Usability of Information Seeking Tools in 3D Mobile Interaction with Public Displays

Mayra Donaji Barrera Machuca[1(✉)], Winyu Chinthammit[2], and Weidong Huang[3]

[1] SIAT, Simon Fraser University, Surrey, BC V3T 0A3, Canada
mbarrera@sfu.ca

[2] School of Technology, Environments and Design, University of Tasmania, Launceston, TAS 7248, Australia
winyu.chinthammit@utas.edu.au

[3] Department of Computer Science and Software Engineering, Swinburne University of Technology, Melbourne, VIC 3122, Australia
weidonghuang@swin.edu.au

Abstract. We designed a 3D mobile interaction technique that utilizes mobile devices as 3D user interfaces to facilitate the use of the user's natural skills to control public displays. To achieve this, we provide three layers of interaction, where users can see and share content at the same time. Another feature of our user interface is that it provides different tools for information seeking, such as new content creation. In this paper we present a study that examined how these tools were being used in three different scenario-based case studies. The results of this study indicate that participants found these tools useful.

Keywords: Public displays · Mobile devices · 3D user interfaces
Augmented reality

1 Introduction

Public displays are screens located in public places that show information related to that place useful to the people around them. Nowadays, public displays have become increasingly ubiquitous and can be found in spaces, such as bus stations, public theaters, airports and roadsides [5]. Public displays serve specific purposes depending on their location, for example, a display near the entrance of a shopping mall is for customers to explore the mall to find a specific store. On the other hand a display at a theater is to inform viewers of the latest shows. To fulfill these purposes, some of the challenges of interactive public displays are how to motivate users to start an interaction with the display, and once the interaction starts, how to keep users engaged [1, 5, 9].

In an attempt to address these challenges, we developed a 3D mobile interaction technique that allows users to collaboratively interact with the public display for information seeking purposes [2, 3]. Our 3D mobile interaction technique uses the screen of mobile devices to give individual users a unique and private perspective of the information on the public display. To achieve this, we utilize augmented reality (AR) [6, 11, 12] to allow users to see private 2D and 3D content imposed on the public

Y. Luo (Ed.): CDVE 2018, LNCS 11151, pp. 16–23, 2018.
https://doi.org/10.1007/978-3-030-00560-3_3

display. We have implemented a prototype and conducted a user study evaluating the usability of our interaction technique. The results of the study found that users were satisfied with the proposed technique and that this technique met our design objectives [3].

As part of the implemented technique, our prototype also provides various information tools for users to use on their screens, i.e. look for specific information. In this paper, we report on the results related to the usage of these individual tools. These results were collected on the evaluation of our interaction technique, but we have not reported them elsewhere. From this data, we examined how different mobile interaction tools are being used in three different scenario-based case studies. The results indicate that users found these tools useful.

The rest of this paper is organized as follows: the next section describes the information tools of the tablet interface. Section 3 presents the design of the usability study and results. Finally, Sect. 4 presents our conclusions and future work in this area.

2 3D Mobile Interaction

Our 3D mobile interaction technique is based on AR technologies, where a user utilizes a mobile device to interact with the public display [4, 7, 8, 10]. Having two screens creates a multidimensional interaction space consisting of 3 layers: *public*, where public 2D content is displayed; *virtual*, where public and private 3D content exists outside the public display, and *private*, where private 2D content is displayed. This approach allows users to focus on both screens at the same time, thus increasing the space available to display content. A thorough description of the system can be found in Barrera et al. [2, 3]. In this paper, we focus on the tools designed for the private layer, where users see personalized information. The information showed on this layer is considered private and secure. The reason for this is that it can only be seen and accessed from the screen of each individual user mobile device.

2.1 Interactions

In our user interface design, we focused on giving users a clean screen. This would enable them to interact with the content of the public display without having to overlay information on the mobile device screen. See Fig. 1, for an example of a user interface designed for hiking. In our prototype the main interaction zone, the input area, is in the middle of the screen. Here users utilize touch gestures to interact with the content. The available interaction methods are: one finger selection and translation, and two finger scaling and rotation. Using these gestures users can select information on the public layer and bring it to the virtual and private layers. Once a user selects an object, he/she can manipulate it independently of the other users' actions. The second interaction zone, the more input button, is at the bottom right of the screen. When users click this button, it changes the information each user sees in the virtual layer, which is displayed on top of the public display. The specific information tool, the third interaction zone, is in the left side of the screen. Here users can see written information of the selected content. Finally, at the top right corner, there is the private information zone, which shows private information taken from the mobile device. As stated before, our prototype was adapted to a hiking scenario, Table 1 shows the information added in each interaction zone:

