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PROCEEDINGS

Stereoscopic Displays and Applications XXXII

Editors: **Andrew J. Woods,** Curtin University (Australia),
Gregg E. Favalora, Draper (United States),
Nicolas S. Holliman, Newcastle University (United Kingdom), and
Takashi Kawai, Waseda University (Japan)

These papers represent the program of Electronic Imaging 2021, held online 11–28 January 2021.

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Stereoscopic Displays and Applications XXXII

Conference overview

The World's Premier Conference for 3D Innovation

The Stereoscopic Displays and Applications Conference (SD&A) focuses on developments covering the entire stereoscopic 3D imaging pipeline from capture, processing, and display to perception. The conference brings together practitioners and researchers from industry and academia to facilitate an exchange of current information on stereoscopic imaging topics. The highly popular conference demonstration session provides authors with a perfect additional opportunity to showcase their work. Large-screen stereoscopic projection is available, and presenters are encouraged to make full use of these facilities during their presentations. Publishing your work at SD&A offers excellent exposure—across all publication outlets, SD&A has the highest proportion of papers in the top 100 cited papers in the stereoscopic imaging field (Google Scholar, May 2013).

Event

3D Theatre Online

Paper authors listed as of 1 January 2021; refer to manuscript for final authors. Titles that are not listed with the proceedings files were presentation-only.

Stereoscopic Displays and Applications XXXII

SATURDAY 16 JANUARY 2021 AND SUNDAY 17 JANUARY 2021

2021 SD&A 3D THEATER SESSION

Hosts: Eric Kurland, 3-D SPACE (United States); John Stern, retired (United States); and Andrew Woods, Curtin University (Australia)
Held during various times

This perennially popular session of the annual Stereoscopic Displays and Applications Conference showcases the wide variety of 3D films produced and exhibited around the world. It is open to the public and all attendees of the Electronic Imaging symposium, SD&A's parent. Since this year's conference will be 100% online, the 3D Theater Session will stream in full 3D for home viewing. We will break from the tradition of screening only recent 3D films, and instead screen a retrospective of our Best-of-Show award winners from the past decade. This family-friendly event is suitable for viewing either on a compatible 3D TV or with standard red-cyan anaglyph 3D glasses (provide your own). The 3D Theater Session will live-stream at three appropriate times in order to accommodate conference attendees in the Americas, Europe, and Asia starting Saturday January 16, but will not otherwise be available on-demand. Registration is available for this free event via Eventbrite.

MONDAY 18 JANUARY 2021

SD&A INVITED SESSION

Moderator: Gregg Favalora, The Charles Stark Draper Laboratory, Inc. (United States) / **Session Chair:** Nicolas Holliman, University of Newcastle (United Kingdom)
10:15 – 11:15

10:15 SD&A-049
Looking back at a wonderful decade shooting live-action 3D (Invited), *Demetri Portelli, I.A.T.S.E. International Cinematographer's Guild (Canada)*

Invited speaker Demetri Portelli is known for his live action stereography. He has more than 25 years of technical camera experience as a member of the IATSE, the International Cinematographer's Guild. He is also a camera operator and a technician. He was trained in fine arts, worked extensively in the theatre growing up, taught himself cameras with Super8mm, 16mm, and 35mm shorts and music videos before his professional career started. In his role as stereographer and stereo supervisor, Portelli is hands-on during shooting and post-production. He is extremely precise executing stereo on-the-fly, with IO adjustments to 'bake-in' the best possible 3D depth, volumetric shape, and audience proximity. Working alongside the director and cinematographer, his goal is always to design a truly engaging 3D experience from depth planning to shot conception, and through post-production with VFX stereo comps, final geometry checks, and creative convergence placement during the grade.

10:45 SD&A-050
When 3D headache will be over: A decade of movie quality measurements (Invited), *Dmitriy Vatolin, Lomonosov Moscow State University (Russian Federation)*

Invited speaker Dmitriy Vatolin received his PhD from Moscow State University (2000) and is currently head of the Video Group at the CS MSU Graphics & Media Lab. His research interests include compression methods, video processing, and 3D-video techniques (depth from motion, focus and other cues, video matting, background restoration, and high-quality stereo generation), as well as 3D-video quality assessment (metrics for 2D-to-3D-conversion artifacts, temporal asynchrony, swapped views, and more). He is a chief organizer of the VQMT3D project for 3D-video quality measurement.

