



# Stereoscopic Displays and Applications XXXIV

## Conference Chairs

Andrew J. Woods, Curtin University (Australia)

Nicolas S. Holliman, King's College London University (UK)

Takashi Kawai, Waseda University (Japan)

Bjorn Sommer, Royal College of Art (UK)

**PROGRAM AND PROCEEDINGS**

This document details the conference program, held as part of the 2023 IS&T International Symposium on Electronic Imaging, 15-19 January 2023. Manuscripts of conference papers are reproduced from PDFs as submitted and approved by authors; no editorial changes were made.

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## Stereoscopic Displays and Applications XXXIV

### 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. The long-running SD&A 3D Theater Session provides conference attendees with a wonderful opportunity to see how 3D content is being created and exhibited around the world. 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 Theater

**Conference Chairs:** **Nicolas S. Holliman**, King's College London (UK); **Takashi Kawai**, Waseda University (Japan); **Bjorn Sommer**, Royal College of Art, London (UK); and **Andrew J. Woods**, Curtin University (Australia)

**Program Committee:** **Neil A. Dodgson**, Victoria University of Wellington (New Zealand); **Gregg E. Favalora**, Quadratic 3D, Inc. (US); **Justus Ilgner**, University Hospital Aachen (Germany); **Eric Kurland**, 3-D SPACE Museum (US); **John D. Stern**, Intuitive Surgical, Inc. (Retired) (US); **Chris Ward**, Lightspeed Design, Inc. (US); and **Laurie Wilcox**, York University (Canada)

**Founding Chair:** **John O. Merritt**, The Merritt Group (US), *in memoriam*

*Paper authors listed as of 1 January 2023; refer to manuscript for final authors. Titles that are not listed with the proceedings files were presentation-only.*

# Stereoscopic Displays and Applications XXXIV

MONDAY 16 JANUARY 2023

## Stereoscopic Displays (M1)

**Session Chair:** Bjorn Sommer, Royal College of Art (United Kingdom)

8:45 – 9:50 AM

Cyril Magnin II

8:45

### Conference Welcome

8:50

SD&A-383

**Evaluating the angular resolution of a simulated light field display in regards to three-dimensionality, motion parallax and viewing experience**, *Sophie Kergaßner and Jan Fröhlich, Stuttgart Media University (Germany)*

9:10

SD&A-384

**CubicSpace for stereo cards: Enabling universal 3D playback on today's display devices**, *Nicholas Routhier, Mindtrick Innovations Inc. (Canada)*

9:30

SD&A-385

**Upgrading the Curtin HIVE's stereoscopic projection facilities**, *Andrew J. Woods, Wesley Lamont, and Daniel Adams, Curtin University (Australia)*

## KEYNOTE: SD&A 1 (M2.1)

Session Chair: Andrew Woods, Curtin University (Australia)

10:50 – 11:50 AM

Cyril Magnin II

SD&A-386

**KEYNOTE: The long-awaited arrival of holographic interfaces**, *Shawn Frayne, Looking Glass Factory (United States)*

*Inspired by movies in the 80s and 90s, Shawn Frayne has been reaching towards the dream of the hologram for over 20 years. Frayne got his start with a classic laser interference pattern holographic studio he built in high school, followed by training in advanced holographic film techniques at MIT. He has been awarded dozens of patents around the world and serves as co-founder and CEO of Looking Glass Factory, based in Brooklyn and Hong Kong.*

## Stereoscopic Simulation (M2.2)

**Session Chair:** Andrew Woods, Curtin University (Australia)

11:50 AM – 12:30 PM

Cyril Magnin II

11:50

SD&A-387

**Estimation of motion sickness in automated vehicles using stereoscopic visual simulation (JIST-first)**, Yoshihiro Banchi and Takashi Kawai, Waseda University (Japan)

12:10

**Lenny Lipton - In Memoriam**

### **Monday 16 January PLENARY: Neural Operators for Solving PDEs**

Session Chair: Robin Jenkin, NVIDIA Corporation (United States)

