Cutting-Edge VR/AR Display Technologies (Gaze-, Accommodation-, Motion-aware and HDR-enabled)

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Abstract

Near-eye (VR/AR) displays suffer from technical, interaction as well as visual quality issues which hinder their commercial potential. This tutorial will deliver an overview of cutting-edge VR/AR display technologies, focusing on technical, interaction and perceptual issues which, if solved, will drive the next generation of display technologies. The most recent advancements in near-eye displays will be presented providing (i) correct accommodation cues, (ii) near-eye varifocal AR, (iii) high dynamic range rendition, (iv) gaze-aware capabilities, either predictive or based on eye-tracking as well as (v) motion-awareness. Future avenues for academic and industrial research related to the next generation of AR/VR display technologies will be analyzed.

Accommodation-aware VR

Head-mounted Displays (HMDs) often provoke discomfort and nausea. Recent exciting work has showcased that when accommodation and vergence distances match in an HMD, comfort significantly improves [3]. One way to achieve such a match is by combining gaze-contingent, depth-of-field (DoF) rendering with new developments on focus-adjustable lenses or spatial light modulators (SLMs). In this tutorial, the latest advancements on adjustable lenses and SLMs will be examined that provide correct accommodation cues depending on the distance of the object being observed in the virtual scene.

Near-Eye Varifocal AR

New advancements in display engineering and a broader understanding of vision science have led to computational displays for VR and AR. Today, such displays promise a more realistic and comfortable experience through techniques such as lightfield displays, holographic displays, always-in-focus displays, multiplane displays, and varifocal displays. In this talk, new optical layouts for see-through computational near-eye displays are presented that are simple, compact, varifocal, and provide a wide field of view with clear peripheral vision and large eyebox [1]. Key to research efforts so far contain novel see-through rear-projection holographic screens and deformable mirror membranes [2]. Fundamental trade-offs are established between the quantitative parameters of resolution, field of view and the form-factor of the designs; opening an intriguing avenue for future work on accommodation-supporting AR displays.

HDR-enabled

Currently, commercial HMDs are based on standard dynamic range (SDR) imaging systems. High dynamic range display and rendering technologies, capable of depicting the extreme brightness range and an extensive range of colours, could improve visual quality, enhancing immersion and sense of realism [7]. The course will analyze recent developments in relation to high dynamic range content production, rendering and display [6] and how this can be incorporated in VR displays. It will analyze the challenges of introducing higher brightness levels to VR and the effect it could have on visual quality and comfort.

Gaze-aware

Gaze-aware displays can improve interaction and rendering in VR. Recent foveated rendering methods will be presented focusing on foveated ray tracing and techniques optimizing perceivable aliasing or blur [8]. Gaze-controlled VR 3DUIs will be described [11] as well as issues arising when eye movements are involuntary and accidental, provoking frequent interface activation (Midas touch problem). Prediction of gaze direction can accelerate computer graphics rendering in intensive, power-hungry VR applications [4]. Research on low-level attention algorithms inspired from biological brains will be reviewed as well as high level saliency instigated by scene context. Recent applications of gaze prediction in VR will be discussed such as VR stereo grading compressing 3D stereo depth around predicted gaze [5].

Motion-aware

Existing HMDs provide limited input to a user beyond the positional tracking of the HMD and/or controllers. Users currently cannot see or perceive their own body in VR [10]. This course will present experiments conducted with a novel head-mounted marker-less motion capture system in immersive VR applications [9]. The system comprises of two fish-eye cameras attached to an HMD, tracking the motion of a user wearing it. By utilizing such as lightweight capture rig, geared for HMD-based VR, egocentric motion capture is feasible. Applications will be demonstrated in which the user looks down at their virtual self. Current HMD-based systems only track the pose of the display. The tutorial will showcase novel approaches adding motion capture of the wearers full body, evoking a higher level of immersion.

Bios of Speakers

Kaan Akşit (B.S. in Electrical Engineering, Istanbul Technical University, M.Sc. in Electrical Power Engineering, RWTH Aachen University, Germany, Ph.D. in Electrical Engineering, Ko University, Turkey). In 2009, he joined Philips Research at Eindhoven, the Netherlands as an intern. In 2013, he joined Disney Research, Zurich, Switzerland as an intern. His past research includes topics such as visible light communications, optical medical sensing, solar cars, and auto-stereoscopic displays. Since July 2014, he is working as a research scientist at Nvidia Corporation located at Santa Clara, USA, tackling the problems related to computational displays for virtual and augmented reality.

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George-Alex Koulieris (B.Sc. in Computer Science and Telecommunications, University of Athens, M.Sc. in Computer Science, University of Economics and Business, Athens, PhD in Electronic & Computer Engineering, Technical University of Crete, Greece) is a post-doctoral researcher at Inria, France, team GraphDeco, working on near-eye stereo displays. Previously, he was a visiting scholar at UC Berkeley, working on the vergence accommodation conflict for head-mounted displays. During his PhD studies he worked on gaze prediction for game balancing, level-of-detail rendering and stereo grading.

Katerina Mania (B.Sc. Mathematics, University of Crete, Greece M.Sc. & PhD Computer Science, University of Bristol/HP Labs). Her primary research interests integrate perception, vision and neuroscience to optimize computer graphics rendering/VR. After positions at HP Labs and University of Sussex (faculty), she now serves as an Associate Professor at the School of Electrical and Computer Engineering, Technical University of Crete. She has been the Principle Investigator or Co-Investigator of UK, Greek and EU projects. She has co-chaired technical programs and has participated in over 90 international conference program committees. She serves as one of the Associate Editors for Presence, Tele-operators and Virtual Environments and ACM Transactions on Applied Perception.

Rafał K. Mantiuk (PhD in Computer Science, Max-Planck-Institute for Computer Science) is a senior lecturer at the Department of Computer Science and Technology (Computer Laboratory), University of Cambridge (UK). His recent interests focus on designing rendering and display algorithms that adapt to human visual performance and viewing conditions in order to deliver the best images given limited resources, such as computation time, bandwidth or dynamic range. He contributed to early work on high dynamic range imaging, including quality metrics (HDR-VDP), video compression and tone-mapping. In 2017 he was awarded an ERC Consolidator grant to work on perceptual encoding of high dynamic range light fields. More on his research can be found at: http://www.cl.cam.ac.uk/ rkm38/.

Christian Richardt (BA, PhD in Computer Science, University of Cambridge, UK). He serves as a Lecturer (Assist. Prof.) at the University of Bath. He was previously a postdoctoral researcher at Inria Sophia Antipolis, Max Planck Institute for Informatics and the Intel Visual Computing Institute. His research combines insights from vision, graphics and perception to extract and reconstruct visual information from images and videos, to create high-quality visual results and experiences, with a focus on video processing for 360 degree videos, light fields, and for user-centric applications. He has organised two SIGGRAPH courses, on User-Centric Videography (2015) and on Video for Virtual Reality (2017).

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