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Stereoscopic Displays and Applications XXI

Andrew J. Woods
Nicolas S. Holliman
Neil A. Dodgson
Editors

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7003 Kilworth Lane, Springfield, Virginia, 22151 USA
Telephone +1 703 642 9090 (Eastern Time) · Fax +1 703 642 9094
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Introduction

As this volume goes to press, *Avatar*, a movie shot in stereoscopic 3D, has become the highest grossing movie ever, eclipsing *Titanic*. The past three years have seen an explosion in stereoscopic movie making. The Consumer Electronics Show (CES), held shortly before the Stereoscopic Displays and Applications (SD&A) conference, had a plethora of 3D TVs on show. Stereoscopy has hit the consumer in a big way!

Amongst all the activity, SD&A continues to retain its role as the premier venue for the dissemination of research into stereoscopic displays and their applications. It attracts the big players in the industry: We had 10 of the key players on the panels at our discussion forums. It has an excellent technical program: 42 papers were accepted for oral presentation (half of the abstracts submitted) and an additional 23 papers accepted as posters. Overall, we had authors from 16 countries: 40% from Europe, 40% from Asia, and 20% from North America. We heard about the most recent advances in the field and celebrated the 21st birthday of the conference.

This volume contains the technical papers in support of the presentations and posters given at the Stereoscopic Displays and Applications conference. This introduction gives an overview of the conference, a reminder for those who attended, and an insight into what happened for those who were unable to attend.

The conference was held 18–20 January 2010 as part of the 2010 IS&T/SPIE Electronic Imaging: Science and Technology Symposium, at the San Jose McEnery Convention Center and the San Jose Marriott Hotel, in San Jose, California, USA. This year's conference grew once again, making it the best attended since the series began. There was a broad range of topics, presentations, and events.

The **first day** had technical sessions on applications, standards, and entertainment, a lunchtime discussion, the keynote presentation, the 3D theatre, and our 21st birthday banquet.

The **keynote presentation** was given by Bob Whitehill, Stereoscopic Supervisor at Pixar Animation Studios. His presentation on "Three-dimensional storytelling" described the ways in which Pixar uses 3D as a visual storytelling device, analogous to their use of color, composition, and movement. He used examples from *Up*, *Toy Story*, and *Toy Story 2*.

The two-hour **3D Theatre Session** (chaired by Andrew Woods and Chris Ward) is a regular event that showcases 3D content from around the world. This was the

most popular session of the conference, with over 250 attendees in the large ballroom of the Marriott Hotel. This year, we screened the following pieces (or segments thereof) on the 18 foot diagonal stereoscopic projection screen:

- "The Last Reef" – by Giant Screen Films. 4K 3D Digital Mastering by FotoKem. (United States)
- "Ultimate Wave Tahiti (Lightspeed Edit)" – A production of The Stephen Low Company in association with K2 Communications and havoc Television (United States)
- "Cosmic Origins" – by Dr. Nick Holliman, Durham University Visualization Laboratory (United Kingdom)
- "Ding Dong" – by Digital Magic (Hong Kong)
- "Fear" – by Celambarasan Ramasamy (United States)
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- "Planet You" – by The Health Museum and 21st Century 3D (United States)
- "CEVRAMOK VR center" – by GALI-3D s.r.o. (Czech Republic)
- "One Small Step" by Swinburne University (Australia)
- "3D PHOTO WORK with REAL3D W1" – by Takashi Sekitani (Japan)
- "Yellowstone" by 3Ality Digital (United States)
- "Walks along Rostov-on-Don" – by Igor Daurov (Russian Federation)
- "Untitled Work In Progress" – by 21st Century 3D (United States)
- "Trailer for Dimension 3 Forum" – by Cube / Dimension 3 Forum (France)
- "ED-Special FX" – by Stereoscape (Finland)
- "Annie Goes Boating" – by Noel Paul (United States)
- "Hawaii 3D - Kona Underwater" – Produced by: Voyage Films (United States)
- "Blessing of the Animals" – by William Meredith, Stone Circle Productions, Inc. (United States)
- "Essentia: Suicide in Chinatown 3D" – by Karisma Films (Finland)
- "DaumenKinosaurier" – by Marten Reiß (Germany)
- "Red Crabs 3D" – by Mark Simpfendorfer Productions (Australia)
- "A Taste of Gaudi" – by Tom Koester (United States)
- "Lunar Reconnaissance Orbiter (LRO) Insertion Orbit" – by Helen-Nicole Kostis, Greg Shirah, Ernest Wright; Scientific Visualization Studio, NASA/GSFC and University of Maryland Baltimore County (United States)
- "Tractor Assemble" – by Eric Deren, Dzignlight Studios (United States)
- "Decks, Wind and Snow" – by Eric Deren, Dzignlight Studios (United States)
- "Robinzon Cruise" - Film studio "STEREOKINO" - 1947 year production. Transfer to 3D digital format in 2009 by Russian Cinema and Photo Research Institute (NIKFI)
- "Vimma" – by Director & D.P. Kasimir Lehto (Finland)

