Designing Gestures for Mobile 3D Gaming

Florian Daiber
German Research Institute for
Artificial Intelligence (DFKI)
Saarbrücken, Germany
florian.daiber@dfki.de

Lianchao Li
University Kassel
Kassel, Germany
lli@inf.e-technik.uni-
kassel.de

Antonio Krüger
German Research Institute for
Artificial Intelligence (DFKI)
Saarbrücken, Germany
krueger@dfki.de

ABSTRACT

In the last years 3D is getting more and more popular. Besides the increasing number of movies for 3D stereoscopic cinemas and television, serious steps have also been undertaken in the field of 3D gaming. Games with stereoscopic 3D output are now available not only for gamers with high-end PCs but also on handheld devices equipped with 3D autostereoscopic displays.

Recent smartphone technology has powerful processors that allow complex tasks like image processing, e.g. used in augmented reality applications. Moreover these devices are nowadays equipped with various sensors that allow additional input modalities far beyond joystick, mouse, keyboard and other traditional input methods. In this paper we propose an approach for sensor-based interaction with stereoscopic displayed 3D data on mobile devices and present a mobile 3D game that makes use of these concepts.

Keywords

3D User Interfaces, Gestural Interaction, Mobile Interaction, Mobile Gaming, Stereoscopic Display

Categories and Subject Descriptors

H5.2 [**Information interfaces and presentation**]: Multimedia Information Systems

General Terms

Design, Human Factors

1. INTRODUCTION

In the last years there has been an increasing interest in 3D related technology e.g. 3D movies, augmented reality applications and games. Smartphones are nowadays powerful enough to process complex tasks like graphics or image processing. Most recently the release of handheld devices equipped with an autostereoscopic display fosters the development of stereoscopic 3D applications for mobile devices.

Figure 1: Sensor-based interaction with stereoscopically displayed data on a mobile device.

Bringing stereoscopic 3D to mobile devices will allow a more realistic perception of augmented and virtual reality. In this paper we propose sensor-based interactions for stereoscopic displayed data on mobile devices and present a prototype with anaglyph-based 3D visualization as a proof-of-concept.

The paper is structured as follows. After this introduction this paper is placed into the relevant fields of related work. In Section 3 a set of mobile 3D interaction styles are proposed. Based on those interactions, the concept of a game application will be then introduced in Section 4 and Section 5. In the following this game serves as a testbed to evaluate the interaction styles. The paper concludes with a discussion of the results as well as an conclusion and outlook in future work.

2. RELATED WORK

This work covers a wide range of fields but mainly mobile interaction and 3D interaction. Only some researchers have addressed the problem of 3D interaction on mobile devices with so far. In this section a selection of related work for 3D mobile interaction research is presented.

Current 3D user interfaces, as they are for example provided by virtual reality (VR) systems consist of stereoscopic projection and tracked input devices. But these are often expert systems with complex user interfaces and high instrumentation. On the the other hand using stereoscopic
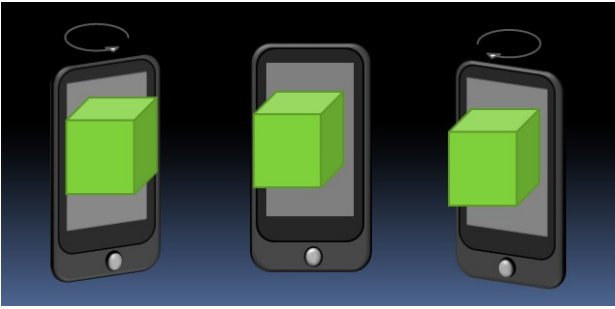
Figure 2: Rotation gesture enables center rotation of the scene around an object.