2:00 PM – 3:00 PM

Cyril Magnin I/II/III

*Deep learning surrogate models have shown promise in modeling complex physical phenomena such as fluid flows, molecular dynamics, and material properties. However, standard neural networks assume finite-dimensional inputs and outputs, and hence, cannot withstand a change in resolution or discretization between training and testing. We introduce Fourier neural operators that can learn operators, which are mappings between infinite dimensional spaces. They are independent of the resolution or grid of training data and allow for zero-shot generalization to higher resolution evaluations. When applied to weather forecasting, neural operators capture fine-scale phenomena and have similar skill as gold-standard numerical weather models for predictions up to a week or longer, while being 4-5 orders of magnitude faster.*

**Anima Anandkumar**, Bren professor, California Institute of Technology, and senior director of AI Research, NVIDIA Corporation (United States)

*Anima Anandkumar is a Bren Professor at Caltech and Senior Director of AI Research at NVIDIA. She is passionate about designing principled AI algorithms and applying them to interdisciplinary domains. She has received several honors such as the IEEE fellowship, Alfred. P. Sloan Fellowship, NSF Career Award, and Faculty Fellowships from Microsoft, Google, Facebook, and Adobe. She is part of the World Economic Forum's Expert Network. Anandkumar received her BTech from Indian Institute of Technology Madras, her PhD from Cornell University, and did her postdoctoral research at MIT and assistant professorship at University of California Irvine.*

### **EI 2023 Highlights Session**

Session Chair: Robin Jenkin, NVIDIA Corporation (United States)

3:30 – 5:00 PM

Cyril Magnin II

*Join us for a session that celebrates the breadth of what EI has to offer with short papers selected from EI conferences.*

*NOTE: The EI-wide "EI 2023 Highlights" session is concurrent with Monday afternoon COIMG, COLOR, IMAGE, and IQSP conference sessions.*

IQSP-309

**Evaluation of image quality metrics designed for DRI tasks with automotive cameras**, Valentine Klein, Yiqi Li, Claudio Greco, Laurent Chanas, and Frédéric Guichard, DXOMARK (France)

SD&A-224

**Human performance using stereo 3D in a helmet mounted display and association with individual stereo acuity**, *Bonnie Posselt, RAF Centre of Aviation Medicine (United Kingdom)*

IMAGE-281

**Smartphone-enabled point-of-care blood hemoglobin testing with color accuracy-assisted spectral learning**, *Sang Mok Park<sup>1</sup>, Yuhyun Ji<sup>1</sup>, Semin Kwon<sup>1</sup>, Andrew R. O'Brien<sup>2</sup>, Ying Wang<sup>2</sup>, and Young L. Kim<sup>1</sup>; <sup>1</sup>Purdue University and <sup>2</sup>Indiana University School of Medicine (United States)*

AVM-118

**Designing scenes to quantify the performance of automotive perception systems**, *Zhenyi Liu<sup>1</sup>, Devesh Shah<sup>2</sup>, Alireza Rahimpour<sup>2</sup>, Joyce Farrell<sup>1</sup>, and Brian Wandell<sup>1</sup>; <sup>1</sup>Stanford University and <sup>2</sup>Ford Motor Company (United States)*

VDA-403

**Visualizing and monitoring the process of injection molding**, *Christian A. Steinparz<sup>1</sup>, Thomas Mitterlehner<sup>2</sup>, Bernhard Praher<sup>2</sup>, Klaus Straka<sup>1,2</sup>, Holger Stitz<sup>1,3</sup>, and Marc Streit<sup>1,3</sup>; <sup>1</sup>Johannes Kepler University, <sup>2</sup>Moldsonics GmbH, and <sup>3</sup>datavisyn GmbH (Austria)*

COIMG-155

**Commissioning the James Webb Space Telescope**, *Joseph M. Howard, NASA Goddard Space Flight Center (United States)*

HVEI-223

**Critical flicker frequency (CFF) at high luminance levels**, *Alexandre Chapiro<sup>1</sup>, Nathan Matsuda<sup>1</sup>, Maliha Ashraf<sup>2</sup>, and Rafal Mantiuk<sup>3</sup>; <sup>1</sup>Meta (United States), <sup>2</sup>University of Liverpool (United Kingdom), and <sup>3</sup>University of Cambridge (United Kingdom)*

