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# ***Stereoscopic Displays and Applications XXIII***

**Andrew J. Woods  
Nicolas S. Holliman  
Gregg E. Favalora**  
*Editors*

**23–25 January 2012  
Burlingame, California, United States**

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**Volume 8288**

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Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Stereoscopic Displays and Applications XXIII*, edited by Andrew J. Woods, Nicolas S. Holliman, Gregg E. Favalora, Proceedings of SPIE-IS&T Electronic Imaging, SPIE Vol. 8288, Article CID Number (2012).

ISSN 0277-786X

ISBN 9780819489357

Copublished by

**SPIE**

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

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Printed in the United States of America.

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**John O. Merritt**, The Merritt Group (United States)

Stereoscopic 3D Image Quality: Quantifying Perception and Comfort:

Joint Session with Conference 8291

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**Hideki Kakeya**, University of Tsukuba (Japan)

# Stereoscopic Displays and Applications XXIII

The World's Premier Conference for 3D Innovation

## Introduction

For a 23rd year, the Stereoscopic Displays and Applications (SD&A) conference was the premier venue for the dissemination of research on stereoscopic displays and their applications. SD&A attracts key players in the field - stereoscopic experts from industry and academia presented our two keynote presentations, participated on our discussion panel, spoke in the technical presentations, and, of course, were in the audience. The conference had an excellent technical program covering a wide range of stereoscopic topics.

This year we had 123 submissions. We were able to accept 53 for oral presentation (43%), with an additional 43 papers accepted as posters (35%), leading to a rejection rate of approximately 22%.

This conference proceedings volume contains the technical papers in support of both the presentations and posters given at the 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 SD&A conference was held 23–25 January 2012 as part of the 2012 IS&T/SPIE Electronic Imaging: Science and Technology Symposium, at the Hyatt Regency San Francisco Airport Hotel, next to San Francisco International Airport, in Burlingame, California, USA. Attendance at this year's event was again very strong with good growth from last year reflecting the high and continued interest in 3D technologies across the entire spectrum.

The **first day** had seven technical sessions, running in two parallel rooms. Topics covered applications, cameras, mobiles, autostereoscopy, perception, quality, comfort, image processing and content adaptation. There was our first keynote, the two-hour 3D theatre, and our conference banquet.

The **first keynote presentation** was given by Masayuki Kozuka of Panasonic. He gave an excellent summary of Panasonic's stereoscopic 3D technologies, standardization and business strategy. The presentation provided a very good overview of the leading position Panasonic is taking to guide the development of the 3D market, and also included several Full-HD stereoscopic 3D video sequences played off Blu-ray 3D.

The two-hour **3D Theatre Session** (chaired by Andrew Woods and Chris Ward) is a regular highlight event that showcases 3D content from around the world. It was the most popular session of the conference, with over 300 attendees. This year, we screened the following pieces (or segments thereof) on the 5.6 meter (18 foot) diagonal stereoscopic projection screen:

<b>Title</b>	<b>Company / Credit</b>	
Brave (trailer)	Pixar Animation Studios (USA)	
Scratch's Continental Crack-up, part 1	20th Century Fox and Blue Sky Studios (USA)	
Sony Two Worlds	Sony and Grey London (USA/UK)	†
UYUYUI!	Santiago Caicedo (Colombia)	†
See You Later	Amusic and Digital Magic Limited (Hong Kong)	
C30 Electric Crash Tests in 3D	Volvo Cars Corporation (Sweden)	†
3D Bubble Mania Extended Cut	Peck Media, Tony Peck, Ron Shaw (USA)	
PlayStation 3 Stereoscopic Games Selection	Sony Computer Entertainment World Wide Studios (UK)	
All Is Not Lost	OK Go and Pilobolus (USA)	†
Random42 Showreel	Hugo Paice (UK)	†
Enxaneta	TV3, Televisió de Catalunya (Spain)	
Hong Kong Skydrive	Volker Kuchelmeister (Australia/Hong Kong)	†
GoPro 3D: Highlight Reel 2011	GoPro Media Team (USA)	
The Blackpool Tower 4D Experience	Sharp Cookies Ltd (UK)	†
De-Visions 3D	Ryan Suits (USA)	
John Carter (trailer)	Disney (USA)	
The Shadower	Jenny Januszewski (USA)	
Pro XXXRW	Brian Drake and Jhonathan Florez (USA)	†
Humor and Heartache of War	Digital Revolution Studios (USA)	
Dancing Girls	Norma Kamali / 21st Century 3D (USA)	†
Cycle 3D (trailer)	Andrew Murchie, Enhanced Dimensions (UK)	
3D from 2D: HMAS Sydney II in 3D	Curtin University, Australian War Memorial, Finding Sydney Foundation, and David Mearns (Australia)	
Make Every Second Count (short version)	Nat Bartholomew (USA)	†