Figure 3: Flipping gesture allows (step-wise) zooming into the scene and out.

displays allow users to perceive 3D data in an intuitive and natural way. Interaction with stereoscopic displayed objects is still a challenging task even in VR-based environments [11]. In the area of multi-touch interaction Reisman [9] and Hancock [6] have proposed touch-based 3D interaction techniques. These are mainly developped for table-top interaction but might also have some potential in touch-based mobile 3D-interaction. Steinicke et al. [12] discuss potentials and limitations for multi-touch interfaces coupled with mobile multi-touch enabled devices to interact with stereoscopic content.
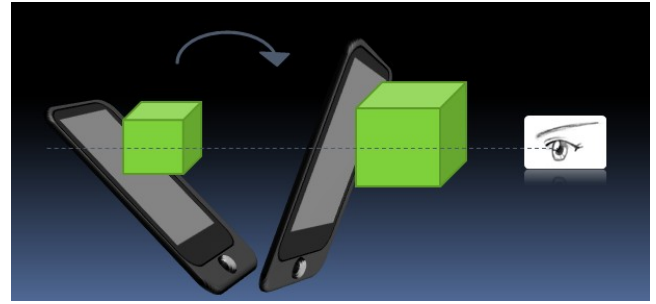
Recent smart phones are equipped with various sensors (e.g. camera, accelerometer, gyrometer, gps etc.) and thus are optimal devices for sensor-based mobile interaction [7]. Boring et al. introduced three interaction concepts to remote control a pointer on a display via scroll-, tilt- and move-gestures with a mobile phone [3] while Benzina et al. [2] explore travel-techniques for VRs using the sensors in the mobile phone. In an early work Rekimoto [10] proposes a handheld device with one button and orientation sensors where 3D interaction is mentioned as one application for such a device. Capin et al. present a camera-based approach to navigate virtual environments on mobile devices [4]. Decle and Hachet present a study of direct versus planned 3D camera manipulation on touch-based mobile phones [5]. Kratz and Rohs [8] extend the virtual trackball metaphor to rear touch input. In contrast to related work multi-touch and sensor-based interaction with 3D stereoscopic data on a mobile device is investigated.

3. INTERACTION

In this section a set of mobile 3D interaction styles is proposed that allow the navigation in the scene as well as the manipulation of objects. These techniques rely on sensor-based input to track how the user is holding, moving and touching the device.

3.1 Navigation

The proposed navigation tasks are realized through rotation and flipping gestures of the mobile device. The movement of the mobile device in the real world also induces a change of view in the virtual world. This simply means that the camera in the 3D scene changes with respect to the movement of the mobile device. The mobile device can be seen metaphorical as a tangible camera. Thus the camera can be physically moved in every direction to change the field of view, its focus, etc.

3.1.1 Rotation

The rotation of the mobile device allows a center rotation around an object or in 3D space. Rotating the mobile device corresponds to a rotation of the virtual camera in the scene. For a large 3D virtual space, rotation provides a viewpoint navigation method in the aspect of virtual camera rotation. For a single 3D object, it presents the 3D object as a fixed state which means a stereoscopic object is fixed in front of the mobile device while performing device rotation gesture (see Figure 2).

3.1.2 Zoom

Zooming is realized though a flipping gesture that moves the virtual camera forwards or backwards in a step-wise manner. A simple but precise navigation in the depth of the scene is realized with this technique. By flipping the mobile device quickly towards the user the virtual camera immerses along the z-axis (see Figure 3). Flipping the mobile device quickly away from the user has an inverse effect.

3.2 Manipulation

Object manipulation is realized by direct touch interaction. Furthermore the combination of tilting and rotation of the mobile with touch extends the interaction space and allows an easy and quick manipulation of 3D objects.

3.2.1 Object selection

Object selection is realized by simple tapping it. The topmost object then will be selected. In combination with the navigation techniques this allows an intuitive and quick way to select objects that are even behind others (e.g. tilt and rotate the device to manipulate the scene and then touch to finally select the object).

3.2.2 Object rotation

Object rotation can be performed by touching an object and holding it followed by a rotation of the mobile device (see Figure 4). This method extends the viewpoint rotation by additional selecting and holding the object gesture to rotate the "fixed" object.

