Butrint Zumeri[1,2], Christian Kalski[3], Benjamin Dixel[3], Steven Wagner[1,2]; [1]*High Temperature Process Diagnostics, Germany;* [2]*Dept. of Reactive Flows and Diagnostics, Germany;* [3]*Automotive - Technologie- und Umweltzentrum (TUZ), TÜV Hessen, Germany.* A mobile exhaust gas measuring TDLAS-system was tested on public roads. It is capable of in-situ detection of CO_2 and H_2O, using multi-pass cells at the tailpipe end, while electronic is located inside the car.

16:30–18:30
CTu5D • Compressive Sensing 2: Spectral Imaging
Presider: Paulo Silveira; CDM Optics Inc, USA

CTu5D.1 • 16:30

Covariance Matrix Estimation from Multiple Subsets in Compressive Spectral Imaging, Elkin D. Díaz Plata[1], Jonathan Arley Monsalve Salazar[1], Andres Guerrero[1], Henry Arguello[1]; [1]*Universidad Industrial de Santander, Colombia.* This paper introduces an optimization problem to estimate the covariance matrix from multiple subsets of compressive measurements using random projection matrices. The proposed optimization is tested with computational simulations for the DD-CASSI and SSCSI optical architectures.

CTu5D.2 • 16:45

Compressive Spectral Polarization Imaging Using a Single Pixel Detector, Jorge L. Bacca[1], Andres Guerrero[1], Daniel Molina[1], Ariolfo Camacho[1], Henry Arguello[1]; [1]*Universidad Industrial de Santander, Colombia.* This paper introduces the compression of spectral polarization images using a single pixel architecture. The proposed technique allows to obtain several compressive 2-D projections with spatial, spectral and polarization coding.

CTu5D.3 • 17:00

Subsampling Schemes for the 2D Nuclear Magnetic Resonance Spectroscopy, Samuel E. Pinilla[1], Kareth León[1], Daniel Molina[1], Ariolfo Camacho[1], Henry Arguello[1]; [1]*Universidad Industrial de Santander, Colombia.* This work analyses several subsampling schemes to recover the two-dimensional nuclear magnetic resonance (2D NMR) spectrum. To validate the performance of each scheme, subsampling rates are varied and applied to different 2D NMR techniques: HMBC, HSQC, JRES, COSY, and TOCSY. Simulation results show that the optimal empirical subsampling rate is 35%.

16:30–18:30
JTu5E • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman II
Presider: Edmund Lam; Univ. of Hong Kong, Hong Kong

JTu5E.1 • 16:30 Invited

Teaching Fourier Optics: What I do Differently after 50 Years, William T. Rhodes[1]; [1]*Florida Atlantic Univ., USA.* My teaching of Fourier optics has evolved since I first took Joe Goodman's course 50 years ago. I will speak briefly on various aspects of the subject that I have added or now treat differently in my own teaching.

JTu5E.2 • 17:00 Invited

ABCD Matrix Analysis for Fourier-Optics Imaging, James R. Fienup[1]; [1]*Univ. of Rochester, USA.* Fourier optics analysis of a general ABCD paraxial optical imaging system is given, including the effects of an aperture stop inside the system.

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free Space Communication

Tangerine

Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:30
DTu5F • Computer-Generated Holograms
Presider: Michal Makowski, Poland

DTu5F.1 • 16:30 Invited
Volumetric display with holographic femtosecond laser accesses, Yoshio Hayasaki[1], Kota Kumagai[1]; [1]*Utsunomiya Univ., Japan.* Volumetric displays with holographic two- and multi-photon excitations using a computer-generated hologram displayed on a liquid crystal spatial light modulator were demonstrated.

DTu5F.2 • 17:00
Calculation of Horizontal-Parallax-Only Holograms Using One-Dimensional Zone-Plates, Yoshitaka Takekawa[1], Yasuhiro Takaki[1]; [1]*Tokyo Univ of Agri and Tech, Japan.* The calculation of horizontal-parallax-only holograms using two-line zone-plates is proposed. The proposed technique enables the efficient elimination of the conjugate image and the zero-order diffraction light using hologram reconstruction systems with the single-sideband filter.

16:30–18:30
3Tu5G • 360-degree Display and Perception
Presider: Yasuhiro Takaki; Tokyo Univ of Agriculture and Technology, Japan

3Tu5G.1 • 16:30 Invited
The retinal input during fixation: Binocular head/eye coordination at the fine scale, Martina Poletti[1]; [1]*Neuroscience, Univ. of Rochester, USA.* In the periods between voluntary gaze shifts, the eyes continually drift following erratic trajectories. We report that these movements compensate for microscopic head movements to yield visual signals with specific characteristics on the retina.

3Tu5G.2 • 17:00 Invited
Optical Properties of Schematic Eye Models, Jim Schwiegerling[1]; [1]*Univ. of Arizona, USA.* Various schematic eye models have been proposed in the optics literature. These models range from first order models to models incorporating aberrations and accommodation. This talk examines the capabilities and limitations of schematic eye models.

16:30–18:30
STu5H • Quantum Protocols II
Presider: Robert Boyd; Univ. of Ottawa, Canada

STu5H.1 • 16:30 Invited
Encoding quantum infomation on the full spatial bandwidth of photons, Mohammad Mirhosseini[1,2], Yiyu Zhou[2], Jiapeng Zhao[2], Seyed Mohammad Hashemi Rafsanjani[3], Alan E. Willner[5,2], Robert W. Boyd[2,4]; [1]*Kavli Nanoscience Inst. and Thomas J. Watson, Sr., Lab of Applied Physics, California Inst. of Technology, USA;* [2]*The Inst. of Optics, Univ. of Rochester, USA;* [3]*Dept. of Physics, Univ. of Miami, USA;* [4]*Dept. of Physics, Univ. of Ottawa, Canada;* [5]*Viterbi School of Engineering, Univ. of Southern California, USA.* Measuring the radial quantum number of single photons paves the way for utilizing the entire transverse structure of light by encoding classical and quantum information in polarization, orbital angular momentum, and the radial degree of freedom.

STu5H.2 • 17:00 Invited
Turbulence-Resistant Free Space Communication Using Vector Beams, Zhimin Shi[1], Brian Kantor[1], Ziyi Zhu[1], Alexander Fyffe[1], Darrick Hay[1]; [1]*Physics, Univ. of South Florida, USA.* We propose a high-dimensional free space communication protocol using vector beams as the information carrier. We show both numerically and experimentally that our protocol is robust against atmospheric turbulence without the need of adaptive optics.

16:30–17:45
PTu5I • Propagation in Scattering Media
Presider: Svetlana Avramov-Zamurovic, US Naval Academy, USA

PTu5I.1 • 16:30 Invited
Measuring Atmospheric Scattering in 3D, Amit Aides[1], Yoav Y. Schechner[1], Vadim Holodovsky[1], Aviad Levis[1], Dietrich Althausen[2]; [1]*Technion Israel Inst. of Technology, Israel;* [2]*Remote Sensing of Atmospheric Processes, Leibniz Inst. for Tropospheric Research, Germany.* To sense the volumetric distribution and microphysics of aerosols and cloud droplets in the 3D atmosphere, we develop passive multi-view scattering tomography. It uses a camera network or spaceborne views, augmented by Lidar.

PTu5I.2 • 17:00
Multilevel Phase Shift Keying using coherently coupled beams with Orbital Angular Momentum, Kaitlyn Morgan[1], Yuan Li[1], Wenzhe Li[1], Keith Miller[1], Joseph Watkins[1], Eric G. Johnson[1]; [1]*Clemson Univ., USA.* This presentation will demonstrate an underwater free space optical link based on the phase modulation of coherently coupled OAM modes. The detection will be performed using passive optics in a correlation receiver optical setup.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon/Lime
Applied Industrial Optics	Joint Imaging Systems and Applications/ Adaptive Optics: Methods, Analysis and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Computational Optical Sensing and Imaging	Joint

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

ATu5A • Bridging Two Worlds - Academics and Industry—Continued

JTu5B • Microscopy & Imaging (IS/AO)—Continued

JTu5B.3 • 17:15
Adaptive Optics for Precise Cell Ablation in vivo, John M. Girkin[1], Charlotte Buckley[2], Mariana Torres-Carvalho[1], Laura Young[1], Sebastien Rider[2], John Mullins[2]; [1]*Univ. of Durham, UK;* [2]*QMRI, Edinburgh Univ., UK.* We have combined adaptive optics and opto-genetics with single plane microscopy to ablate single or groups of cells. Results will be presented demonstrating cellular ablation in the heart and kidney.

JTu5B.4 • 17:30
3D Nanoscopy with Sub-50 nm Resolution Deep Inside Tissue Using Adaptive Optics, Xiang Hao[1], Edward Allgeyer[3], Jacopo Antonello[2], Martin J. Booth[2], Joerg Bewersdorf[1]; [1]*Yale Univ. , USA;* [2]*Univ. of Oxford, UK;* [3]*Univ. of Cambridge, UK.* We have developed a novel adaptive optics strategy to expand the application of isoSTED nanoscopy to thick specimens. Our strategy recovers the aberration-free point-spread function and efficiently suppresses side-lobe contributions.

JTu5B.5 • 17:45
Two-Photon light-sheet microscope with adaptive optics in the illumination and detection path., Reto P. Fiolka[1], Dean Wilding[2]; [1]*UT Southwestern, USA;* [2]*Center for Systems and Control (DCSC), TU Delft, Netherlands.* A light-sheet fluorescence microscope is presented that uses adaptive optics to enable diffraction limited imaging in Zebrafish embryos and tumor spheroids. Using two-photon excitation, a robust and sensorless wavefront optimization scheme is implemented.

LTu5C • Atmospheric & Environmental Monitoring II—Continued

LTu5C.3 • 17:15
QEPAS Trace Gas Analysis of Methane and Water Vapor using an Interband Cascade Laser and an effective FPGA Algorithm, Tobias Milde[1], Morten Hoppe[1,2], Herve Tatenguem[1], Wolfgang Schade[3], Joachim Sacher[1]; [1]*Sacher Lasertechnik GmbH, Germany;* [2]*Technische Hochschule Mittelhessen, Germany;* [3]*Technische Universität Clausthal, Germany.* Newly developed tunable single mode interband cascade laser diodes in the wavelength range around 3.0 µm are combined with the QEPAS technique for trace gas detection of CH4 and H2O.

LTu5C.4 • 17:30
Path-averaged Methane Sensing Using Range-resolving Chirped Laser Dispersion Spectroscopy, Yifeng Chen[1], Andreas Hangauer[2], Gerard Wysocki[1]; [1]*Princeton Univ., USA;* [2]*Siemens AG, Corporate Technology, Germany.* We report a path-averaged remote methane sensing system based on range-resolving chirped laser dispersion spectroscopy with 0.2m accuracy for path-length measurement and 2.7ppm-m/Hz$^{1/2}$ sensitivity for concentration measurement.

LTu5C.5 • 17:45
Multiple-Species DIAL for H_2O, CO_2, and CH_4 remote sensing in the 1.98 – 2.30 µm range, Erwan Cadiou[1,3], Jean-Baptiste Dherbecourt[1], Myriam Raybaut[1], Guillaume Gorju[1], Jean-Michel Melkonian[1], Antoine Godard[1], Jacques Pelon[2]; [1]*ONERA, France;* [2]*LATMOS, France;* [3]*CNES, France.* We report on the experimental demonstration of a direct detection differential absorption LIDAR for CO_2, CH_4, and H_2O concentration measurement. It is based on a high energy parametric source tunable in the 2 µm region.

CTu5D • Compressive Sensing 2: Spectral Imaging—Continued

CTu5D.4 • 17:15
Compressive coded LED and coded aperture spectral video system, Xiao Ma[1], Chen Fu[1], Gonzalo R. Arce[1]; [1]*Univ of Delaware, USA.* A new compressive spectral video system is proposed to obtain a four dimensional (4D) spectral and temporal image signal. Coded aperture and spectral LEDs are introduced to give spatial and spectral modulations. We experimentally verified the 4D reconstruction performance of this proposed imager.

CTu5D.5 • 17:30
Spatial Super-resolution reconstruction via SSCSI Compressive Spectral Imagers, Edgar E. Salazar[1], Alejandro Parada[1], Gonzalo R. Arce[1]; [1]*ECE, Univ. of Delaware, USA.* The spatial super-resolution concept is explored on the Spatial Spectral Compressive Hyperspectral Imager as a function of the coded aperture and detector pitch sizes and the coded aperture positions.

CTu5D.6 • 17:45
Snapshot Compressive Spectral+Depth Imaging with Color-Coded Apertures, Hoover Rueda[1], Daniel L. Lau[2], Gonzalo R. Arce[1]; [1]*Univ. of Delaware, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Kentucky, USA.* We report on the development of an imaging device that employs a color-coded aperture and a time-of-flight sensor to measure spectral+depth information using a single compressive snapshot.

JTu5E • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman II—Continued

JTu5E.3 • 17:30 Invited
Fourier Optics in the Classroom, Masud Mansuripur[1]; [1]*College of Optical Sciences, Univ. of Arizona, USA.* Borrowing methods and formulas from Prof. Goodman's classic *Introduction to Fourier Optics* textbook, I have developed a software package that has been used in both industrial research and classroom teaching. In this presentation, I will show a few optical system simulations that I have used over the past 30 years to convey the power and the beauty of *Fourier Optics* to our students at the Univ. of Arizona's College of Optical Sciences.

Citron	Clementine	Mandarin	Tangerine
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

DTu5F • Computer-Generated Holograms—Continued

DTu5F.3 • 17:15
Occlusion culling techniques for layer-based computer-generated holography algorithms, Athanasia Symeonidou[1,2], Peter Schelkens[1,2]; [1]*Vrije Universiteit Brussel - ETRO/PL9, Belgium;* [2]*imec, Belgium.* Three occlusion processing techniques for computer-generated holography are proposed to support layer-based methods of acquiring holograms from point clouds. The techniques use Gaussian masks and masks generated by dilation per point or per layer.

DTu5F.4 • 17:30
3-D computer-generated hologram with Fourier plane segmentation, Hao Zhang[1], Liangcai Cao[1], Guofan Jin[1]; [1]*Tsinghua Univ., China.* 3-D computer-generated hologram (CGH) is calculated by Fourier plane segmentation with shading and geometric information from multiple parallel projections. The algorithm can reconstruct photorealistic 3-D images with accurate depth information.

DTu5F.5 • 17:45
Dynamic Implementation of Computer-Generated Volume Holograms, Haiyan Wang[1], Rafael Piestun[1]; [1]*Univ. of Colorado Boulder, USA.* We design computer-generated volume holograms and implement on a single spatial light modulator with a folded imaging system. This approach is dynamic, compact, and enhances device performance in terms of diffraction efficiency and multiplexing capacity.

3Tu5G • 360-degree Display and Perception—Continued

3Tu5G.3 • 17:30
Focusing in Depth: Post-Task Accommodation Shifts After Sustained Near Work with Volumetric Multi-Planar Display, Karola Panke[1], Vita Stokmane[1], Tatjana Pladere[1], Aiga Svede[1], Gunta Krumina[1]; [1]*Dept. of Optometry and Vision Science, Faculty of Physics and Mathematics, Univ. of Latvia, Latvia.* Post-task refraction shifts were evaluated with eccentric photorefraction technique to better understand response of visual system and eye accommodation to sustained near work with 3D image formed by volumetric display.

3Tu5G.4 • 17:45
Looking in Depth: Visual Distance Perception of Stimuli on Volumetric Multi-Planar Display, Tatjana Pladere[1], Vita Konosonoka[1], Karola Panke[1], Gunta Krumina[1]; [1]*Univ. of Latvia, Latvia.* Ability to distinguish relative location of visual stimuli on a multi-planar display was evaluated within psychophysical experiment in order to figure out the impact of physical distance between stimuli across depth of volumetric data.

STu5H • Quantum Protocols II—Continued

STu5H.3 • 17:30 Invited
Noise-resistant Entanglement-based Quantum Communication, Mehul Malik[1,2]; [1]*Inst. of Photonic and Quantum Sciences, Heriot-Watt Univ., UK;* [2]*Inst. for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Austria.* Enabled by the natural noise-resilience offered by high-dimensional quantum states of light, we demonstrate the distribution and certification of entanglement under extreme noise conditions corresponding to large amounts of loss or background counts.

PTu5I • Propagation in Scattering Media—Continued

PTu5I.3 • 17:15
Underwater Imaging Using Time-gated Holography and Coherent Multi-frame Processing, Dennis F. Gardner[1], Andrey Kanaev[1], Abbie T. Watnik[1], Christopher Metzler[2], Peter Judd[1], Paul Lebow[1], Kyle Novak[3], James Lindle[1]; [1]*US Naval Research Lab, USA;* [2]*Rice Univ., USA;* [3]*Tekla Research, USA.* We demonstrate an approach to imaging through extended dynamic scattering media that utilizes coherent processing of time-gated holograms. Advantages of the developed system over equivalent gated imager are revealed.

PTu5I.4 • 17:30
Phase Screens of Optical Turbulence Generated by Means of Direct Numerical Simulation of First Principles of Fluid Mechanics, Andreas Muschinski[1], Stephen M. de Bruyn Kops[2]; [1]*NorthWest Research Associates, USA;* [2]*Dept. of Mechanical and Industrial Engineering, Univ. of Massachusetts Amherst, USA.* Split-step Fourier-Fresnel algorithms based on phase screens are powerful tools to computationally simulate optical propagation through atmospheric and oceanic turbulence. Usually, phase screens are generated by means of idealized turbulence models. Here we present and discuss phase screens resulting from direct numerical simulation of the Navier-Stokes equations and the scalar transport equation.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon/Lime
Applied Industrial Optics	Joint Imaging Systems and Applications/ Adaptive Optics: Methods, Analysis and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Computational Optical Sensing and Imaging	Joint

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

ATu5A • Bridging Two Worlds - Academics and Industry—Continued

JTu5B • Microscopy & Imaging (IS/AO)—Continued

JTu5B.6 • 18:00
Modal aberration correction in confocal microscope with CCD camera detection, Pieter Smid[1], Chung See[1], Amanda J. Wright[1]; [1]*Univ. of Nottingham, UK.* We present a confocal microscope with integrated adaptive optics and a CCD camera as a variable pinhole and detector. Aberration correction using a modal routine combined with a ray-tracing pre-correction will be discussed.

JTu5B.7 • 18:15
Matrix approach of optical coherence tomography for in-depth imaging of biological tissues, Victor Barolle[1], Amaury Badon[1], Laura Cobus[1], Kristina Irsch[2], Claude A. Boccara[1], Mathias Fink[1], Alexandre Aubry[1]; [1]*Institut Langevin, France;* [2]*Institut de la Vision, France.* We report on a reflection matrix approach of optical imaging that allows to overcome aberration and multiple scattering issues in microscopy. This allows an in-depth diffraction-limited imaging of biological media over a wide field-of-view.

LTu5C • Atmospheric & Environmental Monitoring II—Continued

LTu5C.6 • 18:00
Standoff Detection of Hazardous Chemicals using a Longwave Infrared Parametric Source, Julie Armougom[1], Jean-Michel Melkonian[1], Myriam Raybaut[1], Jean-Baptiste Dherbecourt[1], Antoine Godard[1], Nicolas Cezard[1], Riaan Coetzee[2], Valdas Pašiškevičius[2], Jirí Kadlčák[3]; [1]*Onera, The French Aerospace Lab, France;* [2]*Dept. of Applied Physics, Royal Inst. of Technology (KTH), Sweden;* [3]*CBRN Protection Division, Military Research Inst. (VVU), Czechia.* We report on a new longwave infrared optical parametric source, and its implementation for long range or medium range standoff detection of gaseous chemical warfare agents.

LTu5C.7 • 18:15
Highly Sensitive H_2S Detection for SF_6 Decomposition Based on Photoacoustic Spectroscopy, Lei Dong[1], Xukun Yin[1], Hongpeng Wu[1], Frank Tittel[2]; [1]*Shanxi Univ., China;* [2]*Rice Univ., USA.* A ppb-level hydrogen sulfide (H_2S) gas sensor for sulfur hexafluoride (SF_6) decomposition analysis was developed using photoacoustic spectroscopy technique and a watt-level excitation laser source. A minimum detection limit of 109 ppb was achieved.

CTu5D • Compressive Sensing 2: Spectral Imaging—Continued

CTu5D.7 • 18:00
Spectral zooming in SSCSI Compressive Spectral Imagers, Edgar E. Salazar[1], Alejandro Parada[1], Gonzalo R. Arce[1]; [1]*Univ. of Delaware, USA.* The dependency of the number of resolvable bands on the coded aperture position s is proved for the SSCSI. This allows a zooming operation over the spectral dimension of the datacube.

CTu5D.8 • 18:15
Compressive Photon-Sieve Spectral Imaging, Oguzhan Fatih Kar[1], Ulas Kamaci[2], Fatih C. Akyon[3], Figen S. Oktem[1]; [1]*Middle East Technical Univ. , Turkey;* [2]*Univ. of Illinois at Urbana-Champaign, Turkey;* [3]*Bilkent Univ., Turkey.* We develop a new compressive spectral imaging modality that utilizes a coded aperture and a photon-sieve for dispersion. The 3D spectral data cube is successfully reconstructed with as little as two shots using sparse recovery.

JTu5E • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman II—Continued

JTu5E.4 • 18:00 Invited
A review of the wonderful discussion of Holography by Professor Goodman in his book: *The Introduction to Fourier Optics*., Raymond Kostuk[1]; [1]*Univ. of Arizona, USA.* In this presentation a summary is given of the different areas of holography that Professor Goodman has so clearly presented in his book: *Introduction to Fourier Optics*. These include the spatial frequency analysis of the Leith-Upatnieks hologram, volume holography, and the detour-phase method of computer generated holography. The presentation concludes with an overview of some recent applications of holography in medical imaging and solar energy conversion processes.

18:30–19:30 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman Reception, *Orange/Lemon/Lime*

19:00–21:00 Illumicon II, *A secret location*

Citron	Clementine	Mandarin	Tangerine
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

DTu5F • Computer-Generated Holograms—Continued

DTu5F.6 • 18:00
Fast Generation of Mesh Based CGH in Head-Mounted Displays using Foveated Rendering Technique, Yeon-Gyeong Ju[1], Jae-Hyeung Park[1]; [1]*Inha Univ., South Korea.* In this paper, we propose a method to generate mesh-based computer-generated-hologram (CGH) rapidly using foveated rendering technique. Mesh-based CGH is one of the CGH techniques which use computer graphical information represented by polygon mesh model. Foveated rendering is a technique used in head-mounted displays (HMDs) to reduce the computational load by reducing the image resolution in peripheral area.

