# Introduction to the Special Issue on Immersive Telecommunications

IMMERSIVE TELECOMMUNICATION is a new challenging field of applications providing users with a sense of presence. The two most relevant applications, immersive videoconferencing and immersive television, will overcome the limits of current videoconference systems and common broadcast TV. Immersive videoconferencing is going to be an attractive alternative for geographically distributed teams collaborating with each other, specifically to avoid traveling and to provide more effective nonverbal communications. The user gets the impression of being part of an extended perceptual space whereby important communication cues like gestures, eye contact, and body language are represented as naturally as possible. Immersive television represents a new concept of future TV entertainment, achieving the goal of providing a future experiential and multisensory home entertainment system which bridges the gap between the audio-visual sensations of current state-of-the art consumer electronics and the real sensation of live events.

The scientific challenges in this field range from high-quality three-dimensional (3-D) analysis and arbitrary view synthesis to encoding of 3-D video and real-time implementation, as well as system architectures and networks. Regarding 3-D video encoding, current standardization activities accompany the research. Furthermore, the new field of presence research and engineering, stimulated by a current EC Future and Emerging Technologies proactive initiative (see, e.g., www.presence-research.org or http://www.cordis.lu/ist/fet/pr.htm) contributes to this research area by taking the human factors aspects into account.

We received 15 contributions to this Special Issue spanning a wide range of topics in immersive telecommunications. After an extensive review process, we selected nine papers for publication based on detailed review reports. The resulting Special Issue presents the latest advances in this emerging field of research, covering the whole range of relevant areas. It is organized in a survey paper and three sections of research papers in the following areas: recent advances in immersive videoconferencing, contributions to immersive television, and research results from the human factors point of view.

The Special Issue opens with a survey article by Isgro *et al.* titled "3-D Image Processing in the Future of Immersive Media." The authors discuss the important technologies and problems associated with immersive telepresence. An extensive structured overview on the current state of the art in both fields of applications is given. Based on the presented concepts, the crucial problems for real-time, highly realistic 3-D video processing and their algorithmic solutions found in the image processing literature are described.

The first part of the section on immersive teleconferencing covers three papers on multiview video analysis and synthesis in the context of immersive videoconferencing scenario. It begins with a paper by Mulligan *et al.* titled "Stereo-Based Environment Scanning for Immersive Telepresence," which describes the tele-cubicle concept of the National Tele-Immersion Initiative in the United States, focusing on aspects in binocular and trinocular matching. The authors address speed and accuracy of their concept, which are important issues for convincing tele-immersion. The second paper by Atzpadin *et al.* deals with a new approach for "Stereo Analysis by Hybrid Recursive Matching for Real-Time Immersive Video Conferencing." The presented concept allows real-time stereo matching for high-resolution images at a video frame rate. This section is concluded by a contribution titled "An Efficient Image-Based Telepresence System for Videoconferencing," presented by Lei *et al.* Here, the focus is on view reconstruction realized by a parallelized implementation using dedicated digital signal processing hardware.

In the second section, recent advances in real-time video-based rendering for immersive television applications are proposed. Due to the increasing number of 3-D video applications, the MPEG standardization body has started with a new activity called 3DAV (3D Audio-Visual) in order to explore the capabilities and challenges for the current MPEG-4 standard. The current state of the art is presented by Smolic *et al.* in their paper "3DAV Exploration of Video-Based Rendering Technology in MPEG." In addition to this overview, they give an example for omnidirectional video as one of the application scenarios in 3DAV. Matsuyama *et al.* discuss multiple aspects of 3-D video processing of high-quality video in their paper "Real-Time Dynamic 3-D Object Shape Reconstruction and High-Fidelity Texture Mapping for 3-D Video." They present a plane-based volume intersection algorithm and describe a concept to parallelize this method.

The application of 3-D video in current TV studio production systems is not far from realization. Grau *et al.* present "A Combined Studio Production System for 3-D Capturing of Live Action and Immersive Actor Feedback," which allows the generation and rendering of 3-D models in preview quality for on-set visualization in real time and in high quality for postproduction applications in an offline phase.

