Interaction and visualization of 3D virtual environments on mobile devices

José M. Noguera · Juan C. Torres

Published online: 29 August 2012
© Springer-Verlag London Limited 2012

1 Introduction

The advent of low energy-consumption Graphics Processing Units (GPUs) [1] has boosted the graphics capabilities of mobile devices, opening the door to the development of interactive 3D applications that were inconceivable just a few years ago [2]. The mobile market is strongly competitive, and an attractive visual interface is an important advantage in creating a successful device. As a result, mobile device manufacturers have rapidly adopted this new hardware, and the market is demanding new applications featuring advanced 3D graphics and interactive virtual worlds.

This scenario opens a wide and interesting research area. Virtual reality applications, until now limited to desktop computers, can now take full advantage of the unique attributes provided by mobile computing: ubiquity, connectivity, context-awareness, and multimodal interfaces. However, these advantages come at a cost. By definition, mobile devices must be small and powered by batteries. These two factors severely limit both their computing power and graphics capabilities. As applications require the handling of larger and more complex 3D scenes, more intelligent and power-efficient techniques will be required. In addition, the nature of handheld devices raises new unprecedented usability issues. The small display sizes,

coupled with the limited input technologies, motivate the study of new ways of interacting with the 3D applications.

The goal of this theme issue of Personal and Ubiquitous Computing is to investigate the implications of adopting 3D graphics and virtual environments in the field of mobile computing. The papers collected in this issue present current research efforts and useful applications that employ 3D graphics with particular focus on addressing the unique features of mobile devices.

Submissions to this theme issue came from an open call for papers. We selected five papers to publish after two rounds of rigorous reviews. A large number of reviewers assisted us in the review process. In order to ensure high reviewing standards, three to four reviewers evaluated each paper.

2 The papers of the theme issue

The five papers selected can be grouped into three categories: 3D visualization techniques, augmented reality (AR), and interaction methods.

An interactive user experience through complex 3D worlds requires the ability to render the scene to an acceptable number of frames per second while keeping image quality as high as possible. The first two papers are primarily devoted to addressing this issue from a technical point of view. Both papers provide client–server alternatives designed to bypass the mobile device limitations in order to handle complex 3D graphics under different scenarios.

- The paper “*A scalable architecture for 3D map navigation on mobile devices*” by Noguera et al. describes a 3D map streaming system for mobile

J. M. Noguera (✉)
Escuela Politécnica Superior, University of Jaén,
Campus Las Lagunillas, Edificio A3, 23071 Jaén, Spain
e-mail: jnoguera@ujaen.es

J. C. Torres
Virtual Reality Lab. (CITIC), University of Granada,
Calle Zamora 127, 18151 Ogijares, Granada, Spain
e-mail: jctorres@ugr.es

phones. Interactive 3D maps are undoubtedly an interesting application for these devices, as they constitute an effective means of accessing location-based services (LBS) and other spatial data. This paper addresses several practical problems, including a client–server architecture for providing 3D maps to a large number—hundreds—of commodity mobile devices with just one server. The paper reports the overall architecture, implementation, and empirical performance evaluation. It finishes with a user study that evaluates the quality of the 3D map from a qualitative point of view.

- The following paper “*Interactive visualization of medical volume models in mobile devices*” by Campoalegre et al. studies the problem of volume rendering of medical data sets on mobile devices. Volume rendering is essential to several applications in medicine that require the visualization of medical imagery. Until recently, these applications were limited to desktop computers. Mobile devices, however, are easier to carry in certain scenarios, such as teaching laboratories or operating theaters. The paper proposes a client–server solution designed to overcome these devices’ intrinsic memory limitations. More specifically, the paper addresses two problems: data transmission to the mobile client and decompression of data for efficient rendering.

Two other papers have focused on augmented reality. AR is an active research field where real-world imagery is augmented or annotated with digital information. While traditional AR applications were limited to overlay either text or simple 2D elements, the selected papers prove that the 3D capabilities of today’s mobile devices allow AR applications to augment the real world with complex 3D objects in real time.

- The paper “*Mobile augmented reality for environmental monitoring*” by Veas et al. presents a mobile AR application for visualization of environmental 2D/3D data following a user-centered design approach. Two different test-bed scenarios were used in their evaluation: a snow science scenario in Davos (Switzerland) in the context of snow avalanches; and a hydrology scenario in the context of watershed modeling in Kylmoja (Finland).
- Continuing in this line of research, the paper “*Smart vidente: advances in mobile augmented reality for interactive visualization of underground infrastructure*” by Schall et al. presents a mobile AR system for onsite modification and surveying of geometric and

semantic attributes of geospatial 3D models. The system incorporates interactive 3D visualizations and is suitable for different civil engineering tasks.

Finally, one of the selected papers deals with human–computer interaction (HCI) techniques. Designing interfaces for navigation and manipulation of 3D data is much more complex than in traditional 2D applications due to the added degrees of freedom. This problem is exacerbated by the limited input/output capabilities of mobile devices.

- The paper “*Dual-finger 3D interaction techniques for mobile devices*” by Telkenaroglu and Capin demonstrates the possibility of using an advanced multitouch-based interface to overcome these issues. This paper proposes and discusses a full set of interaction techniques for 3D content on mobile devices, such as selection, manipulation, and navigation. Finally, the proposed techniques are compared to some state-of-the-art interaction techniques through a user study.

3 Conclusion

Collectively, these papers provide a compelling overview of some of the latest work in this area and can give a lot of insight into how to create interesting 3D applications for mobile devices. The popularity and increasing graphics capabilities of these devices clearly show that, if correctly used, they can afford a new range of possibilities. We do hope that the papers included in this special issue will be inspiring and satisfying for the audience of the PUC Journal and hopefully lead to even greater innovation in the field.

Acknowledgments The guest co-editors would like to take this opportunity to thank the authors who submitted their manuscripts to this theme issue. We also wish to express our gratitude to the referees for giving their time to make this issue possible. Last, but not least, our sincere thanks go to Dr. Peter Thomas, the Editor-in-Chief, for the great support and assistance he provided throughout the publication process of this issue.

References

1. Akenine-Möller T, Ström J (2008) Graphics processing units for handhelds. In: Proceedings of the IEEE 96(5):779–789. doi: [10.1109/JPROC.2008.917719](https://doi.org/10.1109/JPROC.2008.917719)
2. Capin T, Pulli K, Akenine-Möller T (2008) The state of the art in mobile graphics research. Comput Graph Appl IEEE 28(4):74–84. doi: [10.1109/MCG.2008.83](https://doi.org/10.1109/MCG.2008.83)