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Editorial

Foreword to the special section on advanced displays

Display, being the final medium to convey the captured, processed or rendered data to the user, is a critical component of any computer graphics application pipeline. The various complex processes and procedures that go on behind the scenes in any computer graphics application can have the desired impact when shown on an appropriately designed display. On the other hand, a poorly chosen display can be the undoing of even great graphics applications. We dedicate this special section of computers & graphics on advanced displays to the tremendous development we have seen in display technology in the past few years.

This advancement in displays has come from different directions. On one hand, we have seen the advances in miniaturization of LCD and projection technologies making them light, portable and embeddable in small mobile devices. Display quality has largely been retained even in the face of such miniaturizations, leading to retinal LCD displays or focus-less laser projectors. On the other hand, we have also seen a tremendous advancement in enlargement of displays. LCD panel based TVs have kept increasing in size leading to wall-sized TVs while projection based displays have increased in resolution making 4K and 8K projectors a reality. Advancement in automated camera-based registration technologies for multi-projector displays has enabled easily deployable display walls, large immersive VR environments, and spatially augmented reality systems.

In an orthogonal direction, recently displays have advanced beyond 2D. About a decade ago, 3D displays were primarily stereoscopic, either active (via synchronous switching of shuttered glasses with the projection based display) or passive (via selective filtering of differently polarized light from the projectors through glasses). In the last few years, we have seen a rejuvenation of the parallax barrier technology leading to glasses-free light field displays. We have also started to see real holographic displays in small scale. Coupled with the introduction of the light field cameras, these advances promise a scintillatingly exciting future for advanced display technologies. Last, bringing in computation to the displays themselves has allowed to overcome some inherent limitations of existing technologies; together with knowledge of the human visual system and its limitations, this combination may well be the basis for the next revolution in display technology.

In this special section on advanced displays we bring you four high-quality papers exploring different domains of display technologies. We received 12 submissions for this special section, two of which were accepted for publication. A third paper was forwarded from a general issue of Computers & Graphics due to the suitability of its topic. Finally, we invited the authors of the best paper of the 2013 IEEE CVPR Workshop on Computational Cameras and Displays to submit an extended version of their paper, which was accepted for publication after a fresh round of reviews.

We begin the section with *A Survey on Computational Displays*: *Pushing the Boundaries of Optics*, *Computation and Perception* [1], a comprehensive review of the state of the art by Masia and colleagues. The authors make the observation that recent advances in display technology share the common goal of improving the viewing experience by means of a better reconstruction of the plenoptic function, and structure their discussion of existing works around the dimensions of such function. In addition, each section includes an overview of the relevant aspects of human perception that each technology relies on. Apart from a description of the different technologies, the survey also includes an overview of current solutions for content generation in each case. At the end of the paper, the authors provide a global view of the field, identify current trends and hypothesize which future research directions may bring the next big breakthrough.

In *Parallax Walls*: *Light Fields from Occlusion on Height Fields* [2], by Snelgrove et al., the authors introduce a novel passive light field display which, when viewed from different directions in ambient lighting conditions, provides different views of the same scene. This is achieved via an inexpensive height field surface geometry that, when appropriately painted, can produce diffused reflections under ambient lighting conditions to approximate a target light field. Unlike parallax barriers where the barriers are parallel to the display plane, this paper explores the possibilities resulting from wall-like barriers orthogonal to the display plane, suitably termed as *parallax walls*, which create a continuous light field basis that can be discretized and analyzed. This analysis shows an inherent brightness-correlation tradeoff: on one end of the spectrum are the parallax barrier displays with most un-correlated views but with least brightness. A sheet of paper would lie at the other end, with highly correlated views but with maximum brightness. This generalization is one of the core contributions of the paper. The parallax wall display is designed to fall between these two ends, acknowledging the fact that natural light fields are highly correlated.

In *Display Adaptive 3D Content Remapping* [3], Masia and colleagues address the intrinsic trade-off between reproducible spatial frequencies and depth of field in automultiscopic displays. They introduce a novel light-field retargeting method that adapts the perceived depth of a light field differently for different automultiscopic displays, based on device specific constraints like pixel size, number of viewing zones, or thickness. These constraints are coupled to a model of human perception that takes into account the frequency-dependent sensitivity to contrast and the sensitivity to binocular disparity. They propose a nonlinear optimization framework that aims at retaining the sharpness of the content while preserving the original perception of depth.

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In this manner, the same content is retargeted differently for different displays, from hand-held devices to movie theater screens, thus allowing a high-quality, blur-free viewing experience. The framework is versatile enough to be adapted for stereoscopic displays, supporting both dichotomous and non-dichotomous comfort zones.

Last, Yue and colleagues present *Non-Uniform Image Deblurring Using Optical Computing System* [4]. This paper won the Best Paper Award in the 2013 IEEE CVPR Workshop on Computational Cameras and Displays, and as such the authors were invited to submit an extended version to this special issue. The paper first analyzes existing non-uniform deblurring algorithms, and identifies their most costly operations: non-uniform convolution and perspective warping. These are then computed optically, using a projector and a programmable moving platform. Solving this problem in the light transport domain benefits from both speed and parallelism. While the current paper shows a prototype implementation with limited camera motion, the approach can be generalized to more complex scenarios.

We are pleased to have this outstanding set of papers appear in this special section of Computers & Graphics. We are very grateful to Joaquim Jorge, Editor in Chief, for his constant support and help while putting this section together, including his handling of papers which presented a conflict of interest to the Guest Editors, to the authors of all submitted papers, and to the anonymous reviewers who provided thorough and well-considered feedback that helped to ensure the high final quality of the selected submissions.

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Diego Gutierrez is an associate professor at the Universidad de Zaragoza, Spain, where he leads the Graphics and Imaging Lab. He got his PhD from the same university in 2005, on the topic of realistic rendering of participating media. His research interests are mainly global illumination, computational photography and displays, and the mechanisms of the human visual system. He has been Program Chair of top venues like the Eurographics Symposium on Rendering (EGSR 2012) or the ACM Symposium on Applied Graphics and Visualization (APGV 2011), among others. He has also been Conference Chair of EGSR 2013 and APGV 2010. He has served on many program committees, including SIGGRAPH (2013, 2012), SIGGRAPH Asia (2013, 2012, 2009) or Eurographics (2014, 2013, 2011, 2010, 2007). He is currently an associate editor of three journals: Computers & Graphics, ACM Transactions on Applied Perception and MIT Press Perception. Together with other colleagues, he has patented an interactive stereoscopic display for industrial design that has been used by large companies to design the new generation of trains in Spain.

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