Ancient Russia 3D	Andrey Anokhin (Russia)	†
3D Mash-Up 2011	Various Artists. Executive Producer: Lightspeed Design, Inc. (USA)	
The 30 Second Intermezzo	Chris Casady (USA)	
Soar Over Asteroid Vesta in 3D	NASA / JPL-Caltech (USA)	
Galaxy Mergers in the Early Universe	Ralf Kaehler (KIPAC/SLAC) and Tom Abel (Stanford) (USA)	
Universe in a Coffee Cup	Takashi Sekitani (Japan)	
Le Fantôme de l'Opéra: restauration du film dans sa version originale stéréoscopique	A restoration work by Carl Herz (USA)	
Dimension3 2011 Trailer	Dimension3 (France)	†
Monster vs Mini 3D	Mini Cooper / BSUR / Camp David / WW7 / 21st Century 3D (USA)	†
Monkey King	Sight, Sound & Action and Digital Magic Limited (Hong Kong)	
NVIDIA 3D Vision thriller	GALI-3D s.r.o. (Czech Republic)	
Viu en 3D! (Live in 3D)	TV3, Televisió de Catalunya (Spain)	
The Bird Man	Yoshihiro Funabashi (Japan)	†
Bullproof	Digital Revolution Studios (USA)	†
My Dream	Joy Park (director) (Korea)	†
Tarang	Jonny Greenwald, Shyam Kannapurakkaran, Ganesh Rao, Aparupa Chatterjee (USA)	†
Berlin Philharmonic Orchestra 3D	produced by KUK Filmproduktion GmbH for Fraunhofer HHI, directed by Josef Kluger (Germany)	
Scrat's Continental Crack-up, part 2	20th Century Fox and Blue Sky Studios (USA)	

Seventeen of the forty-one entries were exhibited in the Competition category (indicated by '†') and the remaining entries were in the Demonstration category. Entries in the Competition category were judged by two esteemed judges: Bernard Mendiburu (author of "3D Movie Making" and the follow-up "3D TV and 3D Cinema") and Percy Fung (Digital Magic Limited (Hong Kong), SMPTE Fellow and Adjunct Professor at City University of Hong Kong School of Creative Media). Entries in the Demonstration category were not judged.

The judges chose the following 3D content winners:

**Best of Show** – "All Is Not Lost" by OK Go and Pilobolus (USA)

**Honorary Mention** – "The Blackpool Tower 4D Experience"  
by Sharp Cookies Ltd. (UK)

The Best of Show award was accepted by Eric Kurland, Stereographer on "All Is Not Lost."

An illustrated listing of the content shown during this year's 3D Theatre session is available from the conference website:

[www.stereoscopic.org/3dcinema](http://www.stereoscopic.org/3dcinema)

A "3D mash-up" of content from previous 3D Theater sessions was shown at this year's event and can be found on YouTube3D courtesy of DepthQ:

[http://www.youtube.com/watch?v=r\\_d8aozFXLk](http://www.youtube.com/watch?v=r_d8aozFXLk)

The producers of the 2012 SD&A 3D Theater were Andrew Woods (Curtin University, Australia) and Chris Ward (Lightspeed Design, USA). Additional support was provided by John Stern (Intuitive Surgical Inc., retired) and Dan Lawrence (Lightspeed Design).

The evening concluded with our traditional conference dinner. This year it was held at the Benihana Japanese-style teppanyaki restaurant on the bay-front near the conference hotel. Sixty conference attendees mingled and talked, while being entertained by the Benihana chefs preparing everyone's meals in front of them.

