IS&T International Symposium on

Electronic Imaging

SCIENCE AND TECHNOLOGY

28 January 2018 – 1 February 2018 • Burlingame, CA, USA

PROCEEDINGS

Autonomous Vehicles and Machines 2018

Editors: **Patrick Denny,** Valeo (Ireland),
Darnell Moore, Texas Instruments (United States)
Buyue Zhang, Intel Corporation (United States)

These papers represent the program of Electronic Imaging 2018,
held 28 January – 1 February 2018, at the Hyatt Regency San Francisco Airport in Burlingame, CA.

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Autonomous Vehicles and Machines 2018

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Introduction
On behalf of the Conference Committee, we like to begin by thanking the authors, keynotes, and participants who attended the Second Annual Conference on Autonomous Vehicles and Machines (AVM), held during the 2018 IS&T International Symposium on Electronic Imaging (EI2018) in Burlingame, California near San Francisco from January 28th – February 1st. We were thrilled to see the number of submissions double over last year's inaugural conference, with strong technical contributions balanced between academia and industry. Attendance was also up sharply this year, with capacity crowds filling the large meeting rooms of the Hyatt Regency San Francisco Airport.

Continuing last year's format of 20-minute oral presentations, AVM offered seven sessions where speakers presented novel contributions to push the state-of-the-art across a wide gamut of topics, including:

- Automotive Image Quality
- Simulation for Autonomous Vehicles and Machines
- Mapping and Localization
- Sensor Fusion
- Robotic Vision Techniques for Navigation and Vision
- System, Imaging, and Vision Architecture
- Imaging Sensors and Technologies for Automotive Intelligence

AVM also offered three outstanding keynote presentations from industry leaders:

- Future with Autonomous Vehicle (Luc Vincent, Lyft Inc.)
- Mapping and Localization (Sravan Puttagunta, Civil Maps)
- Imaging Sensors and Technologies for Automotive Intelligence (Boyd Fowler, OmniVision)

We invite you to read the papers in the proceedings and consider making submissions for next year's conference. Please visit the AVM page at http://electronicimaging.org for Call for Paper announcements and other important dates.

— Buyue Zhang, Ph.D, Intel
Darnell Moore, Ph.D, Texas Instruments
Patrick Denny, Ph.D, Valeo

AVM 2018 thanks Conference Sponsor

Autonomous Vehicles and Machines 2018

Monday January 29, 2018

Automotive Camera Image Quality I Joint Session

Session Chairs: Stuart Perry, University of Technology Sydney (Australia) and Buyue Zhang, Intel Corporation (United States)

8:50 – 10:20 am
Grand Peninsula Ballroom BC

This session is jointly sponsored by: Autonomous Vehicles and Machines 2018, and Image Quality and System Performance XV.

8:50   AVM-105
Fundamental imaging system analysis for autonomous vehicles, *Robin Jenkin and Paul Kane, ON Semiconductor (United States)*

9:20   AVM-106 [no paper]
Optimizing automotive cameras for image quality, *Felix Heide and Dave Tokic, Algolux (Canada)*

9:40   IQSP-107
Color calibration of digital still cameras used on unmanned aerial vehicles, *Susan Farnand, Rochester Institute of Technology (United States)*

10:00   IQSP-108
No reference prediction of quality metrics for H.264 compressed infrared image sequences for UAV applications, *Kabir Hossain, Claire Mantel, and Soren Forchhammer, Technical University of Denmark (Denmark)*

10:20 – 10:50 am   Coffee Break

Automotive Camera Image Quality II Joint Session

Session Chairs: Luke Cui, Amazon (United States) and Darnell Moore, Texas Instruments (United States)

10:50 am – 12:40 pm
Grand Peninsula Ballroom BC

This session is jointly sponsored by: Autonomous Vehicles and Machines 2018, and Image Quality and System Performance XV.

