

Title of Tutorial: Designing immersive VR systems: from bits to bolts

Proposed length: Half-day

Organizers:

Luciano P. Soares – Tecgraf / Pontifical Catholic University of Rio
Joaquim A. Jorge – Instituto Superior Técnico

Speakers:

Luciano P. Soares – Tecgraf / Pontifical Catholic University of Rio
Joaquim A. Jorge – Instituto Superior Técnico
José Miguel Salles Dias – Microsoft Language Development Center/ISCTE IUL
Alberto Raposo – Tecgraf / Pontifical Catholic University of Rio
Bruno R. de Araújo – Instituto Superior Técnico
Leonel Valbom - Escola Superior Gallaecia
Filipe Gaspar - – Microsoft Language Development Center/ISCTE IUL

Abstract:

Immersive 3D Virtual Environments (VE) have become affordable for many research centers. However, a complete solution needs several integration steps to be fully operational. Some of these steps are difficult to accomplish and require an uncommon combination of different skills. This tutorial presents the most recent techniques developed to address this problem, from displays to software tools. The hardware in a typical VR installations combines projectors, screens, speakers, computers, tracking and I/O devices. The tutorial will discuss hardware options, explaining their advantages and disadvantages. We will cover design decisions from basic software and hardware design, through user tracking, multimodal human-computer interfaces and acoustic rendering, to how to administrate the whole solution. Additionally, we will provide an introduction to existing tracking technologies, explaining how the most common devices work, while focusing on infrared optical tracking. Finally, we briefly cover integration software and middleware developed for most VE settings.

Target Audience:

Novice to experienced technical people

Description:

Section I: Display Technologies (35 minutes) (Luciano)

A brief introduction will be presented about all the topics related to a complete multi-display solution and what are the core ideas behind display technologies. The section will also review some of the history behind immersive VR solutions. Several technologies are available to implement a multi-display facility. We are going to present some of these technologies and devices, and discuss the optimal way to link them. An evaluation of the most common used display techniques and their future will be introduced, highlighting the types of projection screens that are available and the best use for each one.

- Background and History
- Display Features and Controls
- Projectors and Flat Panel Display Technologies
- Stereoscopic technologies
- Screen Issues
- Projection Optics
- Video codification and transmission

Section II: Display Hardware Infrastructure (35 minutes) (Bruno)

In this section, we present several multi-display environments, underlying traditional calibration issues related to each technology and topology. Details in site preparation, ranging from air-conditioning to floor requirements, will be tackled. Control and automation, a mandatory topic in industrial VR facilities, will also be addressed.

- Projection Geometries (Planar, Cubic, Domes)
- Multi-displays (Arrays and Mounts)
- Field Of View, Inter-reflection
- Hardware Color and Geometry Calibration
- Video Warping and Edge-Blending
- Site preparation and Automation solutions

Section III: Tracking (35 minutes)(Miguel Dias,Filipe Gaspar)

Tracking a user in an immersive projection environment is the established way to correct any projection distortion and simplify the interaction in the virtual environment. However tracking solutions are not easy to implement and even traditional tracking hardware needs calibration. We are going to overview common tracking techniques and then we are going to focus in optical tracking since it is becoming very popular in VR installations. We will also present some current trends and new ideas for tracking in VR.

- Why User Tracking
- Tracking Systems Characteristics
- Tracking Technologies
 - Mechanical Tracking
 - Electromagnetic Tracking
 - Acoustic Tracking
 - Inertial Tracking
 - Radio-based Tracking
 - Optical-infrared Tracking
 - Video-based Tracking using Image Analysis and Feature Points
 - Tracking using 3D Cameras (Time of Flight, Structured Light – Kinect)
- Camera Calibration Theory
 - Pinhole Camera Model
 - Extrinsic Camera Parameters
 - Intrinsic Camera Parameters
 - Camera Calibration Algorithm
- Infrared Tracking System in Detail
 - Hardware Setup
 - Software Architecture and Process Workflow
 - Feature Segmentation and Identification
 - 3D Reconstruction
 - Model Fitting
- New trends in Tracking for VR and Video Games

Section IV: Software for Immersive Environments (35 minutes)(Alberto)

Most of the virtual reality software systems available in the market are not ready for immersive environments. In this context, we are going to present some of the development techniques that can be adopted, in order to have a basic system that provides the main features required in a multi-display VR facility. Deep discussions will be conducted mainly on the software side of immersive VR systems.