DTu5F.7 • 18:15
Computer generated holograms for single-beam dynamic optical traps, Jose A. Rodrigo[1], Mercedes Angulo[1], Tatiana Alieva[1]; [1]*Complutense Univ. of Madrid, Spain*. We discuss the current advances in the holographic creation of single-beam laser traps allowing programmable optical transport of micro/nano-particles along arbitrary trajectories. The holographic approach and different optical transport experiments are analyzed.

3Tu5G • 360-degree Display and Perception—Continued

3Tu5G.5 • 18:00
Photo-based Multi-perspective Image Rendering for Tabletop Light-field 3-D Displays, Shunsuke Yoshida[1]; [1]*National Inst Information & Comm Tech, Japan.* An image-based method of rendering multi-perspective images for tabletop light-field 3-D displays is proposed. Whereas conventional methods require 3-D polygon models, our method synthesizes them directly from photographs and ordinary computer-generated images.

3Tu5G.6 • 18:15
Design for 360-degree 3D Light-field Camera and Display, Ali O. YONTEM[1], Daping Chu[1]; [1]*Univ. of Cambridge, UK.* A 360-degree 3D light-field acquisition and display system is proposed. Unlike conventional setups, recording and displaying rectangular volumes, proposed configuration captures and displays a cylindrical volume. Application of display stage for head-up displays is discussed.

STu5H • Quantum Protocols II—Continued

STu5H.4 • 18:00 Invited
Machine Learning for Adaptive Quantum Metrology, Barry C. Sanders[1], Pantita Palittapongarnpim[1], Seyed Shakib Vedaie[1]; [1]*Univ. of Calgary, Canada.* We develop a framework for relating adaptive optical quantum-enhanced metrology, quantum control and reinforcement learning together, and we use these connections to use reinforcement learning methods for determining policies that beat the standard quantum limit.

PTu5I • Propagation in Scattering Media—Continued

18:30–19:30 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman Reception, *Orange/Lemon/Lime*

19:00–21:00 Illumicon II, *A secret location*

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging	Computational Optical Sensing and Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:30–18:30 Registration, *Palms Foyer*

Citron

08:00–09:00
JW1A • Plenary Session III

JW1A.1• 08:00 Plenary
Exoplanet Imaging: From Precision Optics to Precision Measurements, Laurent Pueyo, *Space Telescope Science Institute, USA*. During this plenary talk Laurent will present recent observational results in exoplanet imaging and discuss prospects for similar experiments on NASA missions such as the upcoming James Webb Space Telescope and the currently studied The Large UV/Optical/IR Surveyor.

09:00–10:00 Coffee Break with Exhibitors, *Palms Foyer*

10:00–12:00
AW2A • You Down With OCT (Yeah You Know Me)
Presider: Thomas Haslett; Avo Photonics Inc, Canada

AW2A.1 • 10:00 Invited
On-bench validations of tunable lens based multifocal visual simulations, Vyas Akondi[1], Lucie Sawides[2], Yassine Marrakchi[2], Enrique Gambra[2], Xoana Barcala[1,2], Susana Marcos[1], Carlos Dorronsoro[1]; [1]*Consejo Sup Investigaciones Cientificas, Spain;* [2]*2Eyes Vision SL, Spain.* SimVis is a tunable lens based see-through portable binocular visual simulator of multifocal corrections. It is shown using fast focimetry that accurate SimVis multifocal simulations are possible with iterative evaluation of the theoretical SimVis temporal profile and the correction of the dynamic characteristics of the tunable lens.

10:00–12:00
IW2B • Computer Vision & Image Processing
Presider: Kenneth Barnard; US Air Force Research Lab , USA

IW2B.1 • 10:00 Invited
Incoherent Super-resolution Imaging, Jane N. Sprigg[1]; [1]*Tarsier Optics, USA.* I discuss the benefits and limitations of a second-order high resolution incoherent imaging method produced by correlating the intensity fluctuations from the average measured by two spatially separated detectors. This method isolates a well-resolved second-order image from the unresolved first-order or classical image and achieves a resolution improvement of approximately a factor of 4. This means for a given resolution the lens size could be reduced by a factor of 4, which is useful in fields where reducing lens size or weight is important.

10:00–12:00
LW2C • Velocimetry, Films & Fundamentals
Presider: Steven Wagner; Technische Universität Darmstadt, Germany

LW2C.1 • 10:00 Invited
Single-shot vibrational energy distributions of a microscale detonation using hybrid fs/ps CARS, Chloe E. Dedic[1], James Michael[2], Terrence Meyer[3]; [1]*Mechanical and Aerospace Engineering, Univ. of Virginia, USA;* [2]*Dept. of Mechanical Engineering, Iowa State Univ., USA;* [3]*School of Mechanical Engineering, Purdue Univ., USA.* Single-shot O_2 and N_2 vibrational energy distributions behind gaseous detonations are studied using hybrid fs/ps CARS. Differences in measured vibrational temperature and Chapman-Jouguet predictions are discussed using detonation theory and nonequilibrium kinetics.

10:00–11:45
MW2D • Sparsity Based Priors
Presider: Ulugbek Kamilov; Washington Univ. in St. Louis, USA

MW2D.1 • 10:00 Invited
L2-L0 optimization for single molecule localization microscopy, Arne Bechensteen[1], Simone Rebegoldi[3], Gilles Aubert[2], Laure Blanc-Féraud[1]; [1]*Université Côte d'Azur, CNRS, INRIA, Laboratoire I3S, France;* [2]*Université Côte d'Azur, UNS, Laboratoire DIeudonné, France;* [3]*Dipartimento di Matematica e Informatica, Universita degli studi di Ferrara, Italy.* We focus on the problem of minimizing a least-squares loss function under a k-sparse constraint. We investigate the continuous relaxation approach as well as optimization algorithms to apply on Single Molecule Localization Microscopy.

10:00–12:00
CW2E • Computational Microscopy
Presider: Antony Chan; California Institute of Technology, USA

CW2E.1 • 10:00 Invited
Redesigning microscopes for improved image classification, Roarke Horstmeyer[1], Richard Chen[2], Mark Harfouche[3], Alex K. Muthumbi[4]; [1]*Biomedical Engineering, Duke Univ., USA;* [2]*Y Combinator Research, USA;* [3]*California Inst. of Technology, USA;* [4]*Graduate School in Advanced Optical Technologies, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany.* We use convolutional neural networks to optimize the layout of a microscope and improve image classification accuracies by up to 10%. The method is applied with low-resolution, wide field-of-view systems for high throughput.

Citron	Clementine	Mandarin	Tangerine	Lime
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena	Adaptive Optics: Methods, Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:30–18:30 Registration, *Palms Foyer*

Citron

08:00–09:00
JW1A • Plenary Session III

JW1A.1• 08:00 Plenary

Exoplanet Imaging: From Precision Optics to Precision Measurements, Laurent Pueyo, *Space Telescope Science Institute, USA*. During this plenary talk Laurent will present recent observational results in exoplanet imaging and discuss prospects for similar experiments on NASA missions such as the upcoming James Webb Space Telescope and the currently studied The Large UV/Optical/IR Surveyor.

09:00–10:00 Coffee Break with Exhibitors, *Palms Foyer*

10:00–12:00
DW2F • Deep Learning in DH
Presider: Laura Waller; University of California Berkeley, USA

DW2F.1 • 10:00 Keynote

Machine Learning Enabled Computational Imaging and Sensing for Point-of-Care Medicine and Global Health, Aydogan Ozcan[1]; [1]*Univ. of California Los Angeles, USA*. We provide an overview of our recent work on the use of machine learning, including e.g., deep neural networks, in advancing computational imaging and sensing systems, targeting various global health and point-of-care medicine related applications.

10:30–12:00
3W2G • Measurement II
Presider: Hong Hua; Univ. of Arizona, USA

3W2G.1• 10:00
Withdrawn

10:00–12:00
SW2H • Quantum Protocols III
Presider: Walter Buell; The Aerospace Corporation, USA and Edward Watson; Univ. of Dayton, USA

SW2H.1 • 10:00 Invited

Ultrafast measurement of energy-time entangled states, Kevin Resch[1]; [1]*Univ. of Waterloo, Canada*. We implement fast optical gating to directly measure the temporal correlations in energy-time entangled photon pairs with sub-picosecond resolution. We apply this technique to ultrafast two-photon interferometry and nonlocal dispersion cancellation.

10:00–12:00
PW2I • Atmospheric Propagation
Presider: Sukanta Basu; Delft University of Technology, Netherlands

PW2I.1 • 10:00 Invited

My Journey from Radar Jamming to Coherence Theory, Joseph W. Goodman[1]; [1]*Stanford Univ., USA*. My graduate research was concerned with radar detection, radar countermeasures, passive locating systems, and countermeasures to passive locating system. After I learned some statistical optics, I realized that predicting the effectiveness of a particular countermeasure to passive locating systems could be accomplished rather easily using the Van Cittert-Zernike theorem. This insight will be explained in this talk.

10:00–12:00
OW2J • Wavefront/Beam Control & Sensing I
Presider: Jie Qiao; Rochester Inst. of Technology , USA

OW2J.1 • 10:00 Invited

X-Ray Bimorph Deformable Mirrors: Capabilities and Perspectives, Luca Peverini[1]; [1]*R&D, Thales SESO S.A.S., France*. The principle and performance of a set of XBDM for hard X-rays are reviewed. The examples presented will includes variable focus mirror systems, KB-systems, multilayer coated and nanofocusing mirror optics with slope errors below 200nrad.

Sunset/Fleming — Applied Industrial Optics

Siesta/Biscayne — Imaging Systems and Applications

Largo/Longboat — Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon — Mathematics in Imaging

Orange/Lemon — Computational Optical Sensing and Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AW2A • You Down With OCT (Yeah You Know Me)—Continued

AW2A.2 • 10:30 Invited

Clinical Sensorless Adaptive Optics OCT and Angiography, Yifan Jian[1]; [1]*Simon Fraser Univ., Canada.* We will present our recent progress on Sensorless AO-OCT (SAO-OCT) system development, and several key technology advances will be discussed in detail. Case reports on patients with various retinal pathologies will be presented.

IW2B • Computer Vision & Image processing—Continued

IW2B.2 • 10:30

Measurement of Modulation Transfer Function using Digital Micromirror Devices, Anton Travinsky[1]; [1]*Rochester Inst. of Technology, USA.* We present and discuss a digital micromirror device-based method for measurement of the modulation transfer function. Advantages of this method include remote performance evaluation, arbitrary re-configurable target, and ability to conduct single-shot measurements.

IW2B.3 • 10:45

Bayer and demosaicking effect for imaging the stress field in digital photoelasticity, Juan C. Briñez de León[1], Hermes A. Fandiño Toro[1,2], Alejandro Restrepo Martínez[1], John W. Branch Bedoya[1]; [1]*Universidad Nacional de Colombia, Colombia;* [2]*Sistemas de información, ITM, Colombia.* Imaging the stress field is a complex process performed, and nowadays simulated, in digital photoelasticity. In these simulations we demonstrate that the Bayer and demosaicking effect must be considered because they introduce different errors.

LW2C • Velocimetry, Films & Fundamentals—Continued

LW2C.2 • 10:30

Performant Multispectral LIF System with Spectral and Temporal Features for CBE Detection, Frank Duschek[1], Lea Fellner[1], Florian Gebert[1], Marian Kraus[1]; [1]*German Aerospace Center, Germany.* The classification of CBE hazards is commonly not best performing if based on laser-induced fluorescence. Improving the technology by recording spectral and temporal fluorescence emission a significant gain of information can be achieved. Machine learning algorithms show a major contribution of temporal fluorescence data to the classification of biological agents.

LW2C.3 • 10:45

Water Film Thickness Imaging Based on Time-Multiplexed Near-Infrared Absorption, Marc Lubnow[1], Thomas Dreier[1], Christof Schulz[1]; [1]*Univ. of Duisburg-Essen IVG, Germany.* We demonstrate the imaging of water film thickness measurements at constant temperature by exploiting absorbance ratios of near-infrared (NIR) radiation at two different wavelengths in the water absorption spectrum around 1400 nm with light delivered by diode lasers and signal registered by a fast framing InGaAs focal plane array camera. Measurements are performed in reflection mode from opaque film support surfaces.

MW2D • Sparsity Based Priors—Continued

MW2D.2 • 10:30

Sparse Phase Retrieval Algorithm via Smoothing Function in Compressive Optical Imaging, Samuel E. Pinilla[1], Jorge Bacca[1], Daniel Molina[1], Ariolfo Camacho[1], Henry Arguello[1]; [1]*Universidad Industrial de Santander, Colombia.* This paper proposes an algorithm to solve the phase retrieval problem in optical imaging in two stages. First, we introduce an initialization to estimate the support of the sparse representation Θ in some sparse basis Ψ of an image x. Second, we solve a smoothing optimization problem to reconstruct x. Simulations show that the proposed algorithm requires less number of measurements compared with existing methods.

MW2D.3 • 10:45

Super-Resolution Phase Retrieval Algorithm using a Smoothing Function, Jorge L. Bacca[1], Samuel E. Pinilla[1], Daniel Molina[1], Ariolfo Camacho[1], Henry Arguello[1]; [1]*Universidad Industrial de Santander, Colombia.* This paper presents a super-resolution phase retrieval algorithm which solves a smoothing optimization problem, allowing to obtain a high resolution signal from low-resolution measurements.

CW2E • Computational Microscopy—Continued

CW2E.2 • 10:30

Field-varying aberration recovery in EUV microscopy using mask roughness, Gautam K. Gunjala[1], Antoine Wojdyla[2], Aamod Shanker[1], Stuart Sherwin[1], Markus Benk[2], Kenneth Goldberg[2], Patrick Naulleau[2], Laura Waller[1]; [1]*Univ. of California, Berkeley, USA;* [2]*Lawrence Berkeley National Lab, USA.* We derive and solve a simplified, self-calibrated inverse problem to characterize the field-dependent aberrations of an EUV synchrotron-based full-field microscope, using images of the surface roughness of an EUV photomask under several angles of illumination. We demonstrate diffraction-limited imaging performance at the center of its field-of-view.

CW2E.3 • 10:45

Computational Cannula Microscopy: Utilizing a Simple Glass Needle for Imaging, Jacqueline Cooke[1], Gunghun Kim[1], Jason Shepherd[3], Naveen Nagarajan[2], Elissa Pastuzyn[3], Kyle R. Jenks[3], Mario Capecchi[2], Rajesh Menon[1]; [1]*Electrical and Computer Engineering, Univ. of Utah, USA;* [2]*Human Genetics, Univ. of Utah, USA;* [3]*Neurobiology and Anatomy, Univ. of Utah, USA.* Existing brain imaging sensors are either limited in their depth, resolution, and/or inflict trauma. To improve on these limitations, we demonstrate fluorescent microscopy through an optical cannula for deep tissue imaging.

Citron	Clementine	Mandarin	Tangerine	Lime
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena	Adaptive Optics: Methods, Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

DW2F • Deep Learning in DH—Continued

DW2F.2 • 10:45
In-line Hologram Reconstruction with Deep Learning, Hao Wang[1,2], Meng Lyu[1,2], Ni Chen[1], Guohai Situ[1]; *[1] Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; [2]Univ. of Chinese Academy of Sciences, China.* Deep neural network (DNN) has been applied in many fields. Here, we use DNN to separate interference terms in in-line hologram and reconstruct the pure phase object. The experiment result verifies our method's feasibility.

3W2G • Measurement II—Continued

3W2G.2 • 10:30
Micro Resolution Time-of-Flight Imaging, Fengqiang Li[1], Florian Willomitzer[1], Prasanna V. Rangarajan[2], Andreas Velten[3], Mohit Gupta[3], Oliver S. Cossairt[1]; *[1]Northwestern Univ., USA; [2]Southern Methodist Univ., USA; [3]Univ. of Wisconsin Madison, USA.* We propose a time-of-flight imaging technique with modulation frequencies as high as 1 THz using optical superheterodyne interferometry. Our proposed system provides great flexibility in imaging range and resolution.

3W2G.3 • 10:45
3D Compressive LIDAR Imaging Using Multiscale-Ordered Hadamard Basis, Vladislav Kravets[1], Adrian Stern[1]; *[1]Electro-Optical Engineering, Ben Gurion Univ. of the Negev, Israel.* We introduce an application of multiscale-ordering of the Hadamard basis for compressive LIDAR acquisition on synthetic 3D images. Improvement in quality of the reconstruction and other advantages over conventional compressed sensing, will be presented.

SW2H • Quantum Protocols III—Continued

SW2H.2 • 10:30 Invited
Quantum-Secured Communication at Gbps Rates, Franco N. Wong[1], Zheshen Zhang[1], Changchen Chen[1], Quntao Zhuang[1], Jane E. Heyes[1], Jeffrey H. Shapiro[1]; *[1]MIT, USA.* We achieve Gbps secret-key rates in 10-dB-loss fiber channel quantum key distribution based on a two-way protocol with multimode encoding, decoding by collective multimode homodyne reception, and coincidence-based channel monitoring to prevent frequency-domain collective attacks.

PW2I • Atmospheric Propagation—Continued

PW2I.2 • 10:30
Monostatic LIDAR in Non-Classic Atmospheric Turbulence, Olga Korotkova[1], Jia Li[1], Gordon Martinez-Piedra[1,2]; *[1]Univ. of Miami, USA; [2]Physics, Eton College, UK.* Results of experiments involving He-Ne laser beam propagation through monostatic channel with retro-reflector, in which non-classic (inhomogeneous, anisotropic) air turbulence is generated in several ways. Enhanced Back-Scatter of intensity statistics is investigated.

PW2I.3 • 10:45 Invited
Improving Atmospheric Turbulence Parameterization using Numerical Weather Prediction and Lidars, Stephen Hammel[1]; *[1]SPAWAR Systems Center Pacific, USA.* The atmosphere from earth's surface up through the boundary layer top provides a challenging optical propagation environment. I discuss a project to predict optical system performance assessment by using numerical weather prediction (NWP) and lidars.

OW2J • Wavefront/Beam Control & Sensing I—Continued

OW2J.2 • 10:30
Developing Bimorph Mirrors into Rapidly Deformable Active Optics for Synchrotron X-ray Beamlines, Simon G. Alcock[1], Ioana Nistea[1], John Sutter[1], Robin L. Owen[1], Daniel Axford[1], Andrew Foster[1], Kawal Sawhney[1], Riccardo Signorato[2]; *[1]Diamond Light Source Ltd, UK; [2]CINEL Strumenti Scientifici s.r.l., Italy.* Recent technical improvements have significantly reduced the response time of deformable piezoelectric bimorph mirrors for synchrotron X-ray beamlines. Major changes to the mirror's curvature are now possible in seconds without loss of necessary nanometer precision.

OW2J.3 • 10:45
Wavefront shaping method to focus light through a mouse skull, Nektarios Koukourakis[1], Moritz Kreysing[2], Jürgen Czarske[1]; *[1]TU Dresden, Germany; [2]Max-Planck Inst. of Molecular Cell Biology and Genetics, Germany.* We focus through 400 μm thick mouse skull using digital optical phase conjugation and discuss the memory effect and approaches to use backscattered light to determine the descrambling phase mask.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging	Computational Optical Sensing and Imaging

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AW2A • You Down With OCT (Yeah You Know Me)—Continued

AW2A.3 • 11:00
OCT-Based Wavefront Shaping: Towards OCT Image Enhancement and Depth-Selective Focusing, Jonas P. Kanngießer[1], Maik Rahlves[1], Bernhard Roth[1]; [1]*Hannoversches Zentrum für Optische Technologien, Gottfried Wilhelm Leibniz Universität Hannover, Germany.* We demonstrate the implementation of wavefront shaping in Optical Coherence Tomography (OCT). This combination opens up new ways for OCT signal enhancement as well as for non-invasive focusing of light inside scattering media.

AW2A.4 • 11:15 Invited
Development of a low cost, portable Optical Coherence Tomography system, Adam Wax[1]; [1]*Lumedica, Inc., USA.* OCT is a widely used biomedical imaging tool, primarily to diagnose and stage retinal diseases. To increase access, we developed a portable, low-cost OCT system with comparable imaging performance to commercially available systems.

DEMO

Adam Wax will present the Lumedica low cost OCT system, demonstrating the product features and capabilities and conduct a few imaging examples.

IW2B • Computer Vision & Image processing—Continued

IW2B.4 • 11:00 Invited
Toward Miniature Computer Vision Sensors, Sanjeev Koppal[1]; [1]*Univ. of Florida, USA.* Biological vision performs amazing visual tasks with negligible power consumption. Despite the fantastic strides in computer vision in recent years, delivering such high-performance and real-time capability, within tiny power budgets, is still a distant dream. This talk is about our work in solving the core problems that will enable computer vision on miniature platforms.

LW2C • Velocimetry, Films & Fundamentals—Continued

LW2C.4 • 11:00 Invited
Development of unseeded Molecular Tagging Velocimetry for high-Reynolds number transonic wind tunnels, Paul M. Danehy[1], Ross Burns[2]; [1]*NASA Langley Research Center, USA;* [2]*National Inst. of Aerospace, USA.* This talk describes a molecular tagging velocimetry technique based on femtosecond lasers which has been developed for cryogenic transonic wind tunnels, which simulate high-Reynolds number aircraft flight in ground-based test facilities.

MW2D • Sparsity Based Priors—Continued

MW2D.4 • 11:00 Invited
l1-Analysis Minimization and Generalized (Co-)Sparsity: When Does Recovery Succeed?, Maximilian März[1], Gitta Kutyniok[1], Martin Genzel[1]; [1]*TU Berlin, Germany.* Frame based regularization methods of inverse problems are particularly effective in their analysis formulation. We will present a novel compressed sensing bound on the sample complexity of the l1-analysis basis pursuit.

CW2E • Computational Microscopy—Continued

CW2E.4 • 11:00
Integral Refractive Index Imaging of Flowing Cell Nuclei, Gili Dardikman[1], Yoav Nygate[1], Itay Barnea[1], Nir turko[1], Gyanendra Singh[1], Barham Javidi[2], Natan T. Shaked[1]; [1]*Dept. of Biomedical Engineering, Tel Aviv Univ., Israel;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Connecticut, USA.* We review our new imaging technique for quantitatively measuring the integral (thickness-average) refractive index of the nuclei of live biological cells during flow, combining quantitative phase microscopy with simultaneous 2-D fluorescence microscopy for nucleus localization.