- "Hoquen" - Funded by Cultural Heritage Administration of Korea; Produced by Graduate School of Culture Technology, KAIST (Korea, Republic of)
- "Wild Ocean" – by Giant Screen Films and Yes/No Productions (United States)
- "The Caretaker 3D" – Produced by Jeff Amaral , directed by Sean Isroelit, filmed by Allen Daviau ASC, using 3Ality Digital's TS-2 stereoscopic camera. (United States)
- "Beauty and the Beast 3D (Teaser)" – by Walt Disney Animation Studios (United States).

In recognition of the high quality of material shown at the 3D Theatre, we again offered two 'Best of Show' prizes for non-theatrical submissions. The session chairs and Dr. Samuel Zhou (Director of Image Technology at IMAX Corporation, Canada) chose the winning titles:

Best of Show (Computer Graphics – non-theatrical):
"Cosmic Origins" by Durham University (United Kingdom)
Best of Show (Live Action – non-theatrical):
"The Caretaker 3D," Produced by Jeff Amaral , directed by Sean Isroelit, filmed by Allen Daviau ASC, using 3Ality Digital's TS 2 stereoscopic camera (United States).

An illustrated listing of the content shown during this year's 3D Theatre session will be available from the conference website: www.stereoscopic.org/3dcinema
Many thanks to Dan Lawrence at Lightspeed Design who handled the data wrangling for the 3D Theatre session.

The evening concluded with a special 21st anniversary banquet at the BoTown Chinese Restaurant in downtown San Jose. Approximately 70 conference attendees mingled, talked, and ate in a relaxed atmosphere. The BoTown staff have been very good to us over the years—always friendly and willing to easily accommodate our big once-a-year crowd.

The **second day** of the SD&A conference had technical sessions on DIBR (Depth Image Based Rendering), 3D displays, and stereoscopic image quality, a discussion forum, the demonstration session, and the interactive paper session. The full papers from both the technical sessions and the interactive papers are all contained in this volume.

The first **discussion forum** considered 3D video standards. Mike Weissman (TrueVision Systems) chaired a panel of industry players: David Broberg (SCTE and CAbleLabs), Pete Ludé (SMPTE and Sony), Mark Stockfisch (CEA and Quantum Data), and Steve Venuti (HDMI). After the forum, the discussion continued during the lunch-time discussion round-table.

The final event of the day was the ever-popular **Demonstration Session**, which has run every year since 1990. Since 2006, this has been a symposium-wide event,

open to demonstrators from all of the Electronic Imaging conferences. It was pleasing to see a wide variety of stereoscopic imaging systems on display and to see a large audience actively engaging with the various displays and vendors.
This year the following 3D hardware and 3D software products were on show at the demonstration session:

- **Fujifilm USA** (Jim Calverley) demonstrated the Fujifilm Finepix Real 3D products: the W1 digital 3D camera, the V1 3D photo frame viewer, and 3D prints.
- **NVIDIA** (Dave Cook and Michael McSorley) demonstrated the NVIDIA 3D Vision active shutter glasses paired with four of the new Acer GD235HZ full-HD 24" 3D LCD monitors, including three setup as an ultra-widescreen 3D display. Content included 3D Blu-ray, 3D pictures from the Fuji 3D camera, and the latest PC games in 3D.
- **Lightspeed Design** (Chris Ward and Bob Mueller) demonstrated their new polarization modulator in operation with a DepthQ HD projector – illustrating new options for full-polarized HD 3D from a single projector.
- **SeeFront** (Christoph Grossmann) debuted their new lens kit and software to convert a 2D laptop display into a head-tracked autostereoscopic display, and an autostereoscopic desktop monitor SF223.
- **ELDIM** (Pierre Boher) provided literature on their system for performance characterization of autostereoscopic displays.
- **3DTV Solutions** (Didier Debons) demonstrated a large autostereoscopic HDTV screen showing qualitative content.
- **Polaris Sensor Technologies** (Richard Edmondson) demonstrated a flat panel polarized 3D display system with live and digital inputs coupled with a TALON fully operational bomb disposal robot.
- **Philips** (Rene Klein Gunnewiek) demonstrated their automatic 2D to 3D conversion algorithm on a large screen 3D HDTV.
- **Hologlyphics** (Walter Funk) demonstrated autostereoscopic content generated in real-time, interacting with sound.
- The **Communications Research Centre**, Canada (James Tam), demonstrated a user-interface for modifying depth maps intended as a tool for creating special effects in 3D, getting rid of the cardboard-cutout effect, and for 2D to 3D conversion
- The **National Research Council of Canada** (Eric Paquet) demonstrated a system that can index and retrieve 3D protein structures according to their shape.
- The **National Institute of Standards and Technology** (Afzal Godil) demonstrated their 3D shape retrieval work, which is based on subspaces of view.
- **Durham University** (Nick Holliman) showed clips from the 3D movie "Cosmic Origins" and discussed stereoscopic production with delegates.
- **Osaka City University** (Daisuke Miyazaki) demonstrated a volumetric display system using a roof mirror grid array (RMGA) and a DLP projection engine. The

