StreetGamez: A Moving Projector Platform for Projected Street Games

Matjaž Kljun
University of Primorska, FAMNIT
Glagoljaška 8,
6000 Koper, Slovenia
matjaz.kljun@upr.si

Klen Čopič Pucihar
University of Primorska, FAMNIT
Glagoljaška 8,
6000 Koper, Slovenia
klen.copic@famnit.upr.si

Mark Lochrie
Media Innovation Studio
University of Central Lancashire
PR1 2HE Preston, UK
mlochrie@uclan.ac.uk

Paul Egglestone
Media Innovation Studio
University of Central Lancashire
PR1 2HE Preston, UK
pegglestone@uclan.ac.uk

Figure 1. StreetGamez

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Abstract

Moving Projector Platform (MPP) is a concept of using an autonomous vehicle, such as Unmanned Aerial Vehicle (UAV), commonly known as a 'drone', as a means to deliver and move the projection to arbitrary location. As a proof of concept this paper presents a design plan for a *Moving Projector Game* (MPG) called StreetGamez, which facilitates the game play through motion tracking and projection of a playing area, which can move and follow players in the game.

StreetGamez platform introduces novel abilities, such as: (i) to move the gaming platform before and during the game to the desired location and (ii) to free players from carrying the gaming equipment. Consequently this instigates possibilities to explore and study new exergame paradigms and players' attitudes towards the system as a whole. The concept also has the potential to provide a breakthrough in the social acceptance of drones in gaming scenarios whilst contributing to current debates on the legislation governing drone flights and furthering knowledge in human-drone interaction.

Author Keywords
Moving projector platform; MPP; moving projector game; MPG; moving projector; moving projections;

ACM Classification Keywords
H.5.2 User Interfaces: *Input devices and strategies*

Introduction

Street games (e.g. skipping rope) and sidewalk chalk games (e.g. hopscotch) have been played outdoors by children for centuries all around the world. Such games are beneficial for the physical well-being of players [5], their development of movement patterns, motor performance and skills whilst positively effecting muscular and skeletal development. The steady rise in physical inactivity due to sedentary lifestyles of all society (including work/school as well as entertainment activities) is having an impact on health and well-being. One of the major sedentary entertainment activities is playing traditional video games where players sit looking at the screen whilst controlling the game with traditional input devices such as mouse and keyboard, a touch screen or purpose built game controllers.

The use of additional hardware to encourage physical activity in video games (e.g. sensors) has contributed to the development of a new type of games called exergames. Exergames aim to persuade players to exercise while gaming. In the earlier development exergames required a static setup in which games are most commonly played indoors in front of a monitor and with a support of a gaming console (e.g. Nintendo Wii). This limits playing the games to a particular room where required hardware is set up.

With the accessibility of mobile devices (in particular mobile phones) new possibilities have been introduced to exergaming. The game infrastructure can be now carried to arbitrary locations and immerse the game in the environment. These Location Based Games (LBG) can be divided into those where the whole infrastructure consists of mobile devices (e.g. Free All Monsters [3], They Howl [4]) and those where additional infrastructure (e.g. RFID tags) needs to be placed into the environment (e.g. PAC-LAN [6]). The problem with most LBG on mobile devices is the dependence of games on what is shown on the screen, be it the object of play or the instructions of the game. This often (i) contributes to disconnecting the user from the environment and (ii) interrupts communication between players within multiplayer games, as they need to follow events on the screens in order to progress in the game.

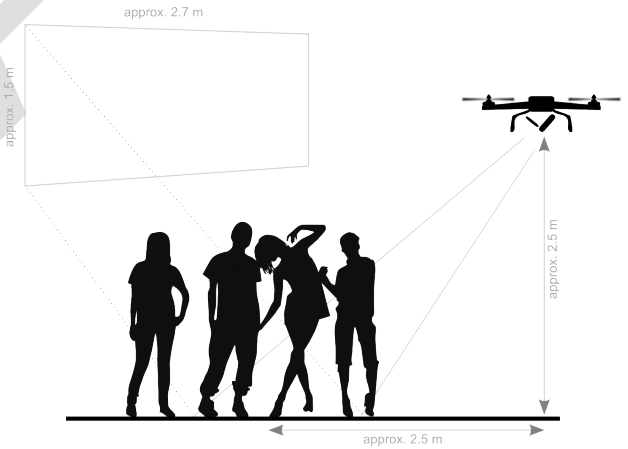

Figure 2. The approximate flying height of the drone from the ground is 2.5m — the same as the horizontal distance between the drone and the centre of the

Notes:

1. Po-motion: http://www.po-motion.com
2. EyePlay: http://eyeplay.info/
3. LumoPlay: http://www.lumoplay.com/

projected image. At this position a micro projector can project a playing area of about 1.5m x 2.7m.