HPCI-228

**Physics guided machine learning for image-based material decomposition of tissues from simulated breast models with calcifications**, *Muralikrishnan Gopalakrishnan Meena<sup>1</sup>, Amir K. Ziabari<sup>1</sup>, Singanallur Venkatakrisnan<sup>1</sup>, Isaac R. Lyngaas<sup>1</sup>, Matthew R. Norman<sup>1</sup>, Balint Joo<sup>1</sup>, Thomas L. Beck<sup>1</sup>, Charles A. Bouman<sup>2</sup>, Anuj Kapadia<sup>1</sup>, and Xiao Wang<sup>1</sup>; <sup>1</sup>Oak Ridge National Laboratory and <sup>2</sup>Purdue University (United States)*

3DIA-104

**Layered view synthesis for general images**, *Loic Dehan, Wiebe Van Ranst, and Patrick Vandewalle, Katholieke University Leuven (Belgium)*

ISS-329

**A self-powered asynchronous image sensor with independent in-pixel harvesting and sensing operations**, *Ruben Gomez-Merchan, Juan Antonio Leñero-Bardallo, and Ángel Rodríguez-Vázquez, University of Seville (Spain)*

COLOR-184

**Color blindness and modern board games**, *Alessandro Rizzi<sup>1</sup> and Matteo Sassi<sup>2</sup>; <sup>1</sup>Università degli Studi di Milano and <sup>2</sup>consultant (Italy)*

### **SD&A Conference 3D Theater (M4)**

**Hosts:** Eric Kurland, 3-D SPACE (United States); Dan Lawrence, Lightspeed Design, Inc. (United States); John Stern, retired (United States); and Andrew Woods, Curtin University (Australia)

6:00 – 7:30 PM

Cyril Magnin II

*This ever-popular session of each year's Stereoscopic Displays and Applications Conference showcases the wide variety of 3D content that is being produced and exhibited around the world. All 3D footage screened in the 3D Theatre Session is shown in high-quality polarized 3D on a large screen. The final program will be announced at the conference and 3D glasses will be provided.*

## **TUESDAY 17 JANUARY 2023**

### **Stereoscopy in Education and Vergence Accommodation (T1)**

**Session Chair:** Takashi Kawai, Waseda University (Japan)

8:50 – 10:10 AM

Cyril Magnin II

8:50

SD&A-388

**A review of the VR workshop at the Grand Challenge 2022**, *Bjorn Sommer, Kam Raooft, Robert Daniel Philips, Laura Ferrarello, Ashley Hall, and Paul Anderson, Royal College of Art (United Kingdom)*

9:10

SD&A-389

**Use of a multi-display, mobile 2D / 3D video wall in surgical operating theatres**, *Justus F. Ilgner, Thien A. Duong Dinh, Martin Westhofen, and Stephan Hackenberg, RWTH Aachen University (Germany)*

9:30

SD&A-390

**Investigating the use of spectacle lenses to alleviate vergence-accommodation mismatch in a stereoscopic remote vision system**, *Eleanor O'Keefe<sup>1</sup>, Kirk Moffitt<sup>2</sup>, Eric Seemiller<sup>3</sup>, Marc Winterbottom<sup>4</sup>, and Steven Hadley<sup>4</sup>; <sup>1</sup>KBRwyle, <sup>2</sup>Moffitt Consulting, <sup>3</sup>EIS, and <sup>4</sup>United States Air Force (United States)*

9:50

SD&A-391

**Observed optical resolution of light field display: Empirical and simulation results**, *Yuta Miyanishi, Qi Zhang, Erdem Sahin, and Atanas Gotchev, Tampere University (Finland)*

**KEYNOTE: SD&A 2 (T2.1) Joint Session**

Session Chair: Nicolas Holliman, King's College London (United Kingdom)

10:50 – 11:50 AM

Cyril Magnin II

*This session is jointly sponsored by: Engineering Reality of Virtual Reality 2023, and Stereoscopic Displays and Applications XXXIV.*

SD&A-224

**KEYNOTE: Human performance using stereo 3D in a helmet mounted display and association with individual stereo acuity, Bonnie Posselt, RAF Centre of Aviation Medicine (United Kingdom)**