10:50   AVM-145 [no paper]
P2020 - standard for automotive system image quality, *Patrick Denny, Valeo Vision Systems (Ireland)*

11:20   AVM-146
LED flicker: Root cause, impact and measurement for automotive imaging applications, *Brian Deegan, Valeo Vision Systems (Ireland)*

11:40   AVM-147
Visual quality evaluation of the multi-camera visualization in automotive surround view systems, *Vladimir Zlokolica[1,2], Mark Griffin[1], Aidan Casey[1], Daniela Solera[1], Brian Deegan[1], Patrick Denny[1], and Barry Dever[1]; [1]Valeo Vision Systems (Ireland) and [2]University of Novi Sad (Serbia)*

12:00   AVM-148
Detection probabilities: Performance prediction for sensors of autonomous vehicles, *Marc Geese, Ulrich Seger, and Alfredo Paolillo, Robert Bosch GmbH - Leonberg (Germany)*

12:20   AVM-149
Realistic image degradation with a measured PSF, *Christian Wittpahl, Hatem Ben Zakour, Matthias Lehmann, and Alexander Braun, Düsseldorf University of Applied Sciences (Germany)*

12:40 – 2:00 pm   Lunch

Plenary Session

2:00 – 3:00 pm
Grand Peninsula Ballroom D

Overview of Modern Machine Learning and Deep Neural Networks - Impact on Imaging and the Field of Computer Vision, *Greg Corrado, Google, Inc. (United States)*

Dr. Greg Corrado, co-founder of Google Brain, principal scientist, and director of augmented intelligence research at Google, provides an overview of modern machine learning and deep neural networks, with particular attention to its impact on imaging and the field of computer vision.

Dr. Corrado is a senior research scientist interested in biological neuroscience, artificial intelligence, and scalable machine learning. He has published in fields ranging across behavioral economics, neuromorphic device physics, systems neuroscience, and deep learning. At Google he has worked for some time on brain inspired computing, and most recently has served as one of the founding members and the co-technical lead of Google's large scale deep neural networks project. Prior to joining Google, Dr. Corrado was a staff research scientist at IBM. He received his MS in computer science and PhD in neuroscience from Stanford University.

3:00 – 3:30 pm   Coffee Break

Simulation for Autonomous Vehicles and Machines Joint Session

Session Chairs: Peter Catrysse, Stanford Univ. (United States); Patrick Denny, Valeo Vision System (Ireland); and Darnell Moore, Texas Instruments (United States)

3:30 – 4:50 pm
Grand Peninsula Ballroom BC

This session is jointly sponsored by: Autonomous Vehicles and Machines 2018, and Photography, Mobile, and Immersive Imaging 2018.

3:30   PMII-161
Image systems simulation for automotive intelligence, *Henryk Blasinski, Trisha Lian, Joyce Farrell, and Brian Wandell, Stanford University (United States)*

3:50   AVM-162 [no paper]
Large scale collaborative autonomous vehicle simulation on smartphones, *Andras Kemeny[1,2], Emmanuel Icart[3], and Florent Colombet[2]; [1]Arts et Métiers ParisTech, [2]Renault-Nissan, and [3]Scale-1 Portal (France)*

4:10   AVM-163
Auto-simulator preparation for research into assessing the correlation between human driving behaviors and fixation patterns, *Mingming Wang, Kate Walders, Martin E. Gordon, Jeff B. Pelz, and Susan Farnand; Rochester Institute of Technology (United States)*

4:30   AVM-164
Virtual simulation platforms for automated driving: Key care-about and usage model, *Prashanth Viswanath, Mihir Mody, Soyeb Nagori, Jason Jones, and Hrushikesh Garud, Texas Instruments India Ltd. (India)*

5:00 – 6:00 pm   All-Conference Welcome Reception

Tuesday, January 30, 2018

7:15 – 8:45 am   Women in Electronic Imaging Breakfast

Keynote: Future with Autonomous Vehicles
Session Chair: Buyue Zhang, Intel Corporation (United States)
9:10 – 10:10 am
Grand Peninsula Ballroom BC