The **second day** of the conference began with the second SD&A keynote. This was followed by three technical sessions on image quality, including two joint sessions with the HVEI conference (Human Vision and Electronic Imaging) on quantifying stereoscopic perception and comfort. In the evening there was the demonstration session and the poster session. The full papers from both the technical sessions and the poster session are all contained in this volume – except for four of the papers ([8291-19], [8291-20], [8291-21] and [8291-22]) from the joint session which will appear in the HVEI proceedings (*Proc. of SPIE* volume 8291)

The **second keynote presentation** was given by Pete Bradshaw and Debargha Mukherjee, about the development and future of YouTube3D. The presenters provided a very interesting background of the history of YouTube3D from its inception as a side project to the highly successful platform that we know today.

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 range of demonstrations and to see a large audience actively engaging with the various displays and vendors. The energy in the demonstration session was astounding and many demonstrators were still going strong after two and a half hours.

This year the following 3D hardware and 3D software products were on show at the demonstration session:

- **University of Tsukuba** (Hideki Kakeya and Shimpei Sawada), a prototype integral volumetric imaging display
- **University of Tsukuba** (Hideki Kakeya), a simulation of time-division multiplexing anaglyphs
- **Christopher Tyler**, taking Kinect depth maps as input to plot live random-dot autostereograms presented on a large-screen TV
- **Infitec**, optimized 4-3-band filter configuration for color filters to provide improved color matching in the two eyes compared to their earlier 3-3-band filter configuration
- **Raytrix**, a 3D light-field camera
- **Ronald Karpf**, active Pulfrich-effect glasses
- **University of Tokushima** (Hirotugu Yamamoto, Hiroki Bando, and Shiro Suyama), a prototype cross-mirror array to form floating 3D LED signs
- **SLAC National Accelerator Lab** (Ralf Kähler and Tom Abell), interactive stereoscopic visualization of large-scale astrophysical simulation shown on a 3D capable laptop
- **PolarScreens, Inc.** (Jean-Etienne Gaudreau), full-resolution autostereoscopic display with an all-electronic tracking system
- **ELDIM**, equipment for optical characterization of different types of 3D displays
- **Qualcomm**, real-time stereoscopic camera calibration on a mobile phone platform outputting to a large-screen 3DTV
- **NVIDIA**, stereoscopic gaming running on a new LightBoost 3D monitor and the new 3D Vision 2 active shutter glasses with the new 3D game "Trine"
- **Volfofi** (Bernard Mendiburu), universal active shutter glasses, polarization modulator and universal 3D emitter
- **IMAX**, provided a stack of free IMAX 3D movie posters
- **University of Ottawa** (Luis Gurrieri), an interactive demonstration of image-based stereoscopic telepresence running on a laptop.

A prize was awarded for the best demonstration at the session. The judging panel was chaired by Prof. Neil Dodgson (Cambridge University, UK). The prize was awarded to Hirotugu Yamamoto, Hiroki Bando, and Shiro Suyama, of the University of Tokushima, for "Design of cross-mirror array to form floating 3D LED signs."

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](http://www.stereoscopic.org)

The **third day** of the SD&A conference had four technical sessions on games, cinema, displays and the popular discussion forum. The evening concluded with the Electronic Imaging symposium reception which included a 3D gaming demonstration.

The **discussion forum** considered whether 3D moving images will become ubiquitous. The panel comprised **Lenny Lipton** (moderator), **Bob Whitehill** (Pixar Animation Studios), **Ray Zone** (The 3D Zone), **Art Berman** (Insight Media), and **Jon Peddie** (Jon Peddie Research). The panel was up-beat about the long term prospects for stereoscopic 3D. The consensus was that all technologies will have the capability for stereoscopic 3D but that not all content will be stereoscopic. Panelists expressed concerns for the short term. The mainstream media has heavily criticized stereoscopic 3D, but there are signs that we are getting past blanket criticism of all things stereoscopic. The hope is that critics will move to considering each movie on its own merits rather than damning all stereoscopy. One sign that stereoscopy is maturing is that it is being used for movies other than science fiction and spectacle. *Hugo* [2011] and *The Great Gatsby* [2012] are early examples of stereoscopy in traditional drama. Lenny noted that, in this genre, stereoscopy turns the cinema into something akin to an intimate live theatre production. However, he also commented that the current 3D camera rigs are proving too cumbersome for live action directors and cameramen. Turning to television, Jon and Bob commented that (live) sport is likely to be the content that fuels the rise of stereoscopic 3D, in the same way that it fueled the rise of color and of HDTV. Where the panel disagreed was over the use of glasses in the home. Jon thought that people are not averse to glasses, per se, because most are quite happy to wear corrective spectacles or sunglasses. Bob disagreed, thinking that autostereoscopy was the way forward. The audience had strong opinions also, leading to lively debate. We will have to wait and see whether passive glasses are acceptable to the general consumer, or whether we really do need an autostereoscopic solution.

