Augmented Invaders: A Mixed Reality Multiplayer Outdoor Game

Michael Bonfert
University of Bremen
Bremen, Germany
bonfert@uni-bremen.de

Inga Lehne
University of Bremen
Bremen, Germany
ilehne@uni-bremen.de

Ralf Morawe
University of Bremen
Bremen, Germany
r.morawe@uni-bremen.de

Melina Cahnbley
University of Bremen
Bremen, Germany
mac6@informatik.uni-bremen.de

Gabriel Zachmann
University of Bremen
Bremen, Germany
zachmann@uni-bremen.de

Johannes Schöning
University of Bremen
Bremen, Germany
schoening@uni-bremen.de

ABSTRACT

Many virtual and mixed reality games focus on single player experiences. In this paper, we describe the concept and prototype implementation of a mixed reality multiplayer game that can be played with a smartphone and an HMD in outdoor environments. Players can team up to fight against attacking alien drones. The relative positions between the players are tracked using GPS, and the rear camera of the smartphone is used to augment the environment and teammates with virtual objects. The combination of multiplayer, mixed reality, the use of geographical location and outdoor action together with affordable, mobile equipment enables a novel strategic and social game experience.

CCS CONCEPTS

• **Applied computing** → Computer games;

KEYWORDS

Augmented Reality, AR, Mixed Reality, Games, GPS, Multiplayer

1 INTRODUCTION & RELATED WORK

Last year, the hype around *Pokémon Go* [Niantic Inc. 2016] pushed the popularity of augmented reality (AR) and mixed reality (MR) games. People searched the streets for rare Pokémon often in small groups [Colley et al. 2017] although players cannot cooperate within the game. The game uses GPS to determine the location of the players and map it onto the virtual world. However, the appearance of virtual objects in MR is only approximate and not at the same physical location for every player. There are some mixed or virtual
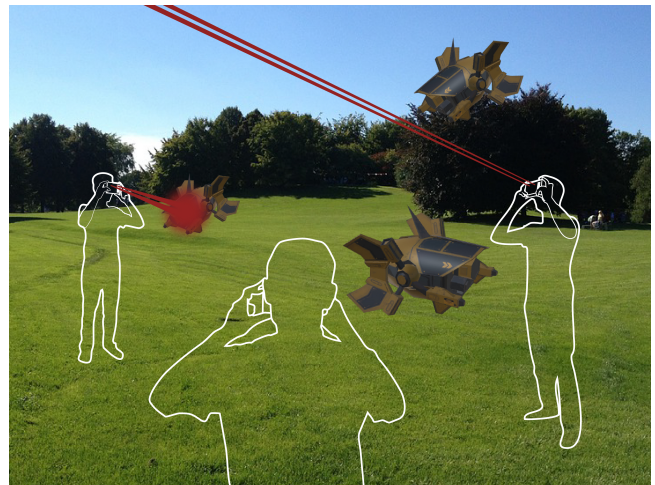
Figure 1: Illustration of the game setting with three players shooting virtual drones in a park.

reality (VR) games that offer a multiplayer experience. Most of these games require specific and expensive hardware (e.g. Oculus Rift or HTC Vive). One approach is to equip only one player with a head-mounted display (HMD) while others act in supporting roles by giving the player in the virtual world instructions or by interacting with the conventional controllers of the game console (e.g. *The Playroom VR* [Japan Studio 2013]). Another approach is that all players need the same VR hardware and play in different rooms, for example in *Star Trek: Bridge Crew* [Red Storm Entertainment 2017]. The established platforms are incompatible with each other, which leads to a fragmentation of target audiences. This makes it less attractive for large game studios who wish to develop across platforms, as well as for users who can only play with those using the same platform. Moreover, these devices have a high demand of system resources, which constrains their usage to stationary indoor computer setups. In contrast to this, our prototype runs on Android and can be built for iOS, together serving 99.7% of the smartphone market [IDC 2017]. One example that features no multiplayer mode, but is an outdoor AR game, is *Sky Invaders 3D* by [Avery et al. 2006]. In this game, the player fires at virtual space shuttles. Despite the intrusive hardware ten years ago, the study results show that people found

the augmented version of the game more joyful and intuitive than the same game on a stationary computer. *Father.IO* [Proxy42 Inc. 2017], on the other hand, is a multiplayer MR game where the player can fire at opponents, who are visible through the smartphone's camera. Despite the capabilities of smartphones, an additional piece of hardware including several sensors is needed to play the game. While the described games either feature no direct interaction, do not use the player's exact location, equip only one player with an HMD, only run on certain platforms without interoperability, are stationary, or require additional hardware, this paper presents a game prototype that improves on these shortcomings. We aimed to conceive an inclusive outdoor MR game for multiple players that gives an immersive first-person experience to everyone.

2 GAME CONCEPT AND INTERACTION

Augmented Invaders attempts to make MR games more accessible to the general public by using cheap and mobile VR headsets for smartphones and by enabling groups of players to indulge in short, spontaneous multiplayer sessions with low access barrier. The game is played outdoors due to the need of location services via GPS and a large play area like a park to move freely (min. 20m x 20m recommended). This experimental game prototype is an homage to the arcade classic *Space Invaders* [Nishikado 1978].
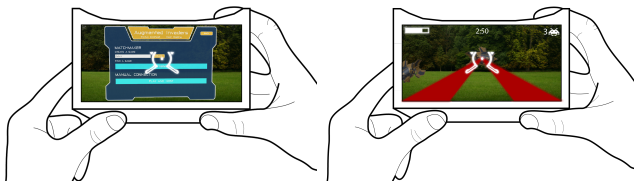

Figure 2: Illustrations of the main menu and shooting a drone from the player's perspective.