CW2E.5 • 11:15
Compressive hyperspectral imaging for snapshot multi-channel fluorescence microscopy, Jijun He[1], Jiamin Wu[1], Zhi Lu[1], Qionghai Dai[1]; [1]*Tsinghua Univ., PRC, China, China.* We present a snapshot multi-channel fluorescence microscopy by compressive hyperspectral imaging, especially for the fluorescence with an overlap in spectrum. Our method creates a spatial-spectral coded image, and retrieves the multi-channel data with over-complete dictionary.

Citron	Clementine	Mandarin	Tangerine	Lime
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena	Adaptive Optics: Methods, Analysis and Applications

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DW2F • Deep Learning in DH—Continued

DW2F.3 • 11:00
Classification of Digital Holograms with Deep Learning and Hand-Crafted Features, Tomi Pitkaaho[1], Aki Manninen[2], Thomas J. Naughton[1]; [1]*Maynooth Univ., Ireland;* [2]*Biocenter Oulu, Univ. of Oulu, Finland.* Digital holographic microscopy allows a single-shot label-free imaging of living microscopic objects using a low intensity laser. Using reconstructed quantitative phase as an input to a convolutional neural network, detection of tumorigenic samples is possible.

DW2F.4 • 11:15
3D Optical Diffraction Tomography Using Deep Learning, George Nehmetallah[1], Thanh Nguyen[1], Vy Bui[1]; [1]*Catholic Univ. of America, USA.* We developed a 3D deep convolutional neural network (3D-DCNN) to perform 3D diffraction optical tomography. We experimentally demonstrate the ability of a 3D-DCNN to reconstruct the 3D index of refraction distribution of a phantom dataset.

3W2G • Measurement II—Continued

3W2G.4 • 11:00
Classifying Transverse Motion in Time-of-Flight Range Imaging, Lee Streeter[1], Michael Cree[1]; [1]*Univ. of Waikato, New Zealand.* Classification of step motion in time-of-flight imaging using the stochastic oscillator and autocorrelation is proposed. Machine learning algorithms correctly identify the step location in 65–75% of trials, with apparent good noise robustness.

3W2G.5 • 11:15
Refractive Diffusers for Efficient Time-of-flight Illumination, Tasso R. Sales[1], Donald J. Schertler[1], Amber Betzold[1], Stephen Chakmakjian[1], G. M. Morris[1], Jim Northup[1]; [1]*RPC Photonics Inc, USA.* We discuss the use of Engineered Diffusers™ for efficient illumination of scenes for time of flight and 3D sensing applications. These diffusers can provide controlled, inverse-cosine intensity for uniform illumination at the scene or sensor.

SW2H • Quantum Protocols III—Continued

SW2H.3 • 11:00 Invited
Structured Waves: From Matter to Light, Dmitry A. Pushin[1], Dusan Sarenac[1], Joachim Nsofini[1], Ian Hincks[1], Paulo Miguel[1], Michael G. Huber[2], Benjamin Heacock[3], Muhammad Arif[2], Charles W. Clark[2,4], David G. Cory[1,5]; [1]*Univ. of Waterloo, Canada;* [2]*National Inst. of Standards and Technology, USA;* [3]*North Carolina State Univ., USA;* [4]*Joint Quantum Inst., USA;* [5]*Perimeter Inst. for Theoretical Physics, Canada.* Neutrons are important probes of mater and quantum physics. They are particularly powerful at characterizing magnetic structures. In order to extend the applications of neutron physics as a quantum sensors we have developed methods based on Quantum Information Processing for preparing structured waves of neutrons. I will show how to prepare and characterize neutron beams with specific orbital and spin-orbit structure based on neutron interferometry and will show how we can apply these methods to other type of probes such as light.

PW2I • Atmospheric Propagation—Continued

PW2I.4 • 11:15
Modulation of Optical Turbulence by Atmospheric Aerosols: Influence of Vertical Distribution and Residence Time, Anand N. Sarma[1], Satheesh S K[1], Krishna Moorthy K[1]; [1]*Indian Inst. of Science, India.* We report how atmospheric aerosols modulate optical turbulence by varying the refractive index structure parameter (C_n^2). As the residence time and concentration of aerosols increases, the modulation would transform from weak to strong turbulence regime.

OW2J • Wavefront/Beam Control & Sensing I—Continued

OW2J.4 • 11:00
Scene-based Shack-Hartmann Wavefront Sensor for Light-Sheet Microscopy, Keelan Lawrence[1], Yang Liu[1], Rebecca Ball[2], Ariel VanLeuven[2], James D. Lauderdale[2], Peter Kner[1]; [1]*College of Engineering, Univ. of Georgia, USA;* [2]*Dept. of Cellular Biology, Univ. of Georgia, USA.* Light Sheet Microscopy is well suited for imaging model organisms and tissue sections that are hundreds of microns thick. Adaptive Optics is needed to correct aberrations in these samples. Here we describe our design of a scene based Shack Hartmann Wavefront Sensor for Light Sheet Microscopy.

OW2J.5 • 11:15
Dynamic Adaptive Optical Image Correction for Velocimetry, Lars Buettner[1], Martin Teich[1], Hannes Radner[1], Jürgen Czarske[1]; [1]*Technische Universität Dresden, Germany.* Imaging, correlation-based velocity measurements through time-varying optical distortions are presented for application in microfluidics. Using a deformable membrane mirror and an iterative FPGA-based optimization process, aberrations up to several 100 Hz can be corrected.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon
Applied Industrial Optics	Imaging Systems and Applications	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging	Computational Optical Sensing and Imaging

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AW2A • You Down With OCT (Yeah You Know Me)—Continued

IW2B • Computer Vision & Image processing—Continued

IW2B.5 • 11:30
Illumination Pattern Estimation for Multiple Exposures Extraction in a Snapshot Imaging Technique, Karolina Dorozynska[1], Elias Kristensson[1]; [1]*Lunds Universitet, Sweden.* We present an improvement to the snapshot imaging technique, FRAME, where the phase information is included in the illumination pattern estimation for image extraction. This can potentially improve the image storage capacity and resolution.

IW2B.6 • 11:45
Data-Driven Non-Line-of-Sight Imaging With A Traditional Camera, Matthew Tancik[1], Tristan Swedish[1], Guy Satat[1], Ramesh Raskar[1]; [1]*MIT, USA.* Non-line-of-right (NLOS) imaging has recently been demonstrated using traditional cameras. Here we present a data-driven technique for NLOS imaging. We experimentally analyze the role of scene geometry and clutter on reconstruction quality.

LW2C • Velocimetry, Films & Fundamentals—Continued

LW2C.5 • 11:30
Determination of O_2-O_2 S-branch Raman linewidths using time-resolved picosecond pure rotational coherent anti-Stokes Raman scattering, Christian Meißner[1,2], Jonas Hölzer[1,2], Thomas Seeger[1,2]; [1]*Univ. of Siegen, Germany;* [2]*Center for Sensorsystems (ZESS), Germany.* The evaluation of O_2-O_2 S-branch Raman linewidths for different temperatures at ambient pressure using time-resolved picosecond dual-broadband pure rotational coherent anti-Stokes Raman scattering is presented. S-branch Raman linewidths are compared to corresponding Q-branch literature data.

LW2C.6 • 11:45
Theoretical limits of nonuniform temperature retrievals with single-beam absorption spectroscopy, Nathan Malarich[1], Gregory B. Rieker[1]; [1]*Univ. of Colorado Boulder, USA.* We assess the potential to resolve line-of-sight gas temperature along a single large-frequency-bandwidth laser beam. We describe a regularization method to recover the maximum temperature, a key combustion quantity.

MW2D • Sparsity Based Priors—Continued

MW2D.5 • 11:30
The geometry of convex regularized inverse problems, Pierre Weiss[1]; [1]*Université de Toulouse, CNRS, France.* In this talk, I will present recent results regarding the geometry of solutions of inverse problems regularized by a convex regularizer.

CW2E • Computational Microscopy—Continued

CW2E.6 • 11:30
Cell imaging by phase extraction neural network (PhENN), Shuai Li[1], Ayan Sinha[1], Justin Lee[1], George Barbastathis[1,2]; [1]*MIT, USA;* [2]*Singapore-MIT Alliance for Research and Technology (SMART) Centre, Singapore.* We trained a phase extraction neural network (PhENN) using a spatial light modulator (SLM) and applied it to a wide-field microscope to reconstruct the phase profiles of cell samples.

CW2E.7 • 11:45
Quantitative Phase Maps of Live Cells Classified By Transfer Learning and Generative Adversarial Network (GAN), Moran Rubin[1], Omer Stein[1], Raja Giryes[1], Darina Roitshtain[1], Natan T. Shaked[1]; [1]*Tel Aviv Univ., Israel.* We suggest a new approach for classification of label-free quantitative phase maps of live cells using only a small training set, based on a combination between generative adversarial networks (GANs) and transfer learning.

12:00–13:00 Applications of Visual Science Technical Group Networking Lunch, *Salon C*

12:00–13:30 Lunch on your Own

Citron	Clementine	Mandarin	Tangerine	Lime
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena	Adaptive Optics: Methods, Analysis and Applications

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DW2F • Deep Learning in DH—Continued

DW2F.5 • 11:30
Compressing Macroscopic Near-field Digital Holograms With Wave Atoms, Tobias Birnbaum[1], David Blinder[1], Colas Schretter[1], Peter Schelkens[1]; [1]*Virje Universiteit Brussels - ETRO-IMEC, Belgium.* Pushing digital holography into mainstream markets requires efficient compression algorithms. Using a recent technique based on wave atoms, we explore its compression performance for macroscopic near-field holograms as a function of the Fresnel number.

DW2F.6 • 11:45
A Novel Training Method for Faster R-CNN based Object Detection in Multi-modal Images, Fan Yang[1], Sheng Lu[1], Sidan Du[1], Yang Li[1]; [1]*School of Electronic Science and Engineering, Nanjing Univ., China.* Conventional methods feed multi-modal images indiscriminately into model during training, introducing possible downgrading of performance. A novel stepwise method that trains different parts of multi-modal Faster R-CNN using different sub-datasets is presented, showing satisfactory results.

3W2G • Measurement II—Continued

3W2G.6 • 11:30
Pupil Function Engineered for Improved SLAM Feature Localization, Paulo E. Silveira[1]; [1]*Euclid Consulting, USA.* FAST has become one of the most utilized methods for finding features in image-based SLAM. However, most algorithms assume operation with images captured by conventional imaging systems, ignoring the advantages enabled by engineered pupil functions.

3W2G.7 • 11:45
Monocular SLAM Using Probabilistic Combination of Point and Line Features, Yang Li[1], Bing Yu[1], Chao Ping Chen[1], Nizamuddin Mailto[1], Wen Bo Zhang[1], Lan Tian Mi[1]; [1]*Shanghai Jiao Tong Univ., China.* We propose a monocular SLAM, in which a probabilistic combination of point and line features is adopted. Compared with point-based ORB-SLAMs, our solution is effective in improving both the accuracy and robustness under low-textured scenarios.

SW2H • Quantum Protocols III—Continued

SW2H.4 • 11:30 Invited
Free-Space Quantum Communication Links using Orbital-Angular-Momentum, Alan E. Willner[1]; [1]*Univ. of Southern California, USA.* A photon can carry different values of orbital-angular-momentum (OAM), thereby representing a larger set of possible orthogonal states for quantum communication systems. This paper will describe issues related to such links, including data encoding and turbulence mitigation.

PW2I • Atmospheric Propagation—Continued

PW2I.5 • 11:30 Invited
Coherent Lidar Techniques for Atmospheric Turbulence Measurements and Imaging, Zeb W. Barber[1], Jason Dahl[1], Christopher Blaszczyk[1], Stephen Crouch[2], Jordan Love[2], Brennan Kilty[2], Emil Kadlec[2], Randy Reibel[2]; [1]*Spectrum Lab, Montana State Univ., USA;* [2]*Blackmore Sensors and Analytics, USA.* Coherent lidar techniques by providing direct measurement of optical phase enables advanced techniques for long-range imaging, atmospheric turbulence measurements, and potentially imaging through turbulence without the use of adaptive optics.

OW2J • Wavefront/Beam Control & Sensing I—Continued

OW2J.6 • 11:30
A highly-miniaturized optofluidic refractive adaptive optics system, Kaustubh Banerjee[1], Pouya Rajaeipour[1], Çağlar Ataman[1], Hans Zappe[1]; [1]*Univ. of Freiburg, Germany.* We demonstrate a novel electrostatically actuated optofluidic transmissive phase modulator for an in-line refractive adaptive optics system. The phase modulator has a best-flat of 20 nm and is able to perform corrections of Zernike polynomials up to the 4th radial order.

OW2J.7 • 11:45
Adaptive Optics for 3D Structured Illumination Fluorescence Microscopy, Mantas Zurauskas[1], Ian Dobbie[2], Martin J. Booth[1,3]; [1]*Centre for Neural Circuits and Behaviour, Univ. of Oxford, UK;* [2]*Micron Advanced Bioimaging Facility, Univ. of Oxford, UK;* [3]*Dept. of `engineering Science, Univ. of Oxford, UK.* We present a three-beam interference adaptive 3D SIM fluorescence microscope. Here, wavefront control for aberration correction and remote focusing is enabled by novel hybrid wavefront sensing approach that combines interferometric and image quality driven sensing.

12:00–13:00 Applications of Visual Science Technical Group Networking Lunch, *Salon C*

12:00–13:30 Lunch on your Own

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon
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13:30–15:30
AW3A • Animal Optics: The Facts of Light
Presider: Cushla McGoverin; Univ. of Auckland, New Zealand

AW3A.1 • 13:30
Nanoscale 3D Shape Process Monitoring Using TSOM, Ravikiran Attota[1]; *[1]NIST, USA.* Through-focus scanning optical microscopy (TSOM) is sensitive to three-dimensional shape changes of nanoscale to microscale targets. Here we demonstrate process monitoring method of 3D targets using TSOM down to sub-nanometer.

AW3A.2 • 13:45
Investigation of Optical Signatures for Discriminating Salmon Lice from Other Species of Zooplankton, Josefine H. Nielsen[1,2], Jord C. Prangsma[2], Thomas Kiørboe[3], Mikkel Brydegaard[4,5], Christian Pedersen[1], Peter John Rodrigo[1]; *[1]DTU Fotonik, Technical Univ. of Denmark, Denmark; [2]FaunaPhotonics ApS, Denmark; [3]DTU Aqua, Technical Univ. of Denmark, Denmark; [4]Norsk Elektro Optikk Lund AB, Sweden; [5]Lund Laser Centre, Lund Univ., Sweden.* We present a study of optical signatures of salmon lice and the ability to distinguish them from a reference zooplankton species. This forms the basis for developing an instrument for detecting salmon lice *in situ.*

13:30–15:30
CW3B • Machine Learning in Computational Sensing and Imaging I
Presider: Patrick Llull; Google, Inc., USA

CW3B.1 • 13:30 Invited
A Neuro-Inspired Model for Image Motion Processing, Kaiser Niknam[1], Amir Akbarian[4], Behrad Noudoost[3], Neda Nategh[1,2]; *[1]Electrical and Computer Engineering, Univ. of Utah, USA; [3]Ophthalmology and Visual Sciences, Univ. of Utah, USA.* This study develops a computational framework for robust image analysis in the presence of observer motion, such as a moving camera, based on the brain code of robust motion computations during eye movements.

13:30–15:30
LW3C • Techniques for Reactors, Shock Tubes & Cells
Presider: Wolfgang Meier; German Aerospace Center DLR, Germany

LW3C.1 • 13:30 Invited
Recent developments in time-resolved laser absorption techniques for high-temperature chemical kinetics, Subith S. Vasu[1]; *[1]Univ. of Central Florida, USA.* Current work will focus on using shock tubes and recent absorption-based laser-based diagnostics for acquiring quantitative high-temperature species concentration time-histories and chemical kinetic reaction rates for a variety of applications in energy, propulsion, and explosions.

13:30–15:30
MW3D • Application in 3D Microscopy
Presider: Jun Ke; Beijing Inst. of Technology, China

MW3D.1 • 13:30 Invited
Signal Processing Methods for Cell Localization and Activity Detection from Calcium Imaging Data, Pier L. Dragotti[1]; *[1]EEE, Imperial College London, UK.* Two-photon calcium imaging enables the study of brain activity at single-cell resolution. However, a comprehensive study of activity in even one brain area can produce terabytes of imaging data which presents a considerable signal processing challenge. In this talk, we present a flexible method for the automatic segmentation of regions of interest and for accurate calcium transient detection which leverages from recent developments in sampling theory and signal processing methods.

13:30–15:15
JW3E • Aerospace Imaging (COSI/IS)
Presider: Matthew Arnison; Canon Info. Sys. Research Australia, Australia

JW3E.1 • 13:30 Invited
2017 Eclipse Across America: Through the Eyes of NASA, C Alex Young[1]; *[1]Heliophysics Science Division, NASA Goddard Space Flight Center, USA.* Dr. Young presents NASA supported science to image the Sun's corona and study Earth's atmosphere from the ground, high altitude balloons, aircraft and spacecraft during the August 21, 2017 total solar eclipse.

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free Space Communication

Tangerine

Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

Lime

Adaptive Optics: Methods, Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

13:30–15:30
DW3F • Multi-wavelength Digital Holography
Presider: Pablo Ruiz; Loughborough Univ., UK

DW3F.1 • 13:30 Invited
Multi-Wavelength Digital Holography for Erosion Measurements inside the ITER Tokamak, Giancarlo . Pedrini[1], Igor Alekseenko[1], Wolfgang Osten[1], Govind Jagannathan[2], Mark Kempenaars[3], George Vayakis[4]; [1]*Universität Stuttgart, Germany;* [2]*Port Plugs and Diagnostic, ITER, France;* [3]*ITER, France*. Experimental results of remote shape measurements of objects located at a distance of more than 6 m from the detector with depth accuracies of 10 micrometers are presented. The system is planned for erosion measurements inside the ITER Tokamak reactor.

13:30–15:30
3W3G • Light Field Display
Presider: Bahram Javidi; Univ. of Connecticut, USA

3W3G.1 • 13:30 Invited
3D Hand Gesture Recognition using Integral Imaging, Filiberto Pla[1], Pedro Latorre-Carmona[1], Eva Salvador-Balaguer[1], Bahram . Javidi[2]; [1]*Institue of New Imaging Technologies, Univ. Jaume I, Spain;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Connecticut, USA*. The work here presented uses 3D information provided by Synthetic Aperture Integral Imaging (SAII) with a particular focus on the type of the quality of 3D information recovered some challenging partially occluded conditions.

13:30-14:30
SW3H • Components II
Presider: Edward Watson; Univ. of Dayton, USA

SW3H.1 • 13:30 Invited
Lasers for LIDAR & LIDAR Systems: Recent Developments at Quantel and Keopsys, Spanning Pulsed Laser Diodes, Eyesafe Fiber Lasers and High Average Power DPSS Lasers, Patrick Maine[1], Guillaume Canat[2], Frédéric Chiquet[2], Céline Canal[1], Paul Wazen[1]; [1]*QUANTEL SA, France;* [2]*KEOPSYS, France*. Keopsys and Quantel have joined forces and are a laser designer of choice for many in the LIDAR community, from science to industry to space agencies. We will discuss the latest LIDAR targeted laser developments we have made for Automotive, Wind, 3D survey, Temperature and Pollutant detection.

13:30–15:15
PW3H • Environmental Propagation
Presider: Karin Stein; Fraunhofer IOSB, Germany

PW3H.1 • 13:30 Invited
An Analysis of Near-Surface Turbulence and Aerosol Concentration Coupling during a Solar Eclipse, Steven Fiorino[1], Kevin Keefer[1], Lee Burchett[2], Aaron Archibald[1]; [1]*Air Force Inst. of Technology, USA;* [2]*Booz Allen Hamilton, USA*. Paper links dynamics of near-surface aerosol particles with meteorological observations as well as derived optical turbulence during a solar eclipse while suggesting causes for the unanticipated direct correlation of turbulence fluctuations and aerosol particle counts.

13:30–15:00
OW3J • Wavefront/Beam Control & Sensing II
Presider: Sergio Restaino; US Naval Research Lab, USA

OW3J.1 • 13:30 Invited
Adaptive Optics and Wavefront Metrology for High-Intensity Laser Systems, Christophe Dorrer[1]; [1]*Univ. of Rochester, USA*. Focusing laser beams to a tight high-intensity focal spot requires good wavefront quality. Devices and methods for the characterization and modulation of optical wavefronts in high-intensity laser systems are reviewed.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon
Applied Industrial Optics	Computational Optical Sensing and Imaging	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging	Joint Computational Optical Sensing and Imaging/Imaging Systems and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AW3A • Animal Optics: The Facts of Light—Continued

AW3A.3 • 14:00
Bacterial Species Identification Using SYTO 9, Claire Honney[1], Cushla M. McGoverin[2,1], Scott Choi[3], Yaqub Jonmohamadi[1], Simon Swift[1], Frederique Vanholsbeeck[2,1]; [1]*Univ. of Auckland, New Zealand;* [2]*Dodd-Walls Centre for Photonics and Quantum Technologies, New Zealand;* [3]*Veritide Ltd, New Zealand.* Rapid bacterial species identification is necessary in the food industry and medicine. We have investigated the fluorescence spectra collected from several stained bacterial species for the purpose of identifying species specific signatures.

AW3A.4 • 14:15
Impact of structure of compression plates on medical imaging in a diffuse optical tomography system for breast cancer detection: a simulation study, Hao Yang[1], Hanlin Sun[2], Justin Wong[4], Xianlin Wei[3], Taixiang Shi[3], Huabei Jiang[1]; [1]*Univ. of South Florida, USA;* [2]*Saratoga High School, USA;* [3]*3Hualoha Medical Inc, China;* [4]*The Lawrenceville School, USA.* We present simulation results based on a compression plates based DOT system for breast cancer imaging. Three different structures of compression plate are compared. For the first time, we demonstrate that the parallel-plate provides the best image quality.