The newest technology introduced to exergames involves a projector, which projects the graphical game elements onto a physical environment. These game elements become interactive through motion tracking of players. Such implementation frees players from holding any device allowing them to focus on the game, its elements in the environment, and possibly other players. One such example is Augmented Climbing [2] where a projected chainsaw is introduced to a climbing wall. Players need to move on the wall and avoid being 'touched' by it. Projection based games are now available to end-users with products such as Po-motion[1], EyePlay[2] and LumoPlay[3]. The issue with these is that they can only be played where the system is located — similar to traditional video game setups. Moving such systems involves dismantling, transferring, and setting up the equipment at a new location. Thus, the playing surface is bound to a present location and cannot change during the game.

In this paper we define a *Moving Projection Platform (MPP)*—a concept of using an autonomous vehicle, such as Unmanned Aerial Vehicle (UAV), commonly known as a 'drone', as a means to deliver and move the projection of a playing surface to an arbitrary location. As a proof of concept we propose a design plan for a *Moving Projector Game* (MPG) called StreetGamez, which facilitates the game play through motion tracking of players and projection of a playing area, which can move and follow players in the game (Figure 1 and 2). StreetGamez is an exergaming platform featuring the independence of the gaming location. This reintroduces exergaming to the streets where various traditional games have been played for centuries. The ability to move the gaming platform during the game also introduces novel possibilities to explore new game paradigms. However, there are several challenges that need to be addressed and answered as explained in the following sections.

Legal Aspects and Challenges

Civil aviation regulations driven largely by safety concerns currently make some aspects of MPG challenging. Inconsistencies in the operational legalities of drones in different countries also make it difficult to offer a universally acceptable solution. For example, the action of paying for a drone-based service would breach current UK Civil Aviation Authority regulations whilst delivering the same service freely would not. Autonomous flights in the context intended here, whilst technically possible, are illegal. At the time of writing the regulatory framework is changing in the US and evolving in both EU and none EU countries recognising demands from citizens to use drones for a wide variety of civic (none military) applications — from aerial survey work to parcel delivery. StreetGamez brings the voice of the gaming community into these discussions and informs the current debate from a different perspective.

System Design and Challenges

StreetGamez platform is designed as an open platform that can facilitate various types of street and chalk games utilizing a drone as a method for delivering the mounted game infrastructure to a requested location in order to support the game play (see Figure 2). To deliver this infrastructure to a location requested by players, the drone needs to support autonomous flying utilizing pre-planned GPS routes. The infrastructure

Figure 3. 2-axis gimbal used for projection stabilization.

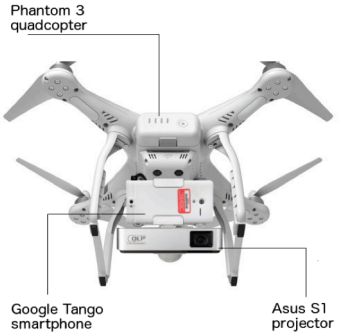

Figure 4. Drone configuration: Phantom 3 quadcopter, Asus S1 projector, and Google Tango.

carried by the drone is used to perform three tasks: (i) project graphics onto arbitrary surfaces, (ii) enable interaction within the projected surface through motion tracking (e.g. track players movement), and (iii) enable interaction through players' mobile device (e.g. calling the platform to a desired location, selecting games). To support projecting a game surface, the drone also needs to be capable of precise hovering over a certain location with minimal drift (e.g. locking position using vision based tracking).

The design of the described system poses several challenges. One such challenge is the size and weight of the (whole) system. The weight of the drone, its battery and game infrastructure that it needs to carry, affects the required size of the drone (ideally the drone should be as small as possible to minimize the danger of flying in public), the battery life and consequently the flying time. The optimal solution to minimizing weight is to utilize a bespoke hardware solution. However, to keep the platform as accessible as possible to researchers and early system adopters, the design focuses on utilizing off-the-shelf hardware components that are supported by freely accessible software libraries.

In case of pursuing bespoke hardware solution the flying time is expected to increase, yet it is still likely to remain the key limiting factor affecting the game time and game delivery range. For this reason the StreetGamez platform focuses on small range delivery scenarios (e.g. facilitating street games at festivals, main squares, promenades, parks, etc.)

The second challenge relates to the quality of projection. The stabilization of a projected image is similar to the problem of stabilizing camera capture by a drone in flight commonly solved with a 2-axis gimbal (see Figure 3). The brightness of projected light can also be problematic. In order to keep the size of the payload to a minimum, the projector needs to come from the micro projector family. However, the brightness of these projectors is not particularly high and the image produced fades considerably with increased projection distance. This problem is even greater when projecting on dark surfaces (e.g. on a pavement). Hence, the system might only be usable in shady places of late afternoon light or at night under artificial illumination.