The players can see their physical environment through the rear camera and are surrounded by virtual alien drones that are invading the world (see Figure 1). They fight the intruders as a team by shooting them with lasers coming from their eyes (see Figure 2). To shoot, the players pull the magnetic trigger of the HMD. This main interaction principle is introduced to the players already in the menu while setting up a game session (see Figure 2). The drones are displayed in the exact same position of the real world for all players. There is no avatar representing a player since the team members are already visible through the camera. Only the laser beams originating from their eyes are augmented. Finally, after the timer is elapsed, an overlay with the score of the team indicates the end of the session.

2.1 Implementation

The game was implemented with the *Unity3D* game engine [Unity Technologies 2017]. We used the built-in networking service *UNet* to communicate between all players. To create the MR scene, we used the *Vuforia* toolkit [PTC Inc. 2017], which handles communication with the mobile device's camera and the rendering into stereoscopic images. The positions of the players are obtained using GPS and converted from the spherical earth coordinate system

into the cartesian Unity world coordinate system with the help of an open-source script provided by [Taylor 2013]. At the start of the game, the player who created the game session determines the origin of the virtual world space according to the initial GPS location. This calibration is then synchronized to all other players. Thereby, the position of drones and lasers in virtual space corresponds directly to a physical location on earth and is displayed in the same spot for every team member. Also, the players' movements are constantly synchronized to determine the starting point and direction vector of lasers shot by team members.

3 CONCLUSION

In this paper, we presented *Augmented Invaders*, a mixed reality multiplayer outdoor game. We showed that it is feasible to develop an MR game that is location-based and features multiplayer aspects directly in the augmented world, enabling exciting strategic team-play within the own physical environment for everyone. One of our current system's deficiencies is the player's field of view that is strongly limited by the phone's screen. Albeit walking is still possible, the most part of the ground is cut off the player's view. Thus, the player is moving more carefully and slowly than without the HMD. Secondly, our approach does not account for occlusion of the drones and lasers by real world objects. For example, a drone that is far away would not be covered by another player or a tree. This affects the immersion and distorts the perceived distance. Furthermore, the tracking accuracy is insufficient as GPS signals are noisy and lack precision. The adjustment of the drones' and lasers' positions according to the movement of the player turned out smoother and calmer than expected, but should be further stabilized with e.g. gyroscope data or optical flow analysis. After improving and completing the prototype, the game concepts will enable a variety of intriguing studies, e.g. on strategic team play and group dynamics, on playing with many players on a large scale, or on social acceptance of spontaneous, inclusive game sessions.

REFERENCES

Benjamin Avery, Wayne Piekarski, James Warren, and Bruce H. Thomas. 2006. Evaluation of User Satisfaction and Learnability for Outdoor Augmented Reality Gaming. In *Proceedings of the 7th Australasian User Interface Conference - Volume 50 (AUIC '06)*, Vol. 50. Australian Computer Society, Inc., Darlinghurst, Australia, Australia, 17–24. http://dl.acm.org/citation.cfm?id=1151758.1151759

Ashley Colley, Jacob Thebault-Spieker, Allen Yilun Lin, Donald Degraen, Benjamin Fischman, Jonna Häkkilä, Kate Kuehl, Valentina Nisi, Nuno Jardim Nunes, Nina Wenig, et al. 2017. The geography of Pokémon GO: beneficial and problematic effects on places and movement. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 1179 – 1192.

IDC. 2017. Smartphone OS Market Share, 2017 Q1. (2017). Retrieved September 20, 2017 from https://www.idc.com/promo/smartphone-market-share/os

Japan Studio. 2013. The Playroom. Game. (nov 2013). Retrieved August 16, 2017 from https://www.playstation.com/en-gb/games/the-playroom-vr-ps4/

Niantic Inc. 2016. Pokémon Go. Game. (july 2016). Retrieved July 4, 2017 from http://www.pokemongo.com/

Tishihiro Nishikado. 1978. Space Invaders. Game. (1978). Retrieved August 16, 2017 from http://spaceinvaders.net/

Proxy42 Inc. 2017. Father.IO. Game. (2017). Retrieved August 17, 2017 from https://www.indiegogo.com/projects/father-io-massive-multiplayer-laser-tag-app#/

PTC Inc. 2017. Vuforia. (2017). Retrieved July 4, 2017 from https://developer.vuforia.com/downloads/sdk

Red Storm Entertainment. 2017. Star Trek: Bridge Crew. Game. (may 2017). Retrieved July 4, 2017 from https://www.ubisoft.com/de-de/game/star-trek-bridge-crew/

Michael Taylor. 2013. UnityGPSConverter. Unity Package. (2013). Retrieved July 4, 2017 from https://github.com/MichaelTaylor3D/UnityGPSConverter

Unity Technologies. 2017. Unity3D. Game Engine. (2017). Retrieved July 4, 2017 from https://unity3d.com/