CW3B • Machine Learning in Computational Sensing and Imaging I—Continued

CW3B.2 • 14:00 Invited
Optical Sensing and Control Based on Machine Learning, Ryoichi Horisaki[1,2]; [1]*Osaka Univ., Japan;* [2]*JST, PRESTO, Japan.* We have introduced machine learning techniques to optical sensing and control. It enables imaging and focusing through random and/or nonlinear phenomena.

LW3C • Techniques for Reactors, Shock Tubes & Cells—Continued

LW3C.2 • 14:00
Gas phase Raman spectroscopy: comparison of continuous wave and cavity based methods, Lee Weller[1], Maxim Kuvshinov[1], Simone Hochgreb[1]; [1]*Cambridge Univ., UK.* Comparison of cavity-enhanced Raman spectroscopy to continuous wave detection for gas phase molecules in air. We show continuous measurements with calculated emission and discuss the potential benefits (two orders more signal) of using a cavity.

LW3C.3 • 14:15
In situ monitoring of aerosols by Raman spectroscopy – particle polymorphism and gas-phase temperature, Leo Bahr[1,3], Stefan Will[2,3], Andreas S. Braeuer[1]; [1]*Inst. of Thermal Process Engineering, Environmental and Natural Material Processing, Technische Universität Bergakademie Freiberg, Germany;* [2]*Lehrstuhl für Technische Thermodynamik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany;* [3]*Erlangen Graduate School in Advanced Optical Technologies, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany.* Our contribution shows a compact sensor system - based on Raman spectroscopy - that is capable of measuring important properties of particle aerosols, like polymorphic modifications and temperature instantly and *in situ*.

MW3D • Application in 3D Microscopy—Continued

MW3D.2 • 14:00
Three-Dimensional Fluorophore Orientation Imaging with Multiview Polarized Microscopy, Talon Chandler[1], Min Guo[2], Shalin Mehta[3], Abhishek Kumar[2], Hari Shroff[2], Rudolf Oldenbourg[4], Patrick La Riviere[1]; [1]*Univ. of Chicago, USA;* [2]*National Inst.s of Health, USA;* [3]*Chan Zuckerberg Biohub, USA;* [4]*Marine Biological Lab, USA.* We show that polarized fluorescence microscopes make band-limited measurements in the angular frequency domain. We use this result to propose and demonstrate efficient algorithms for reconstructing three-dimensional fluorophore orientations from multiview polarized microscope data.

MW3D.3 • 14:15 Invited
Splitting Based Methods for Structured Illumination Microscopy., Emmanuel Soubies[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland.* Structured Illumination Microscopy (SIM) provides a good trade-off between spatial and temporal resolutions. This makes SIM a method of choice for imaging biological processes. Here, we present a formulation of the SIM inverse problem that allows for the use of proximity operators which admit closed form expressions. It reduces the computational cost of the associated optimization algorithms.

JW3E • Aerospace Imaging (COSI/IS)—Continued

JW3E.2 • 14:00 Invited
Accelerated Product-based Camera Designs for a Feature-rich Mid-resolution Earth Monitoring Mission, Ignacio Zuleta[1]; [1]*planet, USA.* Here we describe a generalized focal plane design for a mid-resolution, high revisit-rate earth observation mission. We discuss the most significant trades offs and choices and challenges of miniaturizing payloads while keeping the performance on par with missions 100X larger - while increasing higher spectral and spatial resolution. Finally, we discuss how a product an imagery product that is both interoperable and novel can be achieved this way.

Citron	Clementine	Mandarin	Tangerine	Lime
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena	Adaptive Optics: Methods, Analysis and Applications

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DW3F • Multi-wavelength Digital Holography—Continued

DW3F.2 • 14:00
Synthetic Wavelength Calculation in Dual-illumination Digital Holographic Contouring Without Knowing Illumination Angle and Tilt Angle, Che I. Ping[1], Wen Xiao[1], Feng Pan[1]; [1]*Key Lab of Precision Opto-mechatronics Technology, School of Instrumentation Science & Optoelectronics Engineering, Beihang Univ., China.* We introduce a novel method to compute the synthetic wavelength in dual-illumination digital holographic contouring by using a calibrated step. Notably, the method requires no knowledge about illumination angle and tilt angle.

DW3F.3 • 14:15
Enhanced Quantitative Imaging of Living Cells and Dissected Tissues Utilizing Multi-Spectral Digital Holographic Microscopy, Björn Kemper[1], Alvaro Barroso[1], Lena Kastl[1], Jürgen Schnekenburger[1], Steffi Ketelhut[1]; [1]*Univ. of Muenster, Germany.* We explored, if coherence properties of partial coherent light sources can be generated synthetically utilizing spectrally tunable lasers. The performance of the method is demonstrated by label-free quantitative phase imaging of living pancreatic tumor cells.

3W3G • Light Field Display—Continued

3W3G.2 • 14:00 Invited
Reconfigurable and dynamically tunable droplet-based compound micro-lenses, Sara Nagelberg[1], Lauren D. Zarzar[2], Kaushikaram Subramanian[3], Vishnu Sresht[4], Daniel Blankschtein[4], George Barbastathis[1], Moritz Kreysing[3], Timothy Swager[5], Mathias Kolle[1]; [1]*Dept. of Mechanical Engineering, MIT, USA;* [2]*Dept. of Materials Science and Engineering and Dept. of Chemistry, The Pennsylvania State Univ., USA;* [3]*Max Planck Inst. of Molecular Cell Biology and Genetics, Germany;* [4]*Dept. of Chemical Engineering, MIT, USA;* [5]*Dept. of Chemistry and Inst. for Soldier Nanotechnologies, MIT, USA.* Liquid compound micro-lenses with dynamically tunable focal lengths, inspired by the architectures found in the retina of nocturnal animals are presented. The lenses are formed from bi-phase emulsion droplets that focus light and form images.

SW3H • Components II—Continued

SW3H.2 • 14:00
Single Frequency Er:YAG Methane/Water Vapor DIAL Source, Patrick M. Burns[1], Moran Chen[1], David Pachowicz[1], Slava Litvinovitch[1], Fran Fitzpatrick[1], Nicholas Sawruk[1]; [1]*Fibertek Inc., USA.* Fibertek is developing Pound Drever Hall PDH injection locked, resonantly pumped Er:YAG laser systems for methane and water vapor differential absorption lidar (DIAL). We have achieved 6mJ at 1645nm and a spectral purity of 99.9%

SW3H.3 • 14:15
High Power (51W), Wide bandwidth (25nm), Highly Efficient 1.5 um-WDM Fiber Laser Transmitter for Space Lasercom, Doruk Engin[1], Mark Storm[1], Andrew Schober[1]; [1]*Fibertek inc, USA.* 51W average power, 7 Channel WDM Fiber Laser Transmitter with 25nm flat gain has been demonstrated for optical space communication applications. Power Amplifier supports >10kW/channel SBS limited peak power and achieves o-o efficiency 44%.

PW3H • Environmental Propagation—Continued

PW3H.2 • 14:00
Validation of Tilt Anisoplanatism Models through Simulation, Szymon Gladysz[1], Grigorii Filimonov[2], Valeriy Kolosov[2]; [1]*Fraunhofer Inst. IOSB, Germany;* [2]*V.E. Zuev Inst. of Atmospheric Optics, Russia.* The concept of differential motion allows in principle for very precise characterization of optical turbulence. The models for motion decorrelation with increasing distance have to be validated before the technique becomes established. This validation is done here with the help of Monte-Carlo simulations.

PW3H.3 • 14:15
Evaluating a Coupled Mesoscale Modeling and Ray Tracing Framework over an Urban Area, Sukanta Basu[1], Santasri R. Bose-Pillai[2], Steven Fiorino[2], Jack E. McCrae[2]; [1]*Delft Univ. of Technology, Netherlands;* [2]*Air Force Inst. of Technology, USA.* A newly developed coupled modeling approach is utilized to simulate optical wave propagation over an urban area. The simulated results are validated against a time-lapse imagery-based unique dataset of refractive index gradient.

OW3J • Wavefront/Beam Control & Sensing II—Continued

OW3J.2 • 14:00
Process-oriented adaptive optics control method in the multi-pass laser amplifiers, Qiao Xue[1]; [1]*Research Center of Laser Fusion, China.* The process-oriented adaptive optics wavefront control method is proposed. The experiments validate that the novel approach can effectively prevent the beam quality from worsening and ensure the successful reality of multi-pass laser amplification.

OW3J.3 • 14:15
High Efficiency Laguerre-Gauss (LG) Spectrum Measurement using Variable Focus Lenses, Mumtaz Sheikh[1,2], Haad Rathore[1], Sohaib A. Rehman[1], Usman Javid[1], Hamza Ahmed[1], Syed A. Reza[1]; [1]*Lahore Univ. of Management Sciences (LUMS), Pakistan;* [2]*Forman Christian College (FCCU), Pakistan.* We present the design and experimental demonstration of a novel LG spectrum measurement technique in which the detection efficiency of all modes in an unknown, incoming superposition state is simultaneously the maximum possible.

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These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AW3A • Animal Optics: The Facts of Light—Continued

AW3A.5 • 14:30
Diffuse optical imaging for breast screening using a dual-direction measuring module of parallel-plate architecture, Jhao-Ming Yu[1], Liang-Yu Chen[1], Min-Cheng Pan[2], Yi-Ling Lin[1], Sheng-Yih Sun[3], Chia-Cheng Chou[3], Min-Chun Pan[1]; [1]*Dept. of Mechanical Engineering, National Central Univ., Taiwan;* [2]*Dept. of Electronic Engineering, Tungnan Univ., Taiwan;* [3]*Tao-Yuan General Hospital, Taiwan.* A working prototype of an optical breast imaging system involving a dual-direction parallel-plate scanning scheme in combination with a mammography machine was demonstrated and applied in imaging healthy and malignant breasts in a clinical environment.

AW3A.6 • 14:45 Invited
Photonics and the Primary Industries, Miriam C. Simpson[1,2]; [1]*The Photon Factory, The Univ. of Auckland, New Zealand;* [2]*Physics & Chemical Sciences, The Univ. of Auckland, New Zealand.*
U. Auckland's Photon Factory applies high-tech lasers to challenges for agriculture: from sperm sorting by sex to "point of cow" diagnostics to mussel bed nutrition. I discuss how advanced photonics underpins primary industries success.

DEMO

Orbis Diagnostics will give dairy farmers the data they need to make decisions about the health, reproductive and nutritional status, and productivity of their herd at a cow-by-cow level. Our "point-of-cow" diagnostics is a new technology that joins centrifugal microfluidics and optical imaging and spectroscopy.

CW3B • Machine Learning in Computational Sensing and Imaging I—Continued

CW3B.3 • 14:30
Deep Learned Phase Mask for Single Image Depth Estimation and 3D scanning, Harel Haim[1], Shay Elmalem[1], Raja Giryes[1], Alex Bronstein[1,2], Emanuel Marom[1]; [1]*Tel-Aviv Univ., Israel;* [2]*Computer Science, Technion, Israel.* Single image depth estimation is achieved using computational imaging and Deep Learning (DL). Imaging with phase-mask is also modeled as a DL-layer, and the mask and DL parameters are jointly designed using labeled data

CW3B.4 • 14:45
Neural Network classification for intensity imaging through multimode optical fibres, Piergiorgio Caramazza[1,2], Daniele Faccio[2], Roderick Murray-Smith[3]; [1]*School of Engineering and Physical Sciences, Heriot-Watt Univ., UK;* [2]*School of Physics & Astronomy, Glasgow Univ., UK;* [3]*School of Computing Science, Glasgow Univ., UK.* A neural network algorithm is employed to successfully classify with intensity-only measurements, gray-scale hand-written digits propagated through a multimode fibre, promising an efficient approach for imaging through fibres.

LW3C • Techniques for Reactors, Shock Tubes & Cells—Continued

LW3C.4 • 14:30
Kinetic Studies of HO_2 Radical in a Photolysis Reactor Using Faraday Rotation Spectroscopy, Chu Teng[1], Chao Yan[1], Aric Rousso[1], Timothy Chen[1], Yiguang Ju[1], Gerard Wysocki[1]; [1]*Princeton Univ., USA.* Using a digitally-balanced detection scheme, we perform Faraday Rotation Spectroscopy at 7.2 µm to measure HO_2 formation in a photolysis reactor. Fuel concentration and gas temperature are also quantified in the same laser spectroscopic setup.

LW3C.5 • 14:45
Simultaneous measurement of methane and acetylene based on IH-QCL absorption sepctroscopy, Guangle Zhang[1], Kuanysh Khabibullin[1], Aamir Farooq[1]; [1]*King Abdullah Univ. of Sci. & Tech., Saudi Arabia.* A novel IH-QCL (integrated heater quantum cascade laser) is used to simultaneously detect methane and acetylene during the high temperature pyrolysis of iso-octane behind the reflected shock waves using scanned-wavelength direct absorption spectroscopy.

MW3D • Application in 3D Microscopy—Continued

MW3D.4 • 14:45
Towards Realistic Superresolution of Incoherent Point Sources, Jaroslav Rehacek[1], Zdenek Hradil[1], Bohumil Stoklasa[1], Martin Paur[1], Andrej Krzic[2], Jai Grover[2], Luis L. Sanchez-Soto[3,4]; [1]*Palacky Univ., Czechia;* [2]*European Space Research Technology Centre, Netherlands;* [3]*Universidad Complutense, Spain;* [4]*Max-Planck-Institut für die Physik des Lichts, Germany.* We establish the multiparameter quantum Cramer-Rao bound for quantum inspired imaging of two incoherent point sources and discuss the optimal detection schemes achieving the ultimate precision predicted by quantum theory thus paving the way for future practical implementations.

JW3E • Aerospace Imaging (COSI/IS)—Continued

JW3E.3 • 14:30 Invited
How to Take a Picture of a Black Hole, Katie Bouman[1,2]; [1]*Massachusetts Inst. of Tec, USA;* [2]*Harvard-Smithsonian Center for Astrophysics, USA.* I discuss techniques we have developed to photograph the Milky Way's evolving black hole using a network of ground-based radio telescopes distributed across the globe.

Wednesday, 27 June

Citron	Clementine	Mandarin	Tangerine	Lime
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena	Adaptive Optics: Methods, Analysis and Applications

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DW3F • Multi-wavelength Digital Holography—Continued

DW3F.4 • 14:30
Multi-wavelength Digital Holography using Acousto-Optics, Wen-Jing Zhou[1], Ting-Chung Poon[1], Partha P. Banerjee[2], Ujitha Abeywickrema[2]; [1]*Dept. of Electrical and Computer Engineering, Virginia Tech, USA;* [2]*Dept. of Electro-Optics and Photonics, Univ. of Dayton, USA.* With an acousto-optic frequency shift of 80 MHz, a synthetic wavelength in the order of meters can be achieved. Accurate surface maps are obtained for a multi-depth object using multi-wavelength digital holography without using phase-unwrapping.

DW3F.5 • 14:45
Angular Multiplexed Volume Holograms for Simultaneous Generation of Airy Beam Shapes, Sunil Vyas[1], Yu-Hsin Chia[1], Yuan Luo[1]; [1]*National Taiwan Univ., Taiwan.* To simultaneously obtain three Airy beam shapes from a single holographic optical element, an angularly multiplexed volume holographic grating (AMVHG) is recorded in PQPMMA photopolymer. The wavelength degeneracy property is utilized for the multi-wavelength reconstruction.

3W3G • Light Field Display—Continued

3W3G.3 • 14:30
Systematic Analysis Method for Multilayer Light Field Display, Mohan Xu[1]; [1]*Univ. of Arizona, USA.* We propose a systematic analysis method for the multilayer light field display by simulating the retinal image of a 3D scene rendered at different depths. The retinal image is calculated by convoluting the reconstructed image at test depth and the accumulated point spread function. We evaluate the retinal image with a slope difference method. Then investigate the trade-offs and guidelines for optimal display design.

3W3G.4 • 14:45
Improvement of image quality by using viewpoint following in multi-layer light field display, Ryo Furukawa[2], Tsukasa Tadano[2], Shinsaku Hiura[2], Hiroshi Kawasaki[1]; [1]*Kyushu Univ., Japan;* [2]*Hiroshima City Univ., Japan.* Image qualities of multi-layer light field display depend on the size of viewpoint area. By dividing the light filed samples into subsets and reproducing the light field for each subset, the image quality is improved.

PW3H • Environmental Propagation—Continued

PW3H.4 • 14:30
Analysis of Joint Impact of Optical Refractivity and Turbulence on Laser Beam and Image Characteristics, Mikhail A. Vorontsov[2,1], Victor A. Kulikov[1], Zhijun Yang[1]; [1]*Univ. of Dayton, USA;* [2]*Optonicus LLC, USA.* The results of numerical analysis demonstrate that an inverse temperature layer (ITL) located in the vicinity of a propagation path could significantly impact the laser beam statistical characteristics and image formation.

PW3H.5 • 14:45
Evidence of Anisotropic Optical Turbulence Over Runway, Melissa K. Beason[1], Joseph Coffaro[1], Christopher Smith[1], Jonathon Spychalsk[1], Frank Sanzone[1], Franklin Titus[1], Bruce Berry[1], Robert Crabbs[1], Larry Andrews[1], Ronald L. Phillips[1]; [1]*Univ. of Central Florida, CREOL, USA.* Scintillation index for a Gaussian beam calculated from data taken over a runway in August 2017 is presented which shows evidence of anisotropic conditions early and late in the day and isotropic conditions during midday.

OW3J • Wavefront/Beam Control & Sensing II—Continued

OW3J.4 • 14:30
High Beam Quality of the Third Harmonic for the SG-II Super Beamlet Using Improved Adaptive Optics Technology, Haidong Zhu[1], Chong Liu[1], Ping Zhu[1]; [1]*SIOM, CAS, CHINA, China.* we especially improved the numerical algorithm of adaptive optics to further correct the low spatial frequency wavefront of 1ω, at 1.053μm, in this paper. The far field of the third harmonic of 3ω has been significantly enhanced from the 27 times to the 12 times diffraction limit for the SG-II Super Beamlet.

OW3J.5 • 14:45
The Exo-Life Finder (ELF) Telescope: Advanced strategies for Extreme Adaptive Optics and cophasing for an extremely large telescope dedicated to extremely high contrast, Maud P. Langlois[1], Jeff Kuhn[2], GIL MORETTO[1], Michel Tallon[1], Eric Thiébaut[3], Andrew Norton[4], Magali Loupias[1], Svetlana Berdyugina(5; [1]*CNRS, France;* [2]*Institut for astronomy, USA;* [3]*Université de Lyon, France;* [4]*Stanford Univ., USA;* [5]*KIS, Germany.* We present new strategies for building a giant telescope dedicated to exoplanetary life signal with large circular segments using extreme adaptive optics correction independently for each of these segments.

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AW3A • Animal Optics: The Facts of Light—Continued

CW3B • Machine Learning in Computational Sensing and Imaging I—Continued

CW3B.5 • 15:00
Phase Unwrapping Using Residual Neural Networks, Gili Dardikman[1], Natan T. Shaked[1]; [1]*Dept. of Biomedical Engineering, Tel Aviv Univ., Israel.* We demonstrate 2-D phase unwrapping of optically thick objects in quantitative phase microscopy, using a deep neural network trained on data consisting of steep spatial gradients.

CW3B.6 • 15:15
Bending-Independent Imaging through Glass-Air Disordered Fiber Based on Deep Learning, Jian Zhao[1], Yangyang Sun[1], Zheyuan Zhu[1], Donghui Zheng[2], Jose Enrique Antonio-Lopez[1], Rodrigo Amezcua Correa[1], Shuo Pang[1], Axel Schülzgen[1]; [1]*CREOL, College of Optics and Photonics, Univ. of Central Florida, USA;* [2]*School of Electronic and Optical Engineering, Nanjing Univ. of Science and Technology, China.* We demonstrate a bending-independent imaging system for the first time by combining deep neural networks (DNNs) and a meter-long silica-air disordered optical fiber. High-quality artifact-free images can be reconstructed from the transported raw images.

LW3C • Techniques for Reactors, Shock Tubes & Cells—Continued

LW3C.6 • 15:00
Strategy for Determining Absolute Concentration Levels of SiO in Low Pressure Gas Phase Synthesis Flames for Silica Nanoparticles, Robin Chrystie[1], Felix Ebertz[1], Thomas Dreier[1], Christof Schulz[1]; [1]*IVG, Universität Duisburg-Essen, Germany.* Silica nanoparticles are conveniently synthesized in gas phase H_2/O_2 premixed flames and a silicon-carrying precursor (e.g., hexamethyldisiloxane, HMDSO). For flame kinetics mechanism validation including particle growth a technique for absolute concentration measurements of the intermediate SiO based on laser-induced fluorescence and Rayleigh scattering is demonstrated.

LW3C.7 • 15:15
Development of Hollow Cathode Cell for Sputtering of Metal Samples from Electrodes, Daisuke Ishikawa[1], Yuta Yamamoto[1], Fumiko Yoshida[1], Yoshihiro Iwata[1], Shuichi Hasegawa[1]; [1]*the Univ. of Tokyo, Japan.* A hollow cathode glow discharge plasma cell has been developed to vaporize samples placed on electrodes. We have shown possibility to apply this system to gases, liquid residues, and solid metals for nuclear engineering waste.

MW3D • Application in 3D Microscopy—Continued

MW3D.5 • 15:00
Mathematical Tools for Regularized Coherence Retrieval, Zhengyun Zhang[1], Chenglong Bao[2], Hui Ji[3], Zuowei Shen[3], George Barbastathis[4,1]; [1]*Singapore-MIT Alliance for Res & Tech Ct, Singapore;* [2]*Yau Mathematical Sciences Center, Tsinghua Univ., China;* [3]*Dept. of Mathematics, National Univ. of Singapore, Singapore;* [4]*Dept. of Mechanical Engineering, MIT, USA.* We have developed a rigorous forward model, appropriate regularizers and a numerical algorithm that comprise a mathematical framework for coherence retrieval a.k.a. phase space tomography, which enables estimating the state of coherence from intensity measurements.

MW3D.6 • 15:15
Turbulent flow in coherent speckle, Aamod Shanker[1], Girish Nivarti[2], Laura Waller[1], Carola-Bibiane Schoenlieb[2]; [1]*Univ. of California Berkeley, USA;* [2]*Univ. of Cambridge, UK.* Concepts of flow in turbulent fluids are extended to the transport of optical energy and optical phase in coherent laser speckle. The momentum and mass transport of the Navier-Stokes equations translate directly to the intensity and phase transport equations in scalar diffraction theory, since light acts like a pure, incompressible, inviscid fluid. The non-linear term in the phase transport equation describes the emergence of cusps and singularities , shown with measurements of propagated speckle intensity from a diffusive surface.