AVM-198 [no paper]

Lyft's approach to autonomous vehicles, *Luc Vincent, Lyft, Inc. (United States)*

Dr. Luc Vincent is vice president of engineering at Lyft, where he leads the company's Marketplace & Autonomous Platform division. His responsibilities include real-time supply and demand matching, real-time pricing, mapping, and also Lyft's "Level 5" group, focused on Self-Driving Technology. Prior to Lyft, he spent 12 years at Google, most recently as Sr Director of Engineering, leading all imagery-related activities of Google's Geo group. His team of engineers, product managers, program managers, and operations experts was responsible for collecting ground-based, aerial, and satellite imagery at global scale and through computer vision, 3D modeling, and deep learning, make it universally accessible and useful to users around the world - from end-users on a mobile phone to geo scientists researching climate change. Dr. Vincent is recognized in particular for having bootstrapped Street View and turned it into an iconic Google product, available in over 80 countries around the globe. He earned his BS from Ecole Polytechnique (France), MS in computer science from University of Paris XI, and PhD in mathematical morphology from Ecole des Mines de Paris. In addition, he was a postdoctoral fellow in the Division of Applied Sciences of Harvard University.

10:00 am – 7:30 pm   Industry Exhibition

10:10 – 10:40 pm   Coffee Break

Keynote: Mapping and Localization
Session Chair: Buyue Zhang, Intel Corporation (United States)
10:40 – 11:40 am
Grand Peninsula Ballroom BC

AVM-216 [no paper]

Scalable autonomous vehicle mapping and localization on the edge, *Sravan Puttagunta, Civil Maps (United States)*

Sravan Puttagunta is a co-founder and chief executive officer of Civil Maps, an autonomous vehicle technology company that enables cars to have Cognition through AI, 3D mapping, advanced localization, and crowdsourcing. As CEO, he is executing on a vision for safer, smarter, fully autonomous driving. With his direction, Civil Maps is on track to triple revenue from last year and is providing key technology to several major automakers. He leads the company's technology teams, who are developing innovative ways for cars to localize in six dimensions (6D) and crowdsource 3D maps at a continental scale. In his previous work, he invented video fingerprinting for linear broadcast TV to track viewing habits and developed software that runs in more than 160 million TVs. He has written substantial portions of artificial intelligence (AI) algorithms for cars which map the world in 3D. Puttagunta holds a master's in electrical engineering and computer science from the University of California, Berkeley.

Sensor Fusion

Session Chairs: Umit Batur, Rivian Automotive (United States) and Darnell Moore, Texas Instruments (United States)

11:40 am – 12:40 pm
Grand Peninsula Ballroom BC

11:40   AVM-256
Multi-sensor fusion for automated driving: Selecting model and optimizing on embedded platform, *Shyam Jagannathan, Mihir Mody, Jason Jones, Pramod Swami, and Deepak Poddar, Texas Instruments India Ltd. (India)*

12:00   AVM-257
Multi-sensor data fusion for vehicle detection in autonomous vehicle applications, *Abu Hasnat Mohammad Rubaiyat[1], Yaser Fallah[2], Xin Li[3], and Gaurav Bansal[4]; [1]University of Virginia, [2]University of Central Florida, [3]West Virginia University, and [4]Toyota (United States)*

12:20   AVM-258
Camera radar fusion for increased reliability in ADAS applications, *Ziguo Zhong, Stanley Liu, Manu Mathew, and Aish Dubey, Texas Instruments (United States)*

12:40 – 2:00 pm   Lunch

Plenary Session

2:00 – 3:00 pm
Grand Peninsula Ballroom D

Fast, Automated 3D Modeling of Buildings and Other GPS Denied Environments, *Avideh Zakhor, University of California, Berkeley (United States)*

Professor Avideh Zahkor discusses fast, automated 3D modeling of buildings and other GPS denied environments with examples from her work in 3D reality capture, and visual and metric documentation of building interiors. Dr. Zakhor is a serial entrepreneur with startups in outdoor mapping, indoor mapping, and micro-lithography, currently CEO and founder of Indoor Reality, a Silicon Valley startup with products in 3D reality capture, and visual and metric documentation of building interiors.

