LittleProjectedPlanet: An Augmented Reality Game for Camera Projector Phones

Markus Löchtefeld
Institute for Geoinformatics
University of Münster
Weseler Str. 253
48151 Münster, Germany
loechtefeld@wwu.de

Johannes Schöning
German Research Center for
Artificial Intelligence (DFKI)
Stuhlsatzenhausweg 3
66123 Saarbrücken, Germany
johannes.schoening@dfki.de

Michael Rohs
Deutsche Telekom
Laboratories, TU Berlin
Ernst-Reuter-Platz 7
10587 Berlin, Germany
michael.rohs@telekom.de

Antonio Krüger
German Research Center for
Artificial Intelligence (DFKI)
Stuhlsatzenhausweg 3
66123 Saarbrücken, Germany
krueger@dfki.de

ABSTRACT

With the miniaturization of projection technology the integration of tiny projection units, normally referred to as pico projectors, into mobile devices is not longer fiction. Such integrated projectors in mobile devices could make mobile projection ubiquitous within the next few years. These phones soon will have the ability to project large-scale information onto any surfaces in the real world. By doing so the interaction space of the mobile device can be expanded to physical objects in the environment and this can support interaction concepts that are not even possible on modern desktop computers today. In this paper, we explore the possibilities of camera projector phones with a mobile adaption of the Playstation 3$^{\text{TM}}$(PS3) game LittleBigPlanet$^{\text{TM}}$. The camera projector unit is used to augment the hand drawings of a user with an overlay displaying physical interaction of virtual objects with the real world. Players can sketch a 2D world on a sheet of paper or use an existing physical configuration of objects and let the physics engine simulate physical procedures in this world to achieve game goals.

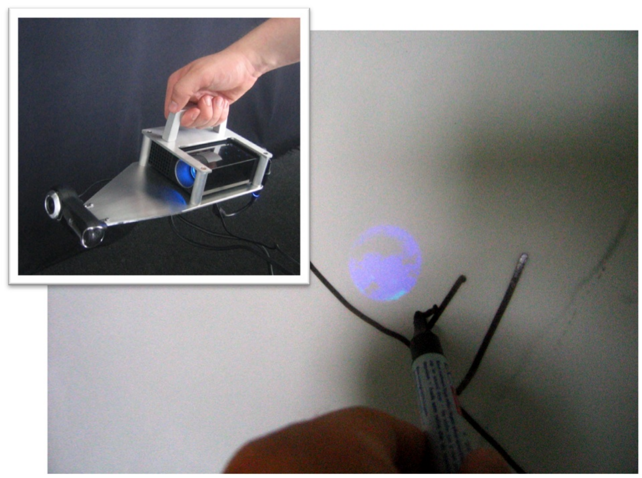

Figure 1: The *LittleProjectedPlanet* hardware prototpye: (upper left corner). A user playing the game. He is sketching a marble run and projected tennis balls are bouncing on it (center).

1. INTRODUCTION & RELATED WORK

Mobile phones are used for a wide range of applications and services in today's everyday life, but still they have many limitations. Aside from the lack of memory and processor power the small display size is one of the major bottlenecks. Digital projectors are shrunken to the size of a mobile phone. The next step is to integrate them directly into the mobile device. Such phones could overcome the shortage of the small screen and even make it possible to present large and complex information like maps or web pages without zooming or panning as presented by Hang et al. [11]. Up to now several prototypes have been presented, and the first series-production device is already up for pre-order. Considering the possibility of a phone with integrated camera and projector available in just a few months, still less research has been conducted to investigate the potential of such a mobile unit (in the following we use the term mobile camera projection units as a synonym for a camera projector mobile phone). We propose a mobile game combining hand drawn sketches of a user in combination with objects following a physics engine to achieve game goals (see figure 1).