JW3E • Aerospace Imaging (COSI/IS)—Continued

JW3E.4 • 15:00
Snapshot Spectral Imaging Experiment on Tethered Balloon, Jianrong Wu[1], Enrong Li[1], Xia Shen[1], Zhishen Tong[1], Chenyu Hu[1], Zhentao Liu[1], Liu S. Ying[1], Shensheng Han[1]; [1]*Shanghai Inst. of Optics and Fine Mechanics,Chinese Academy of Sciences, China.* Snapshot spectral imaging is conducted with the prototype of spectral camera based on ghost imaging via sparsity constraint (SC-GISC) loaded on the tethered balloon. The distinguishable size is 0.34m@1km. The rRMSE for the reconstructed spectral distribution of the eight color targets is 0.65.

15:30–16:30 Coffee Break with Exhibitors, *Palms Foyer*

Citron	Clementine	Mandarin	Tangerine	Lime
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena	Adaptive Optics: Methods, Analysis and Applications

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DW3F • Multi-wavelength Digital Holography—Continued

DW3F.6 • 15:00
Three-wavelength phase-shifting interferometry with six wavelength-multiplexed holograms, Tatsuki Tahara[1,2], Reo Otani[3], Yasuhiko Arai[1], Yasuhiro Takaki[4]; [1]*Kansai Univ., Japan;* [2]*PRESTO, Japan Science and Technology Agency, Japan;* [3]*SIGMAKOKI CO. LTD., Japan;* [4]*Tokyo Univ. of Agriculture and Technology, Japan.* We propose three-wavelength phase-shifting interferometry with six wavelength-multiplexed images and specific phase shifts. Three object waves are analytically derived. A three-dimensional surface shape is reconstructed with multiwavelength phase unwrapping.

DW3F.7 • 15:15
Direct phase retrieval with single-shot dual-wavelength digital holography, Junwei Min[1], Meiling Zhou[1], Xun Yuan[1], Kai Wen[1], Baoli Yao[1]; [1]*Xi'an Inst Optics & Precision Mech CAS, China.* By using the single-shot recorded in-line dual-wavelength hologram, the quantitative three-dimensional image of the specimen can be retrieved. Skipping the phase-shift makes the proposed method computationally fast and the practicability is demonstrated.

3W3G • Light Field Display—Continued

3W3G.5 • 15:00
Dense Multi-view Autostereoscopic Three-Dimensional Display System Based on Shutter Parallax Barriers with Dynamic Control, Yang Meng[1], Laurence L. Chen[1,2], Zhongyuan Yu[1], Chunyu Zhang[1], Yumin Liu[1]; [1]*Beijing Univ of Posts & Telecom, China;* [2]*4D perception LLC, USA.* An autostereoscopic three-dimensional (3D) system using a two-dimensional display panel and a customized shutter-parallax-barrier screen in front is proposed. The modeling of multiple view zones and system design analysis are described. The simulated results show the high density of viewpoints.

3W3G.6 • 15:15
The Image Processing and Data Analysis of Dense Multi-view Autostereoscopic 3D Display System Based on Dynamic Parallax Barriers, Chunyu Zhang[1], Yang Meng[1], Laurence L. Chen[1,2], Zhongyuan Yu[1], Yumin Liu[1]; [1]*Beijing Univ of Posts & Telecom, China;* [2]*4D perception LLC, USA.* It is important for autostereoscopic 3D display system of dense multi-view based on dynamic parallax barriers that image processing and data analysis. Imaging reconstruction technique based on principle of novel system is proposed. This demands good cooperation between image and dynamic parallax barriers. The pixel structure of imaging reconstruction is optimized within allowable crosstalk limits and brighter luminance. The result shows that image structure plays an important role on the effect of 3D display in the best viewing zone.

PW3H • Environmental Propagation—Continued

PW3H.6 • 15:00
Impact of Strong Refractive Index Gradients on Laser Beam Propagation through Deep Turbulence, Victor A. Kulikov[1], Sukanta Basu[2], Mikhail A. Vorontsov[1,3]; [1]*Univ. of Dayton, USA;* [2]*Faculty of Civil Engineering and Geosciences, Delft Univ. of Technology, Netherlands;* [3]*Optonicus LLC, USA.* Atmospheric modeling shows that strong refractive index gradients can appear in the surface layer during certain periods of the diurnal cycle. These gradients and associated turbulence can significantly impact laser beam propagation.

OW3J • Wavefront/Beam Control & Sensing II—Continued

15:30–16:30 Coffee Break with Exhibitors, *Palms Foyer*

15:30–16:30
JW4A • Poster Session III

JW4A.1
Holographic Display using Volume Holographic Recording Medium, Dae-Youl Park[1], Jae-Hyeung Park[1]; [1]*Inha Univ., South Korea.* We propose a holographic display technique that reproduces complex optical field by combing analog hologram and digital referencing. In the proposed method, large number of basis light are pre-recorded in a volume holographic recording medium and they are optically addressed and reconstructed by using a spatial light modulator.

JW4A.2
Mid-Infrared Laser Heterodyne Radiometry for Ground-based Monitoring of GHGs in the Atmospheric Column, Weidong Chen[1]; [1]*Universite du Littoral, France*. A mid-infrared laser heterodyne radiometer was been developed for ground-based remote measurements of greenhouse gases (GHGs) in the atmospheric column.

JW4A.3
Stain-Free Interferometric Phase Microscopy of Individual Sperm Cells and Machine Learning Analysis, Natan T. Shaked[1], Simcha Mirsky[1], Itay Barnea[1], Mattan Levi[1], Hayit Greenspan[1]; [1]*Tel-Aviv Univ., Israel.* Human sperm cells were imaged using interferometric phase microscopy, features were extracted, and a support vector machine was trained to classify sperm cells by morphology. Precisions of 90% and higher were obtained.

JW4A.5
High-speed Quantitative 3D Blood Flow Imaging by Dual-illumination Holographic Microscopy, Dario Donnarumma[1], Nitin Rawat[1], Alexey Brodoline[1]; [1]*Laboratoire Charles Coulomb, France.* A multidirectional holographic microscopy setup using two illumination beams with a large angle of separation (90 degrees) is proposed to image blood microcirculation in preclinical models. This setup allows an easier manipulation of the sample.

JW4A.6
3D object encryption scheme based on Fresnel diffraction and fractional Fourier transform, Mei-Lan Piao[1], Zi-Xiong Liu[1], Hui-Ying Wu[2], Nam Kim[2]; [1]*Jilin Univ., China;* [2] *Chungbuk National Univiersity, South Korea.* We propose a 3D object encryption scheme based on Fresnel diffraction and fractional Fourier transform with two phase only masks. The numerical simulations show that the method is effective and suitable for encrypting 3D object.

JW4A.7
Holographic Tomography with Spherical Wave Illumination, Julianna Winnik[1], Tomasz Kozacki[1], Bryan M. Hennelly[2,3]; [1]*Inst. of Micromechanics and Photonics, Warsaw Univ. of Technology, Poland;* [2]*Dept. of Electronic Engineering, National Univ. of Ireland, Maynooth, Ireland;* [3]*Dept. of Computer Science, National Univ. of Ireland, Maynooth, Ireland.* The paper investigates the influence of spherical wave illumination on the reconstruction process in holographic tomography. Moreover, it proposes a reconstruction algorithm that accounts for spherical wave illumination. The algorithm is tested using numerical simulations.

JW4A.8
Reconstruction quality improvement of digital holograms using multi-scale global search, Ravi shekhar[2], Gopinathan Unnikrishnan[2], Naveen K. Nishchal[1]; [1]*Indian Inst. of Technology Patna, India;* [2]*Defence Inst. of Advanced Technology, India.* Reconstructed images need quality improvement because of issues related to inaccuracy related to reconstruction distance. A multi-scale global search and fine level curve fitting technique can be seen as an alternative to obtain the best reconstruction.

JW4A.9
Hybrid In-line and Off-axis Digital Holography with Single-shot Dual-wavelength, Dayong Wang[1], Fengpeng Wang[1], Jie Zhao[1], Yunxin Wang[1], Lu Rong[1]; [1]*Beijing Univ. of Technology, China.* The in-line and off-axis digital holograms with different wavelengths are recorded by a color camera with a single shot. The reconstruction is carried using an iterative algorithm. Then higher quality amplitude and phase images can be retrieved, which are verified by experiments.

JW4A.10
High-Resolution Holographic Projection Based on a Coherent Matrix of Spatial Light Modulators, Adam Kowalczyk[1], Izabela Ducin[1], Michal Makowski[1]; [1]*Faculty of Physics, Warsaw Univ. of Technology, Poland.* Experimental results of holographic image projection with the use of a collective matrix of two phase-only SLMs. We have achieved a controlled field interference from both modulators and observed increased resolution in one direction.

JW4A.11
Quality enhancement of Digital Holography by averaging of wavelength-filtered LED, Janghyun Cho[1], Sungbin Jeon[1], Jinsang Lim[1], No-Cheol Park[1]; [1]*Yonsei Univ., South Korea.* By adding bandpass filter with rotation, we propose the quality-enhanced low-coherence digital holography. Without complexity, averaging multiple wavelength-modulated holograms could reduce speckle or systematic noise, which is verified by quantitative analysis.

JW4A.12
Beam Shaping by a Stack of Fizeau Wedges for Metrology, Elena Stoykova[1], Marin Nenchev[2], Margarita Deneva[2], Youngmin Kim[3]; [1]*Inst Optical Materials & Tech to the BAS, Bulgaria;* [2]*Optoelectronics and Laser Eng. Dept., Technical Univ. - Plovdiv Branch, Bulgaria;* [3]*Korea Electronics Technology Inst., South Korea.* Existence of multiple transmission peaks for a single Fizeau wedge limits its application in metrology. We have shown by an angular spectrum method and experiment that a stack of Fizeau wedges has extended spectral range.

JW4A.13
Low-cost/high-yield fabrication of microlens array for light-field imaging, Hyun Myung Kim[1], Min Seok Kim[1], Young Min Song[1]; [1]*Gwangju Inst. of Science and Technol, South Korea.* We present a fabrication method of microlens array with large-area/low-cost. We also produce a hand-crafted light field camera using the customized microlens array and demonstrate a light field imaging feature.

JW4A.14
Monitoring of Gaseous CO_2 in the Headspace of Champagne Glasses by Infrared Laser Spectrometry, Raphael Vallon[1], Anne-Laure Moriaux[1], Bertrand Parvitte[1], Clara Cilindre[1], Gerard Liger-Belair[1], Virginie Zeninari[1]; [1]*Universite de Reims Champagne-Ardenne, France.* We report the development, the validation and the application of an infrared diode laser spectrometer devoted to the monitoring of gaseous carbon dioxide in the headspace of Champagne and sparkling wines glasses.

JW4A.15
Glasses-free stereoscopic imaging based on a distant binocular filter with mutually antiphase liquid crystal layers, Vasily A. Ezhov[1], Peter Ivashkin[1], Alexander Galstian[1]; [1]*Coherent and nonlinear optics, GPI RAS, Russia.* A distant binocular filter with mutually antiphase nematic liquid crystal layers allows to implement glasses-free stereoscopic imaging even at very short (millisecond) durations of images of 3D scene views. Experimental results are presented for selection of optical pulses of view images with both edges of 0.1 ms.

JW4A.16
Spatially Offset Raman Spectroscopy of $NaNO_3$ Under PTFE layer, Xiaohua Zhang[1], Qiushi Liu[1], Yuchen Li[1]; [1]*China Inst. of Atomic Energy, China.* A kind of opaque PTFE container was devised, and the spatially offset Raman spectra of $NaNO_3$ powder contained in it have been measured and analyzed for the first time.

JW4A.17
Green Laser Photoswitchable Azobenzene Polymers for Rewritable Hologram with High Diffraction Efficiency, Jae-Won Ka[1], Inhye Jeon[1], Mijin Choi[1], Aejin Yeon[1], Hak Rin Kim[2]; [1]*KRICT, South Korea;* [2]*School of Electronics Engineering, Kyungpook National Univ., South Korea*. In order to develop a green laser rewritable hologram material, azobenzene monomers and polymers were synthesized and holographic properties such as diffraction efficiency, rewritability were measured. As a result, it has been found that even if repeated recording and rewriting are performed, the recoding medium is maintained in a stable state and we confirmed that G#-5/95, which has an absorption wavelength more suitable for green laser (532 nm), has higher diffraction efficiency than G-5/95

JW4A.18
Imaging of Tear Film Lipids Using Quantum Dots, Maitreyee . Roy[1], Sidra Sarwat[1], Peter O'Mara[1], Mazin Almaimani[1], Richard Tilley[1], Justin Gooding[1], Mark Willcox[1], Fiona Stapleton[1]; [1]*Univ. of New South Wales, Australia.* We report on the development of a novel optical imaging technique for visualizing tear film lipid using scandium doped silicone quantum dots with varying surface chemistries; lipophilic and hydrophilic.

15:30–16:30
JW4A • Poster Session III

JW4A.19
Laser Speckle Noise Suppression using a Rotating Diffuser in Optimal Modified Lateral Shearing Interferometer, Kwang-Beom Seo[1], Ho-Chul Lee[1], Seung-Ho Shin[1]; [1]*Physics, Kangwon National Univ., South Korea.* We propose laser speckle noise suppression using a rotating diffuser in an optimal modified lateral shearing interferometer. We have confirmed that the phase errors caused by the laser speckle noise are reduced in reconstruction.

JW4A.20
Stimulated Raman with Broadband LED Stokes Source for Analysis of Glucose and Hemoglobin, Peter S. Bullen[1], Ioannis Kymissis[1], Adler Perotte[2]; [1]*Columbia Univ., USA;* [2]*Columbia Univ. Medical Center, USA.* We demonstrate stimulated Raman gain using a broadband LED Stokes source in vibrational modes of glucose and hemoglobin. This versatile and cost-effective method increases the signal of Raman modes within the LED spectrum.

JW4A.21
Image Achromatization for Conical Multiplex Hologram, Yih-Shyang. Cheng[1], Fu-Shiuan Guo[1]; [1]*Dept. of Optics and Photonics, National Central Univ., Taiwan.* With a filtering-slit oriented at the achromatic angle, master hologram is recorded as a disk hologram. Retrieved information is then directly recorded on conical holographic film. The regenerated image from final hologram show achromatization.

JW4A.22
Impact on the Fidelity of Hyperspectral Imagery Produced by a Phenoptic Hyperspectral Imaging System, Timothy J. Lindsey[1], R. Barry Johnson[1]; [1]*Alabama A&M Univ., USA.* A simulation of a "perfect" telecentric hyperspectral phenoptic imager has been constructed to determine image fidelity resulting from diffractive spectral contamination and its comparison to imagery produced by a Surface Optics SOC716 VNIR hyperspectral camera.

JW4A.23
Using computer vision methods for the measurement of freeform surfaces with experimental ray tracing, Tobias Binkele[1], David Hilbig[1], Friedrich Fleischmann[1], Thomas Henning[1]; [1]*City Univ. of Applied Sciences Bremen, Germany.* Experimental Ray Tracing has proven its abilities in many different applications. We use this technique and combine it with the high efficient methods of computer vision to create a new measurement technique for specular surfaces.

JW4A.24
Learning-based Single Shot Phase Retrieval for Reflective Digital Holographic Microscopy, Dongheon Yoo[1], Byounghyo Lee[1], Jaebum Cho[1], Byoungho . Lee[1]; [1]*Seoul National Univ., South Korea.* We propose the novel single shot phase retrieval method using machine learning algorithm for reflective digital holographic microscopy. The feasibility of this method is verified through experiments with fingerprint specimens.

JW4A.25
A Simple Fringe Pattern Profilometry Phase-shift Error Quantification Method, Lin Wang[3,1], Hongbo Zhang[2], Yu Xin[3]; [1]*Virginia Polytechnic Inst. and State Univ., USA;* [2]*Virginia Military Inst., USA;* [3]*Nanjing Univ. of Science and Technology, China.* We propose a method to acquire the real value of phase-shift from the capture images in fringe pattern profilometry, it helps to improve the quality of 3D shape reconstruction.

JW4A.26
A Conversion Method of 2D Image into 3D Holographic Projection, Lin Hu[1], Yunxiu Shui[1], Gang Zhu[1], Yan Yang[1]; [1]*Chongqing Univ. of technology, China.* In order to realize the holographic display by a 2D image and to suppress speckle noise of reconstructed images, Fresnel kinoform is calculated by adding the phase information, which is obtained based on the gray curve of a 2D image by computing a polynomial equation into initial phase factor of a complex object. A vivid holographic reconstructed projection image with real phase information can be observed with naked eye.

JW4A.27
Study of heterogeneous dynamics by Holographic Time Resolved Correlation (HTRC), Michel Gross[1], Adrian M. Philippe[1], Luca Cipelletti[1], Anne C. Genix[1]; [1]*Laboratoire Charles Coulomb UMR5221 CNRS - Université Montpellier, France.* HTRC is a new ligth scattering technique that measures by holography the field amplitude scattered by a sample, and analyze its spatial correlations. HTRC outperforms other light scattering techniques like DLS, DWS and TRC.

JW4A.28
Digital Holography Reconstruction for 3D Muller-Matrix Imaging of Phase-Inhomogeneous Objects, Igor Panko[1]; [1]*Chernivtsi National Univ., Ukraine.* A new principle for recording information about the structure of optically inhomogeneous layers is proposed. Principles of variations in the state of polarization of illuminating laser radiation using a reference wave are used. The digital holographic algorithm for obtaining three-dimensional Muller-matrix images of phase-inhomogeneous layers is presented. The azimuthally invariant parameters that characterize the layered anisotropy of biological layers are found.

JW4A.29
Measurement of microfluidic refractive index by digital holographic microscopy, Chan Sun[1], Yutong Cui[1], Zhe Wang[1], Zhuqing Jiang[1]; [1]*College of Applied Sciences, Beijing Univ. of Technology, China.* A measurement of microfluidic refractive index is presented by digital holography. Salt solutions of different concentrations are each injected within microfluidic chip, and their refractive indexes are obtained according to the digital holographic phase imaging.

JW4A.30
Evaluation of Shape Influence on Spheroidal Particle Size Characterization by Light Extinction Method, Yi Zhou[1], Jun Chen[1], Huinan Yang[1], Tan Li[1], Mingxu Su[1]; [1]*USST, China.* By combining extinction spectrum prediction based on the generalized Mie theory with regularization inversion algorithm, the effect of particle shape on particle size characterization in multi-wavelength light extinction method is evaluated numerically and then concluded.

JW4A.31
Obtain point spread function of scattering medium via spatial correlation, Huizu Lin[1], Quan Li[1], WeiTao Liu[1]; [1]*Natl Univ Def Tech , China.* We propose to measure intensity transmission matrices of diffusers then point-spread-function (PSF) of scattering medium via spatial correlation with incoherent light. Possible applications in imaging are also discussed.

JW4A.32
Applying Analytical Solution of Diffusion Equation to Verify Diffuse Optical Imaging System, Liang-Yu Chen[1], Ya-Ting Liang[1], Jhao-Ming Yu[1], Min-Cheng Pan[2], Min-Chun Pan[1]; [1]*Dept. of Mechanical Engineering, National Central Univ., Taiwan;* [2]*Dept. of Electronic Engineering, Tung-Nan Univ., Taiwan.* We applied analytical solution of diffusion equation to verify diffuse optical imaging system by comparing the solution and measurement data. A high scattering Lipovenoes phantom was designated to verify our circular scanning imaging system.

JW4A.33
Chromatic aberration analysis in holographic image combiner for Bragg mismatch condition, Seokil Moon[1], Dukho Lee[1], Byoungho . Lee[1]; [1]*Seoul National Univ., South Korea.* Eye box enlargement in augmented reality (AR) head mounted display (HMD) system is a crucial issue. Expansion of the eye-box formed from the holographic image combiner can be achieved by exploiting Bragg mismatch condition in holographic optical elements (HOEs). In this paper, analysis of chromatic aberration in holographic image combiner is carried out with experimental set up and results when Bragg condition is not satisfied.

JW4A.34
Enhancing the Edge Detection by Gradient-Plus-Canny Filters, Miguel Mora-González[1], Ricardo Sevilla-Escoboza[1]; [1]*Universidad de Guadalajara, Mexico.* In this work the development of a hybrid edge detector for the application of fill regions, based in the compass gradient convolution mask and the Canny operator, is presented. The results obtained were an edge detector with higher resolution, more sections detected and a larger filling area in the image. The method was compared with traditional edge detectors obtaining favorable results.

JW4A.35
Fluence calculation using portal images, Rakesh Manjappa[1], Vyankatesh Shejal[3], Rajesh Kumar[2], Rajan Kanhirodan[1]; [1]*Indian Inst. of Science, India;* [2]*RPAD, BARC, India;* [3]*Radiotherapy, Manipal Hospital, India.* Radiotherapy treatment has seen major improvements in plan quality since advent of intensity modulation(IMRT). Fluence computation is crucial for dose verification. In this study, we calculate fluence from EPID measurements and compare it with Treatment planning system (TPS).

15:30–16:30
JW4A • Poster Session III

JW4A.36
High Accuracy 3D face reconstruction from single 2D image, Tao Yang[1,2]; [1]*Xi'an Jiaotong Univ., China;* [2]*Media Lab, MIT, USA.* This paper proposes a high accuracy 3D face model reconstruction method which is based on machine learning algorithm. The framework contains a features auto-encoder and a Generative-Adversarial Network. We use more than 20,000 high quality 3D face medal to train this network.

JW4A.37
Implementation of a graphical interface for an adaptive optics system Implementation of a graphical interface for an adaptive optics system, Marco A. Betanzos-Torres[1,2], Eva O. Barrera Martinez[2], Juan Castillo Mixcoatl[1]; [1]*Benemérita Univ Autonoma de Puebla, Mexico;* [2]*Sistemas Automotrices, Universidad Tecnologica de Puebla, Mexico.* In this work, a graphical interface is presented, which allows to understand and interpret the principle of an adaptive optics system, when you want to dabble into this area of research for the first time.

JW4A.38
Dither-Enhanced Lidar, Joshua Rapp[1,2], Robin M. Dawson[2], Vivek K. Goyal[1]; [1]*Boston Univ., USA;* [2]*Draper, USA.* We present the design of a subtractively-dithered time-correlated single photon counting ranging system, resulting in improved depth resolution.

