ThumbCam: Returning to single touch interactions to explore 3D virtual environments

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Abstract

Three-dimensional virtual environments are present in many different applications, being used even in small handheld devices. To navigate in these environments using such devices, most of current solutions rely on multi-touch interactions. However, previous works have already stated that multi-touch gestures on smartphones are not always feasible. In this work we present ThumbCam, a novel single-touch technique for camera manipulation on 3D virtual environments. With our solution, the user is able to move and look around and circle points of interest, while interacting using only his thumb. We compare ThumbCam with other state-of-the-art techniques, showing that it can offer more operations with a single touch. A qualitative user evaluation revealed that users found our solution appealing.

Author Keywords

Touch; Camera Manipulation; 3D Virtual Environments

ACM Classification Keywords

H.5.2 [User Interfaces]: Interaction styles.

Introduction

Camera manipulation is a very important task within 3D virtual environments (VE). Whether it is a design review task, a virtual tour, or even a game, it is often necessary

to explore both the virtual scene in general and have a detailed look on specific objects. On the other hand, small interactive devices, such as tablets and smartphones, are getting ever more computational power, starting to rival traditional computers in some tasks, such as design and review of 3D engineering models [2]. Today's common solutions for interacting with VE with touch enabled devices mainly rely on multi-touch gestures or buttons to apply different camera transformations. It has already been shown that multi-touch gestures can surpass button based interactions [4]. When considering smartphones, multi-touch gestures imply that the user needs to hold the device with both hands, which can be tiresome and not always possible [1]. Also, smartphones' small screens offer little space for multi-touch gestures, which may occlude a significant part of the imagery displayed. Moreover, studies [6] have shown that users tend to interact with their smartphones using a single finger, being the thumb the more often used finger.

We present ThumbCam, a camera manipulation solution that allows users to move, look and circle around within a virtual environment using only one thumb. In this paper, we show a comparison with other state-of-the-art techniques, as well as a preliminary qualitative user evaluation.

Related Work

Aware of the limitation of using both hands while interacting with smartphones, Boring et al. [1] proposed the FatThumb technique, which allows users to interact with a 2D map using the thumb's contact size. Considering 3D Virtual Environments, Hatchet et al. [5] introduced Navidget for camera placement, that uses sketched circles to obtain the point of interest (POI) representing the end point of the desired camera's trajectory and position. ScrutiCam [3] implements a

manipulation technique to move the camera around objects by moving an area of interest to the center of the screen, using a single touch. In Drag'n Go [9] the user controls the camera progression in the VE by combining target acquisition with touch input gestures. Move&Look [8] extends the Drag'n Go method in the sense that it uses single-touch interactions to move around the VE and multi-touch to manage the camera's orientation. Jankowski et al. [7] compared several techniques and concluded that a stroke-based method can achieve better results for street level navigation tasks. In this document, we will follow the concepts of move around, look around and circle around, as described by Marchal et al. [8]. We also resort to the notations used by the same authors for camera translations (Tx, Ty, Tz), look around rotations (Rx, Ry) and circle around transformations (Ox, Oy).

ThumbCam

Aiming for a touch solution that could enable users to manipulate the camera in 3D VE using a single contact point, we developed ThumbCam. With our solution, it is possible to look and move freely in the virtual scene and to circle around specific points of interest, without occluding too much of handheld devices' small screen. To support these different types of interaction with only one touch, we resorted to a state machine (Figure 1) to decide which behaviour should be followed at any given moment. We have three states that modify the current view: Rotate, Drag and Move, which are described below. These states are selected depending on user's inputs: tap (a very brief touch without any significant movement - we consider less than 0.3 seconds between touch begin and end); touch begin (longer than a tap); touch move; and touch holding (we consider a touch in the same place for longer than 0.5 seconds).
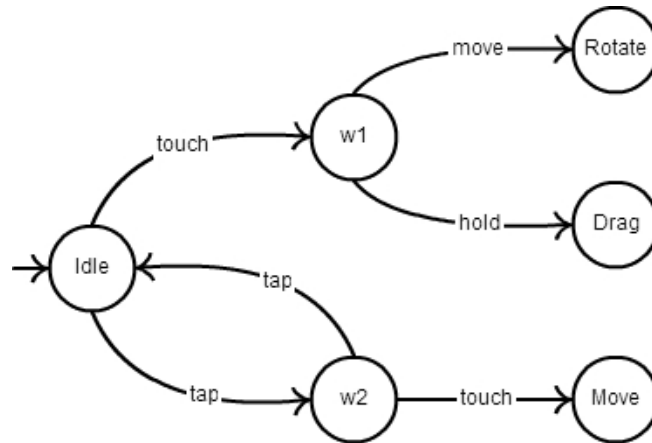
Figure 1: Simplified view of our state machine. States w1 and w2 are waiting for another input to decide which transition to make (they do not modify the current view).

Rotate

When the user starts an interaction by placing and moving a touch, we enter the Rotate state. We support two modes of camera rotation: look around (Figure 2) and circle around (Figure 3). Two sequential taps while in the Idle state toggle between these two modes. When transitioning from the look around to circle around mode, a ray from the second tap is casted into the scene, and the intersection with the nearest object defines the POI and the orbit's center. In circle around mode, a target is shown to indicate the POI being orbited. Horizontal movements of the user's touch will then rotate the camera around a vertical axis (Ry in look around mode or Oy in circle around mode). Likewise, vertical movements of the touch will rotate the camera around a horizontal axis (Rx in look around mode or Ox in circle around mode).

Figure 2: Looking around in the VE (Rx and Ry simultaneously).

Figure 3: Circling around a POI in the VE (Ox and Oy simultaneously). The red target indicates the orbit's center.