3.2.3 Object translation

Translating an object can be done by touching and dragging which translates an object in 3D space with respect to the rotation and tilt of the mobile device. Figure 5 shows
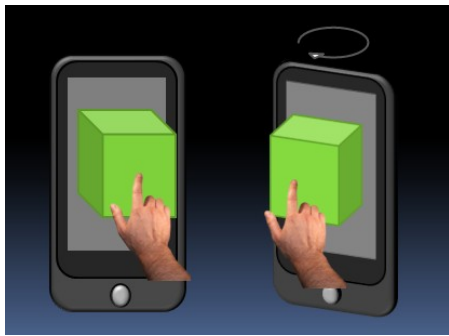
Figure 4: Touch in combination with rotation gesture enables the rotation of an object.

Figure 5: Touching and dragging gesture enables the translation of an object.

an example of moving an object with respect to the vertical plane defined by the position of the mobile device.

The latter interaction styles can be seen as a basic set of interactions for mobile 3D interaction. Dependent on a specific use case or application there might be the need to adapt the set to the requirements of the application. In the following an exemplary application is presented that illustrates this adaption.
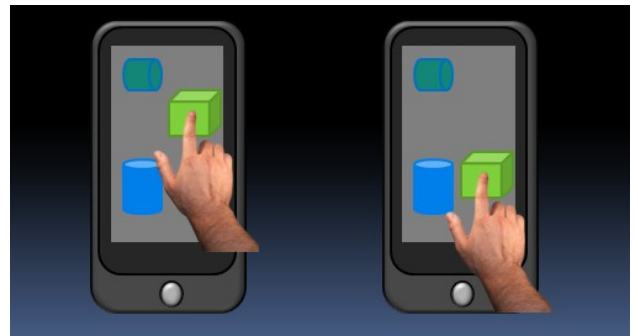
4. FLIGHT CONTROL 3D

Based on the proposed interactions various application concepts can be developed. In this chapter a conceptual mobile 3D game "Flight Control 3D" is presented.

Flight Control 3D is a mobile game that combines the interaction styles proposed above with a 3D mobile game design. The game is inspired by Flight Control a popular game for mobile device platforms. The goal of this game is to safely land planes and prevent collision with each other. New planes or helicopters that appear periodically can be landed by selection and sketching a trace to the appropriate airport. If a collision of two (or more) aircrafts happens, the game will be over. So players need to plan and sketch the traces carefully to avoid collisions and to land as many aircrafts as possible which results in higher scores.

In contrast to the original game the planes have to be controlled in a 3D world. This leads to several design issues and a game experience that totally differs from the original. First a simple 3D world has been developed that is based on a three layer concept: Ground layer, Sky1 layer and Sky2 layer (see Figure 6). The aircrafts are freely moving on Sky1 layer and Sky2 layer and only approach to the Ground layer when landing. The aircrafts can not collide when flying on different layers. So one strategy to avoid collision is the distribution of planes on the different layers.

By tilting the mobile device the view can be continuously changed from an above-view to a side-view. Depending on the view the user can define a trace to determine the movement of an aircraft. From above he or she can sketch the trace and from aside a layer change can be performed. The user has to do two things: defining the trace of a plane and make it sink until it reaches the airport on the Ground layer. As in the 2D version traces are defined by selecting and sliding. Layer changes are invoked by tilting the device in moving the plane to another level. Landing can be seen a special level change and is only possible from the level next

to the ground level which is Sky1 layer in Figure 6. Layer changes are also needed in the landing procedure for the planes that are in Sky2 layer. Successfully landing will be awarded just like in the original version.

5. IMPLEMENTATION

The prototype of the game was developed with the Android API [1] using OpenGl ES 2.0 (embedded system). It has two main components: the 3D virtual world renderer and the sensor controller. The objective of the 3D virtual world renderer is to create a virtual world with multiple objects such as the game map, airplanes, traces, airports etc. and to realize a stereoscopic renderer (i.e. anaglyph) by separating the camera with respect to different color masks (red-blue). The sensor controller on the other hand is aiming to control the sensors such as touch sensor, orientation sensor and accelerometers as input methods.