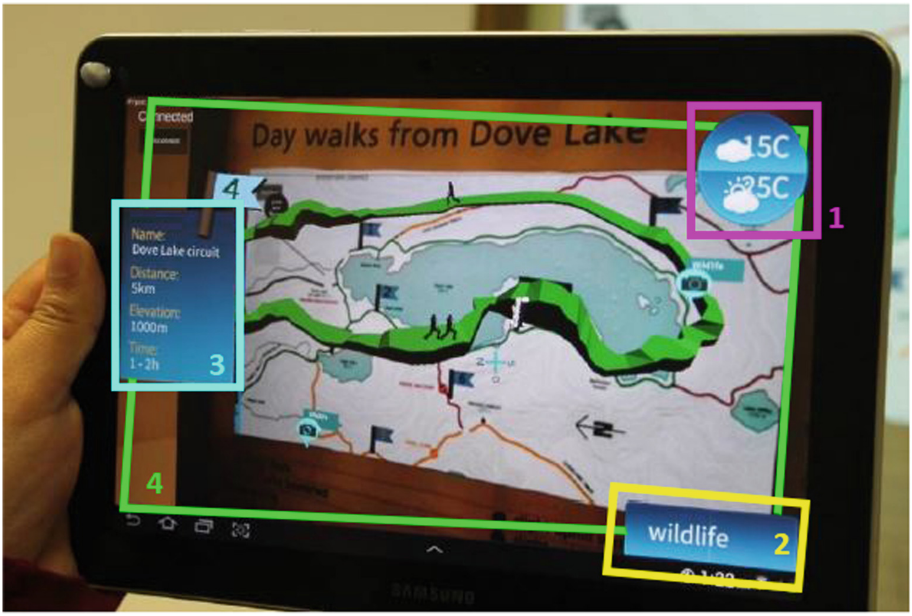

Fig. 1. A user interface showing the private information (1); more info button (2); specific info tool (3); and the input area (4).

Table 1. Use of each interaction zone in our prototype.

Name	Interaction zone	Action
Wildlife	More info button	It shows pictures of what type of wildlife have been sighted on that position
Landscapes	More info button	It shows pictures of the possible view from that position
Notes	More info button	It shows comments other hikers could have left
Weather	Private information	It shows the current weather
Trail name and extra info	Specific info tool	It displays extra information about the selected 3D model
3D Model	Input area	It shows a 3D model of the selected trail

2.2 Prototype

The prototype uses a 21.5 in monitor as a public display and an Android Tablet as a mobile device. We implemented the prototype using Unity and C#. The core tracking capabilities are taken from an AR software library (Vuforia).

3 Experiment

In our experiment participants were asked to role play as two tourists planning a day hike to Dove Lake at Cradle Mountain National Park in Tasmania, Australia. The experiment was conducted over three scenario-based circumstances. We briefly described these three scenarios and our evaluation design in the next two sub-sections, followed by the evaluation results on how individual information seeking tools were used. For more details on the evaluation design, see [3].

3.1 Scenarios

Scenario 1: Participants role-played as a couple of advanced hikers who looked to challenge themselves by choosing a trail from two available trails that has the shortest distances to the pre-selected destination even though it could be more challenging (e.g. steeper slope). The weather was set to be cloudy on the day and the starting time of the hike was at 10:00am.

Scenario 2: Participants role-played as a couple of old-aged hikers who had to consider at a half-way point of the trail whether to continue (in a clockwise direction) and complete the trail or turn around and return to where they started. The couple wished to avoid steep slopes and too hot weather. The weather was set to be hot on the day and the starting time of the hike was at 1:00 pm.

Scenario 3: Participants role-played a couple of young casual hikers who looked for a location that was relatively leveled so that they could relax and have lunch. The selected location must have a good view of the national park, which was located at higher altitude. The weather was set to be windy on the day and the starting time of the hike was at 9:00am.

3.2 Evaluation Design

The evaluation was conducted in a controlled room at the HIT Lab AU in the University of Tasmania, Newnham campus. A total of 40 participants (22 males, 18 females; age range 19–58; mean age 24.5 years) participated in the study. Most of the participants were computer science students, but some were also community members interested in the study. The participants were asked to come with a friend, and each pair was randomly assigned to either the traditional group (which used a static public display) or the mobile group (which used the proposed 3D mobile interaction prototype). In this paper we present and discuss the results of the usability of the information seeking tools. We use the information of how each participant used the tools available on their mobile device to achieve this. The mobile application has a built-in data logging capability to capture the interaction activities on the mobile tools made by the users. And we also distributed questionnaires to collect user feedback.

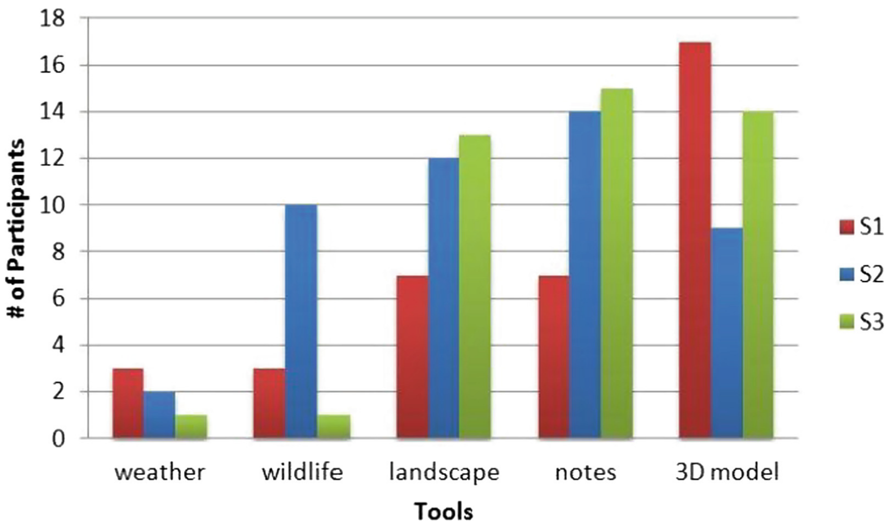

Fig. 2. Mobile group tools used.

