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Imaging Sensors and Systems 2022

MONDAY 17 JANUARY 2022

PLENARY: Quanta Image Sensors: Counting Photons Is the New Game in Town
10:00 – 11:10

Eric R. Fossum, Dartmouth College (United States)

The Quanta Image Sensor (QIS) was conceived as a different image sensor—one that counts photoelectrons one at a time using millions or billions of specialized pixels read out at high frame rate with computation imaging used to create gray scale images. QIS devices have been implemented in a CMOS image sensor (CIS) baseline room-temperature technology without using avalanche multiplication, and also with SPAD arrays. This plenary details the QIS concept, how it has been implemented in CIS and in SPADs, and what the major differences are. Applications that can be disrupted or enabled by this technology are also discussed, including smartphone, where CIS-QIS technology could even be employed in just a few years.

Eric R. Fossum is best known for the invention of the CMOS image sensor "camera-on-a-chip" used in billions of cameras. He is a solid-state image sensor device physicist and engineer, and his career has included academic and government research, and entrepreneurial leadership. At Dartmouth he is a professor of engineering and vice provost for entrepreneurship and technology transfer. Fossum received the 2017 Queen Elizabeth Prize from HRH Prince Charles, considered by many as the Nobel Prize of Engineering "for the creation of digital imaging sensors," along with three others. He was inducted into the National Inventors Hall of Fame, and elected to the National Academy of Engineering among other honors including a recent Emmy Award. He has published more than 300 technical papers and holds more than 175 US patents. He co-founded several startups and co-founded the International Image Sensor Society (IISS), serving as its first president. He is a Fellow of IEEE and OSA.

TUESDAY 18 JANUARY 2022

Image Sensing I
Session Chairs: Jon McElvain, Dolby Laboratories (United States) and Arnaud Peizerat, CEA (France)
11:30 – 12:35

11:30
Conference Introduction

11:35 N/A
Time domain noise analysis of oversampled CMOS image sensors [Presentation-Only], *Andreas Suess, Mathias Wilhelmsen, Liang Zuo, and Boyd Fowler, OmniVision (United States)*

11:55 N/A
A 40/22nm 200MP stacked CMOS image sensor with 0.61μm pixel [Presentation-Only], *Masayuki Uchiyama[1], Geunsook Park[1], Sangjoo Lee[1], Tomoyasu Tate[1], Masashi Minagawa[2], Shino Shimoyamada[2], Zhiqiang Lin[1], King Yeung[1], Lien Tu[1], Wu-Zang Yang[3], Alan Hsiung[1], Vincent Venezia[1], and Lindsay Grant[1]; [1]OmniVision Technologies, Inc. (United States), [2]OmniVision Technologies Japan (Japan), and [3]OmniVision Technologies Taiwan (Taiwan)*

12:15 ISS-155
An offset calibration technique for CIS column-parallel SAR ADC using memory, *Jaekyum Lee[1] and Albert Theuwissen[1,2]; [1]TU Delft (the Netherlands) and [2]Harvest Imaging (Belgium)*

Sensing for Autonomous Driving JOINT SESSION
Session Chairs: Patrick Denny, Valeo Vision Systems (Ireland) and Hari Tagat, Casix (United States)
13:00 – 14:00

This session is hosted jointly by the Autonomous Vehicles and Machines 2022 and Imaging Sensors and Systems 2022 conferences.

13:00 N/A
KEYNOTE: Recent developments in GatedVision imaging - Seeing the unseen [Presentation-Only], *Ofer David, BrightWay Vision (Israel)*

Imaging is the basic building block for automotive autonomous driving. Any computer vision system will require a good image as an input at all driving conditions. GatedVision provides an extra layer on top of the regular RGB/RCCB sensor to augment these sensors at nighttime and harsh weather conditions. GatedVision images in darkness and different weather conditions will be shared. Imagine that you could detect a small target laying on the road having the same reflectivity as the back ground meaning no contrast, GatedVision can manipulate the way an image is captured so that contrast can be extracted. Additional imaging capabilities of GatedVision will be presented.

Ofer David has been BrightWay Vision CEO since 2010. David has more than 20 years' experience in the area of active imaging systems and laser detection, and has produced various publications and patents. Other solutions in which David is involved with, include fog penetrating day/night imaging systems and visibility measurement systems. David received his BSc and MSc from the Technion – Israel Institute of Technology and his PhD in electro-optics from Ben-Gurion University.