Dr. Zakhor has been faculty member at University of California, Berkeley since 1994 where she holds the Qualcomm Chair in the electrical engineering and computer science department. She co-founded OPC technology in 1996, which was acquired by Mentor Graphics in 1998, and UrbanScan Inc. in 2005, acquired by Google in 2007. UrbanScan created the first fully automated 3D outdoor mapping system for 3D exterior models of buildings in urban environments. She has received a number of best paper awards in 3D computer vision, image processing, signal processing, is an IEEE fellow, and received the presidential young investigator award in 1992. Dr. Zakhor received her BSc in electrical engineering, from the California Institute of Technology (1983), and her MS (1985) and PhD (1987) in electrical engineering and computer science from MIT.

3:00 – 3:30 pm   Coffee Break

Mapping and Localization

Session Chairs: Umit Batur, Rivian Automotive (United States) and Patrick Denny, Valeo Vision System (Ireland)

3:30 – 5:20 pm
Grand Peninsula Ballroom BC

3:30   AVM-280 [no paper]
VOLA large-scale volumetric data for map-building, navigation, autonomy, and machine intelligence at global scale, *David Moloney, Movidius (Intel) (Ireland)*

4:00   AVM-281
Visual SLAM and localization – the hard cases, *Catherine Enright[1] and [2]Bassam Abdallah; [1]Valeo Vision Systems (Ireland) and [2]Valeo Driving Assistance Research (France)*

4:20   AVM-282
Dense surround view computation with perspective correctness, *Christian Fuchs and Dietrich Paulus, University of Koblenz-Landau (Germany)*

4:40   AVM-283 [see IRIACV proceedings]
Vehicle pose estimation from drive recorder images by monocular SLAM and matching with rendered 3D point cloud of surrounding environment, *Akiyoshi Kurobe[1], Hideo Saito[1], and Hisashi Kinoshita[2]; [1]Keio University and [2]DENSO Corporation (Japan)*

5:00   AVM-284
Loop closure detection in simultaneous localization and mapping using learning based local patch descriptor, *Dong-won Shin and Yo-Sung Ho, Gwangju Institute of Science and Technology (Republic of Korea)*

Symposium Demonstration Session

5:30 – 7:30 pm
Grand Peninsula Ballroom E

Wednesday, January 31, 2018

Robotic Vision Techniques for Navigation and Vision I JOINT SESSION

Session Chairs: Patrick Denny, Valeo Vision System (Ireland) and Darnell Moore, Texas Instruments (United States)

8:50 – 10:10 am
Grand Peninsula Ballroom BC

This session is jointly sponsored by: Autonomous Vehicles and Machines 2018, and Intelligent Robotics and Industrial Applications using Computer Vision 2018.

8:50   IRIACV-301
Reliable primitive approximation for estimation of robot grasping parameters using 3D-deep neural network, *Takuya Torii and Manabu Hashimoto, Chukyo University (Japan)*

9:10   IRIACV-302
Real-time visual loop closure detection for unmanned aerial vehicles, *Semih Karakaya[1], Can Erhan[1], Evangelos Sariyanidi[2], and Hakan Temeltas[1]; [1]Istanbul Teknik Üniversity (Turkey) and [2]Queen Mary University of London (United Kingdom)*

9:30   AVM-303 [no paper]
Semantic image segmentation using Encoder-Decoder Architecture Assisted by Global and Local Attention Models (EDA-GLAM), *Hao Xu, Siyang Li, and Chun-Chieh Kuo, Univeristy of Southern California (United States)*