NOTES

Wednesday, 27 June

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Computational Optical Sensing and Imaging

Largo/Longboat

Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:30
AW5A • Orlando: The New Silicon Valley?
Presider: Arlene Smith; Avo Photonics, USA

AW5A.1 • 16:30
UCF Business Incubation Program - The First Twenty Years, Gordon Hogan, *Director, UCF Business Incubation Program, USA.* Abstract not provided.

Panel • 17:00
While Silicon Valley is widely thought of as the heart of technical entrepreneurship, in recent years Orlando has gained prominence as a new hub of innovation. Is Central Florida the new home for Photonics start-ups?

Panel

Alexandre Fong, *Hyperspectral Imaging, HinaLea Imaging, USA*

Gordon Hogan, *UCF Business Incubation Program, USA*

16:30–18:30
CW5B • Machine Learning in Computational Sensing and Imaging II
Presider: Aydogan Ozcan; University of California Los Angeles, USA

CW5B.1 • 16:30 Invited
Deep Learning for Imaging System Design, Vidya Ganapati[1]; [1]*Engineering, Swarthmore College, USA.* This work uses deep learning for end-to-end design of imaging systems, in order to obtain fast imaging, high resolution, and large field-of-view at the same time. We present examples related to fluorescence localization microscopy and Fourier ptychography.

CW5B.2 • 17:00 Invited
Fourier ptychographic imaging and a machine learning approach, Guoan Zheng[1], Shaowei Jiang[1], Kaikai Guo[1]; [1]*Univ. of Connecticut, USA.* We will introduce the principle of the Fourier ptychography approach. We will also discuss the recent developments and a machine learning approach for Fourier ptychography.

16:30–18:30
LW5C • Ultra-fast Techniques & High-speed Imaging II
Presider: Thomas Seeger; Universität Siegen, Germany

LW5C.1 • 16:30 Invited
Development of Robust Ultrafast CARS Thermometry and Species Detection, Alexis Bohlin[1]; [1]*Delft Univ. of Technology, Netherlands.* We develop simultaneous spatially-correlated high-repetition-rate gas-phase thermometry, as a unique tool to investigate the stability of distributed auto-ignition combustion modes with reduced emissions of NOx, particulates, CO and unburned hydrocarbons in a prototype jet-engine combustor.

LW5C.2 • 17:00
Investigation of Femtosecond Two-Photon LIF of CO at Elevated Pressures, Yejun Wang[1], Waruna Kulatilaka[1]; [1]*Texas A&M Univ., USA.* Recent advances of femtosecond two-photon LIF (fs-TPLIF) for CO imaging is explored for high-pressure applications. The overall signal levels, laser pulse energy, and quenching dependencies are studied at elevated pressures up to 10 bars.

LW5C.3 • 17:15
Two- and Three-Photon LIF Detection of Atomic Hydrogen Using Femtosecond Laser Pulses, Ayush Jain[1], Waruna Kulatilaka[1]; [1]*Texas A&M Univ., USA.* Two- and three-photon, femtosecond-duration laser-induced fluorescence (fs-LIF) schemes of atomic hydrogen are investigated. Measured LIF profiles in premixed, methane-air flames are comparable amid different levels of stimulated emission and photoionization effects.

16:30–18:30
MW5D • Model-based Imaging
Presider: Lei Tian; Boston Univ., USA

MW5D.1 • 16:30 Invited
Title to be Determined, Charles A. Bouman[1]; [1]*Purdue Univ., USA.* Abstract not available.

MW5D.2 • 17:00
Direct inversion of intensity diffraction tomography with a computational microscope, Waleed Tahir[1], Ling Ruilong[1], Lei Tian[1]; [1]*Boston Univ., USA.* Intensity diffraction tomography (IDT) enables 3D phase recovery from intensity-only measurements. We present a novel IDT technique that enables motion-free, 3D phase and absorption reconstruction using a computationally efficient algorithm.

MW5D.3 • 17:15
Nonconvex Optimization for Diffractive Imaging, Yanting Ma[2], Hassan Mansour[3], Dehong Liu[3], Petros Boufounos[3], Ulugbek S. Kamilov[1]; [1]*Washington Univ. in St. Louis, USA;* [2]*North Carolina State Univ., USA;* [3]*Mitsubishi Electric Research Labs, USA.* Image reconstruction under multiple scattering of light is often formulated as a nonconvex optimization problem. We describe a new optimization method for image reconstruction under multiple scattering based on a new convergent variant of the popular fast iterative shrinkage/thresholding algorithm (FISTA). The proposed method is suitable for sparsity-driven diffraction tomography where multiple scattering cannot be neglected.

Orange/Lemon

Joint Computational Optical Sensing and Imaging/Imaging Systems and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:30
JW5E • Spectral Imaging (COSI/IS)
Presider: Casey Streuber; Raytheon Missile Systems, USA

JW5E.1 • 16:30 Invited
A Multispectral Light Field Camera for 3D Imaging from a Single Lens, Antonio Robles-Kelly[1], Ran Wei[1], Shaodi You[1]; [1]*Data61-CSIRO, Australia.* We present a multispectral light field camera configuration which benefits from the spatial resolution of focused plenoptic cameras while exhibiting low angular bias. This delivers a small form-factor 3D chemical imaging platform with ample applications.

JW5E.2 • 17:00
Toward Real-time Terahertz Imaging with Spectral Encoding of the k-space, Hichem Guerboukha[1], Kathirvel Nallappan[1], Maksim Skorobogatiy[1]; [1]*Ecole Polytechnique de Montreal, Canada.* Acquisition time is a major hurdle in terahertz imaging. To reduce the number of pixels, we use spectral encoding in a single-pixel detection scheme. We demonstrate the reconstruction process for amplitude and phase masks.

JW5E.3 • 17:15
Hyperspectral ghost imaging camera based on a flat-field grating, Liu S. Ying[1,2]; [1]*Shanghai Inst of Optics and Fine Mech, China;* [2]*Univ. of Chinese Academy of Sciences, China.* We propose a hyperspectral ghost imaging camera based on a flat-field grating, which can improve spectral resolution of spectral camera and provide a possibility of optimizing measurement matrix according to light fields with different wavelengths.

Citron

Digital Holography & 3-D Imaging

16:30–18:15
DW5F • OptoFluidic and Life Applications of DH
Presider: Giancarlo Pedrini; Universität Stuttgart, Germany

DW5F.1 • 16:30 Invited
Compact Solutions for Off-axis Holography in Optofluidics, Biagio Mandracchia[1], Vittorio Bianco[1], Melania Paturzo[1], Pietro Ferraro[1]; [1]*Inst. of Applied Sciences and Intell, Italy.* The state-of-the-art fabrication of micro-optics gives the opportunity to embed complex optical devices in small spaces. Here we show a compact interferometer on a commercial plastic chip for off-axis Digital Holography microscopy.

DW5F.2 • 17:00 Invited
Digital holographic microscopy as means of remote life detection, Gene . Serabyn[1], Kurt Liewer[1], Kent Wallace[1], Chris Lindensmith[1], Jay Nadeau[2]; [1]*Jet Propulsion Lab, USA;* [2]*Portland State Univ., USA.* Compact digital holographic microscope configurations are being developed to enable searches for microbial life in remote terrestrial sites and the oceans of outer solar system moons. Rapid volume imaging at sub-micron resolution is provided.

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

16:30–18:15
3W5G • Interferometry & OCT
Presider: Yasuhiro Takaki; Tokyo Univ of Agriculture and Technology, Japan

3W5G.1 • 16:30
Real-Time 3-D Processing and Visualization by Optimal Bandwidth Capacity Interferometry, Natan T. Shaked[1], Gili Dardikman[1], Moran Rubin[1]; [1]*Tel-Aviv Univ., Israel.* We suggest new platforms for compressing up to 16 off-axis interferograms into a single interferogram for data compression and real-time 3-D processing and visualization.

3W5G.2 • 17:00 Invited
Title to be Provided, Aristide Dogariu[1]; [1]*Univ. of Central Florida, CREOL, USA.* Abstract not available.

Lime

Joint Applied Industrial Optics/ Adaptive Optics: Methods, Analysis and Applications

16:30–18:30
JW5I • Turbulence & Propagation (pcAOP/AO)
Presider: Julian Christou; Large Binocular Telescope Observatory, USA

JW5I.1 • 16:30 Invited
Optical Turbulence Forecast in the Adaptive Optics Realm, Elena Masciadri[1], Alessio Turchi[1], Luca Fini[1]; [1]*INAF Osservatorio Astrofisico di Arcetri, Italy.* Scientific drivers related to the optical turbulence forecast applied to the ground-based astronomy supported by Adaptive Optics, the state of the art of the achieved results and the most relevant challenges for future progresses are presented.

JW5I.2 • 17:00
Comparison of Measurement Techniques Used to Determine Atmospheric Structure Parameter, Cody A. Fernandez[1], Gisele Bennett[1]; [1]*Georgia Tech Foundation, Inc, USA.* C_n^2 measurements were taken at the recent CABLE/TRAX test at the NASA Shuttle Landing Facility along a 1.5 km horizontal path by three atmospheric turbulence measurement devices (DELTA, PROPS, IACS) and two commercial-grade scinitillometers (BLS-900 and K&Z LAS). The fundamental operating principles of these devices and their measurement data are analyzed for consistency in measurement outcomes.

JW5I.3 • 17:15 Invited
Adaptive Optics Correction for Oceanic Turbulence-Affected Laser Beams, Italo Toselli[1], Szymon Gladysz[1]; [1]*IOSB, Fraunhofer , Germany.* We investigate theoretically the performance of adaptive-optics correction for Gaussian beams affected by oceanic turbulence. Action of adaptive optics is modeled as removal of a certain number of Zernike modes from the aberrated wavefront. We found that, similarly to atmospheric turbulence, adaptive optics is very effective in improving optical system performance of laser communication links in weak oceanic turbulence.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon
Applied Industrial Optics	Computational Optical Sensing and Imaging	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AM5A • Orlando: The New Silicon Valley?—Continued

CW5B • Machine Learning in Computational Sensing and Imaging II—Continued

CW5B.3 • 17:30
Speckle suppression using the convolutional neural network with an exponential linear unit, Tianjiao Zeng[1], Zhenbo Ren[1], Edmund Y. Lam[1]; [1]*EEE, Univ. of Hong Kong, Hong Kong*. We describe a convolutional neural network for image despeckling with the exponential linear unit activation function, which outperforms state-of-the-art approaches on the reduction of speckle noise.

Panel • 17:45

Deep Learning
Deep Learning is a learning paradigm that seeks to discover increasingly abstract representations of data by cascading several processing layers that each progressively transform the input into more abstract representations. By compositing enough of these transformations, it is possible to learn highly complex input-output relationships. The above simple learning paradigm has significantly improved the state-of-the-art in speech recognition, visual object recognition, object detection and other domains including drug discovery and genomics. In recent times, Deep Learning has been used to tackle a variety of inverse problems in imaging ranging from imaging through scattering media to Phase Retrieval and Super-Resolution.

This panel discussion seeks to promote a broader discussion on the topic and help identify newer opportunities, while addressing misgivings about Deep Learning. The panel will be moderated by Aydogan Ozcan and will include imaging experts that practice the art of Deep Learning.

Panelist

George Barbastathis, *MIT, USA*

Bahram Jalali, *UCLA, USA*

Vidya Ganapathi, *Swarthmore College, USA*

LW5C • Ultra-fast Techniques & High-speed Imaging II—Continued

LW5C.4 • 17:30 Invited
Advantages of Ultrafast LIBS for High-Pressure Diagnostics, Anil K. Patnaik[1], Paul S. Hsu[1], Adam J. Stolt[2], Jordi estevadeordal[2], James R. Gord[3], Sukesh Roy[1]; [1]*Spectral Energies LLC, USA;* [2]*Dept. of Mechanical Engineering, North Dakota State Univ., USA;* [3]*Aerospace Systems Directorate, Air Force Research Lab, USA.* Ultrafast laser generates controlled plasma even at high gas pressures (40 bars), which helps in increasing the measurement stability of the laser-induced breakdown (LIBS) based fuel-air ratio measurement.

LW5C.5 • 18:00 Invited
Advanced Optical Diagnostic Approaches for Combustion Systems, Benjamin Emerson[1]; [1]*Aerospace Engineering, Georgia Inst. of Technology, USA.* Recent advances of high repetition rate pulsed laser technology have revolutionized the world of combustion system diagnostics. These diagnostics produce non-intrusive, multi-dimensional measurements such as spatio-temporally resolved velocity vector fields and chemical species fields.

MW5D • Model-based Imaging—Continued

MW5D.4 • 17:30 Invited
Binary Sensing Matrix Design for Super-Resolution IR Compressive Imaging, Jun Ke[1], Edmund Y. Lam[2]; [1]*Beijing Inst. of Technology, China;* [2]*The Univ. of Hong Kong, Hong Kong.* In IR compressive imaging, diffraction due to small sizes of micro-mirrors affects system resolution besides the resolution of a DMD. To deal with this issue, super-resolution IR compressive imaging with binary sensing matrix design is studied in this work.

MW5D.5 • 18:00
Incoherent Diffraction-Free Space-Time Light Sheets Produced From a Broadband LED, Murat Yessenov[1], Hasan E. Kondakci[1], Monjurul F. Meem[2], Rajesh Menon[2], Ayman F. Abouraddy[1]; [1]*CREOL, Univ. of Central Florida, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Utah, USA.* We demonstrate experimentally diffraction-free space-time light sheets produced from a broadband incoherent LED. Self-similar propagation is engendered through tight correlations introduced between the field's spatial and temporal degrees-of-freedom.

MW5D.6 • 18:15
Time Reversal using Bianisotropic Metasurfaces, Nitish Chandra[1]; [1]*Univ of North Carolina Charlotte, USA.* Design of two complimentary metasurfaces composed of bianisotropic structures to code and decode the evanescent fields from the sources into propagating waves for analog detection of sources placed at subwavelength separation using time reversal.

Orange/Lemon	Citron	Clementine	Lime
Joint Computational Optical Sensing and Imaging/Imaging Systems and Applications	Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Joint Applied Industrial Optics/ Adaptive Optics: Methods, Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

JW5E • Spectral Imaging (COSI/IS)—Continued

JW5E.4 • 17:30
Multispectral Wavefront Sensing for Characterizing Spatiotemporal Coupling in Ultrashort Pulses, Seung-Whan. Bahk[1], Christophe Dorrer[1]; [1]*Univ. of Rochester, USA.* A multispectral wavefront sensor is presented based on a lateral shearing interferometry technique and a multispectral image sensor. The measurement of first-order spatiotemporal coupling effects agrees well with the expectation.

JW5E.5 • 17:45
Supervised Classification of Hyperspectral Images using Side Information, Carlos A. Hinojosa[1], Karen Sanchez[1], Henry Arguello[1]; [1]*Universidad Industrial de Santander, Colombia.* This paper proposes a classification method that fuses superpixels-segmentation information from an RGB image with a hyperspectral image without estimating the high spatial-spectral resolution cube. This methodology improves the classification accuracy while boosting the performance.

JW5E.6 • 18:00
Highly Crossalked Integral Field Spectrometer with Computational Inversion, Maciej Baranski[1], Sanathanan S. Muttikulangara[1], George Barbastathis[2,3], Jianmin Miao[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*3 MIT, USA;* [3]*Singapore-MIT Alliance for Research and Technology (SMART) Centre, Singapore.* We investigate integral field spectrometer architecture in the highly crosstalked regime. It allows measurement of spectral datacube with higher spatial and spectral resolution, however it requires computational inversion to obtain spectral datacube. Inversion is based on optimization and employs regularization using low rank prior on the observed object.

JW5E.7 • 18:15
Spectral Imaging Subspace Clustering with 3-D Spatial Regularizer, Carlos A. Hinojosa[1], Jorge L. Bacca[1], Henry Arguello[1]; [1]*Universidad Industrial de Santander, Colombia.* This paper proposes a spectral image clustering approach that uses a 3-D Gaussian filter to incorporate the spatial information of the scene in the Sparse Subspace Clustering model obtaining a more accurate representation coefficient matrix.

DW5F • OptoFluidic and Life Applications of DH—Continued

DW5F.3 • 17:30
Integrated dual-mode tomography for unlabeled free-floating single cell imaging, Yu-Chih Lin[1], Vinoth Balasubramani[1], Xin-Ji Lai[1], Han-Yen Tu[2], Chau-Jern Cheng[1]; [1]*National Taiwan Normal Univ., Taiwan;* [2]*Chinese Culture Univ., Taiwan.* Integrated dual-mode tomography system is proposed and demonstrated. The spatial frequencies are filled up by full-angle sample and beam rotation, in which a large frequency coverage is obtained to enhance spatial resolution in x-y-z direction.

DW5F.4 • 17:45
Holographic Phase Imaging for Full-field Thickness Mapping of Evolving Thin Liquid Films, Biagio Mandracchia[1], Zhe Wang[2,1], Vincenzo Ferraro[3], Ernesto Di Maio[3], Pier Luca Maffettone[3], Pietro Ferraro[1]; [1]*Inst. of Applied Sciences and Intelligent Systems, Italy;* [2]*College of Applied Sciences, Beijing Univ. of Technology, China;* [3]*Univ. of Naples, Italy.* The dynamics of thin liquid films are of great interest to industrial processes and life science. Here we propose a holographic system for the evaluation of the 3D topography and thickness of evolving thin liquid film.

DW5F.5 • 18:00
Improved 3D Imaging of Zebrafish Larvae Microcirculation by Digital Holography, Alexey Brodoline[1], Nitin Rawat[1], Daniel Alexandre[1], Michel Gross[1]; [1]*Laboratoire Charles Coulomb, France.* A microscopic technique based on digital holography is proposed to investigate blood microcirculation and vascular development in model organisms such as zebrafish larvae. Recent achievements in 3D imaging of blood flow in vessels are presented.

3W5G • Interferometry & OCT—Continued

3W5G.3 • 17:30
Digital Phase Conjugation for Improving the Focused Spot in Weakly Scattering Medium for OCT, Keisuke Harukaze[1], Noriyuki Nakatani[1], Xiangyu Quan[1], Kouichi Nitta[1], Osamu Matoba[1]; [1]*Kobe Univ., Japan.* Digital phase conjugation is applied to improve the focusing property in a weakly scattering medium for achieving high-resolution OCT. Experimental results for improving the focusing property are presented.

3W5G.4 • 17:45
Multidirectional holographic interferometer for 3D gas density reconstruction, François Olchewsky[1], Frédéric Champagnat[2], Jean-Michel . Desse[1]; [1]*ONERA, France;* [2]*ONERA, France.* A multidirectional holographic interferometer is built for analyzing and reconstructing the 3D gas density field. It is composed by six different sights of views and the holographic interferograms are processed by 2D Fourier transforms. This interferometer is applied to reconstruct the gas density of 3D laminar helium jet and small supersonic jets.

3W5G.5 • 18:00
3D Image Quality Improvement for Optical Projection Tomography via Point Spread Function Modelling, Xiaoqin Tang[1], Gerda Lamers[1], Fons Verbeek[1]; [1]*Leiden Univ., Netherlands.* We present a method to model the 3D point spread function in optical projection tomography imaging system, which subsequently contributes to the improvement of 3D image quality. Experiments are implemented on several 3D images of zebrafish embryos.

JW5I • Turbulence & Propagation (pcAOP/AO)—Continued

JW5I.4 • 17:45
Generating Infinitely Long Phase-Screens with the Karhunen-Loève Decomposition, Szymon Gladysz[1], Esdras Anzuola[1]; [1]*Fraunhofer Inst. IOSB, Germany.* We introduce a method for creating temporally evolving wavefront distortions that uses Karhunen-Loève decomposition and the associated temporal power spectra. We demonstrate that the method is able to produce dynamic wavefronts that follow the behavior predicted by the theory while introducing key advantages in terms of calculation speed and storage in computer memory.

JW5I.5 • 18:00 Invited
Characterising atmospheric turbulence using SCIDAR techniques, James Osborn[1]; [1]*Physics, Durham Univ., UK.* Knowledge of the structure of the Earth's atmospheric turbulence is critical for astronomical adaptive optics well as optical communications. Here we present the state of the art Stereo-SCIDAR technique for night time profiling. This high-sensitivity and high-resolution optical turbulence profiler has been in regular operation on La Palma and Paranal. Here we present the instrument, statistics and comparisons with other profiling instruments and numerical forecast models in the context of AO.

Sunset/Fleming	Siesta/Biscayne	Cedar/Marathon
Applied Industrial Optics	Imaging Systems and Applications	Digital Holography & 3-D Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:30–16:00 Registration, *Palms Foyer*

08:00–09:00 Postdeadline Papers *(schedule and location listed in the congress update sheet)*

09:00–09:45 Coffee Break with Exhibitors, *Palms Foyer*

09:45–11:45
ATh2A • Another Day, Another Detector
Presider: Garrett Cole; Crystalline Mirror Solutions LLC, USA

ATh2A.1 • 09:45 Invited
Cryostats for Cryophobes--a revolutionary "one-button" desktop 1.7 K cryostat for superconducting optoelectronics, Aaron J. Miller[1]; [1]*Quantum Opus, LLC, USA.* I will present an overview of our commercial superconducting photon detector technology and how we expect to reduce the cryogenic barrier-to-entry by the development of the world's first "one-button" desktop 1.7 Kelvin cryostat.

DEMO

Demonstration of the world's first "desktop" one-button cryogenic system operating at 1.7 Kelvin using less than 300 Watts of wall-plug power. A description of the technology and potential novel applications will be discussed in the preceding talk.

ATh2A.2 • 10:30
Non-Absorbing, Point-of-Use, High-Power Laser Power Meter, Alexandra B. Artusio-Glimpse[1], Ivan Ryger[1], Paul Williams[1], John Lehman[1]; [1]*NIST, USA.* We have developed a compact, high-power laser power meter in the form of a folding mirror, precluding the need for beam splitters that considerably increase measurement uncertainty. Furthermore, our symmetric design inhibits responsivity to gravity.

09:45–11:45
ITh2B • Sensors & Optics
Presider: Dale Linne von Berg; US Naval Research Lab, USA

ITh2B.1 • 09:45 Invited
CMOS Image Sensor Evolution toward Sensing World, Hirotaka Murakami[1]; [1]*Sony Electronics Inc., USA.* CMOS image sensors have made exceptional advances in sensitivity and resolution. Future evolution will occur along the lines of spectral diversity, 3D sensing, and higher frame rate accomplished with three dimensional system integration.