Initial research on mobile projection interfaces was conducted by Raskar et al. [13] followed up by Beardsley et al. [5] and Cao et al. [7]. Blasko et al. [6] explored the interaction with a wrist-worn projection display by simulating the mobile projector with a steerable projector in a

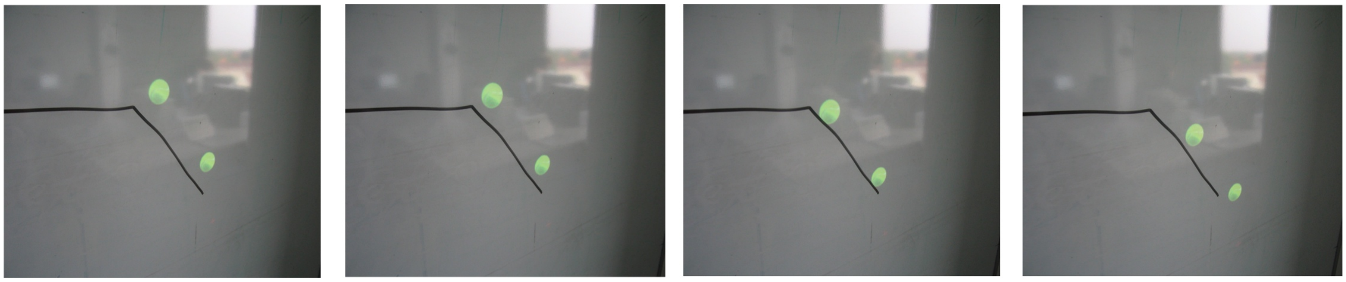

Figure 2: Projected tennis balls are bouncing on a run sketched by a user.

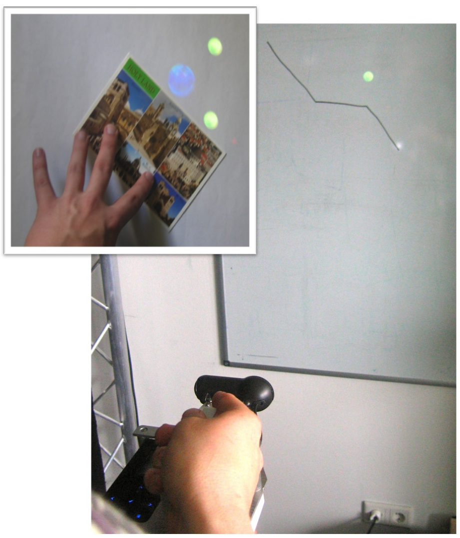

Figure 3: *LittleProjectedPlanet* game screenshot: A user playing the game with a postcard (upper left corner). User is sketching a marble run and projected tennis balls are bouncing on it (center).

lab. First mobile setups were presented by Hang et al. [11], Tamaki et al. [17] or Schöning et al. [15]. From this development a rich design space for mobile games could emerge. Actual mobile games are characterized by simple graphics and miniaturized input modalities. That is why many mobile games are just played when the user wants to overcome a period of unused time. With a built in projector not only the graphical resolution of the games can be increased, also the possibilities to develop mobile augmented reality games will improve. To create visual overlays for augmented reality games, in the past often head mounted displays where used [8]. This retrenched not only the comfort of the user it also limited the mobility. As a consequence of the display being attached to a single player, games using a head mounted display can only be played in multiplayer scenarios when using a large amount of hardware. Another common technique for dynamic overlays is to use the screen of the mobile device like a magic lens [14] and so be struggle again with the small size and resolution. Moreover such a magic lens display is not really enjoyable to use with more than one player at the same time. Projecting a dynamic overlay directly onto a surface of the real world may enhance the playability even though it is hard to identify the overlay in bright light. Dao et al. have already shown first approaches for using a projected image in mobile gaming [9, 12] (but not in a mobile setting). In *CoGame* the players can steer a robot by connecting visual overlays with their mobile projectors, which contain parts of a path the robot should follow. With PlayAnywhere [18], Andrew Wilson demonstrated the possibilities of mobile camera projector units in mobile entertainment. It consisted of an easy to set up camera projector unit allowing the user to play games on any planar surface, which can be used as a projection area, by controlling the games with their hands. Enriching sketching in combination with physical simulation was presented by Davis et al. [4, 10]. The *ASSIST* system, was a sketch understanding system that allows e.g. an engineer to sketch a mechanical system as she would on paper, and then allows her to interact with the design as a mechanical system, for example by seeing a simulation of her drawing.