Most sessions in the main SD&A conference hall, including the keynotes and panel, were recorded. Editing is underway and the content will be available online very soon.

The Electronic Imaging Symposium Reception on the Wednesday evening was a great way to chat and relax with colleagues. A large-screen **3D Gaming Experience** was also setup during the reception - kindly provided by Sony Computer Entertainment and JVC Professional. Each system consisted of a JVC RS40 LCoS Full-HD 3D projector, driven by a PlayStation 3 console running in 3D mode, projecting onto a large projection screen and viewed using active shutter

glasses. The PS3 3D game being shown was "Motorstorm Apocalypse" which runs in full stereoscopic 3D using the retail released game. This was a great example of the type of 3D experience people can now have in their own home.

A final **prize** was offered at the conference for the best use of the stereoscopic projection tools during the technical presentations. The winner, chosen by the SD&A conference chairs, was:

- "Case study: the introduction of stereoscopic games on the Sony PlayStation 3" by Ian Bickerstaff, Sony Computer Entertainment Europe Ltd. (UK)

Ian's presentation was presented wholly in stereoscopic 3D – every slide. It even included several 3D video sequences to illustrate the effect of varying stereoscopic camera parameters.

The prizes this year were:

- "Stereoscopic Displays and Applications 1990-2009: A Complete 20-Year Retrospective and The Engineering Reality of Virtual Reality 1994-2009 (Special Collection) (DVD-ROM)" (ISBN: 9780819476593), published by SPIE in 2010;
- Bernard Mendiburu's latest book "3D TV and 3D Cinema: Tools and Processes for Creative Stereoscropy," published in 2011 by Focal Press; and
- Autographed copies of Lenny Lipton's 1982 book "Foundations of the Stereoscopic Cinema."

Congratulations to all our prize-winners in the 3D Theatre, demonstration session, and technical presentation categories.

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

- There were six major sponsors of this year's conference. Our gold sponsors were **IMAX Corporation** (Canada), **NVIDIA Corporation** (USA), **Qualcomm Incorporated** (USA) and **Technicolor** (USA). Our silver sponsors were **DepthQ Stereoscopic** (USA) and **ELDIM** (France). Conference sponsorship is a valuable way for companies to support the running of the conference and to gain marketing exposure. Our sponsors are 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: **Christie Digital** (USA), **Visitech 3D** (USA), **STRONG / MDI Screen Systems** (Canada) and **Fakespace Labs** (USA). The ability to present high-quality large-screen stereoscopic images and video at the conference is vital to the success of the conference. This year we had a Christie Digital Mirage HD10K-M projector (1920×1080 resolution, 16:9 aspect ratio, 3 chip DLP, 10,000 ANSI lumens, provided by Christie Digital) projecting onto a 4.9×2.7 meter silvered screen (provided by STRONG / MDI Screen Systems and setup by Visitech 3D), outputting frame-sequential circularly-polarized

3D (at 120Hz) by way of a DepthQ active polarization modulator (provided by DepthQ Stereoscopic). The system was driven by a DepthQ stereoscopic media server for playback of all of the stereoscopic video content shown during the 3D Theatre. Blu-ray 3D playback was performed from a PlayStation 3 console (provided by Fakespace Labs). Many thanks also to the individuals who worked tirelessly on-site: **Chris Ward** from DepthQ Stereoscopic; **Wayne Bickley** from Christie Digital; **Brad Nelson** from Visitech 3D; **Ian McDowall** from Fakespace Labs; and **Adrian Romero** and staff from Spectrum Audio Visual. The AV setup was project managed by **Stephan R. Keith**; **Diana Gonzalez** from IS&T; and **Andrew Woods**.

- We thank our media sponsors who helped promote the conference: **Veritas et Visus**, **Dimension 3**, **3D Roundabout**, and **River Valley TV**.
- We very much appreciate the dedicated support of **Stephan R. Keith** (SRK Graphics Research), who had a multi-tasked role at this conference, including help support the AV needs of all of our presenters.
- 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.
- Many thanks to JT Tidwell and Ian Bickerstaff from **Sony Computer Entertainment**, Rod Sterling and Steve Inoue from **JVC Professional**, and **Stephan Keith** for providing equipment, games, and assistance with the 3D Gaming Experience.
- 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, **Neil Dodgson**, **Hideki Kakeya**, **Takashi Kawai**, **John Stern**, **Vivian Walworth**, **Chris Ward**, **Michael Weissman**, and **Samuel Zhou**.
- Thanks also to the staff at IS&T and SPIE, the two organizing societies, who were instrumental in organizing all manner of aspects of 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.