Additional components of the system comprise a phone as navigation facilitation, game storage and a motion sensor for interaction. Ideally this should all be integrated in one device to lower the weight. Currently, the Google Tango platform offers a wide variety of sensors which enable real time depth map capture, different connectivity options, and freely accessible libraries. However, at the time of writing this paper, only the ("heavier") tablet version has been released to the public. Nonetheless, as early reports suggest, a ("lighter") phone variant is likely to become available as the next generation Nexus device [1].

Considering several options we opted for the following hardware: (i) a commercially available drone Phantom III with reported lifting power of approximately 0.5kg and flight time of 15 minutes, (ii) Asus S1 Projector of 200 lumen with smaller battery pack (~180g), (iii) Google Tango phone for video rendering, motion capture and connectivity (~170g), and (iv) a 2-axis gimbal (~150g) (see Figure 4). Admittedly, with the advances of technologies, better hardware will be

Figure 5. Children playing with StreetGamez platform (this image is an illustration of the system in action).

available in the future (e.g. longer battery life, lower weight, higher brightness of projections,). Once available, we should look at ways of redesigning the system in order to improve its utility.

Game Scenarios

To get a better understanding of the MPG concept and the StreetGamez platform we describe two scenarios here and present what kind of games can be played.

Scenario 1: A group of parents with children take a walk on a promenade by the seaside on a summer evening. The parents sit on a bench but children have nothing to play with. One of the parents takes out the phone and calls the StreetGamez platform, which computes a route to a destination where gaming infrastructure is required. She selects a multiplayer game, which is then projected on a promenade and children start playing the game (see Figure 5).

Scenario 2: A group of students are having an evening picnic in the park. However, they realise that no one has brought any playing equipment such as frisbee. One of the students calls the StreetGamez platform, which arrives at the destination, and a group of students selects a game to play.

Once at the location, the platform may support various game settings:

Static hover: this setting is the same as in the examples of projected games presented in the introduction with the exception that the playing surface can be positioned and moved anywhere without much hassle. The drone hovers at the fixed position and facilitates the game being played on the ground (e.g. whack-a-mole, hopscotch, etc.).

On-the-move: this is a new setting that has not yet been explored in the literature. The drone moves with players and facilitates the game whilst on the move (e.g. treasure hunt). The drone could change its position in response to the players' movements providing human-drone interaction.

Drone-as-game-element: this is also a new setting. The drone becomes the game element where it takes an active role as a player (e.g. hide and seek, tag). As before, this can facilitate new interaction possibilities.

Project Plan

The project team started the prototype assembly process with the goal of getting a working prototype ready in the next two months. Once assembled and the basic platform functionalities (flight to a selected destination, motion sensing and image projection) are up and running, the team plans to start experimenting with *static hover* games. After achieving a satisfying gaming experience, the team plans to start studying the platform in real-world settings and explore optimal interaction and communication metaphors and the players response, relations, and attitude towards the designed drone system. At the same time we intend to open-source the plans and the code to the community in order to speed up the research and uptake of the proposed concept.

Implications for Research Community

The main contribution of this paper is a novel concept called MPG where a drone is utilized as a (i) delivery system for game infrastructure and as a (ii) tool for

facilitating the game and play in the real-world setting. The design presented envisions moving the game to arbitrary location whilst (i) maintaining the game play, (ii) enabling seamless integration of the environment into the game whilst (iii) mitigating the effect on social interaction between players of the game. The later, as explained in the introduction section, is considered problematic during the game play in case of LBG played on mobile devices (e.g. looking at the screen serves to disconnect us from the physical environment and hinders social interaction amongst players of the game). The ability of players to freely move during the game play opens up a potential for the game to integrate all three game settings previously explained in the Game Scenario section. This is particularly important for the research community as it opens up novel exergame play scenarios, which can further the research possibilities of human-drone interaction.

The StreetGamez concept challenges aspects of the current regulatory framework that could be classed as commercially restrictive where they are not specifically intended to prevent harm. This project speaks to research in this area and could contribute to the on-going development of civil aviation regulations for the civic use of drones.

People have a wide range of opinions about drones, with privacy issues at the forefront. Nevertheless, drones are becoming the norm for many work and social environments (e.g. in dangerous environments). The exergames have a potential to provide a breakthrough in accepting this promising technology. For these reasons, StreetGamez is designed as an open-research platform to attract other researchers to participate in designing new games, studying exergaming in novel settings, studying human-drone interaction, and furthering the knowledge in these areas.

Conclusion and Future work

This paper presents a novel concept called Moving Projector Platforms (MPP), which utilizes an autonomous vehicle, such as Unmanned Aerial Vehicle (UAV), as a means to deliver and move the projection to arbitrary location. As a proof of concept this paper presents a design plan for Moving Projector Game (MPG) called StreetGames. The goal behind the design is to make an open research platform that will be accessible to researchers and the wider audience allowing extensive exploration of this gaming space, opening new perspective on game infrastructure, which may bring games back to the street where they have been played for centuries. Consequently, the platform can open up a new area for exploring human perception of drones in the gaming environment and human-drone interaction.

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