6. DISCUSSION

Recent mobile technology is equipped with various sensors and powerful processors and thus is well suited even for 3D in- and output. Sensor-based interaction that enables the user to navigate in the virtual world by interacting with his whole body offers a rich set of metaphors and interaction for 3D. Movement in the real world such as viewpoint changes as well as travelling can be more or less directly mapped to the corresponding interactions in the virtual world.

From the game perspective interactions such as viewpoint navigation and object manipulation help to realize the game tasks. For selection, the airplane is simply selected by tapping on the screen on the relevant position. Moreover, tilting the device correspondingly rotates the viewpoint of the camera and adjusting an appropriate angle may help to select an airplane which is blocked by other airplanes. Drawing traces and landing lead in some cases to problems because sometimes it is hard to identify the current layer of an airplane from above. And as already discussed above, only in the layer next to the Ground layer the airplane can land so that the user needs to make sure to which layer the intended airplane belongs to. However, frequently tilting of the device assumes to be a solution for this problem: The layers of the airplanes are clearly achieved by getting the side view of the virtual world. Moreover, tilting the device over a threshold angle may trigger the layer change mode. Therefore, tilting the device as well as selecting and sliding the airplane may
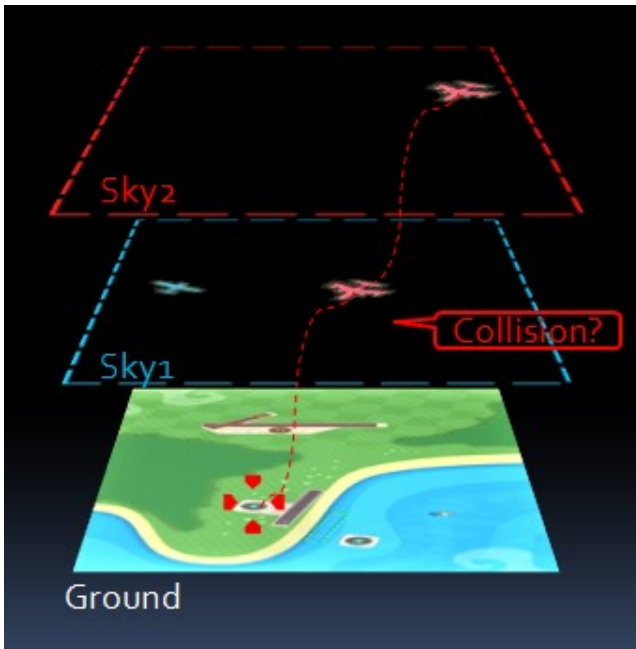
Figure 6: Layered 3D world with Ground layer, Sky1 layer and Sky2 layer: aircrafts do not collide when flying on different levels (layers).

perform a layer change operation.

Some problems occur when adapting the interactions to the game. In the gaming scenario the flipping gesture (for viewpoint movement) has the disadvantage that flipping the devices is already associated with the rotating gesture. This can annoy the user when he or she does not want to rotate the device. For example, frequently watching the unexpected tilting of the stereoscopic scene will cause ergonomic problems because flipping is much more exhausting than normal tilting. The conclusion that can be drawn from this is that the design of gestural interactions for games needs to be carefully done. In general, other requirements than the input modalities play an important role and might restrict input to few and distinct gestures to make the game playable at all.

7. CONCLUSION & OUTLOOK

In this work we presented interaction styles for 3D interaction on mobile devices using touch and motion sensors. These interaction concepts were applied to a mobile (anaglyph-based) 3D game that was realized on the android platform.

Initial user feedback from the design process is promising. Users that have tried out the first prototypes have given positive feedback on the interaction as well as on the game. To adress this feedback we plan a thorough evaluation of the interaction concepts in an upcoming study. Especially the 3D perception and navigation has to be investigated more in depth. Beyond that the game needs to be tested on devices with different display technologies (e.g. auto-stereoscopic displays).

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