STEREOSCOPIC DEVELOPMENTS

Moderator: Nicolas Holliman, University of Newcastle (United Kingdom) /
Session Chair: Gregg Favalora, The Charles Stark Draper Laboratory, Inc. (United States)
11:45 – 12:45

11:45 SD&A-054
Light field rendering for non-Lambertian objects, *Sarah Fachada[1], Daniele Bonatto[1,2], Mehrdad Teratani[1], and Gauthier Lafruit[1]; [1]Universite Libre de Bruxelles and [2]Vrije Universiteit Brussel (Belgium)*

12:05 SD&A-055
Custom on-axis head-mounted eye tracker for 3D active glasses, *Vincent Nourrit[1], Rémi Poilane[2], and Jean-Louis de Bougrenet de la Tocnaye[1]; [1]IMT Atlantique Bretagne-Pays de la Loire - Campus de Brest and [2]E3S (France)*

12:25 SD&A-056
Immersive design engineering, Part 2 – The review (Talk only), *Bjorn Sommer, Chang Lee, Nat Martin, and Savina Toirrisi, Royal College of Art (United Kingdom)*

STEREOSCOPIC DISPLAYS, CAMERAS, AND ALGORITHMS

Moderator: Gregg Favalora, The Charles Stark Draper Laboratory, Inc. (United States) / **Session Chair:** Nicolas Holliman, University of Newcastle (United Kingdom)
13:15 – 14:35

13:15 SD&A-057
Near eye mirror anamorphosis display, *Kedrick Brown, Lightscope Media LLC (United States)*

13:35 SD&A-058
Hybrid stereoscopic photography – Analogue stereo photography meets the digital age with the StereoCompass app, *Bjorn Sommer, Royal College of Art (United Kingdom)*

13:55 SD&A-059
A new hybrid stereo disparity estimation algorithm with guided image filtering-based cost aggregation, *Hanieh Shabanian and Madhusudhanan Balasubramanian, The University of Memphis (United States)*

14:15 SD&A-350
Stereoscopic quality assessment of 1,000 VR180 videos using 8 metrics, *Dmitriy Vatolin, Lomonosov Moscow State University (Russian Federation)*

AUTOSTEREOSCOPIC DISPLAYS

Moderator: Andrew Woods, Curtin University (Australia) / **Session Chair:** Takashi Kawai, Waseda University (Japan)
18:15 – 19:15

18:15 SD&A-010
Holographic display utilizing scalable array of edge-emitting SAW modulators, *Gregg Favalora, Michael Moebius, John LeBlanc, Valerie Bloomfield, Joy Perkinson, James Hsiao, Sean O'Connor, Dennis Callahan, William Sawyer, Francis Rogomentich, and Steven Byrnes, The Charles Stark Draper Laboratory, Inc. (United States)*

18:35 SD&A-011
Towards AO/EO modulators in lithium niobate for dual-axis holographic displays, *Mitchell Adams, Caitlin Bingham, and Daniel Smalley, Brigham Young University (United States)*

18:55 SD&A-012
Enhancing angular resolution of layered light-field display by using monochrome layers, *Kotaro Matsuura, Keita Takahashi, and Toshiaki Fujii, Nagoya University (Japan)*

KEYNOTE: UNDERWATER 3D

Moderator: Takashi Kawai, Waseda University (Japan)
Session Chair: Andrew Woods, Curtin University (Australia)
19:45 – 20:45

SD&A-029
KEYNOTE: Underwater 3D system for ultra-high resolution imaging, *Pawel Achtel, Achtel Pty Limited (Australia)*

