3D Mobile Interactions for Public Displays

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ABSTRACT

We propose the use of 3D mobile interactions as a way to give public displays viewers (users) new ways to collaborate among them with the public display. Getting and maintaining the user attention is one of the main struggles of public displays but previous research has shown that collaboration among viewers are able to engage users with public displays more. Our proposed 3D mobile interactions for public displays utilize mobile devices as 3D user interfaces to facilitate the use of the user's natural skills to control 3D content. The 3D content can also be positioned outside the public display, which let us explore new interaction techniques. We present a prototype of our 3D mobile interaction that demonstrates the proposed interaction as well as describes one of the use case scenarios.

CR Categories

H.5.2 [Information Interfaces and Presentation]: User Interfaces - Interaction styles; H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces – Collaborative computing.

Keywords

Public Displays; Mobile Devices; 3D User Interfaces; Augmented Reality.

1. INTRODUCTION

Public displays are becoming common in public spaces like bus stops, movie theatres and work places. A challenge that public displays as a medium face is to motivate users to start an interaction, because users have concerns about their privacy and the way other people may see them. Once they start an interaction public displays struggle to engage users in long sessions as they dispute their attention with other source of information [Müller, *et al,* 2010]. Therefore there is a need to investigate public display interactions to propose interactions that can help engage users with the public display more.

In this paper we choose to investigate collaboration as a way to improve user engagement with public displays based in previous results where creating a shared experience for an audience made the participants engaged with the activity [Scheible and Ojala, 2005; Reid, et al, 2004]. In order to give users tools to collaborate with other users we proposed the use of 3D user interfaces, because controllers that allow for natural movements have the potential to offer greater affordances for social interaction [Lindley, et al, 2008]. And to solve users privacy concerns we utilize mobile interactions, where a mobile screen can be used to display private and personalized information.

In the proposed 3D mobile interaction we utilize the mobile device screen to augment 3D content on the public display utilizing an Augmented Reality (AR) tracking approach. We propose that having 3D content gives public displays a new layer of depth for collaboration between users. With this new layer users can create novel interactions where they not only consider the content on the public display but also the position of the users around it, as each user has a unique and individual perspective of the content on the public display.

2. RELATED WORK

Collaborative environments using public displays where users can relate physical objects to virtual objects have been explore before. In Augmented Surfaces [Rekimoto and Saitoh, 1999] users can transfer information from their laptops to the public display (table and wall) and vice versa. This system uses a setup that include video projectors and cameras to recognize the patterns on the physical objects and the users touch points. Other projects have explored the use of mobile interactions to interact with public displays. These mobile interactions drawn from research in different domains, most notably from server networking and augmented reality.

Many projects explore the use of mobile devices as tools to store and share information. Users of Digifieds [Alt, *et al,* 2011] utilize a mobile client to create new content and to consult previously stored content without the need of the public display. In Plasma Poster [Carter, *et al*, 2004] besides creating new content using their mobile devices, users can augment other posts with annotations. In both instances the mobile devices serve as an easy way to create content in privacy that later can be shared to the public display.

With the popularization of mobile devices with cameras interactions where the user points the mobile device camera to the public display were presented. These interactions establish their relationship with the public display using visual codes that are tracked through tracking algorithms (e.g. model-based and feature extraction) to determine

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position and orientation of the mobiles with respect to a location. An example of this is Sweep and Point & Shoot [Ballagas, *et al*, 2005] that allows people to control the public display by moving the mobile device. Hyakutake, *et al*. [2010], proposed an interaction that not only calculate the position of the mobile devices in (X, Y), but also uses the distance to the screen as a value. This gives the user the ability to diminish or grow the content depending on the camera distance to the screen.