The Special Issue concludes with two papers presenting in-depth surveys on human factors aspects in immersive telecommunication applications. The presence research community contributes to many aspects of user-centered communication, including the optimization of 3-D video. This is highly relevant as the usability, user acceptance, and user friendliness strongly depend on a careful design of future video communication applications. The paper "A Survey of Perceptual Evaluations and Requirements of 3-D TV" by Meesters

*et al.* provides the latest results in this field. Importantly, immersive telecommunication may not be limited to aural and visual senses only; haptics also have the potential to greatly increase the sense of presence. Reiner discusses this topic in the last contribution to this Special Issue entitled by "The Role of Haptics in Immersive Telecommunication Environments".

The team of Guest Editors would like to thank all of the authors for their submissions to this Special Issue reflecting the latest advances in their field of research. We are grateful to all the reviewers who gave a great deal of time and care to work on the papers. Their expertise and recommendations have improved the quality of the papers and helped the authors prepare the final versions. Many of the reviewers have been asked to work within a tight schedule and to check the revised versions in a second round. The quality of such a Special Issue and the timely publication strongly depends on the reliable support of the reviewers.

Finally, we would like to thank the Editor-in-Chief, T. Sikora, for suggesting this Special Issue and his support and guidance in the publication.

OLIVER SCHREER
Heinrich-Hertz-Institut
Fraunhofer Institute for Telecommunications
Berlin, D-10587 Germany

HENRY FUCHS
University of North Carolina
Department of Computer Science
Chapel Hill, NC 27599-3175 USA

WIJNAND IJSSELSTEIJN
Technical University Eindhoven
Department of Technology Management
Eindhoven, MB 5600 The Netherlands

HIROSHI YASUDA
The University of Tokyo
Research Center for Advanced Science & Technology (RCAST)
Tokyo, 153-8904 Japan
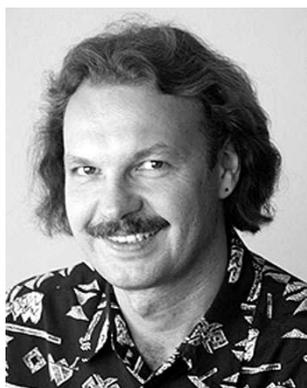
**Oliver Schreer** received the degree in electronics and electrical engineering and the Ph.D. degree in electrical engineering from the Technical University of Berlin, Berlin, Germany, in 1993 and 1999, respectively

From 1993 until 1998, he was an Assistant Teacher with the Institute of Measurement and Automation, Faculty of Electrical Engineering, Technical University of Berlin. He was responsible for lectures and practical courses in the fields of image processing and pattern recognition. His research interests have been camera calibration, stereo image processing, three-dimensional (3-D) analysis, navigation, and collision avoidance of autonomous mobile robots. Since August 1998, he has been working as a project leader in the "Immersive Media & 3-D Video"- Group, Image Processing Department, Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut (FhG/HHI), Berlin, Germany. In this context, he is engaged in research for 3-D analysis, novel view synthesis, real-time videoconferencing systems, and immersive TV applications. He was the representative from FhG/HHI within the European FP5 IST project VIRTUE and leader of the "Real-time" work package. Since autumn 2001, he has been an Adjunct Professor with the Faculty of Electrical Engineering and Computer Science, Technical University of Berlin.

Dr. Schreer has served as a Guest Editor for the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY and is a reviewer for several IEEE and IEE journals.