Cinematographer and inventor, keynote speaker Pawel Achtel, ACS, will explain some of the challenges we face in 3D underwater cinematography and how his breakthrough innovation made it to the set of one of the most anticipated Hollywood blockbuster movies. Underwater flat ports and dome ports, a compromise we've all come to expect and live with since the advent of underwater photography, substantially limit underwater image quality as camera resolutions increased. Additional constraints on the size of the underwater optics used in Stereoscopic 3D setups further impacted the quality of images down to approximately standard definition levels. Submersible lenses are now the industry's gold stanaard and combined with Achtel's invention, a submersible beam-splitter, allow images so much in advance of other solutions that the results are as good as or even better as those achieved on land. Achtel uses his scientific approach where almost every aspect of image quality is meticulously measured, compared, and ultimately improved. This leads to measurable outcomes that can be objectively quantified. Achtel also holds a Master's degree in engineering, which allowed him to design one of the most advanced underwater 3D system ever built. His company's patented 3D beam-splitter was recently used extensively on James Cameron's latest Avatar sequels, in New Zealand, prompting the legendary Hollywood director to write that the results were the best underwater 3D images he'd ever seen, by far. Indeed, his underwater 3D system is capable of resolving 8K corner-to-corner measured resolution on screen and without any distortions, aberrations, or image plane curvature. It is the world's first. Achtel will share some of his insights on what to expect from underwater images when Avatar 2 hits the screens in 2022.

TUESDAY 19 JANUARY 2021

PLENARY: DEEP INTERNAL LEARNING—DEEP LEARNING WITH ZERO EXAMPLES

Session Chair: Charles Bouman, Purdue University (United States)
10:00 – 11:10

Deep internal learning—Deep learning with zero examples
Michal Irani, *professor, Department of Computer Science and Applied Mathematics, Weizmann Institute of Science (Israel)*

Michal Irani is a professor at the Weizmann Institute of Science. Her research interests include computer vision, AI, and deep learning. Irani's prizes and honors include the Maria Petrou Prize (2016), the Helmholtz "Test of Time Award" (2017), the Landau Prize in AI (2019), and the Rothschild Prize in Mathematics and Computer Science (2020). She also received the ECCV Best Paper Awards (2000 and 2002), and the Marr Prize Honorable Mention (2001 and 2005).

STEREOSCOPIC CONTENT AND QUALITY

Moderator: Andrew Woods, Curtin University (Australia) / **Session Chair:** Takashi Kawai, Waseda University (Japan)
18:15 – 19:15

18:15 SD&A-098
Evaluating user experience of different angle VR images, *Yoshihiro Banchi and Takashi Kawai, Waseda University (Japan)*

18:35 SD&A-099
JIST-first: Crosstalk minimization method for eye-tracking based 3D display, *Seok Lee, Juyong Park, and Dongkyung Nam, Samsung Advanced Institute of Technology (Republic of Korea)*

18:55 SD&A-100
Sourcing and qualifying passive polarised 3D TVs, *Andrew Woods, Curtin University (Australia)*

CONFERENCE DEMONSTRATION

19:15 – 19:45

SD&A-100D
SD&A DEMO: "Sourcing and qualifying passive polarised 3D TVs", *Andrew Woods, Curtin University (Australia)*

Andrew Woods will demonstrate how to source and qualify passive polarized 3D TVs.

KEYNOTE: DIGITAL STEREOSCOPIC MICROSCOPY

Moderator: Takashi Kawai, Waseda University (Japan) / **Session Chair:** Andrew Woods, Curtin University (Australia)
19:45 – 20:45

SD&A-088
KEYNOTE: Resolution limitations in digital stereoscopic microscopy, *Michael Weissman, SB3D Technologies, Inc. (United States)*

Keynote speaker Michael Weissman, PhD, founder of TrueVision Systems, Inc., is a technical visionary and entrepreneur with mcre than 40 years of R&D experience. As one of the world's leading stereoscopic experts, Weissman has been developing 3D stereoscopic video systems for more than 25 years. His 3D systems have traveled two miles under the sea, into radioactive waste sites, and into hospital operating rooms.