Once mobile devices incorporate touch capacities, interactions that let users interact with the public display from any distance by using the mobile device touch screen were presented. In Touch Projector [Boring, *et al,* 2010] users can transfer content from one public display to another by using a drag and drop interaction in the real world. Video Wall [Baldauf, *et al,* 2012] augment the video stream with content so users can select videos from the public display and watch them privately on their mobile device screen. TouchScreen [Schmidt, *et al*, 2012] use the mobile phone as a way to parameterize user input and to give users a personal user interface that will move with them

Collaboration between users interacting with public displays through mobile interactions has been explored before. In MobiComics [Lucero, 2012] a group of users create and edit comic strips using their mobile phones, and then they share those strips to two public displays. Lucero, *et al* [2012] found that people enjoyed creating panels collaboratively and sharing content to public displays. In Electric Agents [Ballagas, et al, 2013] two users work together to find words in a room using AR, after finding the words the user send that information to a public display on the room. Ballagas, et al [2013] found that AR supports specific patterns of collaboration, for example gestures in physical space, verbal referencing physical objects and physically guiding other users controllers.

Previous research focuses on using 2D content on public displays. However in the past few years, the computational power of mobile devices has significantly increased making them able to process complex visual tracking algorithm while at the same time renders 3D content. Therefore there is an opportunity to investigate how 3D user interfaces and 3D content influence user interactions with public displays.

3. INTERACTION DESIGN

Our goal with the proposed 3D mobile interactions for public displays is to spatially link between the interaction space on mobile device(s) and the interaction space on a public display regardless their size. An important design criteria is to avoid using specialized equipment or requiring a complicated setup such as the one found in Augmented Surfaces [Rekimoto and Saitoh, 1999], because public displays are set in open spaces where the equipment could be damaged or stolen. Using mobile phones as 3D user interfaces for public displays gives users the benefit of having the use of natural and familiar skills to control content. The use of 3D content was thought as a way to integrate the public display into its ambient, as the content is not attached to the surface of the public display's screen. In a collaborative settings where users work together to reach a common goal, the (augmented) 3D content make the physical location of the user(s) around the public display an additional factor in the interaction design space as explored by Szalavbri, Z, Eckstein, E., et al [1998] and Lee, G., et al [2006]. Therefore our proposed interaction design aim to keep interactions for public displays open and simple enough so users collaborating with other users may be able to find additional forms of expression built on top of our interaction techniques. This *new expressions* may use metaphors intuitive in each particular application contexts and can help to engage users with the public display more.

As shown in Figure 1, we conceptualise the interaction space as having three different layers of information visualization: public layer, virtual layer, and private layer. In the *Public layer* we have the public display information accessible by all the people around the public display with or without a mobile device, as is the case of a normal static public display. The *Virtual layer* is the virtual space; here the public display users that are seeing the public display through their mobile device can see the 3D content spatially stabilised in the real world. The *Private layer* is the private space, where the information is personalized to each user (each mobile device), as the information is only visible/accessible on their individual mobile device screen as is the case of a normal mobile interaction. Our proposed interaction gives each user a private view of the 3D content via the mobile screen and at the same time we have two interaction layers where users can collaborate together.

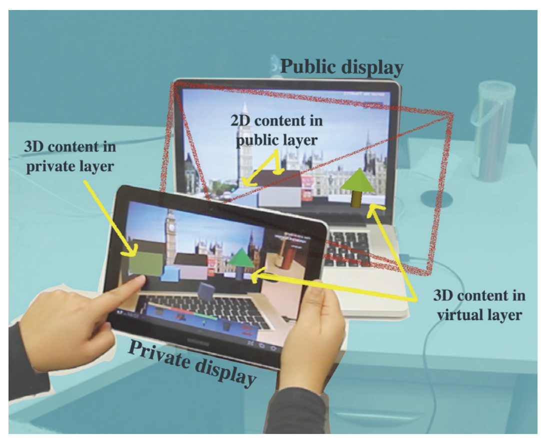

Figure 1. Conceptual layout of 3D mobile interactions

In order to achieved our proposed interaction design we use a combination of the mobile robust visual tracking capability (based on Vuforia a product of 2014 Qualcomm Connected Experiences, Inc.), multi-touch interaction, and live rear view camera of the mobile to create an interaction space between mobile devices and the content on the public display. Our proposed 3D mobile interactions for public displays are designed to enable cooperation between users of public display as the processing of the 3D content and the tracking occur in each individual mobile device, therefore the number of users actively interaction in one public display increase. More importantly, each user has a different perspective of the 3D content on the public display, making their view of the public content unique.