9:50   AVM-304 [no paper]
A method for reducing the false positives in power line detection, *Alexander Cerón, University Militar Nueva Granada (Colombia)*

10:00 am – 4:00 pm   Industry Exhibition

10:10 – 10:50 pm   Coffee Break

Robotic Vision Techniques for Navigation and Vision II JOINT SESSION

Session Chairs: Patrick Denny, Valeo Vision System (Ireland) and Darnell Moore, Texas Instruments (United States)

10:50 am – 12:40 pm
Grand Peninsula Ballroom BC

This session is jointly sponsored by: Autonomous Vehicles and Machines 2018, and Intelligent Robotics and Industrial Applications using Computer Vision 2018.

10:50   AVM-345
Pedestrian detection at night using deep neural networks and saliency maps (JIST-first), *Duyoung Heo, EunJu Lee, and Byoung Chul Ko, Keimyung University (Republic of Korea)*

11:10   AVM-346
Context aware hyperspectral scene analysis, *Christian Winkens and Dietrich Paulus, University of Koblenz-Landau (Germany)*

11:30   AVM-347
Multiple pedestrian tracking in moving vehicle using online learning of random ferns and feature descriptor of pre-trained shallow convolutional neural networks, *SangJun Kim, Jaeyeal Nam, and ByoungChul Ko, Keimyung University (Republic of Korea)*

11:50   AVM-348
Raindrop detection considering extremal regions and salient features, *Vijay C S, Radhesh Bhat, and Vijaya Ragavan, PathPartner Technology Pvt Ltd. (India)*

12:10   AVM-349 [no paper]
Removing shadows and shading from road surfaces in real time, *Bruce Maxwell and Casey Smith, Tandent Vision Science, Inc. (United States)*

12:40 – 2:00 pm   Lunch

Plenary Session

2:00 – 3:00 pm
Grand Peninsula Ballroom D

Ubiquitous, Consumer AR Systems to Supplant Smartphones, *Ronald T. Azuma, Intel, Corp. (United States)*

Dr. Ronald T. Azuma, researcher and augmented reality pioneer, shares his vision for achieving ubiquitous, consumer AR systems. Recent large investments in augmented reality reflect the commercial interest in its inherent potential to replace current smartphone technology, but much remains to be done. In his talk, Dr. Azuma gives a vision for achieving this goal, which requires not just solving numerous technical challenges but also determining new, compelling AR experiences that will establish AR as a new platform and novel form of media.

Dr. Azuma leads a team in Intel Labs that designs and prototypes novel experiences and key enabling technologies to enable new forms of media. These technology areas include computational imaging and photography, computational displays, and head-worn displays. Dr. Azuma is recognized as a pioneer and innovator in augmented reality, and has held prominent leadership roles in that research area, including leading and implementing research projects and demonstrations in areas such as AR, visualization, and mobile applications. Dr. Azuma received his BSc (1988) in electrical engineering from University of California, Berkeley, and MS (1990) and PhD (1995) in computer science from University of North Carolina, Chapel Hill. Prior to joining Intel, he was a research leader at Nokia Research Center Hollywood, and a senior researcher at Hughes Research Laboratories.

3:00 – 3:30 pm   Coffee Break

System, Imaging, and Vision Architecture

Session Chairs: Patrick Denny, Valeo Vision System (Ireland) and Darnell Moore, Texas Instruments (United States)

3:30 – 4:10 pm
Grand Peninsula Ballroom BC

3:30   AVM-358
Understanding vehicle E/E architecture topologies for automated driving: System partitioning and tradeoff parameters, *Mihir Mody, Jason Jones, Kedar Chitnis, Rajat Sagar, Gregory Shurtz, Yashwant Dutt, Manoj Koul, Biju Mg, and Aish Dubey, Texas Instruments India Ltd. (India)*

3:50   AVM-359 [no paper]
Camera-aware neural architecture for robust automotive vision, *Felix Heide and Dave Tokic, Algolux (Canada)*

Discussion: Autonomous Vehicles and Machines 2018
Moderators: Patrick Denny, Valeo Vision System (Ireland); Darnell Moore, Texas Instruments (United States); and Buyue Zhang, Intel Corporation (United States)
4:10 – 5:30 pm
Grand Peninsula Ballroom BC

The conference chairs invite AVM authors and participants to join an interactive session to discuss questions in a moderated open forum.