In contrast to the related work in this paper we present a game called *LittleProjectedPlanet* that is designed for a mobile projector phones combing real world objects and projected ones utilizing a physics engine. We think that this kind of mobile projection camera unit can been utilized to improve the learning and collaboration in small groups of pupils (cause of the mobile setup of our prototype) in contrast to more teacher-centered teaching e.g. one interactive white board (as shown by Davis et al. [4, 10]).

2. GAME CONCEPT

The slogan of the popular Playstation 3 game LittleBigPlanet [2] by Media Molecule (some parts of the *ASSIST* sketch understanding system were used for the game) is "play with everything" and that can be taken literally. The player controls a little character that can run, jump and manipulate objects in several ways. A large diversity of prebuild objects is in the game to interact with, and each modification on such an item let them act in a manner physically similar to those they represent. The goal of each level is to bring the character from a starting point to the finish. Therefore it has to overcome several barriers by triggering physical actions. But the main fascination and potential of the game is the feasibility to customize and create levels. Creating new objects is done by starting with a number of basic shapes, such as circles, stars and squares, modify them and then place them in the level. Having done so, the user can decide on how these objects should be connected mechanically.

We took this designing approach as an entry point for a mobile augmented reality game using a mobile camera projector unit. It allows the user to design a 2D world in reality, which is then detected by a camera. Out of this detection a physical model is being calculated. Into this model the user can place several virtual objects representing items like tennis balls or bowling balls. These virtual objects then get projected into the real world by the mobile projector. When starting the physic engine, the application simulates the interaction of the virtual and the real world objects and projects the results of the virtual objects onto the real world surface. Just like in LittleBigPlanet our application offers the user different ways of playing: One is like the level designer in LittleBigPlanet; the user can freely manipulate the 2D World within the projected area and place virtual objects in it. Similar to children building tracks for marbles in a sandpit, the player can specify a route and then let the virtual marbles running along it. A different gaming mode is a level based modus, but instead of steering a character as in LittleBigPlanet, the user designs the world. As a goal the user has to steer a virtual object e.g. a tennis ball from its starting point to a given finish. The game concept uses a direct manipulation approach. Enabling the player to modify the world at runtime let the real world objects become the users tangible interface. But not only the objects are used for the interface, by changing the orientation and position of the projector the user can also modify the physical procedures (e.g. gravity by turning the mobile camera projector unit).

3. INTERACTION CONCEPTS

For designing a 2D world the players can use several methods. Basically they have to generate enough contrast that can be detected by using a standard edge recognition algorithm (utilizing the Sobel operator [16]). Sketching on a piece of paper or a white board for example can do this, but simply every corner or edge of a real world object could generate a useful representation in the physics engine. So there is no need for an extra sketching device or other for example IR based input methods. Just requiring the camera projector unit itself the game is playable nearly anywhere with nearly everything and it is easy to set up. Figure 3 show a user using a standard whiteboard as well as a user "playing with a postcard". An important problem to allow a smooth and seamless interaction for the user is that the "gravity in the projection" is aligned with the real worlds gravity. For that a Nintendo Wii is attached under the camera-projection unit (as can be seen in figure 4 (left)). Also gravity can be utilized in the game to control some action. A user can take control of the gravity by changing the orientation of the projector. Doing this the user can let virtual objects "fly" through the levels