RMGA consists of a two-dimensional array of dihedral corner reflectors and forms a real image at a plane-symmetric position.

- The **University of Tsukuba** (Hideki Kakeya) demonstrated 3D display system combining multi-view and volumetric solutions, which realize natural 3D vision without convergence-accommodation conflict.
- **StereoJet** exhibited a selection full color, high-resolution 3D prints and transparencies - showing a recent update of the technology. StereoJet remains the only method available for printing of full-color 3D images which can be viewed with polarized 3D glasses.
- **21st Century 3D** (Jason Goodman) demonstrated a professional stereoscopic camera system using a pair of RED cameras mounted on a mirror-rig designed to overcome the polarization problems normally encountered with mirror-rigs.
- **Bernard Mendiburu** was on hand to sign copies of his new book, *3D Movie Making: Stereoscopic Digital Cinema from Script to Screen*. He also showed an Acer Aspire 5738DG 3D laptop setup with a pair of Microsoft Lifecam 720P webcams connected as a stereo-pair.

There were also several stereoscopic items at the Electronic Imaging Exhibition on the main concourse on Tuesday and Wednesday:

- **JVC Professional** demonstrated the JVC 46" MicroPol based 3D HDTV.
- **3DTV Solutions** demonstrated a large screen autostereoscopic display.
- The "Art in Virtual Reality" exhibit (curated by Ben Chang from the School of the Art Institute of Chicago) used a large rear-screen polarized stereoscopic projection system to showcase the virtual reality artworks of a selection of authors. Further details are available from www.bcchang.com/artvr2010/

Also in the exhibit area was the annual **Phantogram Exhibit**, organized by Terry Wilson from Terryfic3D. Phantograms are a fascinating 3D art form which allow the illusion to be created of real objects sitting in the real-space in front of you. The exhibit included phantograms from: Manuel Gil San Martin, Yitzhak Weissman, Gary Greenspoon, Steve Hughes, Takashi Sekitani, Boris Starosta, Bruce Springsteen, Faramarz Ghahremanifar, Barry Rothstein, Achim Bahr, and Terry Wilson. Of particular note were the seven phantograms of Spanish castles by Manuel Gil San Martin – captured by flying over the landscape at close range in a paramotor. Another highlight was the collection of lenticular phantograms by Yitzhak Weissman. Ordinarily, the only way of printing phantograms is using the anaglyph 3D technique which precludes full-color 3D images. The use of lenticular 3D with a phantogram allows a full-color image and also avoids the use of glasses (although with some restrictions on viewing position). As far as we are aware this is the very first example of a lenticular phantogram. Perhaps next year we can also see a StereoJet phantogram.

An extensive photo montage and listing of the demonstration session and exhibits from this year's SD&A conference will be available on the conference website: www.stereoscopic.org

The **third day** of the SD&A conference had technical sessions on cameras, content, 2D to 3D conversion, and human factors, the second discussion forum, and the symposium reception with a 3D gaming demonstration.

The second **discussion forum** considered the business of 3D: how to build successful business models. Chris Chinnock (Insight Media) chaired a panel of 3D professionals who, between them, have worked in the industry for decades: Chris Ward (Lightspeed Design), Lenny Lipton (Oculus3D), Jim Calverley (FujiFilm) and Sunil Jain (Intel). The discussion again flowed from the forum into lunch.

A 3D gaming demonstration was setup during the Wednesday night Electronic Imaging Reception. Ben Chang setup a large screen polarized stereoscopic projection system running a game version of Scalable City from Sheldon Brown. The video version of Scalable City won an award at last year's 3D Theatre session.