**Henry Fuchs** (M'76–SM'81) received the Ph.D. degree in computer science from the University of Utah in 1975.

He is the Federico Gil Professor of Computer Science, Adjunct Professor of Biomedical Engineering, and Adjunct Professor of Radiation Oncology at the University of North Carolina at Chapel Hill. He has worked on graphics rendering algorithms (BSP trees), graphics hardware (Pixel-Planes), high-speed networking and graphics (VISTAnet), three-dimensional (3-D) computer vision and immersive displays (National Tele-Immersion Initiative), and medical applications with virtual environments technologies. He has served as an Associate Editor of *ACM Transactions on Graphics* and as Guest Editor of its first issue in 1982. He has served on numerous conference program committees, including often on the Siggraph Papers Committee, was chair of the 1985 Conference on Advanced Research in VLSI, and chair of the 1986 Chapel Hill Workshop on Interactive 3-D Graphics, the first meeting of what is now the ACM Siggraph Symposium on Interactive 3-D Graphics. He was also co-chair in 1990 of the NATO Advanced Research Workshop on 3-D Imaging in Medicine.

Prof. Fuchs is a member of the National Academy of Engineering and a fellow of the American Academy of Arts and Sciences. He was the recipient of the 1992 ACM-Siggraph Achievement Award, the 1992 Academic Award of the National Computer Graphics Association, and the 1997 Satava Award from the Medicine Meets VR Conference.

**Wijnand A. IJsselsteijn** was trained as a psychologist at Utrecht University, with a specialization in neuropsychology.

From 1996 to 2000, he was with the Institute of Perception Research (IPO), Eindhoven, The Netherlands, on the ACTS TAPESTRIES project, where his input was aimed at developing and applying psychological assessment methodologies that are suited to evaluate the subjective impact and potential side-effects of stereoscopic entertainment media. His research interests focus on the psychological evaluation of new display and communication media, in particular the sense of (social) presence these media may elicit. Since August 2000, he has been working as an Assistant Professor with the Human-Technology Interaction Group, Department of Technology Management, Eindhoven University of Technology, Eindhoven, where his research interests have broadened to include multilevel presence theory (ranging from neuroscientific to sociological perspectives), multisensory interactions, and haptic interfaces, studied from the perspective of applied experimental psychology. He was project coordinator for the IST PRESENCE project (2001–2002) and is currently workpackage leader for the perceptual evaluation work within the IST ATTEST project and project coordinator for the IST OMNIPRES project. He has published in various journals and conference proceedings and has co-edited a recent book on presence: *Being There—Concepts, Effects and Measurement of User Presence in Synthetic Environments* (Amsterdam, The Netherlands: IOS Press, 2003).

**Hiroshi Yasuda** (S'67–M'72–SM'91–F'98) received the B.E., M.E., and Dr.E. degrees from the University of Tokyo, Tokyo, Japan in 1967, 1969, and 1972, respectively.

He then joined the Electrical Communication Laboratories of NTT in 1972. After serving 25 years (1972–1997), with his last position being Vice President, Director of NTT Information and Communication Systems Laboratories at Yokosuka, he left NTT and joined The University of Tokyo. He is now Director of The Center for Collaborative Research (CCR), and a Professor in the Research Center for Advanced Science & Technology. His area of study is applied information technology. He has been involved in video coding, image processing, tele-presence, B-ISDN network and services, and Internet and computer communication applications. He has begun research on digital rights management and "Kansei" (more human) communication. He is now advocating collaboration between industry and academia as the Director of CCR. He served as the Chairman of ISO/IEC JTC1/SC29 (JPEG/MPEG Standardization) from 1991 to 1999 in the area of international standardizing. He also served as the President of the Digital Audio Video Council (DAVIC) from September 1996 to September 1998.

Dr. Yasuda is a fellow of the EICEJ and IPSJ and a member of the Television Institute. He was the recipient of the Takayanagi Award in 1987, the Achievement Award of EICEJ in 1995, The EMMY from The National Academy of Television Arts and Science in 1995–1996, and the Charles Proteus Steinmetz Award from the IEEE in 2000. He wrote the "International Standardization of Multimedia Coding" in 1991, the "MPEG/International Standardization of Multimedia Coding" in 1994, "The Base for the Digital Image Coding" in 1995, "The Text for Internet" in 1996, "The Text for MPEG" in 2002, and "The Text for Content Distribution" in 2003.