This year we again offered authors the opportunity of having their manuscripts fully peer-reviewed. This process adds a second level of reviewing to papers and requires authors to respond to detailed comments from anonymous reviewers. The review chair was Nick Holliman. Four papers successfully passed the peer-review process and these were:

- **Focus mis-match detection in stereoscopic content**, Frédéric Devernay, Sergi Pujades, Vijay Ch.A.V., INRIA Rhône-Alpes (France) [8288-12]
- **YouDash3D: exploring stereoscopic 3D gaming for 3D movie theaters**, Jonas Schild, Univ. Duisburg-Essen (Germany); Sven Seele, Hochschule Bonn-Rhein-Sieg (Germany); Maic Masuch, Univ. Duisburg-Essen (Germany) [8288-42]
- **Investigating the cross-compatibility of IR-controlled active shutter glasses**, Andrew J. Woods, Jesse Helliwell, Curtin Univ. (Australia) [8288-49]
- **Designing stereoscopic information visualization for 3D-TV: what can we can learn from S3D gaming?**, Jonas Schild, Maic Masuch, Univ. Duisburg-Essen (Germany) [8288-97]

The long term benefit of publishing at SD&A is that a well established, historically significant number of the most highly cited stereoscopic research papers have been published in these proceedings over its 23-year history. The additional quality of this year's peer-reviewed papers will help improve the citation quality of these works and also help improve the impact of the SD&A proceedings. The Chairs and authors would like to thank the anonymous reviewers for their timely and thorough comments.

Each year authors of SD&A papers of particular merit are encouraged to submit extended versions of their work to the *Journal of Electronic Imaging* (JEI). Following the January 2011 conference, several SD&A authors were asked to submit to a special issue of JEI on Stereoscopic Displays and Applications. The special issue is now complete and will be published as JEI Volume 21, issue 1, March 2012. <http://spiedigitallibrary.org/jei/resource/1/jeime5/v21/i1> This special issue of JEI includes articles on visual comfort and viewing experience, stereoscopic display design, image processing, camera design, and cinematography. The authors collectively describe substantial advances that will have lasting technical and theoretical impact on the field. In addition, reflecting the strong interest in the field of stereoscopic imaging, the sister SPIE publication *Optical Engineering* has a special section on "3D and 4D Imaging Techniques and Applications" in its February 2012 issue. It is pleasing to see the excellent work that is published at the SD&A conferences flowing into the refereed journals and this represents an ongoing maturing process for our field.

Conference activities do not stop at the end of the January meeting. The SD&A conference website and LinkedIn group provide focuses for conference activities during the time between conferences. We will soon be actively seeking abstracts for the 2013 conference, with a deadline in June 2012 – see the website for details and deadlines. You can join the SD&A LinkedIn group to receive conference announcements. 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. The SD&A conference LinkedIn group is available at:

[www.linkedin.com/groups?gid=1945944](http://www.linkedin.com/groups?gid=1945944)

You may visit the conference website to gain an understanding of the past, present, and future of stereoscopic imaging. Please think now about submitting a paper or attending next year's conference. The Stereoscopic Displays and Applications conference website is at:

[www.stereoscopic.org](http://www.stereoscopic.org)

Next year, the 24th annual SD&A conference will be held for three days in the period 4–7 February 2013 at the Hyatt Regency San Francisco Airport Hotel, as part of the 2013 IS&T/SPIE Electronic Imaging: Science and Technology Symposium. The hotel is just five minutes from the San Francisco International Airport (via a free shuttle bus) and some 20 minutes from central San Francisco by public transport. Parking is easy for local attendees. Looking further ahead, the 25th SD&A conference in 2014 is planned to be held in downtown San Francisco.

The 2013 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 2013 event. We hope to see you there!

**Andrew J. Woods**  
**Nicolas S. Holliman**  
**Gregg E. Favalora**

(Additional editorial: Neil A. Dodgson)



# Stereoscopic Displays and Applications XXIII (2012)

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