*Wing Commander (Dr) Bonnie Posselt is a medical officer in the RAF (UK) specialising in Aviation and Space Medicine. Bonnie is currently based at the RAF Centre of Aviation Medicine in Bedfordshire, UK, having recently returned from a 3.5year exchange tour to Wright-Patterson Air Force Base in Ohio. While working with the 711th Human Performance Wing and the Air Force Research Laboratory (AFRL) in Ohio, Bonnie undertook a PhD in Helmet Mounted Displays and vision standards in collaboration with the University of Birmingham (UK). Bonnie is a graduate of the University of Manchester, King's College London, and the International Space University. She is an associate fellow of the Aerospace Medical Association and elected member of the Royal Aeronautical Society.*

**Stereoscopy in VR (T2.2) Joint Session**

Session Chair: Nicolas Holliman, King's College London (United Kingdom)

11:50 AM – 12:30 PM

Cyril Magnin II

*This session is jointly sponsored by: Engineering Reality of Virtual Reality 2023, and Stereoscopic Displays and Applications XXXIV.*

11:50

SD&A-225

**Incidence of stereo-blindness in a recent VR distance perception user study, Michael Wiebrands, Andrew J. Woods, and Hugh Riddell, Curtin University (Australia)**

12:10

SD&A-226

**Evaluating requirements for design education in a virtual studio environment, Bjorn Sommer<sup>1</sup>, Ayn Sayuti<sup>2</sup>, Zidong Lin<sup>1</sup>, Shefali Bohra<sup>1</sup>, Emre Kayganaci<sup>1</sup>, Caroline Yan Zheng<sup>1</sup>, Chang Hee Lee<sup>3</sup>, Ashley Hall<sup>1</sup>, and Paul Anderson<sup>1</sup>; <sup>1</sup>Royal College of Art (United Kingdom), <sup>2</sup>Universiti Teknologi MARA (UiTM) (Malaysia), and <sup>3</sup>Korea Advanced Institute of Science and Technology (KAIST) (Republic of Korea)**

## Tuesday 17 January PLENARY: Embedded Gain Maps for Adaptive Display of High Dynamic Range Images

Session Chair: Robin Jenkin, NVIDIA Corporation (United States)

2:00 PM – 3:00 PM

Cyril Magnin I/II/III

*Images optimized for High Dynamic Range (HDR) displays have brighter highlights and more detailed shadows, resulting in an increased sense of realism and greater impact. However, a major issue with HDR content is the lack of consistency in appearance across different devices and viewing environments. There are several reasons, including varying capabilities of HDR displays and the different tone mapping methods implemented across software and platforms. Consequently, HDR content authors can neither control nor predict how their images will appear in other apps.*

*We present a flexible system that provides consistent and adaptive display of HDR images. Conceptually, the method combines both SDR and HDR renditions within a single image and interpolates between the two dynamically at display time. We compute a Gain Map that represents the difference between the two renditions. In the file, we store a Base rendition (either SDR or HDR), the Gain Map, and some associated metadata. At display time, we combine the Base image with a scaled version of the Gain Map, where the scale factor depends on the image metadata, the HDR capacity of the display, and the viewing environment.*

**Eric Chan**, Fellow, Adobe Inc. (United States)

*Eric Chan is a Fellow at Adobe, where he develops software for editing photographs. Current projects include Photoshop, Lightroom, Camera Raw, and Digital Negative (DNG). When not writing software, Chan enjoys spending time at his other keyboard, the piano. He is an enthusiastic nature photographer and often combines his photo activities with travel and hiking.*

**Paul M. Hubel**, director of Image Quality in Software Engineering, Apple Inc. (United States)

*Paul M. Hubel is director of Image Quality in Software Engineering at Apple. He has worked on computational photography and image quality of photographic systems for many years on all aspects of the imaging chain, particularly for iPhone. He trained in optical engineering at University of Rochester, Oxford University, and MIT, and has more than 50 patents on color imaging and camera technology. Hubel is active on the ISO-TC42 committee Digital Photography, where this work is under discussion, and is currently a VP on the IS&T Board. Outside work he enjoys photography, travel, cycling, coffee roasting, and plays trumpet in several bay area ensembles.*