Several sessions at this year's SD&A conference were video recorded – the two discussion forums and presentations in some of the technical sessions. Editing is underway and we plan to make some content available via the conference website through the year.

Two **prizes** were offered at the conference for the best use of the stereoscopic projection tools during the technical presentations. Many presentations used stereoscopic projection as an integral part of their presentations and the two winners, chosen by the SD&A conference chairs, were:

- "Beauty and the Beast: from 2D to 3D" by Tara H. Turner (Walt Disney Animation Studios) who discussed stereoscopic viewing systems for stereoscopic movie production, and presented previews of the 2D to 3D conversion work done on the movie Beauty and the Beast. A longer clip was also shown during the 3D Theater session.
- "What every surgeon wants: practical aspects on the use of stereoscopic applications in operative theatres" by Justus Ilgner (Aachen University Hospital, Germany). Justus' presentation included videos of surgery and stereoscopic still images of the stereoscopic equipment in situ in his operating theatres.

The prizes for stereoscopic projection and for the 3D Theatre were signed copies of Bernard Mendiburu's book, *3D Movie Making: Stereoscopic Digital Cinema from Script to Screen*, presented personally by the author.

Many individuals and companies contributed in various ways to the success of this year's SD&A conference:

- This year's conference was sponsored by **IMAX Corporation** (Mississauga, Ontario, Canada) and **NVIDIA Corporation** (Santa Clara, California). Conference sponsorship is a valuable way for companies to support the running of the conference and to gain marketing exposure. IMAX and NVIDIA are both key players in the stereoscopic industry, and we thank them for their support.
- We also appreciate the support of this year's stereoscopic projection sponsors: **DepthQ Stereoscopic** (Bellevue, Washington), **JVC Professional** (Cypress, California), **Christie Digital** (Cypress, California), and **STRONG / MDI Screen Systems** (Joliette, Quebec, Canada).
  The ability to present high-quality large-screen stereoscopic images and video at the conference is vital to the conference's success. This year we had two stereoscopic projection systems setup across two rooms. In the main SD&A conference room we had a Christie Digital 'HD6K' projector (1920×1080 resolution, 16:9 aspect ratio, 3 chip DLP) (provided by Christie Digital) projecting onto a new 10.7×6 foot rear-screen (provided by Brad Nelson) outputting frame-sequential polarized 3D (at 120Hz) by way of a DepthQ active polarization modulator (provided by DepthQ Stereoscopic). A second, larger system was setup in the large ballroom of the Marriott Hotel for the Keynote presentation and 3D Theatre session. This system consisted of a pair of JVC 'DLA-SH4KG' projectors (4K resolution per projector (4096 x 2400 pixels), 16:9 aspect ratio, three panel LCoS) (provided by JVC Professional) projecting onto a new 16x9 foot silvered screen (provided by Strong / MDI Screen Systems). Both stereoscopic projection systems were each driven by DepthQ stereoscopic media servers (one for each stereoscopic projection system) for playback of all of the stereoscopic video content shown during the 3D Theatre (except 4K 3D content) and in the main SD&A conference room. The 4K 3D content on the JVC 4K projector was served by a Doremi 'DSV-J2' special venue player and two Doremi 'MB-4K' playback processors (provided by Doremi Labs and JVC Professional). This year's setup was particularly complicated and risky. Many thanks for a for a job done extremely well go to: **Chris Ward**, **Bob Mueller**, and **Dan Lawrence** from DepthQ Stereoscopic; **Rod Sterling** from JVC Professional; **Wayne Bickley** from Christie Digital; **François Barrette** from Strong / MDI Screen Systems; **Adrian Romero** and staff from Spectrum Audio Visual; **Ron Williams** from Doremi Labs; **Diana Gonzalez** from IS&T; and **Brad Nelson**. The AV setup was project managed by **Andrew Woods**.

- We thank our media sponsors who helped promote the conference: **Veritas et Visus**, **Dimension 3**, **Meant to be Seen 3D** (MTBS3D), **DisplayDaily.com**, and **Market Saw**.

- We very much appreciate the dedicated support of **Stephan R. Keith** (SRK Graphics Research), who had a multi-tasked role at this conference, helping support the AV needs of all of our presenters, controlling the room lights, adjusting the sound mixer desks, handling the microphones, and running the video cameras. We have no idea how all this can be done by one person, but he did it wonderfully!

- We are grateful to all of the providers of 3D content for the 3D Theatre session for allowing their content to be shown to the conference audience.

- Thanks to the demonstration session presenters for bringing equipment to show. A lot of equipment traveled from overseas, making the contribution to the meeting particularly worthy of additional praise.

