Guest Editors' Introduction

Metaverse: Technologies for Virtual Worlds

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Virtual worlds can be a powerful tool for a variety of applications, including education, visualization, collaboration, or entertainment. Some of these virtual worlds utilize augmented reality (AR), virtual reality(VR), or extended reality (XR); others use Web 3.0 technologies. These virtual worlds can be isolated or interconnected within a metaverse and some can even use blockchain technologies to enforce permanent records of, for example, ownership of part of the virtual world. For this special issue, we solicited manuscripts focused on a variety of technologies for such virtual worlds, including AR, VR, and XR as well as Web 3.0 and blockchain technologies, running on different devices ranging from web browsers, hand-held devices or head-mounted displays to full-scale CAVE-type systems. Based on the formal IEEE Computer Graphic and Applications review process, we were able to accept 5 out of the 9 submissions that were received.

In "Procedural Defect Modeling for Virtual Surface Inspection Environments", Bosnar and coauthors describe methods for creating virtual models for different types of manufacturing defects. Based on appropriate lighting methods, very realistic models can be created. These models can then be used to create virtual representatives of defective products. By creating a variety of such defective models, the resulting database can be used for visual inspection system training.

The manuscript "Virtual Flavor: High-fidelity simulation of real flavor experiences" expands the capabilities of a virtual environment by including flavors to cover an additional sense. Based on six to nine cartridges, the device can generate a variety of smells to deliver taste and retronasal smell. In a pilot study, participants were exposed to real and virtual samples of different flavors. The experiment showed that it is possible to provide the ability to enjoy a meal or drink in a virtual environment by analyzing the flavor components and then synthesize the sensation with the virtual flavor device.

To compare the efficacy of virtual reality serious games versus web video games, López-Fernán-

dez and coauthors performed a robust empirical study with 289 participants in their manuscript titled “Are virtual reality serious video games more effective than web video games?”. A serious game was developed to learn the software development framework Scrum that supports virtual reality through head-mounted displays and another version based on WebGL. The results show a statistically significant improvement in learning performance when using virtual reality over the web-based version.

In order to accelerate the process of creating virtual reality-based training software for the medical domain, Zikas and coauthors present a novel SDK in their manuscript titled “MAGES 4.0: Accelerating the world's transition to medical VR training”. This framework allows developers to create medical simulations in a low-code environment. It supports collaborative environments integrating both virtual and augmented reality. The SDK incorporates realistic simulation of organic tissues and highly realistic cutting and tearing algorithms. This framework was successfully deployed in a variety of virtual medical training scenarios.

As outlined by Patel and coauthors in the manuscript “Computer-Supported Experiential Learning Tool for Advanced Healthcare Skills”, virtual training can be an effective tool to improve specific skills. These virtual scenarios present a participant with a realistic encounter of different types of patients. This provides a learning environment in which the trainee can improve their skills at their own time by just installing an application on their phone or other devices. This provides a safe learning environment. The empirical results show an improvement of compassion and empathy toward their patient after completing the learning experience.

After publishing the call for papers for this Special Issue, one of our Guest Editors, namely André Stork, was elected new Editor-in-Chief for CG&A. He started this new role in January 2023. In accordance with the rules of IEEE, as EIC he was not involved in the decision making on the submissions. This process was run by the corresponding Associate EIC for Special Issues Pak Chung Wong.

We wish to thank Pak Chung Wong for his guidance in producing this Special Issue and we also wish to thank the authors and reviewers for their hard work. We hope you enjoy reading these manuscripts and learn more about the various technologies for virtual worlds.

Thomas Wischgoll is currently a full professor and NCR Endowed Chair at Wright State University. His research interests include scientific visualization, flow and scientific visualization, virtual environments and display technologies, as well as biomedical imaging and visualization. Dr. Wischgoll devised different algorithms for analyzing and visualizing different flow data sets, medical data, including CT and MRI, and other types of data sets. He utilized various display systems for virtual reality applications, ranging from head-mounted displays to full-scale walkable immersive systems, and applied these display systems to different virtual and augmented reality applications, including highly immersive experiments involving human subjects for a better understanding of human behavior. His research work in the fields of scientific visualization, data analysis, and AR/VR resulted in more than ninety peer-reviewed publications, including IEEE and ACM.

André Stork is head of the Competence Center for Interactive Engineering Technologies and honorary professor at Technical University (TU) Darmstadt. André Stork received his doctoral degree from the TU Darmstadt in 2000. His major research interests are geometry modelling and shape processing, 2D/3D interaction techniques, simulation, and scientific visualization. André Stork has authored and co-authored more than 170 papers in the field of his various interests. He has been a member of the pro-

gram committee or acted as a reviewer in many international conferences, workshops, and journals. He lectured “Computer Graphics III” and has lectured “Geometric Methods in CAD/CAE” at TU Darmstadt. André Stork is a member of IEEE, Eurographics, ACM, Gesellschaft für Informatik (GI), and VDI. In January 2023 he became EIC of IEEE CG&A.

Herbert Schilling is the Team Lead of the Scientific Computing and Visualization Team at the NASA Glenn Research Center. In that role, he leads the Graphics and Visualization (GVIS) Lab which has developed advanced AR/VR applications and other visualizations for the Center and the Agency for over 30 years. The Lab develops for a wide variety of visualization hardware including large-scale immersive environments, including a CAVE™. He also does scientific software development on projects for researchers and engineers at the Center. He is a member of the NASA Agency XR and AI/Machine Learning Working Groups. A strong advocate of STEM community outreach, he has mentored hundreds of students during his career.

Gerik Scheuermann is currently a full Professor with Leipzig University, Leipzig, Germany, since 2004. His research interests include visualization and Visual Analytics, especially on feature and topology-based methods, flow-, tensor-, environmental-, document visualization, and visualization for life sciences. He is also interested in combing visualization and virtual reality. The results were published in more than 250 peer-reviewed book chapters, and journal and conference papers, including IEEE TVCG, CGF, and IEEE CG&A. He has been a paper co-chair of all major visualization conferences like IEEE VIS, IEEE PacificVis, and EuroVis. He co-organized IEEE VIS 2018, EuroVis 2013, three Dagstuhl seminars, and several smaller events, and serves as General Chair of EuroVis 2023.