13:40 N/A

Potentials of combined visible light and near infrared imaging for driving automation, *Korbinian Weikl[1,2], Damien Schroeder[1], and Walter Stechele[2]; [1]Bayerische Motoren Werke AG and [2]Technical University of Munich (Germany)*

LIDAR and Sensing JOINT SESSION

Session Chairs: Robin Jenkin, NVIDIA Corporation (United States) and Min-Woong Seo, Samsung Electronics (Republic of Korea)
18:00 – 19:00

This session is hosted jointly by the Autonomous Vehicles and Machines 2022 and Imaging Sensors and Systems 2022 conferences.

18:00 N/A

Real-time LIDAR imaging by solid-state single chip beam scanner, *Jisan Lee, Kyunghyun Son, Changbum Lee, Inoh Hwang, Bongyong Jang, Eunkyung Lee, Dongshik Shim, Hyunil Byun, Changgyun Shin, Dongjae Shin, Otsuka Tatsuhiro, Yongchul Cho, Kyoungho Ha, and Hyuck Choo, Samsung Electronics Co., Ltd. (Republic of Korea)*

18:20 N/A

A back-illuminated SOI-based 4-tap lock-in pixel with high NIR sensitivity for TOF range image sensors [Presentation-Only], *Naoki Takada[1], Keita Yasutomi[1], Hodaka Kawanishi[1], Kazuki Tada[1], Tatsuya Kobayashi[1], Atsushi Yabata[2], Hiroki Kasai[2], Noriyuki Miura[2], Masao Okihara[2], and Shoji Kawahito[1]; [1]Shizuoka University and [2]LAPIS Semiconductor Co., Ltd. (Japan)*

18:40 N/A

An 8-tap image sensor using tapped PN-junction diode demodulation pixels for short-pulse time-of-flight measurements [Presentation-Only], *Ryosuke Miyazawa[1], Yuya Shirakawa[1], Kamel Mars[1], Keita Yasutomi[1], Keiichiro Kagawa[1], Satoshi Aoyama[2], and Shoji Kawahito[1]; [1]Shizuoka University and [2]Brookman Technology, Inc. (Japan)*

Processing and AR/VR

Session Chairs: Jon McElvain, Dolby Laboratories (United States) and Jackson Roland, Apple Inc. (United States)
19:15 – 20:15

19:15 N/A

KEYNOTE: Sensing and computing technologies for AR/VR [Presentation-Only], *Chiao Liu, Meta Reality Labs Research (United States)*

Augmented and Virtual Reality (AR/VR) will be the next great wave of human oriented computing, dominating our relationship with the digital world for the next 50 years, much as personal computing has dominated the last 50. AR glasses require multiple cameras to enable all the computer vision (CV) and AI functions while operating under stringent weight, power, and socially acceptable form factor constraints. The AR sensors need to be small, ultra-low power, with wide dynamic range (DR) and excellent low light sensitivity to support day/night, indoor/outdoor, all day wearable use cases. The combination of lowest power, best performance, and minimal form factor makes AR sensors the new frontier in the image sensors field. In this talk, we will first introduce some CV and AI functions to be supported by AR sensors and their associated camera sensor requirements. We will then present a new ultra-low power, ultra-wide dynamic range Digital Pixel sensor (DPS) designed to meet above specific challenges. Finally, we will discuss some system level tradeoffs and architecture directions.

Chiao Liu received his PhD in EE from Stanford University. He was a Senior Scientist at Canesta Inc (now part of Microsoft), developing the very first CMOS time-of-flight (ToF) depth sensors. He was a Technical Fellow at Fairchild Imaging (now part of BAE Systems), and worked on a wide range of scientific and medical imaging systems. In 2012, he joined Microsoft as a Principal Architect and was part of the 1st generation Microsoft AR Hololens team. Currently he is the director of research at Meta Reality Labs Research, leading the Sensors and Systems Research team. Liu is a member of the IEEE International Electron Devices Meeting (IEDM) technical committee. He also served as guest reviewer for Nature and IEEE Transactions on Electron Devices.