3.3 Results and Discussion

Scenarios Comparisons. We recorded the number of times each tool was used (Fig. 2) and the number of tools used. We then used this information to see how engaged the participants were with the interaction, as the scenarios were designed to only need one or two tools to answer them. We hypothesize that participants who are more engaged with the interaction would use a greater number of tools. Analyzing the obtained results, participants rely on the tools that help them augment information on top of the map, such is the case of landscapes and notes. However, they complemented that information with the 3D model tool, which showed the slope of the trail and brought the extra information to the screen. One meaning of this is that the 3D models are useful when comparing two spots on the same trail, as it helps to differentiate them. For example, in scenario 2 that compares two spots on a trail, the most used tools were notes and landscape. However, in scenario 1 that compares two trails, the most used tool was the 3D model.

Interaction Usability. This data is related to the participant's opinion of each tool in the proposed 3D mobile interaction prototype and how useful they found that tool. It is important to analyze this data because it will help to better design the user experience of future prototypes. As shown in Table 2, in general participants thought that the information is clear enough to be able to understand it (5 in a 7 points Scale). Below we describe the results of each tool individually.

Table 2. Usability scores for each tool

Tools	Usability score (7 points scale)
Weather	4.5
Wildlife	5
Landscape	6
Notes	7
Specific info	6
3D info	6

Weather Tool: As explained before this tool mimics personal and private information taken from the mobile device. In the experiment the weather tool complemented the information given in the scenario about the type of day, i.e. sunny, windy, etc. From our 20 participants, 10 participants never used this tool during the session and for the other 10 participants the median answer was 4.5 from 7 points. These results show that participants did not find this tool useful. Some of the reasons for this conclusion are the following: the participants were already given information about the weather in the scenario description, and the weather was a mockup and not the real data.

Wildlife Tool: As explained before, this tool was one of the options in the more information button. Once users selected this option, it augmented the map on the public layer with positions where sightings of wildlife have occurred. In the experiment the wildlife tool was used in an extra scenario thought for the traditional group to use the 3D mobile interaction prototype. Mobile group participants also did this scenario. Based on this usage each group participant answered a usability question about the wildlife tool. From the 20 mobile group participants, 1 did not use the wildlife tool at all. For the rest of the participants the median answer was 5 from 7 points. These results mean that most users used the wildlife tool, and that participants found this tool useful.

Landscape Tool: This tool is also one of the options available in the more information button. Once users selected this option, it augmented the map on the public layer with pictures of possible views from that positions. From the 20 mobile group participants, all used the landscape tool, with a median answer of 6 from 7 points. This means that the landscape tool is very useful and that all participants used it for answering the scenario questions. Especially as these questions were related to information available on the landscape tool.

Notes Tool: This tool is also one of the options available in the more information button. Once users selected this option, it augmented the map on the public layer with notes left by previous hikers. From the 20 mobile group participants, all used the notes tool, with a median answer of 7 from 7 points. These results mean that all participants found the notes tool very useful for answering the scenarios questions. This result goes accordingly to the scenarios proposed, as scenarios 2 and 3 had information related to them on the landscape tool.

Specific Info Tool: This information was displayed after the participants selected a trail from the public display. It showed the following extra information about the trail: name, distance, elevation and estimated time. From the 20 mobile group participants, 4 did not use the specific info tool. From the rest of the participants the median answer was 6 from 7 points. These results mean that the specific info tool is very useful, but that its information could be found somewhere else.

3D Info: This information was the 3D model of each trail displayed in the virtual layer after the user had selected the trail in the public display. From the 20 mobile group participants, all used the 3D info, with a median answer of 6 from 7 points. These results mean that the 3D info is very useful.

4 Conclusions

In this paper we present the information tools designed as part of our 3D mobile interaction technique for public displays. This interaction merges the advantages of using mobile devices' screens to display content together with the natural skills of 3D user interfaces. Specifically the information tools we present augment the public screen with private information. Based on the interaction design, we developed a prototype to show the proposed 3D mobile interaction using Unity3D and C#.

We test this prototype in a usability study of 20 pairs of participants. In our study participants solved three case-based scenarios. In this paper we report and discuss the usability of each information tool and how it affects each scenario. In general participants found more useful the tools that augment the public display information with private content, i.e. pictures of the view of a position on a trail, and 3D models that allow them to see 3D information, i.e. the 3D model of a trail. This finding helps sustain that private information and 3D information can be useful for users of public displays.

In the future we will test the proposed 3D mobile interaction in other scenarios to identify how our proposed tools work.

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