4. IMPLEMENTATION

Due to the unavailability of sophisticated projector phones (with an optimal alignment of camera and in-build projector) we used for our prototype a Dell M109S, a mobile projector with a maximum resolution of 800×600 and a weight of 360g, in combination with a Logitech QuickCam 9000 Pro. All together our prototype weighs around 500g and is therefore okay to handle (e.g. compared to the prototype used in [15] our prototype is "just 240g" heavier, but the projector has 50 lumen instead of just 10 and also has a larger resolution). Table 1 compares some key characteristics of both prototypes. We think our prototype presented in this paper provides a good trade-off between mobility and sophisticated projection quality. In contrast to the few mobile devices with built in projectors, our projector and camera are mounted in such a way that the camera field of view fits nearly the projected area. But because of the different focal lengths of camera and projector in this setup the camera image is always wider than the projected image. Therefore the prototype needs a calibration to clip the right parts of the camera image. For controlling the application and to determine the orientation (to set the gravity) a Nintendo Wii remote is attached to the camera projector unit. Most actual Smart Phones are already equipped with an accelerometer or an electronically compass, so the functionality of the Wii remote can easily be covered using a mobile phone. The application is fully implemented in Java using the QuickTime API to obtain a camera image. As a physics engine Phys2D [1], an open source, Java based engine is used. The communication with the Wii remote is handled by WiiRemoteJ [3]. Connected to a standard laptop or PC the camera projector unit has a refresh rate of approximately 15fps when running the application. Only the area of the camera image containing the projected image is processed via an edge recognition algorithm. This area is about one forth of the whole camera image of 640×480. Every pixel of a detected edge gets a representation as a fixed block in the physics engine. That gives the user total freedom in designing the world. Such a physic world update is done every $300ms$ but it can be stopped by the users, for example for editing the sketch. Adapting the gravity of the physical model to the actual orientation of the camera projector unit is done through calculating the roll[1] of the Wii remote. Up to now there is no correction on the projected image. In first preliminary user test we found out that this is not affecting the user experience. Several methods for image correction are already available (e.g. from Raskar et al. [13]), but are not implemented in the current prototype. The video `http://www.youtube.com/watch?v=eCF2Q0w6hkg` shows the game concept and our running prototype in different situations.

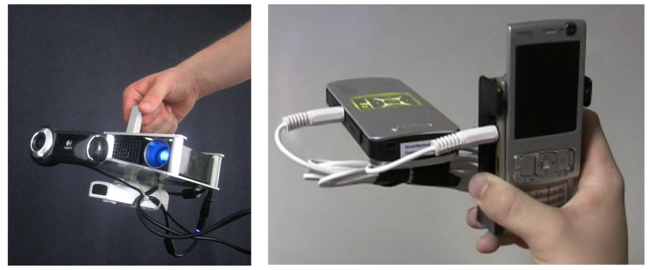

Figure 4: Different hardware prototpyes. Our current prototype (left) compared to the prototype used in [15] (right).

5. CONCLUSION AND FUTURE WORK

We have introduced a mobile adaption of LittleBigPlanet for mobile camera projector units. The *LittleProjectedPlanet* augmented reality game shows the abilities and flexibility that a camera projector unit provides for mobile gam-

[1]This denotes the angular deviation along the longest axis of the Wii remote.

Characterics	*LittleProjectedPlanet*	Map Torchlight[15]
Weight	580g	340g
Lumen	50	10
Camera Res.	3 Megapixel	5 Megapixel
Projector Res.	800×600	320×240
Wireless	No	Yes

Table 1: Characterics of the *LittleProjectedPlanet* prototype compared to the Map Torchlight protoype.

ing. Expanding the interaction space to physical objects creates interaction techniques that are not possible on modern desktop computers. We think that these kinds of applications are helpful entertainment scenarios and in classroom settings and an informative user study is planned to evaluate the prototype. In addition we think that future of mobile gaming is definitely be influenced by the launch of camera phones with build in projectors. Especially the creativity in designing a world embodied by the nearly endlessly possibilities will be interesting to see. Definitely the approach of total freedom in the design space has its disadvantages. Also the detection of projected virtual objects in some strange lightning situations is an issue to work on. However the edge detection without any parameterization of the objects still seems to be the most flexible technique for a user to design a level without any restrictions.

6. ACKNOWLEDGMENTS

Removed for blind review.

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