Drag
Touching and holding the screen will enter the Drag state, showing two vertical arrows to inform the user (Figure 4 left), which disappear as the user moves the finger. The behaviour of this state follows the Drag'n Go technique [9]. The intersection of the ray casted from the touch start position with the scene will define the target of the movement. Dragging the touch downwards translates the camera towards said target along the path defined by the ray casted (Figure 4), while upward movements of the touch will translate backwards along the same path (Tz). The distance between the start position of the touch and the bottom of the screen is mapped to cover the entire length of the path from the camera's start position and the target. While traversing the path, horizontal movements rotate the camera sideways (Ry). These horizontal movements do neither affect the camera position nor the previously defined path.
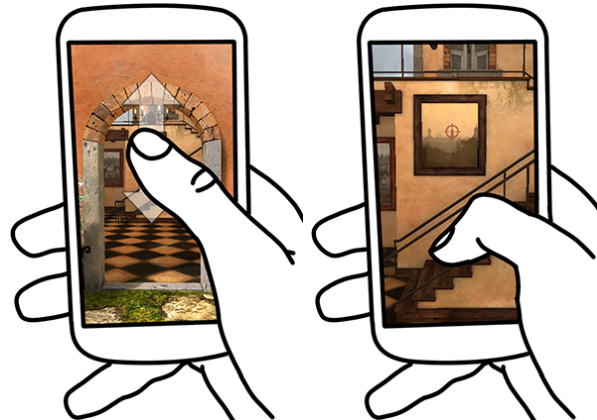

Figure 4: Moving towards a POI (indicated by the red target) using the Drag'n Go technique (Tz).

Move
The Move state can be achieved by tapping and immediately touching the screen, i.e. a quick sequence of touch begin, touch end and another touch begin actions. In this state, users can translate the camera sideways (Tx) with horizontal movements, and upwards and downwards (Ty) using vertical movements of the touch (Figure 5). In a similar fashion to the Drag state, four arrows are displayed on the screen upon entering the Move state (Figure 5 left), to inform the user of the action he is now performing.
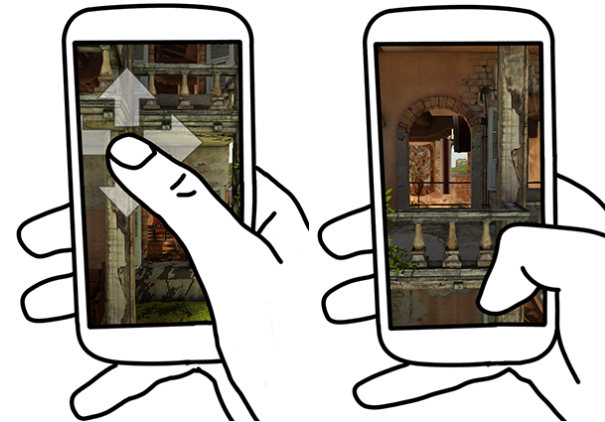

Figure 5: Moving around in the VE (Tx and Ty simultaneously).

Comparison with Other Techniques
In Table 1 we show how ThumbCam compares to the most relevant state-of-the-art techniques for camera manipulation. Navidget offers only POI based navigation, being not possible to look around. Scruticam focus solely on object visualization, offering no actual scene exploration. Drag'n Go, although making move around

Technique	Move Around	Look Around	Circle Around	# Contact Points
Navidget [5]	Tx, Ty, Tz	-	Ox, Oy	1
ScrutiCam [3]	Tx, Ty	-	Ox, Oy	1
Drag'n Go [9]	Tz, Ry	Ry	-	1
Move&Look [8]	Tz, Ry	Rx, Ry	Oy	2
ThumbCam	Tx, Ty, Tz, Ry	Rx, Ry	Ox, Oy	1

Table 1: Comparison of the most relevant techniques and our ThumbCam.

interactions possible, neither allows looking up and down nor circle around points of interest. Move&Look is a more complete solution than the previous, but lacks Tx and Ty transformations and resorts to two touches interactions, which have been shown being not always possible. Our proposed technique, ThumbCam, offers more camera transformation than the remainder, and all actions can be done within reach of the user's thumb.

Moreover, the hand grip on a smartphone, although not being static, renders impossible the thumb to reach all screen real state, which hinders targets' acquisition. ThumbCam was designed in a way that all targets can be acquired by the user's thumb when in range, and the rotation gesture is available to relocate the target on the screen, when it is out of reach.

Qualitative Evaluation

We conducted a small user experiment to assess whether our technique was appealing to users. For this experiment, five participants were asked to explore a virtual environment and report their feedback. The ThumbCam prototype's virtual scenario was built using the cross-platform Unity3D engine.

Through this qualitative user evaluation, we found out that our method requires a small period of habituation

(around 5 minutes), which when exceeded, users could fulfill the desired camera transformations without difficulty. Also, they stated that our technique was enjoyable to use, mainly due to the relaxed way of grasping of the device and interacting with only the thumb.

Conclusions and Future Work

In this work we present ThumbCam, a novel single-touch technique for camera manipulation on 3D virtual environments that builds up from the limitations of multi-touch gestures on smartphones. We described the designed interactions for move, look and circle around transformations, and also the technique's on-screen feedback system. Regarding the compared techniques, our solution is able to apply more camera transformations while using only a single touch. Although test subjects demonstrated a positive opinion, we intend to carry out a more extensive user evaluation to assess how our method performs against other techniques. Since our solution only applies one contact point, ThumbCam can be used in a multitude of devices, ranging from smartphones, tablets and tabletops to mouse-based desktop computers. In addition, we believe that ThumbCam might be suitable to remotely interact with virtual environments on large screen displays, and we would like to study its feasibility.

Acknowledgements

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