ITh2B.2 • 10:15 Invited
Spherically Curved Image Sensors, Geoffrey McKnight[1], Andrew Keefe[1], Brian Guenter[2], Neel Joshi[2], Richard Stoakley[2], Ryan Freeman[1]; [1]*MML, HRL Labs, USA;* [2]*Microsoft, USA.* We present methods and analysis for the creation of highly curved CMOS and hybridized InGaAs image sensors using a newly developed pneumatic forming technique along with prototype camera performance data.

09:45–11:45
DTh2C • Digital Holographic Microscopy
Presider: Aydogan Ozcan; Univ. of California Los Angeles, USA

DTh2C.1 • 09:45 Invited
Telecentric imaging in reflection and transmission digital holographic microscopy, Jorge Garcia-Sucerquia[1]; [1]*Universidad Nacional de Colombia, Colombia.* In this contribution telecentric imaging, both in transmission and reflection digital holographic microscopy (DHM), is reviewed. An analysis of the effects of the microscope objectives in both configurations of DHM is presented. The findings are utilized to show that the most effective method to avoid phase perturbations due to the imaging system of the microscope, is the recording of the digital holograms with an infinity-corrected microscope objective in telecentric configuration with a tube lens. The performance of this recoding architecture for both modes of operation of DHM is analyzed theoretically and validated with experimental results. Transparent biological and reflective non-biological samples are imaged with telecentric-DHM operating in transmission and reflection modes, in that order.

DTh2C.2 • 10:15
Two-coupled Mach-Zehnder interferometers in a multi-camera setup for phase-shifting applied to digital holographic microscopy, Carlos A. Trujillo[1], Jorge Garcia-Sucerquia[1]; [1]*Univ Nacional de Colombia Medellin, Colombia.* The use of two-coupled Mach-Zehnder interferometers for four $\pi/2$-phase shifting interferometry which includes a multi-camera arrangement is presented. This proposal is validated in digital holographic microscopy to visualize a biological sample of epidermal onion cells.

DTh2C.3 • 10:30
Extraction of Biophysical Parameters from Label-free Digital Holographic Phase Microscopy Images for Cell Culture Quality Control, Lena Kastl[1], Michael Isbach[1], Dieter Dirksen[1], Jürgen Schnekenburger[1], Björn Kemper[1]; [1]*Univ. of Muenster, Germany.* We demonstrate the extraction of biophysical parameter sets such as refractive index, volume and dry mass from label-free quantitative phase microscopy images for assessment of cell culture quality control.

Orange/Lemon/Lime	Citron	Clementine
Computational Optical Sensing and Imaging	Digital Holography & 3-D Imaging	Adaptive Optics: Methods, Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:30–16:00 Registration, *Palms Foyer*

08:00–09:00 Postdeadline Papers *(schedule and location listed in the congress update sheet)*

09:00–09:45 Coffee Break with Exhibitors, *Palms Foyer*

09:45–11:15
CTh2D • Phase Retrieval
Presider: Seung-Whan Bahk; Univ. of Rochester, USA

CTh2D.1 • 09:45 Invited
Plenoptic imaging from intensity correlations, Francesco Vincenzo Pepe[3], Francesco Di Lena[1], Aldo Mazzilli[1], Eitan Edrei[2], Augusto Garuccio[1], Giuliano Scarcelli[2], Milena D'Angelo[1]; [1]*Università degli Studi di Bari, Italy;* [2]*Fischell Dept. of Bioengineering, Univ. of Maryland, USA;* [3]*Sezione di Bari, INFN Istituto Nazionale di Fisica Nucleare, Italy.* We demonstrate, theoretically and experimentally, the possibility to perform plenoptic imaging by measuring intensity correlations of light. Unlike standard plenoptic procedures, the technique we propose does not sacrifice spatial resolution to achieve directional resolution.

CTh2D.2 • 10:15
A new method for designing highly efficient metasurface devices: Local Phase Method, Liyi Hsu[1], Matthieu Dupre[1], Abdoulaye Ndao[1], Boubacar Kante[1]; [1]*Univ. of California San Diego, USA.* We have proposed and developed a new and versatile approach named Local phase method to quantify the phase error of each element within a metasurface accounting for the near-field coupling. This method can improve the performance of any devices based on metasurfaces.

CTh2D.3 • 10:30
Novel Optimizations for Phase Retrieval, Ashish Tripathi[1], John Barber[1], Richard Sandberg[1]; [1]*Los Alamos National Lab, USA.* We demonstrate improvements in iterative phase retrieval algorithms for coherent diffractive imaging using novel non-convex and nonlinear numerical optimization techniques. We incorporate all prior knowledge of the experimental geometry and sample physics.

09:45–11:45
DTh2E • Advances in DH Techniques 2
Presider: Yoshio Hayasaki; Utsunomiya Univ., Japan

DTh2E.1 • 09:45 Invited
Near-field imaging using digital holographic interferometry with total internal reflection and surface plasma resonance, Jianlin Zhao[1], Jiwei Zhang[1]; [1]*Northwestern Polytechnical Univ., China.* Near-field refractive index and film thickness on prism or metal surface can be determined, by measuring the complex amplitude distributions of reflected light in total internal reflection and surface plasma resonance using digital holographic interferometry.

DTh2E.2 • 10:15 Invited
Optical cryptography with biometrics and optical scanning holography, Aimin Yan[1], Zhijuan Hu[1], Peter Tsang[2], Ting-Chung Poon[3]; [1]*Shanghai Normal Univ., China;* [2]*City Univ. of HongKong, China;* [3]*Virginia Tech, USA.* In this invited talk, we will review optical cryptography with biometrics for multi-depth objects using optical scanning holography (OSH). We also focus on the discussion of key distribution.

09:45–11:30
OTh2F • AO Systems II
Presider: Szymon Gladysz; Fraunhofer Inst. IOSB, Germany

OTh2F.1 • 09:45 Invited
New Technologies for Astronomical Adaptive Optics, Donald T. Gavel[1]; [1]*Univ. of California Observatories, USA.* In this presentation we discuss the technology advances that have enabled high performance adaptive optics for astronomy and discuss prospects for the future.

OTh2F.2 • 10:15 Invited
Adaptive Optics in Optical Communication Systems, Alan E. Willner[1]; [1]*Univ. of Southern California, USA.* Adaptive optics plays an important role in combatting deleterious effects in free-space optical communication systems. This paper will describe issues related to the mitigation of data-degrading effects (e.g., atmospheric turbulence) for single and multiple beam systems.

Sunset/Fleming

Applied Industrial Optics

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

ATh2A • Another Day, Another Detector—Continued

ATh2A.3 • 10:45
UV-Controlled Triboelectric Formation of Two-Beam Interference Pattern with Nano-Volcano Array, Jaeyoun Kim[1], Qiang Li[1]; [1]*Iowa State Univ., USA.* Adding sub-structures to sub-micron-scale to polymer surface patterned through two-beam interference has been deemed highly challenging. Using replica molding, triboelectric effect, and electrohydrodynamic lithography, we achieve decoration of sinusoidally corrugated NOA73 surface with nanoscale volcano arrays.

ATh2A.4 • 11:00 Invited
High-performance Optoelectronic and Nanophotonic Devices Enabled by Ultra-thin, Smooth, and Low-loss Doped Silver, Cheng Zhang[1], Henri J. Lezec[1], Wenqi Zhu[1], Amit Agrawal[1]; [1]*NIST, USA.* We present a new plasmonic material termed 'doped Ag', and its applications in various optoelectronic and nanophotonic devices with improved performance, including organic solar cells, polymer light emitting diodes, hyperbolic metamaterials, and plasmonic interconnects.

Siesta/Biscayne

Imaging Systems and Applications

ITh2B • Sensors & Optics—Continued

ITh2B.3 • 10:45
2-Terminal Organic FPA Pixel Design for Curved Image Sensors, Zhao Ma[1], Christopher K. Renshaw[1,2]; [1]*CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA;* [2]*Physics, Univ. of Central Florida, USA.* We demonstrate a novel 2-terminal pixel design to enable fabrication of curved image sensors using organic semiconductors. The vertically-stacked anti-polar diode (VAD) pixel incorporates a blocking diode to provide a low-current and light-independent OFF state under forward bias.

ITh2B.4 • 11:00 Invited
Engineered Materials for Next Generation EO/IR Sensors, Clara Rivero-Baleine[1], Andrew Kirk[1], Megan Driggers[1], Johann Veras[1], Erwan Baleine[1], Kathleen Richardson[2], Myungkoo Kang[2], Anupama Yadav[2], Juejun Hu[3], Tian Gu[3], Yifei Zhang[3], Mikhail Y. Shalaginov[3], Ray Hilton[4], Tom Loretz[4]; [1]*Lockheed Martin, USA;* [2]*Univ. of Central Florida, USA;* [3]*MIT, USA;* [4]*Amorphous Materials Inc., USA.* Next generation Electro-Optical / Infrared (EO/IR) sensors will require innovative materials that can be engineered to serve complex optical functions. Here we highlight how these properties can be tailored to enable next generation EO/IR sensors.

ITh2B.5 • 11:30
Infrared Monolithic Double Diffractive Kinoform Doublet on a Planar Substrate - Coupled Design Model, Kim W. Larsen[1]; [1]*NVESD, US ARMY RDECOM CERDEC, USA.* Monolithic double diffractive doublets on a planar substrate for infrared color correction are modeled using a coupled physical and phase model in a ray-trace program for optical design with custom coupling and analysis macros.

Cedar/Marathon

Digital Holography & 3-D Imaging

DTh2C • Digital Holographic Microscopy—Continued

DTh2C.4 • 10:45
Full compensation of quantitative phase images of digital holographic microscopy using GPU, Carlos A. Trujillo[1], Raúl Castañeda[1], Pablo Piedrahita-Quintero[1], Jorge Garcia-Sucerquia[1]; [1]*Univ Nacional de Colombia Medellin, Colombia.* A GPU-accelerated method that fully compensates the quantitative phase measurements in off-axis digital holographic microscopy (DHM) is presented. The algorithm has been validated on DHM holograms of biological samples running at attractive processing times.

DTh2C.5 • 11:00
Compact and flexible digital holographic microscopy based on wavefront segmentation, Liangcai Cao[1], Wenhui Zhang[1], Hua Zhang[1], hao zhang[1], Guofan Jin[1]; [1]*Tsinghua Univ., China.* A compact digital holographic microscopy with high stability and high flexibility based on wavefront segmentation is proposed. The system only consists of a few optical elements without strict alignments, making it robust and easy-to-implement.

DTh2C.6 • 11:15
Spatial Analysis of Osteocytes Membrane Fluctuations under LMHF Vibration Using Digital Holographic Microscopy, Cao Runyu[1], Xiaosu Yi[1], Wen Xiao[1], Feng Pan[1]; [1]*Beihang Univ., China.* We measured membrane fluctuations of osteocytes under vibration caused by sound wave using digital holographic microscopy (DHM). Distinct differences in frequency spectrum were found between cells and backgrounds.

DTh2C.7 • 11:30
Wavefront Reconstruction in Holographic Scanning Microscopy, Yuri Zakharov[1], Mariya Muravyeva[2], Umar Khan[1], Lei Zhang[1], Vladimir Turzhitsky[1], Edward Vitkin[1], Irving Itzkan[1], Le Qiu[1], Lev Perelman[1]; [1]*Harvard Univ., USA;* [2]*Lobachevsky Nizhny Novgorod Univ., Russia.* A reconstruction algorithm for holographic scanning microscopy should take into account scanning-associated phase shifts. Here we present the stable, not prone to noise, algorithm which does not require additional recording of the object wave intensity.

11:45–13:30 Lunch on your Own

13:00–18:00 Tour of Laser Propagation Facilities at Kennedy Space Center *(Extra fee and advanced registration required.)*

Orange/Lemon/Lime

Computational Optical Sensing and Imaging

Citron

Digital Holography & 3-D Imaging

Clementine

Adaptive Optics: Methods, Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

CTh2D • Phase Retrieval—Continued

CTh2D.4 • 10:45
Phase Retrieval Based on Wave Modulation, Xingchen Pan[1], Cheng Liu[1], Jianqiang Zhu[1]; [1]*Shanghai Inst of Optics and Fine Mech, China.* Two novel single-shot phase retrieval algorithms based on the modulation of random aperture, which is insensitive to wavelength, and continuous phase plate, which provides weak modulation, are proposed and demonstrated by experiments respectively.

CTh2D.5 • 11:00
Enhanced Phase Retrieval using Quantum Illumination, Yaotian Wang[1], Hugo Defienne[1], Matthew Reichert[1], Jason W. Fleischer[1]; [1]*Electrical Engineering, Princeton Univ., USA.* We use quantum illumination to improve classical phase retrieval algorithm. The quantum-assisted algorithm shows improved performance over the classical methods.

DTh2E • Advances in DH Techniques 2—Continued

DTh2E.3 • 10:45
Six-Pack Off-Axis Holographic Multiplexing, Natan T. Shaked[1], Gili Dardikman[1], Moran Rubin[1]; [1]*Tel-Aviv Univ., Israel.* We present six-pack off-axis holography, in which six off-axis holograms are compressed into a single multiplexed off-axis hologram without loss of magnification or resolution, allowing more than 50% improvement in the camera spatial bandwidth consumption.

DTh2E.4 • 11:00
Fourier Transform Holography at the Wavelength Limit, Getnet K. Tadesse[1,2], Wilhelm Eschen[2], Robert Klas[1,2], Vinzenz Hilbert[2], Detlef Schelle[2], Anne Nathanael[2], Matthias Zilk[2], Michael Steinert[2], Frank Schrempel[2], Thomas Pertsch[2], Andreas Tünnermann[2,3], Jens Limpert[1,2], Jan Rothhardt[1,2]; [1]*Helmholtz Inst. Jena, Germany;* [2]*Inst. of Applied Physics, Friedrich-Schiller-Univ. Jena, Germany;* [3]*Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We present a table-top Fourier transform holography experiment that achieved a record-high resolution of 34 nm. By employing phase retrieval techniques, the resolution was improved to 23 nm ($<1.3\ \lambda$) limited by wave-guiding effects.

DTh2E.5 • 11:15
Crystalline Silicon (c-Si) Metasurface Holograms in the Visible Range, Augusto Martins[1], JUntao Li[2,3], Achiles F. Mota[1], Yin Wang[2], Luiz G. Neto[1], João Paulo P. do Carmo[1], Fernando Teixeira[4], Emiliano R. Martins[1], Ben-Hur V. Borges[1]; [1]*Dept. of Electrical Engineering, Univ. of São Paulo, Brazil;* [2]*State Key Lab of Optoelectronic Materials & Technologies, Univ. of Sun Yat-Sen, China;* [3]*School of Physics,, Univ. of Sun Yat-Sen, China;* [4]*Dept. of Electrical and Computer Engineering, Ohio State Univ., USA.* This paper presents the first experimental demonstration of c-Si metasurface holograms operating with good quality in the visible range. The measured transmission (diffraction) efficiencies are as high as 47.4% (30%) at the designed wavelength of 532nm.

DTh2E.6 • 11:30
Holographic Phase Masks for Generation of Vortex Beams Recorded in Photo-Thermo-Refractive Glass, Fedor Kompan[1], David Guacaneme[1], Zachary Labossiere[1], Duc-Quy Nguyen[1], Ivan Divliansky[1], Leonid Glebov[1]; [1]*CREOL, Univ. of Central Florida, USA.* Optical angular momentum (OAM) beams have been actively studied due to wide range of applications including micromanipulation and telecommunications. We present a method for producing high quality robust phase masks for generation of OAM beams.

OTh2F • AO Systems II—Continued

OTh2F.3 • 10:45 Invited
Astronomical Adaptive Optics: Challenges and Pathways, Katie M. Morzinski[1]; [1]*Center for Adaptive Optics, USA.* General-purpose astronomical AO systems are giving way to custom-built instruments designed for specific applications. I will describe how myriad science cases call for different AO technologies, and discuss challenges from technology development to telescope environment.

OTh2F.4 • 11:15
The ExoLife Finder (ELF) Telescope: New Adaptive Optics and Hybrid Dynamic Live-Optical Surfaces Strategies., Gil Moretto[1], Jeff Kuhn[2], Maud Langlois[1], Michel Tallon[1], Jean-Fabien Capsal je[3], David Audigier[3], Kritsadi Thetpraphi[3], Mike Gedig[5], Andrew Norton[4], Svetlana V. Berdyugina[6], David Halliday[5]; [1]*CRAL/CNRS, France;* [2]*IFA, Univ. of Hawaii, USA;* [3]*LGEF, INSA Lyon, France;* [4]*Lick Observatory,, Univ. of California, USA;* [5]*Dynamic Structures Ltd., , Canada;* [6]*Kiepenheuer Inst. fur Sonnenphysik, Germany.* The exponential growth in exoplanets studies and related science such as detecting life and even civilizations on Earth-like planets requires high angular resolution and high-contrast observations. Such appealing sciences cases are a powerful reason for developing a dedicated high contrast telescope concept – The ExoLife Finder (ELF) Telescope. Here we describe ELF's overall optical, AO and mirrors concepts.

11:45–13:30 Lunch on your Own

13:00–18:00 Tour of Laser Propagation Facilities at Kennedy Space Center *(Extra fee and advanced registration required.)*

Sunset/Fleming

Joint Applied Industrial Optics/ Computational Optical Sensing and Imaging

13:30–15:15
JTh3A • Ptychography, It's Complex (AIO/COSI)
Presider: Jaeyoun Kim; Iowa State Univ., USA

JTh3A.1 • 13:30 Invited
Fourier Ptychographic Method for High Resolution and Wide Field of View Retinal Imaging, Changhuei Yang[1], Jaebum Chung[1]; [1]*California Inst. of Technology, USA.* We present a high-resolution retinal imaging system capable of computationally correcting for the eye's aberration to resolve photoreceptors at cellular level. It is based on a novel adaptation of Fourier ptychographic algorithm and coded apertures.

JTh3A.2 • 14:00
Multiplexed Single-Shot Ptychography, Bing Kuan Chen[1], Pavel Sidorenko[1], Oren Lahav[1], Or Peleg[1], Oren Cohen[1]; [1]*Technion, Israel.* We propose and demonstrate single-shot polarization-resolved ptychographic microscope and ultrahigh-speed ptychographic microscope. They are based on the application of mixed-state reconstruction algorithm in single-shot ptychography (the ptychographic data is recoded in a single CCD exposure).

Siesta/Biscayne

Joint Computational Optical Sensing and Imaging/ Digital Holography & 3-D Imaging

13:30–15:00
JTh3B • Holographic Microscopy (COSI/DH)
Presider: Abbie Watnik; US Naval Research Lab, USA

JTh3B.1 • 13:30
Sampling and processing for multiple scattering in inline compressive holography, Waleed Tahir[2], Ulugbek S. Kamilov[1], Lei Tian[2]; [1]*Washington Univ. in St. Louis, USA;* [2]*Boston Univ., USA.* Inline holography is approached from a computational perspective by incorporating a nonlinear forward model based on the iterative Born approximation (IBA). Sampling and its effects on multiple scattering computations are discussed.

JTh3B.2 • 13:45
Multi-constrained Phase Retrieval for Lens-Free Inline holographic microscopy, Xia Hua[1], Cheng Yang[1], Beibei Xu[2], Feng Yan[1], Xun Cao[1]; [1]*School of Electronic Science and Engineering, Nanjing Univ., China;* [2]*College of Engineering and Applied Sciences, Nanjing Univ., China.* High-resolution wide-field microscopy plays an essential role in various fields. A multi-constrained phase retrieval algorithm is presented for lens-free inline holographic microscopy. Experimental results shown that the proposed method could effectively eliminate twin image noise.

JTh3B.3 • 14:00
Resolution Enhancement in Digital Holographic Microscopy under Grating-based Illumination, Shaohui Li[1], Shaotong Feng[1], Jun Ma[2], Qingyu Ma[1], Caojin Yuan[1]; [1]*Nanjing Normal Univ., China;* [2]*Nanjing Univ. of Science and Technology, China.* We present a single-shot resolution enhancement method under grating-based illumination in the digital holographic microscopy. The recorded information without crosstalk is separated by multiplexing techniques. The method is verified by the experiments.

Orange/Lemon/Lime

Computational Optical Sensing and Imaging

13:30–15:30
CTh3C • Imaging through Aberrations, Structured Illumination & Super Resolution
Presider: Prasanna Rangarajan; Southern Methodist University, USA

CTh3C.1 • 13:30
Temporal Super-resolution Full Waveform LiDAR, Jun Ke[1], Edmund Y. Lam[2]; [1]*Beijing Inst. of Technology, China;* [2]*The Univ. of Hong Kong, Hong Kong.* In full waveform LiDAR, system ranging resolution is limited by the pulse width of a laser source, and the bandwidth of a detector and an A/D. To overcome the limitation, temporal super-resolution is studied in this paper.

CTh3C.2 • 13:45
Super-Resolution Imaging Based on Spectral Dimensional Information, Zhishen Tong[1,2], Jian Wang[3], Zengfeng Huang[3], Zhentao Liu[1], Chenyu Hu[1,2], Xia Shen[1], Jianrong Wu[1], shensheng han[1], Enrong Li[1]; [1]*Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China;* [2]*Univ. of Chinese Academy of Sciences, China;* [3]*School of Data Science, Fudan Univ., China.* A method based on spectral dimensional information is proposed to realize the super-resolution imaging. Numerical simulation shows that performance with spectral constraint is better than no spectral constraint under low signal-to-noise ratio.

CTh3C.3 • 14:00
Remote Sensing of Photoplethysmogram using Multi Spot Illumination, Nisan Ozana[1], Hadar Genish[3], Ran Califa[3], Ariel Schwarz[1], Sagi Polani[3], Javier Garcia[2], Zeev Zalevsky[1]; [1]*Bar Ilan Univ., Israel;* [2]*Universitat de València, Spain;* [3]*ContinUse Biometrics Ltd., Israel.* The ability to remotely extract Photoplethysmogram (PPG) signals is of great interest. A novel approach to overcome motion related noise, based on a multi spot pattern was experimentally demonstrated. Improvement of PPG signal is presented.