### VR Systems and Immersion (T3) **Joint Session**

**Session Chairs:** Margaret Dolinsky, Indiana University (United States) and Ian McDowall, Intuitive Surgical / Fakespace Labs (United States)

3:35 – 5:45 PM

Cyril Magnin II

*This session is jointly sponsored by: Engineering Reality of Virtual Reality 2023, and Stereoscopic Displays and Applications XXXIV.*



- 3:35 ERVR-213  
**Display system sharpness modeling and requirement in VR and AR applications**, Jiawei Lu, Trisha Lian, and Jerry Jia, Meta (United States)
- 4:05 ERVR-214  
**Tangible extended reality with sensor fusion**, Yang Cai, CMU (United States)
- 4:25 ERVR-216  
**Immersion, presence and behavioral validity in virtual and augmented environments**, Daniel R. Mestre; CNRS and Aix-Marseille University (France)
- 4:45 ERVR-217  
**Immersive security personnel training module for active shooter events**, Sharad Sharma and Nishith Mannuru, University of North Texas (United States)
- 5:05 ERVR-218  
**Mobile augmented reality system for object detection, alert, and safety**, Sharad Sharma<sup>1</sup>, Nishith Mannuru<sup>1</sup>, and Don Engel<sup>2</sup>; <sup>1</sup>University of North Texas and <sup>2</sup>University of Maryland, Baltimore County (United States)

## WEDNESDAY 18 JANUARY 2023

### KEYNOTE: AR/VR Special Session 1 (W1) Joint Session

Session Chair: Alexandre Chapiro, Meta (United States)

9:05 – 10:10 AM

Cyril Magnin II

*This session is jointly sponsored by: Engineering Reality of Virtual Reality 2023, Human Vision and Electronic Imaging 2023, and Stereoscopic Displays and Applications XXXIV.*

#### Joint Conference Welcome

HVEI-219

**KEYNOTE: Display consideration for AR/VR systems**, Ajit Ninan, Reality Labs at Meta (United States)

*Ajit Ninan is a display industry veteran and led the way to the industry adopting HDR. His inventions & innovations are manifest in millions of shipped HDR TV's and consumer electronics from multiple companies. He holds 400+ granted patents in imaging and display technology and now works in imaging related to AR/VR at Meta as Senior Director of Applied Perceptual Science and Image Quality. His work spans multiple subjects ranging from Displays, Imaging, Color, Video, Compression, Audio and Networking. His career spans early start-ups to public companies. Ninan is the inventor of the local dimmed quantum dot TV and led the way to the industry adoption of quantum dot displays by working with Vizio, Nanosys and 3M to release the first of its kind R-series QD TV with HDR. He also led the effort with the JPEG committee to standardize JPEG-Xt to enable JPEG HDR images. Ninan was inducted as a SMPTE Fellow for his contributions to imaging and standards. The display that caused the world to adopt HDR called the "Pulsar" capable of 4000nits down to .005nits with P3 color in 2010, built by Ninan and his team, has received many awards including the Advanced Imaging Society's Lumiere award which enabled the development of Dolby Vision and earned Ninan an Emmy.*

## AR/VR Special Session 2 (W2) **Joint Session**

**Session Chairs:** Nicko Caluya, Ritsumeikan University (Japan) and Alexandre Chapiro, Meta (United States)

10:50 AM – 12:30 PM

Cyril Magnin II

*This session is jointly sponsored by: Engineering Reality of Virtual Reality 2023, Human Vision and Electronic Imaging 2023, and Stereoscopic Displays and Applications XXXIV.*

10:50

HVEI-220

**Comparison of AR and VR memory palace quality in second-language vocabulary acquisition (Invited)**, Xiaoyang Tian, Nicko Caluya, and Damon M. Chandler, Ritsumeikan University (Japan)

11:10

HVEI-221

**Projection mapping for enhancing the perceived deliciousness of food (Invited)**, Yuichiro Fujimoto, Nara Institute of Science and Technology (Japan)