- Avatars for immersive environments
- Managing Scene Graphs
- Multi-view frustum
- Optimization techniques

- Interaction issues in immersive virtual reality applications
- Integrating tracking systems
- Developing applications for interacting with VR worlds
- Porting Applications

Section V: Multimodal Interaction and Audio (35 minutes)(Joaquim Jorge, Leonel Valbom)

Most VR systems include an important interaction component. This section addresses the main issues in designing multimodal interaction for immersive Virtual Environments. We intend to present the advantage of multiple human-computer interaction modalities in order to increase the usability of the computer systems over the traditional keyboard and mouse interface. Spatialized Audio increases the sense of immersion in Virtual Environments. Both sound synthesis and sound propagation are important factors addressed in this course, that must be considered in generating realistic auditory display that compliment multi-projection VEs.

- Speech Recognition
- Interaction with Tablets
- Gesture interaction
- Multi-touch Interaction
- Modality integration & fusion
- Sound Propagation and the Hearing and Listening Processes
- Stereo, Surround, Loudspeaker Arrays and Customized Sound Systems
- Audio spacialization techniques
 - Amplitude and time-delay panning
 - Binaural
 - Ambiphonics
 - Vector Base Amplitude Panning - VBAP
 - Ambisonics
 - Wave Field Synthesis -WFS
- Audio Development Libraries
 - System Audio APIs
 - 3D Audio APIs and VR Software
 - Sound servers
 - Software tools for Realtime Synthesis
 - Other Software tools and Audio APIs

The technical level and intended audience:

The objective of this tutorial is to give an introduction to the more relevant issues to consider when planning the installation of a multi-display 3D virtual environment for researches and professional in the computer graphics and virtual reality field. This tutorial is to be taught at an intermediate level. Basic knowledge in computer graphics and virtual reality is sufficient to attend this tutorial. The course will cover all enumerated points with enough detail that any student or professional can follow the presented material.

The expected value to the audience:

This tutorial will present how to design, construct and manage immersive multi-display 3D virtual environments, covering themes from display technologies to computer hardware and software integration. Topics like tracking, multimodal interaction, including speech, touch and gesture, and spatialized audio are going to be explored. At the end, we are going to present important design decisions taken from real cases.

CVs:

Luciano Pereira Soares

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Luciano Pereira Soares holds PhD in Electrical Engineering from Polytechnic School, University of São Paulo in Brazil. He was a postdoctoral research at IST, Instituto Superior Técnico in Portugal, INRIA, Institut National de Recherche en Informatique et en Automatique in France and ISCTE, Instituto Superior de Ciências do Trabalho e da Empresa in Portugal. His research interests include real-time 3D computer graphics and cluster computing. He is currently researcher at the Tecgraf, Computer Graphics Technology Group in PUC-Rio working in several projects at Petrobrás, Petróleo Brasileiro. He worked as support engineer at Silicon Graphics, application engineer at Alias|Wavefront and as project manager at the Integrated Systems Laboratory. He is now in charge of building a VR facility at university with a 4sided CAVE, Hi-Resolution Wall, among others system, and acting as the main consultant for a building at Petrobras research center with 4 large rooms with the most modern immersive technology.

Joaquim A. Jorge

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Joaquim A. Jorge holds PhD and MSc degrees in Computer Science from Rensselaer Polytechnic Institute, Troy New York, awarded in 1995 and 1992 respectively. He is Professor of Computer Graphics and Multimedia at the Department of Information Systems and Computer Engineering at *Instituto Superior Técnico*, the school of Engineering of the Technical University of Lisboa. He has co-authored over 250 internationally refereed papers on Computer Graphics and User Interfaces. Prof. Jorge is a Fellow of the Eurographics Association and is also affiliated with IEEE (SM'01) ACM (SM'07) SIGGRAPH and SIGCHI and is National Representative to IFIP TC13. He has served on the International Program Committees of over 130 international conferences and has organized or helped organize over 30 international scientific events, including EGVE 2006, INTERACT 2011 and IUI 2012. He is Editor-in-Chief of Computers & Graphics Journals and served on the Editorial Boards of five other scientific publications.

José Miguel Salles Dias

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José Miguel Salles Dias holds a Bsc in Electrical Engineering (1985) and an MSc (1988), both from Technical University of Lisbon (Portugal) and a PhD (1998) in Computer Graphics and Multimedia, from ISCTE-IUL (University Institute of Lisbon, Portugal), where he is an Invited Associated Professor, teaching and conducting research in Virtual and Augmented reality and Multimodal Human-Computer Interfaces. Since November 2005, is the Director of the first European R&D Centre in Speech Technologies of Microsoft Corporation, based in Lisbon, Portugal (MLDC, www.microsoft.com/portugal/mldc), which acts in the field of natural spoken human-computer interaction. He is regularly commissioned by the European Commission for R&D project evaluations and reviews. Since 1992, he has participated in 8 National and 27 International R&D projects (ESPRIT, RACE, ACTS, TELEMATICS, TEN-IBC, EUREKA, INTERREG, FP5 IST, FP5 IPS, FP6 IST, ESA, AAL, Marie Curie). He is a member of the editorial board of several journals. He is the Past Vice-President of the Eurographics Portuguese Chapter and he is member of several Program Committees of National and International conferences in Computer Graphics, Virtual and Augmented Reality, Speech technologies, Accessibility and Ambient Assisted Living. He is author or co-author of 1 patent and 150 papers and keynotes in international conferences and journals (209, with national conferences and journals). Miguel Dias is a member of ACM SIGGRAPH, Eurographics, ISCA and IEEE. He is past President of ADETTI, an R&D Institute associated with ISCTE-IUL.

