Review of Bachelor's Thesis

Student: Minda Marek
Title: Augmented Reality on Smartphones (id 19020)
Reviewer: Jost Patrick, BSc MA, FHV

1. Assignment complexity — average assignment

Regarding the complexity of the assignment it can be stated that handheld visual augmented reality is a field which is already scientifically covered pretty thoroughly from a technical point of view. A wide range of software solutions (frameworks) are available. The complexity in the assignment specification lies mostly within the photorealism of rendering on mobile technology. Theoretical exploration of current rendering engines and shaders as well as experiments to approximate usable mobile solutions (e.g. photorealistic texture baking) would have been interesting to research. However, the papers focus lies more on existing AR frameworks and the software solution regarding placing a 3D model in a camera stream based on available mobile sensor data.

2. Completeness of assignment requirements — assignment fulfilled

Although all required specifications are addressed in the work, some parts are not investigated as comprehensively as others and should have been explored on a deeper level (e.g. nature of augmented reality and the real demarcation to virtual reality (see Azuma 1997, characteristics of AR), areas of application, photorealistic rendering possibilities and texturinge.g. texture baking, real-time 3D-photogrammetry). The limited in-depth coverage of these areas influences the usability of the software solution for future application especially in the field of architecture.

3. Length of technical report — in usual extent

The paper meets described standards and comprises 30 pages excluding bibliography and therefore ranges within specifications of norm pages including images.

4. Presentation level of technical report — 75 p. (C)

The overall structure is consistent and follows a clear line of chapters. However, the focus of the final solution is not becoming very obvious throughout reading (e.g. ease-of-use, realism of visualization, performance, tracking accuracy). The chapter about AR tries to define the understanding of AR for the work but is missing explanations on AR properties and different AR technologies (e.g. research on head-mounted possibilities like usage of smartphones in cardboard for mixed-reality possibilities, the matter of field-of-view) as well as some critical analysis on the "virtuality continuum" (e.g. real physical presence of environment required for AR not for VR which is rather a digital condition than a continuum). Overviews on AR concepts and mobile applications (e.g. with illustrations or listings) would have been advisable in this regard.
A few references are not providing the referenced information (e.g. the referenced AR SDK comparison does not include information on Layar). In general explanations and scope of chapters are solid, nonetheless, why certain decisions are made could have been explained with more arguments and deeper investigation of topics would have been desirable.

5. Formal aspects of technical report — 85 p. (B)

The typography and formal layout of the paper is on a very good level. Minor language aspects could still be improved in regard to a more scientific phrasing (e.g. "negatively influences" instead of "kills" performance). As to English grammar specifications some articles were omitted.

6. Literature usage — 60 p. (D)

Literature is generally comprised of links from the internet which are also in parts not scientifically reliable as they are simply entries on websites or blogs and authors and date are not identified or listed. Formal errors in the bibliography can be found (e.g. "GmbH" as author name). A used citation standard (e.g. APA) is not apparent in the bibliography. Usage of current relevant literature also from reviewed journals or books on a greater extend could have provided valuable scientific knowledge for the thesis.

7. Implementation results — 75 p. (C)

The framework used for the implementation is well known and is used according to standards. The source code is documented well and commentary is used to describe necessary methods and their purpose. The solution is capable of demonstrating the visualization of a 3D Object in a real-time video stream on smartphones / handhelds based on Android powered smartphones. The usage of sensors and APIs is reasonably well integrated and combined. The task of placing 3D content on coordinates is solved in a sound approach. Unfortunately, there are no solutions or options regarding improvement of the 3D visualization (texturing) for at least an approximation of photorealism. The limitations in visualization and also regarding to platform could

possibly be addressed, for instance, by using a visualization engine (e.g. Unity 3D).

8. Utilizability of results

The usage of the solution is suffering from limitations on visualization quality and would require some adaptions for platform compatibility. The application in real-world scenarios is therefore limited, especially as the architectural sector is used to high-quality visualization aside from real-time aspects. The usage of a real-time processing optimized 3D-gaming rendering engine like Unity3D or Unreal could have resulted in a more usable solution in this regard. However, the results and performance tests with ray-tracing of actual mobile hardware deliver some insight on state-of-the art possibilities in that sense.

9. Questions for defence

1. What are the characteristics of Augmented Reality and what differentiates AR from VR? *Student should refer to Azuma (1997, p. 2) and state that in VR a physical environment is not present. Therefore, time can, for example, be slowed down or sped up whereas AR is always bound to real-time*.
2. Would your mobile application be classified as AR or VR and what are the reasons for the classification? *Student should be able to address that his application is in fact more a VR application and in detail could be classified as "handheld video see-through augmented reality". If used with Cardboard and head-mounted, it would be a pure VR application because physical reality is blocked out entirely and only a rendered scene can be perceived*.
3. On what findings was the decision for the Wikitude SDK based? *Student should list convincing advantages in comparison to Layar*.
4. What could be possible methods to overcome the currently non-photorealistic rendering of the 3D-building in the application? Are there any possibilities to reduce performance requirements? *Student should state that aside from performance boost through hardware and raytracing there are possibilities like texture baking where photorealistic textures and shading could be pre-calculated on the 3D-model before importing. Furthermore, the usage of a 3D-engine like Unity3D or Unreal could be used as they are optimized for real-time rendering and provide mobile shaders that approximate realism*.

10. Total assessment

75 p. good (C)

The submitted thesis addresses all specified assignment topics. The application is implemented competently with the chosen framework and the APIs from Google. Furthermore, the implementation process is comprehensively covered and documented and the formal aspects of the paper are on a good level. Limited scientific depth, especially in the theoretical aspects of AR and in regard to photorealistic rendering solutions aside from current and future hardware performance, are preventing a better result of the work. Furthermore, why certain decisions are made (e.g. the decision for the framework) could have been explained with more arguments and numerical facts. In general, the paper could be improved by backing explanations of systems or facts with illustrations or listing. The choosing of literature and especially the formal aspects of citing could be improved substantially.

In Brno 19. August 2016

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