- The conference committee plays an important role throughout the year, ensuring the correct technical direction of the meeting. Sincere thanks go to our founding chair, **John Merritt**, and our committee, **Gregg Favalora**, **Takashi Kawai**, **Janusz Konrad**, **Shojiro Nagata**, **Vivian Walworth**, **Chris Ward**, and **Michael Weissman**.

- Thanks also to the staff at IS&T and SPIE, who were instrumental in helping to organize the meeting.

- Most importantly, we thank the conference authors and attendees, who ultimately made this meeting such a successful event. Thanks especially to those who travel a long way to join us each year.

Selected papers in this proceedings volume have been peer reviewed in full. This process was initiated in 2008, to facilitate the improved quality of the proceedings, provide authors with constructive feedback on their submissions, and provide academic authors with addition recognition for their publications. There is an increasing importance of peer-reviewed publications in academic circles worldwide and the SD&A conference wishes to remain the most relevant place for stereoscopic imaging papers to be published. Authors were able to request full peer review of their submitted manuscript. This year, two reviewers were sought for each paper for which peer review was requested. A single-blind review process was conducted for those papers, and authors were given a two-week window to respond to the reviewer comments. The chairs reviewed the author responses to the reviews and decided whether the responses to the reviewer comments justified the paper being classified a peer reviewed technical paper. The peer review process was managed by Nick Holliman. This year the peer reviewed papers were:

- "Matte painting in stereoscopic synthetic imagery," Jonathan Eisenmann, Rick Parent, The Ohio State Univ. (United States) [7524-12]

- "Monocular zones in stereoscopic scenes: A useful source of information for human binocular vision?," Julie M. Harris, Univ. of St. Andrews (United Kingdom) [7524-33]
- "Stereoscopic filming for investigating evasive side-stepping and anterior cruciate ligament injury risk," Marcus J. C. Lee, Paul Bourke, Jacqueline A. Alderson, David G. Lloyd, Brendan Lay, The Univ. of Western Australia (Australia) [7524-05]
- "Comparing levels of crosstalk with red/cyan, blue/yellow, and green/magenta anaglyph 3D glasses," Andrew J. Woods, Christopher R. Harris, Curtin Univ. of Technology (Australia) [7524-25].

Conference activities do not stop at the end of the January meeting. The SD&A conference website provides a focus for conference activities during the time between conferences. We are seeking abstracts for the 2011 conference, with a deadline in June 2010: see the website for details and deadlines. You can join the conference mailing list to receive conference announcements: visit the SD&A conference website for details. The website has an extensive collection of photographs highlighting the activities of past conferences. In addition the website hosts the stereoscopic virtual library, which contains several historically important books that have been digitized, in full, into PDF format, and are available for free download. We have an active discussion group on the business networking site LinkedIn: **www.linkedin.com/groups?gid=1945944** Visit the conference website to gain an understanding of the past, present, and future of stereoscopic imaging and, most of all, think now about submitting a paper or attending next year's conference. The Stereoscopic Displays and Applications conference website is at **www.stereoscopic.org**

Next year, the 22nd conference will be held for three days in the period of 24–27 January 2011, at the Hyatt Regency San Francisco Airport Hotel, as part of the 2011 IS&T/SPIE Electronic Imaging: Science and Technology symposium. The move to south San Francisco has several advantages for us. The hotel is twenty minutes from central San Francisco by public transport. It is close to the international airport and there will be free shuttle buses running from San Francisco International Airport to the conference venue. Parking will be easy for local attendees. The conference will be in the same week as Photonics West (which will be held in central San Francisco) with all SD&A attendees automatically being registered for access for the Photonics West exhibition.

The 2011 SD&A conference will continue a tradition of presenting and demonstrating the latest technologies relevant to stereoscopic displays and applications. Please consider attending, presenting, or demonstrating at the 2011 Stereoscopic Displays and Applications conference. We hope to see you there!

Andrew J. Woods
Nicolas S. Holliman
Neil A. Dodgson

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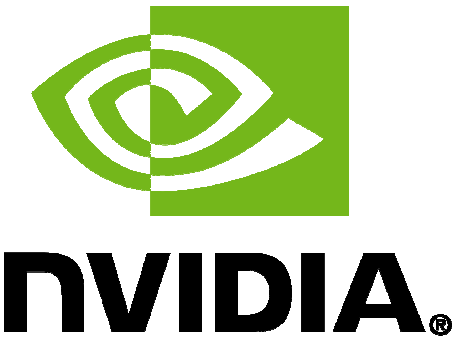

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