Alberto Raposo

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Alberto Raposo holds PhD and MSc degrees in Electrical Engineering from University of Campinas, Brazil. He is currently a professor at the Computer Science Department at the Pontifical Catholic University of Rio de Janeiro and coordinates the Virtual Reality group at the Computer Graphics Technology Group (Tecgraf) in the same university. His research interests include 3D interaction techniques, real-time visualization of massive models, augmented reality, and collaborative environments. He has co-authored more than 80 refereed publications.

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Bruno R. de Araújo is a PhD Student at the Instituto Superior Tecnico from the Technical University of Lisbon. He is a researcher at INESC-ID and the Intelligent MultiModal Interfaces Group. He participated on European Projects such as SMARTSKETCHES researching advanced interaction techniques for 3D surfacing using Calligraphic interfaces and the IMPROVE project proposing innovative interfaces for immersive and mixed reality. He is interested in large scale display based visualization using PC cluster and multi-projector systems, and participated in the LEME (Laboratory in Mobility and Excellence) at IST related with intelligent ambient and tiled display visualization technology.

Leonel Valbom

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Leonel Valbom Holds a Ph.D in Information Systems in University of Minho, Portugal, with the thesis: "Integration of Virtual Reality in the Development of a Model of Immersive Musical Instrument" (1-2007). He is currently Assistant Professor of sound and design technologies at Gallaecia Higher School and digital art project in the University of Minho . His research interests include tridimensional sound, interface design and multimedia. He was Co-founder and organizer of Artech - series of international conferences in Digital Arts. He has served on the International Program Committees, and has several publications in IEEE Computer graphics magazine and Elsevier.

Filipe Gaspar

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Filipe Gaspar is Filipe Gaspar is a PhD student at ISCTE-IUL (Portugal) in Information Sciences and Technologies, field of Computer Graphics and Multimedia. Since 2008 he has been working as researcher at ADETTI-IUL, as associated R&D center of ISCTE-IUL, in fields such as computer vision, 3D object reconstruction and tracking, augmented and virtual reality, and facial biometric information retrieval and matching, maintaining collaborations with companies, such as Vision-Box and YDreams. In 2010, he has joined Microsoft/MLDC to integrate the team of GOLEM: Realistic Virtual Humans, a Marie-Curie project to radically improve the visual appearance and behavior of virtual characters.

Previous Tutorials:

This is a revamped version of five previous tutorials presented at Eurographics, IEEE VR and Sibgrapi. These tutorials were half and full day. The current proposal is even more complete than the previous tutorials, drawing on experience we garnered from teaching the previous tutorials, and presenting the new technology available. Like the last tutorials presented, this proposal is oriented to an intermediate-level audience. In the past two years significant new research appeared on this area and the new material reflects this.

Raposo, A. B., Carvalho, F., Soares, L. P., Jorge, J. A., Dias, M. S., De Araujo, B. R. 2010 . Designing multi-projector VR systems: from bits to bolts. In Sibgrapi 2010 (Gramado , RS/Brasil , September, 2010) Sibgrapi 2010

Soares, L. P., Dias, M. S., Jorge, J. A., Raposo, A. B., De Araujo, B. R. and Bastos, R. 2010 . Designing Multi-Projector VR Systems: From Bits to Bolts. In Eurographics 2010 (Norrköping , Suécia , May, 2010) Eurographics 2010

Soares, L. P., Jorge, J. A., Dias, M. S., Raposo, A. B. and De Araujo, B. R. 2010 . Designing immersive VR systems: from bits to bolts. In IEEE Virtual Reality 2010 (Waltham , MA/EUA , March, 2010) IEEE Virtual Reality 2010

Soares, L. P., Dias, M. S., Jorge, J. A., Raposo, A. B., De Araujo, B. R. and Bastos, R. 2008 . Designing multi-projector VR systems: from bits to bolts. In Eurographics 2008 (Crete, Greece, April, 2008) Eurographics 2008.

Soares, L. P., Dias, M. S., Jorge, J. A., Raposo, A. B. and De Araujo, B. R. 2008 . Designing multi-projector VR systems: from bits to bolts. In IEEE Virtual Reality 2008 (Reno , NV/USA , March, 2008) IEEE Virtual Reality 2008.