4:10
Autonomous Vehicles and Machines Authors Q&A

5:00
Open Discussion

Symposium Interactive Papers (Poster) Session

5:30 – 7:30 pm
The Grove

Meet the Future: A Showcase of Student and Young Professionals Research

5:30 – 7:30 pm
The Grove

Thursday, February 1, 2018

Keynote: Imaging Sensors and Technologies for Automotive Intelligence JOINT SESSION
Session Chairs: Arnaud Darmont, APHESA SPRL (Belgium); Joyce Farrell, Stanford University (United States); and Darnell Moore, Texas Instruments (United States)
8:50 – 9:30 am
Grand Peninsula Ballroom BC

This session is jointly sponsored by: Autonomous Vehicles and Machines 2018, Image Sensors and Imaging Systems 2018, and Photography, Mobile, and Immersive Imaging 2018.

PMII-415

Advances in automotive image sensors, *Boyd Fowler[1] and Johannes Solhusvik[2]; [1]OmniVision Technologies (United States) and [2]OmniVision Technologies Europe Design Center (Norway)*

Dr. Boyd Fowler joined OmniVision in December 2015 as the vice president of marketing and was appointed chief technology officer in July 2017. Dr. Fowler's research interests include CMOS image sensors, low noise image sensors, noise analysis, data compression, and machine learning and vision. Prior to joining OmniVision, he was co-founder and vice president of engineering at Pixel Devices, where he focused on developing high-performance CMOS image sensors. After Pixel Devices was acquired by Agilent Technologies, Dr. Fowler was responsible for advanced development of commercial CMOS image sensor products. In 2003, Dr. Fowler joined Fairchild Imaging as the CTO and vice president of technology, where he developed SCMOS image sensors for high-performance scientific applications. After Fairchild Imaging was acquired by BAE Systems, Dr. Fowler was appointed the technology director of the CCD/CMOS image sensor business. He has authored numerous technical papers, book chapters, and patents. Dr. Fowler received his MSEE and PhD in electrical engineering from Stanford University (1990 and 1995 respectively).

Imaging Sensors and Technologies for Automotive Intelligence JOINT SESSION
Session Chairs: Arnaud Darmont, APHESA SPRL (Belgium); Patrick Denny, Valeo Vision System (Ireland); and Joyce Farrell, Stanford University (United States)
9:30 – 9:50 am
Grand Peninsula Ballroom BC

This session is jointly sponsored by: Autonomous Vehicles and Machines 2018, Image Sensors and Imaging Systems 2018, and Photography, Mobile, and Immersive Imaging 2018.

9:30   IMSE-422
Partial reset HDR image sensor with improved fixed pattern noise performance, *Volodymyr Seliuchenko[1,2], Sharath Patil[1,3], Marcelo Mizuki[1], Saad Ahmad[1], and Maarten Kuijk[2]; [1]Melexis (Belgium), [2]Vrije University Brussel (Belgium), and [3]University of Massachusetts Lowell (United States)*

Autonomous Vehicles and Machines Open Discussion
Moderators: Patrick Denny, Valeo Vision System (Ireland); Darnell Moore, Texas Instruments (United States); and Buyue Zhang, Intel Corporation (United States)
9:50 – 10:30 am
Grand Peninsula Ballroom BC

The conference chairs invite AVM committee members, authors, and conference participants to join an interactive session to discuss various topics in this open forum. Please join us in building the AVM community.