19:55 ISS-183

On quantization of convolutional neural networks for image restoration, *Youngil Seo, Irina Kim, Jeongguk Lee, Wooseok Choi, and Seongwook Song, Samsung Electronics Co., Ltd. (Republic of Korea)*

WEDNESDAY 19 JANUARY 2022

PLENARY: In situ Mobility for Planetary Exploration: Progress and Challenges

10:00 – 11:15

Larry Matthies, Jet Propulsion Laboratory (United States)

This year saw exciting milestones in planetary exploration with the successful landing of the Perseverance Mars rover, followed by its operation and the successful technology demonstration of the Ingenuity helicopter, the first heavier-than-air aircraft ever to fly on another planetary body. This plenary highlights new technologies used in this mission, including precision landing for Perseverance, a vision coprocessor, new algorithms for faster rover traverse, and the ingredients of the helicopter. It concludes with a survey of challenges for future planetary mobility systems, particularly for Mars, Earth's moon, and Saturn's moon, Titan.

Larry Matthies received his PhD in computer science from Carnegie Mellon University (1989), before joining JPL, where he has supervised the Computer Vision Group for 21 years, the past two coordinating internal technology investments in the Mars office. His research interests include 3-D perception, state estimation, terrain classification, and dynamic scene analysis for autonomous navigation of unmanned vehicles on Earth and in space. He has been a principal investigator in many programs involving robot vision and has initiated new technology developments that impacted every US Mars surface mission since 1997, including visual navigation algorithms for rovers, map matching algorithms for precision landers, and autonomous navigation hardware and software architectures for rotorcraft. He is a Fellow of the IEEE and was a joint winner in 2008 of the IEEE's Robotics and Automation Award for his contributions to robotic space exploration.

Processing II

Session Chairs: Jackson Roland, Apple Inc. (United States) and Nitin Sampat, Edmund Optics, Inc. (United States)

13:50 – 14:50

13:50 N/A

Equivalent ray optics model to enable imaging system simulation of 3D scenes [Presentation-Only], *Thomas Goossens[1], Zheng Lyu[1], Jamyuen Ko[2], Gordon Wan[2], Ricardo Motta[2], Joyce Farrell[1], and Brian Wandell[1]; [1]Stanford University and [2]Google Inc. (United States)*

14:10 ISS-231

Using images of partially visible chart for multi-camera system calibration, *Radka Tezaur, Gazi Ali, and Oscar Nestares, Intel Corporation (United States)*

14:30 ISS-232

ESP32-CAM as a programmable camera research platform, *Henry G. Dietz, Dillon Abney, Paul Eberhart, Nick Santini, William Davis, Elisabeth Wilson, and Michael McKenzie, University of Kentucky (United States)*

Image Sensing II

Session Chairs: Boyd Fowler, OmniVision Technologies, Inc. (United States) and Francisco Imai, Apple Inc. (United States)

18:00 – 19:00

18:00 ISS-242

Accurate event simulation using high-speed video, *Xiaozheng Mou, Kaijun Feng, Alex Yi, Steve Wang, Huan Chen, Xiaoqin Hu, Menghan Guo, Shoushun Chen, and Andreas Suess, OmniVision (United States)*

18:20 N/A

Perfect RGB color routers for sub-wavelength size CMOS image sensor pixels [Presentation-Only], *Peter B. Catrysse, Nathan Zhao, and Shanhui Fan, Stanford University (United States)*

18:40 N/A

An anti-UV organic material integrated microlens for automotive CIS [Presentation-Only], *William Tsai, Chia-Chien Hsieh, Yuan-Shuo Chang, Sheng-Chuan Cheng, Ching-Chiang Wu, and Ken Wu, VisEra (Taiwan)*

Imaging Sensors and Systems 2022 Evening Interactive Poster Session
19:00 – 19:30

ISS posters on display in the EI 2022 Posters session in the morning will be presented by the authors during this evening ISS poster session.

ISS-199

P-14: Capture optimization for composite images, *Henry G. Dietz and Dillon Abney, University of Kentucky (United States)*

ISS-200

P-15: DePhaseNet: A deep convolutional network using phase differentiated layers and frequency based custom loss for RGBW image sensor demosaicing, *Irina Kim, Youngil Seo, Dongpan Lim, Jeongguk Lee, Wooseok Choi, and Seongwook Song, Samsung Electronics Co., Ltd. (Republic of Korea)*

ISS-201

P-16: The study and analysis of using CMY color filter arrays for 0.8 um CMOS image sensors, *Pohsiang Wang, An-Li Kuo, Ta-Yung Ni, Hao-Wei Liu, Yu C. Chang, Ching-Chiang Wu, and Ken Wu, VisEra Technologies (Taiwan)*