THURSDAY 21 JANUARY 2021

PLENARY: THE DEVELOPMENT OF INTEGRAL COLOR IMAGE SENSORS AND CAMERAS

Session Chair: Jonathan B. Phillips, Google Inc. (United States)
10:00 – 11:10

The development of integral color image sensors and cameras
Kenneth A. Parulski, *expert consultant: mobile imaging (United States)*

Kenneth Parulski is an expert consultant to mobile imaging companies and leads the development of ISO standards for digital photography. He joined Kodak in 1980 after graduating from MIT and retired in 2012 as research fellow and chief scientist in Kodak's digital photography division. His work has been recognized with a Technical Emmy and other major awards. Parulski is a SMPTE fellow and an inventor on more than 225 US patents.

IMMERSIVE EXPERIENCES — JOINT SESSION

Moderator: Ian McDowall, Intuitive Surgical / Fakespace Labs (United States) / **Session Chair:** Margaret Dolinsky, Indiana University (United States)
13:30 – 14:30

This session is jointly sponsored by: The Engineering Reality of Virtual Reality 2021, and Stereoscopic Displays and Applications XXXII.

13:30 ERVR-167
Interdisciplinary immersive experiences within artistic research, social and cognitive sciences, *Adnan Hadzi, University of Malta (Malta)*

14:10 ERVR-168
Predicting virtual reality discomfort, *Vasilii Marshev, Jean-Louis de Bougrenet de la Tocnaye, and Vincent Nourrit, IMT Atlantique Bretagne-Pays de la Loire - Campus de Brest (France)*

VR AND 3D APPLICATIONS — JOINT SESSION

Moderator: Margaret Dolinsky, Indiana University (United States) / **Session Chair:** Ian McDowall, Intuitive Surgical / Fakespace Labs (United States)
18:15 – 19:15

This session is jointly sponsored by: The Engineering Reality of Virtual Reality 2021, and Stereoscopic Displays and Applicaiions XXXII.

18:15 ERVR-177
Situational awareness of COVID pandemic data using virtual reality, *Sharad Sharma, Bowie State University (United States)*

18:35 ERVR-178
Virtual reality instructional (VRI) module for training and patient safety, *Sharad Sharma, Bowie State University (United States)*

18:55 ERVR-179
Server-aided 3D DICOM viewer for mobile platforms, *Menghe Zhang and Jürgen Schulze, University of California San Diego (United States)*

MONDAY 25 JANUARY 2021

PLENARY: MAKING INVISIBLE VISIBLE

Session Chair: Jonathan B. Phillips, Google Inc. (United States)
10:00 – 11:10

Making invisible visible
Ramesh Raskar, *associate professor, MIT Media Lab (United States)*

Ramesh Raskar is an associate professor at MIT Media Lab and directs the Camera Culture research group. His focus is on AI and imaging for health and sustainability. They span research in physical (e.g., sensors, health-tech), digital (e.g., automated and privacy-aware machine learning), and global (e.g., geomaps, autonomous mobility) domains. He received the Lemelson Award (2016), ACM SIGGRAPH Achievement Award (2017), DARPA Young Faculty Award (2009), Alfred P. Sloan Research Fellowship (2009), TR100 Award from MIT Technology Review (2004), and Global Indus Technovator Award (2003). He has worked on special research projects at Google [X] and Facebook and co-founded/advised several companies.

WEDNESDAY 27 JANUARY 2021

PLENARY: REVEALING THE INVISIBLE TO MACHINES WITH NEUROMORPHIC VISION SYSTEMS: TECHNOLOGY AND APPLICATIONS OVERVIEW

Session Chair: Radka Tezaur, Intel Corporation (United States)
10:00 – 11:10

Revealing the invisible to machines with neuromorphic vision systems: Technology and applications overview
Luca Verre, *CEO and co-founder, Prophesee (France)*

Luca Verre is co-founder and CEO of Prophesee, the inventor of the world's most advanced neuromorphic vision systems. Verre is a World Economic Forum technology pioneer. His experience includes project and product management, marketing, and business development roles at Schneider Electric. Prior to Schneider Electric, Verre worked as a research assistant in photonics at the Imperial College of London. Verre holds a MSc in physics, electronic and industrial engineering from Politecnico di Milano and Ecole Centrale and an MBA from Institut Européen d'Administration des Affaires, INSEAD.