11:30

HVEI-222

**Real-time imaging processing for low-vision users**, Yang Cai, CMU (United States)

11:50

HVEI-223

**Critical flicker frequency (CFF) at high luminance levels**, Alexandre Chapiro<sup>1</sup>, Nathan Matsuda<sup>1</sup>, Maliha Ashraf<sup>2</sup>, and Rafal Mantiuk<sup>3</sup>; <sup>1</sup>Meta (United States), <sup>2</sup>University of Liverpool (United Kingdom), and <sup>3</sup>University of Cambridge (United Kingdom)

12:10

HVEI-253

**A multichannel LED-based lighting approach to improve color discrimination for low vision people**, Linna Yang<sup>1</sup>, Éric Dinet<sup>1</sup>, Pichayada Katemake<sup>2</sup>, Alain Trémeau<sup>1</sup>, and Philippe Colantoni<sup>1</sup>; <sup>1</sup>University Jean Monnet Saint-Etienne (France) and <sup>2</sup>Chulalongkorn University (Thailand)

### **Wednesday 18 January PLENARY: Bringing Vision Science to Electronic Imaging: The Pyramid of Visibility**

Session Chair: Andreas Savakis, Rochester Institute of Technology (United States)

2:00 PM – 3:00 PM

Cyril Magnin I/II/III

*Electronic imaging depends fundamentally on the capabilities and limitations of human vision. The challenge for the vision scientist is to describe these limitations to the engineer in a comprehensive, computable, and elegant formulation. Primary among these limitations are visibility of variations in light intensity over space and time, of variations in color over space and time, and of all of these patterns with position in the visual field. Lastly, we must describe how all these sensitivities vary with adapting light level. We have recently developed a structural description of human visual sensitivity that we call the Pyramid of Visibility, that accomplishes this synthesis. This talk shows how this structure accommodates all the dimensions described above, and how it can be used to solve a wide variety of problems in display engineering.*

**Andrew B. Watson**, chief vision scientist, Apple Inc. (United States)

Andrew Watson is Chief Vision Scientist at Apple, where he leads the application of vision science to technologies, applications, and displays. His research focuses on computational models of early vision. He is the author of more than 100 scientific papers and 8 patents. He has 21,180 citations and an h-index of 63. Watson founded the Journal of Vision, and served as editor-in-chief 2001-2013 and 2018-2022. Watson has received numerous awards including the Presidential Rank Award from the President of the United States.

**PANEL: AR/VR Special Session (W3.1)** **Joint Session**

Session Chairs: Nicko Caluya, Ritsumeikan University (Japan) and Alexandre Chapiro, Meta (United States)

Panelists: Alexandre Chapiro, Meta (United States); Yuichiro Fujimoto, Nara Institute of Science and Technology (Japan); Nicolas Holliman, King's College London (United Kingdom); and Ajit Ninan, Reality Labs at Meta (United States)

3:30 – 4:50 PM

Cyril Magnin II

*This session is jointly sponsored by: Engineering Reality of Virtual Reality 2023, Human Vision and Electronic Imaging 2023, and Stereoscopic Displays and Applications XXXIV.*

**DISCUSSION: Wednesday End of Joint Sessions (W3.2)** **Joint Session**

Session Chair: Damon Chandler, Ritsumeikan University (Japan)

4:50 – 5:30 PM

Cyril Magnin II

*This session is jointly sponsored by: Engineering Reality of Virtual Reality 2023, Human Vision and Electronic Imaging 2023, and Stereoscopic Displays and Applications XXXIV.*

*Please join us for a lively discussion of today's presentations. Participate in an interactive, moderated discussion, where key topics and questions are discussed from many perspectives, reflecting the diverse HVEI community.*

## THURSDAY 19 JANUARY 2023

**Imaging for XR Workshop 2023**

8:45 AM – 6:00 PM

Cyril Magnin I/II

*Engage with Others at Imaging for XR.*

*Held in-person during the Electronic Imaging Symposium and scheduled as the final day for SD&A attendees.*

More at **Imaging for XR 2023**

[[https://www.imaging.org/IST/IST/Conferences/XR/XR2023/Imaging4XR\\_2023.aspx?hkey=35938085-d66f-43e5-a357-7e30f259f94f](https://www.imaging.org/IST/IST/Conferences/XR/XR2023/Imaging4XR_2023.aspx?hkey=35938085-d66f-43e5-a357-7e30f259f94f)]