Image Sensing III
Session Chairs: Boyd Fowler, OmniVision Technologies, Inc. (United States) and Nitin Sampat, Edmund Optics, Inc. (United States)
19:30 – 20:30

19:30 ISS-256

Design and analysis on low-power and low-noise single slope ADC for digital pixel sensors, *Hyun-Yong Jung, Myonglae Chu, Min-Woong Seo, Suksan Kim, Jiyoun Song, Sang-Gwon Lee, Sung-Jae Byun, Minkyung Kim, Daehee Bae, Junan Lee, Sung-Yong Lee, Jongyeon Lee, Jonghyun Go, Jae-kyu Lee, Chang-Rok Moon, and Hyoung-Sub Kim, Samsung Electronics Co., Ltd. (Republic of Korea)*

19:50 ISS-257

World's first 16:4:1 triple conversion gain sensor with all-pixel AF for 82.4dB single exposure HDR, *ChangHyun Park, HongSuk Lee, EunSub Shim, JungBin Yun, KyungHo Lee, Yunhwan Jung, Sukki Yoon, Ilyun Jeong, JungChak Ahn, and Duckhyun Chang, Samsung Electronics Co., Ltd. (Republic of Korea)*

20:10 ISS-258

3-Layer stacked pixel-parallel CMOS image sensors using hybrid bonding of SOI wafers, *Masahide Goto[1], Yuki Honda[1], Masakazu Nanba[1], Yoshinori Iguchi[1], Takuya Saraya[2], Masaharu Kobayashi[2], Eiji Higurashi[3], Hiroshi Toshiyoshi[2], and Toshiro Hiramoto[2]; [1]NHK Science & Technology Research Laboratories, [2]The University of Tokyo, and [3]National Institute of Advanced Industrial Science and Technology (Japan)*

TUESDAY 25 JANUARY 2022

PLENARY: Physics-based Image Systems Simulation
10:00 – 11:00

Joyce Farrell, Stanford Center for Image Systems Engineering, Stanford University, CEO and Co-founder, ImagEval Consulting (United States)

Three quarters of a century ago, visionaries in academia and industry saw the need for a new field called photographic engineering and formed what would become the Society for Imaging Science and Technology (IS&T). Thirty-five years ago, IS&T recognized the massive transition from analog to digital imaging and created the Symposium on Electronic Imaging (EI). IS&T and EI continue to evolve by cross-pollinating electronic imaging in the fields of computer graphics, computer vision, machine learning, and visual perception, among others. This talk describes open-source software and applications that build on this vision. The software combines quantitative computer graphics with models of optics and image sensors to generate physically accurate synthetic image data for devices that are being prototyped. These simulations can be a powerful tool in the design and evaluation of novel imaging systems, as well as for the production of synthetic data for machine learning applications.

Joyce Farrell is a senior research associate and lecturer in the Stanford School of Engineering and the executive director of the Stanford Center for Image Systems Engineering (SCIEN). Joyce received her BS from the University of California at San Diego and her PhD from Stanford University. She was a postdoctoral fellow at NASA Ames Research Center, New York University, and Xerox PARC, before joining the research staff at Hewlett Packard in 1985. In 2000 Joyce joined Shutterfly, a startup company specializing in online digital photofinishing, and in 2001 she formed ImagEval Consulting, LLC, a company specializing in the development of software and design tools for image systems simulation. In 2003, Joyce returned to Stanford University to develop the SCIEN Industry Affiliates Program.

PANEL: The Brave New World of Virtual Reality

11:00 – 12:00

Advances in electronic imaging, computer graphics, and machine learning have made it possible to create photorealistic images and videos. In the future, one can imagine that it will be possible to create a virtual reality that is indistinguishable from real-world experiences. This panel discusses the benefits of this brave new world of virtual reality and how we can mitigate the risks that it poses. The goal of the panel discussion is to showcase state-of-the art synthetic imagery, learn how this progress benefits society, and discuss how we can mitigate the risks that the technology also poses. After brief demos of the state-of-their-art, the panelists will discuss: creating photorealistic avatars, Project Shoah, and digital forensics.

Panel Moderator: Joyce Farrell, Stanford Center for Image Systems Engineering, Stanford University, CEO and Co-founder, ImagEval Consulting (United States)
Panelist: Matthias Neissner, Technical University of Munich (Germany)
Panelist: Paul Debevec, Netflix, Inc. (United States)
Panelist: Hany Farid, University of California, Berkeley (United States)