Augmented Reality Games: What Do We Know and Where Should We Go?

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ABSTRACT

We investigate the evolution and state of the art of augmented reality games in order to develop a classification. In research, games are one of the fewest considered application areas of augmented reality. Relevant works often use a hands-on approach or look at isolated phenomena and form an inconsistent field of study. We use insights from a comprehensive literature review and an application of the Delphi method to develop a classification of augmented reality games and an agenda for further research.

1. INTRODUCTION & RESEARCH AIM

At the end of the last century, augmented reality (AR), i.e. when "3-D virtual objects are integrated into a 3-D real environment in real time" [2], was said to be the new striking technology. Much research has been done and many practical applications have been identified in different fields, including games, but few have sustained. As products could not attract a large group of users, the hype dissolved. However, with smartphones becoming more powerful and widely spread, the topic is gaining the attention of research and practice again. The various sensors of the new generation of handhelds enabled the maturing of the AR technology. Additionally, the concept of smart glasses evolved. Recently, Microsoft introduced "HoloLens", following Google's AR device "Google Glass". However, while technology is advancing fast, the sixty-four-dollar question of what a user-friendly, beneficial AR gaming application should look like remains.

As Zhou [14] has shown, research on AR gives priority to improving technical implementation and usability design or concentrates on various AR applications in different fields. Such AR applications are mostly viewed in industrial practice, marketing, or in a cultural context [4]. Furthermore, throughout the evolution of AR, learning and education was one of the most researched application areas next to maintenance, medical application, and navigation (e.g. [11]). Although many have declared the technique as doomed to fail, it was and still seems to be interesting for different groups of researchers and practitioners.

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Yet, games are one of the fewest considered application areas although older publications (e.g. [6]) as well as recent papers (e.g. [13]) emphasize that the technique seems to be destined for games. Research projects range from Szalavári et al.'s approach to collaborative gaming in 1998 [12] to Oda et al.'s racing game in 2008 [10], Kim's thoughts on mobile AR applications in 2013 [8], and further. Yet, these works often use a hands-on approach or look at isolated phenomena concerning the evolution and favorable design of AR games and, thus, form an inconsistent field of study.

In order to advance research in this fragmented field, our aim is to provide a systematic overview on previous works as well as a research agenda. In addition, we aim at deriving a classification of AR games in order to provide a systematic starting point for further research. Accordingly, our research questions are: (RQ1) Which insights regarding AR games does research provide? (RQ2) How can AR games be classified?

2. METHOD

To answer RQ1 (previous AR games research), we conducted searches using variations and combinations of relevant terms in English and German: "'Augmented Reality' games", "'Augmented Reality' game", "'Augmented Reality' gaming", "'Augmented Reality' play", "'Augmented Reality' Spiele", "'Augmented Reality' Spiel", "'Augmented Reality' spielen", and "'Augmented Reality' gamification". We used search engines and databases with no particular academic focus (Google Scholar, JSTOR, Bielefeld Academic Search Engine, and ScienceDirect) as well as the most comprehensive search engine with a media focus (EBSCO's Communication & Mass Media Complete). As a second step, we analyzed the content of the articles in detail to identify research aim, method used, and results, among others. Backward and forward reference searches provided additional relevant sources.

In order to answer RQ2 (classification of AR games) and to ensure the quality of our research, we combine three data sources and triangulate the findings [5]. Interviews with AR experts are the basis of the classification. For this purpose we have chosen four participants: two with regards to content and two with regards to technology, in each case one practitioner (Evgeni Kouris from AR games developer "Toywheel" for content and Sascha Kiener from AR software developer "Metaio" for technology) and one academic (digital games professor Jochen Koubek from University of Bayreuth for content and AR games engineering professor Gudrun Klinker from Technical University

of Munich for technology). Following the Delphi method [9], we develop a classification of AR games in three rounds with these participants. Two rounds are already completed. This classification is then adapted using our literature review's results as a second data source. In order to broaden the view on possible means of usage and verify the adapted classification, we analyze applications of AR in selected films, books, and other fictional works as a third data source. All of this results in a comprehensive classification of AR games.

3. PRELIMINARY RESULTS

Our insights indicate that the technological implementation is not the most important aspect determining possible ways of using AR in games anymore. Technology was not sufficient just a few years ago, keeping AR games from becoming mainstream. Today, especially mobile devices are widely-used and powerful enough to provide a promising foundation for AR games. Regarding RQ1 (previous AR games research), research has followed suit and emphasizes the non-technological aspects of AR, e.g. content and context [8]. Based on the insights of our literature review, the objects of investigation of research on AR games can roughly be divided into four major groups: educational games, which still is a dominant category, (e.g. Locatory [11]), games with strong focus on social interaction (e.g. MonkeyBridge [3]), augmented tabletop applications (e.g. AR Pong or BattleBoard 3D [1]) and a few commercial games (e.g. Ingress by Google or Mosquito Hunt by Siemens). However, such research is still in its infancy, providing many starting points for further works especially concerning the understanding of AR games on a theoretical level.

Regarding RQ2 (classification of AR games), the first two rounds of the Delphi method reveal a distinction of AR games based on four criteria: Device, mounting, content, and context. These criteria roughly resemble the findings from literature (e.g. [8]), but place more emphasis on the sophisticated underlying technologies available today by distinguishing two kinds of technology. In addition, our classification is more comprehensive, more detailed, and stronger related to practical phenomena than previous works, providing research with a better theoretical foundation to investigate AR games. "Device" refers to the display size and therefore the field of view, which can range from small (e.g. smartphones) to large displays (e.g. smart glasses), or even pure holography. "Mounting" distinguishes between marker-based, GPS-based, environmental, and thermal detection. "Content" includes the common distinctions of genres and goals of games. Finally, "context" describes the apparatus (i.e. dispositif, [7]) encompassing the player experience. This includes e.g. the differentiation between indoor and outdoor games and single- and multiplayer modes. Whether "mounting", "content" and "context" can be displayed using a scale similar to "device" has to be investigated.

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