Citron

Digital Holography & 3-D Imaging

13:30–15:30
DTh3D • Integral Imaging and Holographic Displays
Presider: Liangcai Cao; Tsinghua Univ., China

DTh3D.1 • 13:30 Tutorial
Full Color Holographic Printing Techniques and Fast Digital Hologram Generation Methods, Hoonjong Kang[1]; [1]*Korea Electronics Technology Inst., South Korea.* Abstract to be provided.

Clementine

Adaptive Optics: Methods, Analysis and Applications

13:30–15:15
OTh3E • Control & Simulations
Presider: Caroline Kulcsar; Institut d'Optique Graduate School, France

OTh3E.1 • 13:30 Invited
Advanced Control Algorithms and Control Structures for Adaptive Optics Systems, Michael Böhm[1], Martin Glück[1], Jörg-Uwe Pott[2], Kevin Schmidt[1], Oliver Sawodny[1]; [1]*Inst. for System Dynamics, Univ. of Stuttgart, Germany;* [2]*Max-Planck-Inst. for Astronomy, Germany.* Advanced control structures for adaptive optics in astronomy will be explained briefly and simulations along with LBT experimental data illustrating its benefits will be shown. A different application for model-based control of DMs is sketched.

OTh3E.2 • 14:00
Power-in-the-Bucket and Stoke Efficiency with Woofer-Tweeter Deformable Mirrors and Image Sharpening, Dennis F. Gardner[1], Abbie T. Watnik[1], Mark F. Spencer[2]; [1]*Naval Research Lab, USA;* [2]*U.S. Air Force Research Lab, USA.* Various basis sets are used in an image sharpening algorithm to command dual deformable mirrors in simulation. The power-in-the-bucket measurements and mirror stroke efficiency are used as the performance metrics to compare the basis sets.

Sunset/Fleming

Joint Applied Industrial Optics/ Computational Optical Sensing and Imaging

JTh3A • Ptychography, It's Complex (AIO/COSI)—Continued

JTh3A.3 • 14:15
Fourier Ptychography Using Low-Cost Bayer Color Sensors, Tomas Aidukas[1], Andrew R. Harvey[1], Pavan Konda[1]; [1]*Univ. of Glasgow, UK.* We report a Fourier ptychography reconstruction that enabled the use of low-cost Bayer-filtered color cameras. Using 3D-printing, consumer electronics and robust calibration we demonstrated a microscope capable of capturing sub-micron resolution 25-megapixel images under $150.

JTh3A.4 • 14:30
High-resolution (diffraction limit) single-shot ptychography for ultra-high-speed microscopy, Gil Ilan Haham[1], Or Peleg[1], Pavel Sidorenko[2], Oren Cohen[1]; [1]*Technion, Israel;* [2]*Cornell, USA.* We propose a module that upgrades a conventional single-shot microscope into a single-shot ptychographic microscope, without spoiling its optical performances. This approach paves the way to single-frame or ultrahigh-speed, high-resolution microscopes of complex-valued objects.

JTh3A.5 • 14:45
Fast light source misalignment correction of Fourier ptychographic microscopy, Ao Zhou[1,2], Wei Wang[3], Ni Chen[1], Guohai Situ[1]; [1]*Shanghai Inst. of Optics and Fine Mechanics, China;* [2]*Univ. of Chinese Academy of Sciences, China;* [3]*National Univ. of Singapore, Singapore.* We propose an effective method to correct the LED misalignment in Fourier ptychographic microscopy. The experimental results show the proposed method is faster and more robust than the other simulated annealing based methods.

Siesta/Biscayne

Joint Computational Optical Sensing and Imaging/ Digital Holography & 3-D Imaging

JTh3B • Holographic Microscopy (COSI/DH)—Continued

JTh3B.4 • 14:15
The effects of cytokeratin knock-out on breast cancer cell phase features assessed with telecentric digital holographic microscopy (DHM) and machine learning, Van Lam[1], George Nehmetallah[1], Byung Min Chung[1], Christopher Raub[1]; [1]*Catholic Univ. of America, USA.* A telecentric DHM system and a support vector machine-based classifier were developed to investigate the effects of cytokeratin 19 knockout on the morphology and phase features of MDA-MB-231 breast cancer cells.

JTh3B.5 • 14:30
Phase aberration compensation in digital holographic microscopy using regression analysis, Zhenbo Ren[1], Zhimin Xu[2], Edmund Y. Lam[1]; [1]*Univ. of Hong Kong, Hong Kong;* [2]*SharpSight Limited, Hong Kong, Hong Kong.* In digital holographic microscopy, phase aberration, including the tilt and quadratic aberration, affects the visualization and measurement of the quantitative phase of the object. Here we propose a regression-based method to compensate the phase aberration.

JTh3B.6 • 14:45
Total aberrations compensation for digital holographic microscopy with geometrical transformations, Wenqi He[1], Dingnan Deng[1], Weijuan Qu[2], Xiaoli Liu[1], Xiang Peng[1]; [1]*College of Optoelectronic Engineering, China;* [2]*Ngee Ann polytechnic, Singapore.* We propose a total aberrations compensation method for digital holographic microscopy with geometrical transformations. The rotation transformation with 180° and reflection transformation can be used for compensating the off-axis tilt and parabolic phase aberration, respectively.

Orange/Lemon/Lime

Computational Optical Sensing and Imaging

CTh3C • Imaging through Aberrations, Structured Illumination & Super Resolution—Continued

CTh3C.4 • 14:15
Enlarged Field of View Scattering Imaging Using Speckle Autocorrelation, Rui Yuan[1], Yuegang Fu[1], Jianhong Zhou[1]; [1]*Changchun Univ. of Science and Tech, China.* Large-field imaging through strongly tissues still presents a challenge. We propose a method to enlarge the field of view using digital micromirror device. With speckle autocorrelation and phase retrieval algorithm, the method is practical.

CTh3C.5 • 14:30
Mitigating metalens aberrations via computational imaging, Shane A. Colburn[1], Arka Majumdar[1]; [1]*Univ. of Washington, USA.* We design hybrid imagers where together metalenses and deconvolution improve image quality while minimizing form factor. We aim to mitigate chromatic and geometric aberrations by designing wavelength-invariant point spread functions and characterizing their spatial variance.

Citron

Digital Holography & 3-D Imaging

DTh3D • Integral Imaging and Holographic Displays—Continued

DTh3D.2 • 14:15
Color Image Generation by Multi-Channel Viewing-Zone Scanning Holography, Yasuhiro Takaki[1], Mitsuki Nakaoka[1], Keisuke Hieda[2]; [1]*Tokyo Univ of Agriculture and Technology, Japan;* [2]*HIOKI EE CORPORATION, Japan.* The multi-channel viewing-zone scanning holography, which provides large screen size and viewing zone, is modified to generate color images. The technique to adjust colors among multiple screens using the RGB color luminance meter is developed.

DTh3D.3 • 14:30
A method to enhance the depth range of an integral imaging system using a geometric phase lens, Minyoung Park[1], Hee-Jin Choi[1]; [1]*Sejong Univ., South Korea.* In this paper, we propose a method to provide 3D image with enhanced depth range by integrating them in two central depth planes using a geometric phase lens.

DTh3D.4 • 14:45
Miniature Solid-State Holographic Display with Cloud Computing, Michal Makowski[1], Adam Kowalczyk[1], Izabela Ducin[1], Karol Kakarenko[1], Jaroslaw Suszek[1], Marcin Bieda[1], Paula Kochanska[1]; [1]*Faculty of Physics, Warsaw Univ. of Technology, Poland.* A robust, miniaturized, color, lens-less holographic projection display without moving parts is presented, which offers high efficiency of 35-100 lm/W, small volume below 5 cm^3 and cloud computing capability for built-in projectors of future smartphones.

Clementine

Adaptive Optics: Methods, Analysis and Applications

OTh3E • Control & Simulations—Continued

OTh3E.3 • 14:15
FPGA Implementations of Low Latency Centroiding Algorithms for Adaptive Optics, Manuel Cegarra Polo[1], Fanpeng Kong[1], Andrew Lambert[1]; [1]*UNSW Adfa, Australia.* We describe two innovative low latency centroiding algorithms implemented in an FPGA, exploiting the parallel processing features of these devices, and showing low values in latency and real estate, which eases their integration with complete adaptive optics systems.

OTh3E.4 • 14:30
Adaptive Optic Wavefront Correction using a Convolutional Neural Network, Andrew Norton[1], Noah Toyonaga[1], Bruce Macintosh[1], Steven Chu[2]; [1]*Kavli Inst. for Particle Astrophysics and Cosmology, Stanford Univ., USA;* [2]*Dept. of Molecular and Cellular Physiology, Stanford Univ. , USA.* We show how using a state-of-the-art deep learning convolutional neural network allows for measuring and correcting phase aberrations in astronomy and biological adaptive optic applications.

OTh3E.5 • 14:45
Some simple results about adaptive optics performance evaluation in 'replay mode', Caroline Kulcs´ar[1], Henri-François Raynaud[1],R´emy Juv´enal[1,2], Jean-Marc Conan[2]; [1]*Laboratoire Charles Fabry, CNRS-Institut dOptique France;* [2]*ONERA, The French Aerospace Lab, France.* Replay mode simulations enable to evaluate AO control performance (residual variance) using on-sky telemetry. This paper proposes simple procedures to remove estimation bias and to evaluate the impact of on-sky measurement noise propagation.

Sunset/Fleming

Joint Applied Industrial Optics/ Computational Optical Sensing and Imaging

JTh3A • Ptychography, It's Complex (AIO/COSI)—Continued

JTh3A.6 • 15:00
A deep-learning approach for high-speed Fourier ptychographic microscopy, Thanh Nguyen[1], Yujia Xue[2], Yunzhe Li[2], Waleed Tahir[2], Lei Tian[2], George Nehmetallah[1]; [1]*Catholic Univ. of America, USA;* [2]*Dept. of Electrical and Computer Engineering, Boston Univ., USA.* We demonstrate a new convolutional neural network architecture to perform Fourier ptychographic Microscopy (FPM) reconstruction, which achieves high-resolution phase recovery with considerably less data than standard FPM.

Siesta/Biscayne

Joint Computational Optical Sensing and Imaging/ Digital Holography & 3-D Imaging

JTh3B • Holographic Microscopy (COSI/DH)—Continued

Orange/Lemon/Lime

Computational Optical Sensing and Imaging

CTh3C • Imaging through Aberrations, Structured Illumination & Super Resolution—Continued

Citron

Digital Holography & 3-D Imaging

DTh3D • Integral Imaging and Holographic Displays—Continued

DTh3D.5 • 15:00
Simple geometrical calibration procedure for a projection-type holographic light-field display, Tomoya Nakamura[1,2], Masahiro Yamaguchi[1]; [1]*School of Engineering, Tokyo Inst. of Technology, Japan;* [2]*PRESTO, Japan Science and Technology Agency, Japan.* Holographic light-field display is a 3D display with a holographic optical element. This paper reports a simple calibration procedure for the matrix-type holographic light-field display, and demonstrate the calibration and 3D imaging.

DTh3D.6 • 15:15
Bandwidth utilization improvement methods of Coarse Integral Holographic video displays, Jin Li[1], Quinn Smithwick[2], Daping Chu[1]; [1]*Univ. of Cambridge, UK;* [2]*Disney Research, USA.* This paper introduces two methods to improve the bandwidth utilization in the Coarse Integral Holographic Display architecture, achieving doubled horizontal field of view and fully utilized bandwidth for the spatial light modulator in use.

Clementine

Adaptive Optics: Methods, Analysis and Applications

OTh3E • Control & Simulations—Continued

OTh3E.6 • 15:00
Numerical Simulation of Atmospheric Tomography with Plenoptic Camera, Cheng Li[1], He Liu[1], Pin Lv[1], Yu Ning[2]; [1]*Inst. of Software Chinese Academy of, China;* [2]*College of Optoelectronic Science and Engineering, National Univ. of Defense Technology, China.* This paper propose that one plenoptic camera has potential to replace several Shack-Hartmann WFS in MCAO, in which way it can rebuild turbulence layers by three NGS or LGS at different heights with lightfield tomography.

15:30–16:00 Coffee Break with Exhibitors, *Palms Foyer*

Orange/Lemon/Lime

Computational Optical Sensing and Imaging

16:00–17:45
CTh4A • Quantum Computational Imaging
Presider: Andy Harvey; University of Glasgow, UK

CTh4A.1 • 16:00
Binarization threshold optimization of ghost imaging, Dongyue Yang[1], Junhui Li[2], Guohua Wu[1], Bin Luo[2], Longfei Yin[1], Hong Guo[3]; [1]*School of Electronic Engineering, Beijing Univ. of Posts and Telecommunications, China;* [2]*State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China;* [3]*State Key Lab of Advanced Optical Communication Systems and Networks, Peking Univ., China.* Quantized discrete sampling, in particular, binarization decreases image quality of ghost imaging. Performance optimizing binarization threshold can approach that without quantization. Median is more likely to be the optimal threshold than the first quantization level.

CTh4A.2 • 16:15
Ghost Imaging With Gram-Schmidt Orthogonalization, Pengqi Yin[1], Longfei Yin[1], Bin Luo[2], Guohua Wu[1], Hong Guo[3]; [1]*School of Electronic Engineering, Beijing Univ. of Posts and Telecommunications, China;* [2]*State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China;* [3]*School of Electronics Engineering and Computer Science, Peking Univ., China.* We orthonormalize the reference patterns those are generated by a pseudo-thermal source and calculate new bucket detector responses. The obtained image quality by new orthonormal references and bucket signals is improved.

CTh4A.3 • 16:30
Comparison between ghost imaging and traditional active optical imaging, WeiTao Liu[1]; [1]*Dept. of Physics, College of Liberal Arts and Sciences, National Univ. of Defense Technology, China.* Considering spatial resolution, robustness, detection sensitivity, data acquisition, we made comparison on features of imaging methods between ghost imaging and traditional active optical imaging, under the same experimental conditions.

CTh4A.4 • 16:45
Demonstration of computational temporal ghost imaging: detecting fast signals beyond bandwidth of detectors, Yao-Kun Xu[1], WeiTao Liu[1]; [1]*Natl Univ Def Tech, China.* The signal with time scale of 50ns can be reconstructed via a 1kHz bandwidth detector based on computational temporal ghost imaging. The performance of our technique using detectors with different bandwidths is also discussed.

CTh4A.5 • 17:00
Imaging the Joint Probability Distribution of Spatially Entangled Photon Pairs with a Camera, Matthew Reichert[1], Hugo Defienne[1], Jason W. Fleischer[1]; [1]*Princeton Univ., USA.* We present massively parallel coincidence counting of entangled photon pairs by measuring coincidences between all pairs of pixels in a single-photon-sensitive camera, including the case where both entangled photons arrive in the same pixel.

Citron

Digital Holography & 3-D Imaging

16:00–18:00
DTh4B • System Design and Data Processing in DH
Presider: Pascal Picart; LAUM CNRS Université du Maine, France

DTh4B.1 • 16:00 Invited
Underwater Digital Holography for Particles Research, Victor V. Dyomin[1]; [1]*Tomsk State Univ., Russia.* Methods for extracting information from underwater digital particle holograms are suggested and tested. A set of DHC-sensors adapted for various purposes is described. Results of hardware and software approbation during the Kara Sea mission are presented.

DTh4B.2 • 16:30
Refocus Criterion Based on the Phase in the Fourier Domain for Automatically Refocusing in Multispectral Digital Holographic Microscopy: Accuracy and Dependency Study, Jerome Dohet-Eraly[2], Catherine Yourassowsky[1], Timothy D. Wilkinson[2], Frank Dubois[1]; [1]*Universite libre de Bruxelles, Belgium;* [2]*Univ. of Cambridge, UK.* The fast autofocus criterion using the phase in the Fourier domain, suitable for digital holographic microscopy when the complex field is known for at least two distinct wavelengths, is deeply investigated, which allows finer adjustment.

DTh4B.3 • 16:45
Normalization method for generalized phase-shifting digital holography, Nobukazu Yoshikawa[1], Syouma Namiki[1], Atsushi Uoya[1]; [1]*Saitama Univ., Japan.* We propose a normalization method for generalized phase-shifting digital holography. We present the norm approximation for phase-shifted holograms using the statistical property of the random phase distribution in the Fresnel diffraction field.

DTh4B.4 • 17:00
Multi-look approaches for phase map de-noising in digital Fresnel holography: comparative analysis, Silvio Montresor[1], Pascale Memmolo[2], Vittorio Bianco[2], Pascal Picart[1,3], Pietro Ferrarro[2]; [1]*LAUM CNRS Le Mans Université, France;* [2]*ISASI-CNR, Italy;* [3]*ENSIM, France.* This paper presents a comparative study of multi-look approaches for de-noising phase maps from digital holography experiments. The results demonstrate that the two-dimensional windowed Fourier transform filtering exhibits the best performance in all cases.

Clementine

Adaptive Optics: Methods, Analysis and Applications

16:00–18:00
OTh4C • Adaptive Optics Systems for the Eye
Presider: Julian Christou; Large Binocular Telescope Observatory

OTh4C.1 • 16:00 Invited
Adaptive Optics and Full-field OCT: the expected gain, Claude A. Boccara[1], Peng C. Xiao[1], Viacheslav Mazlin[1], Jules Scholler[1], Mathias Fink[1]; [1]*Institut Langevin, France.* Full-field Optical Coherence Tomography (FFOCT) offers aberration independent resolution. This property is particularly useful for retinal imaging nevertheless where we have to face signal reduction that often impose adaptive optics (AO).

OTh4C.2 • 16:30 Invited
Adaptive-Optics based visual simulators: from on-bench to wearable devices, Susana Marcos[1], Maria Vinas[1], Carlos Dorronsoro[1], Lucie Sawides[2,1], Enrique Gambra[2,1], Clara Benedi[1], Sara ElAissati[1]; [1]*Consejo Sup Investigaciones Cientificas, Spain;* [2]*2EyesVision, Spain.* Adaptive Optics have become useful tools for basic research in visual psychophysics and neuroscience, in the development of new optical corrections, and in the clinic allowing patients to experience prospective corrections prior to implantation.

OTh4C.3 • 17:00 Invited
Adaptive Optics Systems for Vision Science, Enrique-Josua Fernandez[1]; [1]*Universidad de Murcia, Spain.* Adaptive optics contributes to Vision Science in a two-fold approach: to better image the fundus of the eye, and to study how optics affects our vision. This work will mainly focus on the latter.

Computational Optical Sensing and Imaging

CTh4A • Quantum Computational Imaging—Continued

CTh4A.6 • 17:15
Optimization of light field fluctuation patterns in ghost imaging by mutual coherence minimization based on dictionary learning, Chenyu Hu[1,2], Jian Wang[3], Zengfeng Huang[3], Zhishen Tong[1,2], Liu S. Ying[1,2], Shuang Ma[1,2], Zhentao Liu[1], Shensheng Han[1,2]; [1]*Key Lab for Quantum Optics and Center for Cold Atom Physics of CAS, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China;* [2]*Univ. of Chinese Academy of Sciences, China;* [3]*School of Data Science, Fudan Univ., China.* We propose a scheme of optimization in ghost imaging by minimizing the mutual coherence between measurement matrix and an overcomplete dictionary. Simulation results show the effectiveness of the optimization.

CTh4A.7 • 17:30
Characterizing the optical memory effect using quantum illumination, Hugo Defienne[1], Matthew Reichert[1], Jason W. Fleischer[1]; [1]*Electrical engineering, Princeton Univ., USA.* We introduce a general adaptive quantum optics approach to control spatial entanglement and use it to characterize the optical memory effect of a thin scattering medium.

Digital Holography & 3-D Imaging

DTh4B • System Design and Data Processing in DH—Continued

DTh4B.5 • 17:15
Fringe Projection Profilometry Performed with a Light Field Camera, Xiaoli Liu[1], Zewei Cai[1], Xiang Peng[1], Bruce Z Gao[2]; [1]*Shenzhen Univ., China;* [2]*Dept. of Bioengineering, Clemson Univ., USA.* A method of fringe projection profilometry combined with light field camera recording is introduced to achieve high dynamic range 3D imaging. The modulated fringe phases can be detected from multiple directions with light field camera. And employing a novel ray-based calibration approach, phase-height mapping coefficients and height coordinates along each ray direction can be accurately determined independently. The experimental results illuminate that this multidirectional depth estimation can achieve high dynamic range 3D imaging effectively.

DTh4B.6 • 17:30
A Fast Finite Difference Solver for Digital Holographic Based-Transport of Intensity Equation, Honbo Zhang[4], Partha P. Banerjee[1], Ting-Chung Poon[2], Wen-Jing Zhou[3], Lin Wang[2], Ying Liu[2], Qihao Song[2]; [1]*Dept. of Electro-Optics and Photonics, Univ. of Dayton, USA;* [2]*Electrical and Computer Engineering, Virginia Tech, USA;* [3]*Dept. of Precision Mechanical Engineering, Shanghai Univ., China;* [4]*Computer and Information Sciences, Virginia Military Inst., USA.* Transport of intensity, useful for image phase retrieval, requires multiple intensity recordings along the propagation direction. We propose an efficient and accurate finite-difference TIE solver using a single recorded digital hologram for unwrapped phase reconstruction.

DTh4B.7 • 17:45
Holographic Camera Development by Incoherent Digital Holography, Myung Kim[1]; [1]*Univ. of South Florida, USA.* Three-dimensional imaging holographic camera is being developed based on the principles of self-interference incoherent digital holography. Using a simple optical arrangement and numerical processing, 3D scenes are captured with the ability to numerically refocus to any distance within the scene. We report the progress and current status of the development as well as potential issues.

Adaptive Optics: Methods, Analysis and Applications

OTh4C • Adaptive Optics Systems for the Eye—Continued

OTh4C.4 • 17:30 Invited
Adaptive optics for retinal imaging and new prospects in Flood-Illumination Ophthalmoscopy, Serge Meimon[1], Elena gofas-salas[1], pedro mece[2], Cyril Petit[1], Kate Grieve[3], Laurent Mugnier[1], José-Alain Sahel[3], Michel Paques[3]; [1]*ONERA - The french aerospace lab, France;* [2]*Quantel Médical, France;* [3]*Vision Inst., Quinze-Vingts National Ophthalmology Hospital, Paris, France., France.* The retina is the only optically accessible neurovascular network in the human body. After a brief state of the art, the latest results obtained with our Adaptive Optics Flood-Illumination Ophthalmoscope will be presented.

Key to Authors and Presiders

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