3.1 Development

We developed a prototype to show the proposed 3D mobile interactions for public displays using Unity 3D and C# programming language. Our prototype follows server-client architecture and has four main components. The *first component* is the tracking module that determines the location of the mobile devices relative to the public display. We used the Vuforia Unity 3D Extension to provide the core tracking capability. The tracking object is the entire background image of the public display to maintain robust accurate tracking in partial occlusion circumstances. The *second component* is the spatial mapping module that spatially correlates the interaction/touch surface of the mobile devices to the surface area of the large displays. We accomplished this with the use of a transparent augmented-reality mapping grid, which is superimposed in 3 dimensional space just in front of the (entire) surface of the public display. The *third component* is the processing and communication module, here we used an authoritative server that control the clients connected to public display. The server is in charge of controlling the virtual layer by making sure that all clients get updated on the actions of other clients and also by giving personalized feedback to each client depending on their action. In our prototype we can have between 1-5 users connected simultaneously by using the Unity 3D server to control the communication between the public display and the mobile devices. The *fourth component* is the mobile device client, which utilizes existing multi-touch user interaction available on the mobile devices. After the multi-touch interaction is processed in the private layer, a command-based input is sent through a Wi- Fi network to the server to execute the command input (e.g. repositioning) and most importantly where those actions are supposed to occur in both physical and virtual layers.

3.2 Interaction Techniques

The proposed 3D mobile interaction may motivate users to use public displays by creating novel interactions techniques that not only centre on the public display but also take into account the people around them. In this section we are going to describe our proposed interaction techniques for 3D mobile interactions for public displays.

1. ***Content Transfer:*** Users can take information from the public display to their mobile device or send information from their mobile device to the public display. We proposed two types of content transfer. **Public and virtual layers content transfer:** Users can intuitively transfer content between this layers by bring the content "out" the screen. In order to achieve the movement in z axis, we use the user position in relation to the screen to change their reference point. As shown in Figure 2 users always move the objects in two axes but depending on their perspective the coordinate system change. **Private and public layers content transfer*:*** Users can accidentally make their private information public, therefore is important to prevent user privacy. In our prototype users need to specify their approval to transfer the content and then use two fingers to send the content. To bring content from the public display users slide their fingers to them and to send the information users slide their fingers away from them.

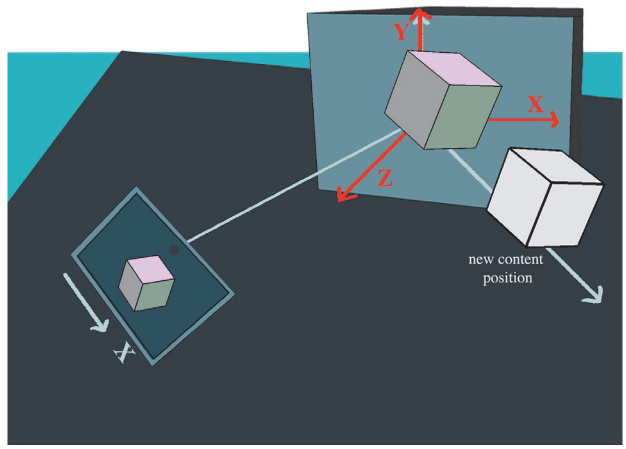

Figure 2. Movement in z axis.

2. ***Content manipulation:*** Users can manipulate content in different ways: 1) repositioning – select/touch the content and moving the finger on the mobile device's screen, 2) scaling – pinch gesture 3) modification – change colour and 4) rotating – two fingers rotation. Rotation in 3D can be difficult to understand especially when using a 2D input (touch screen), therefore our prototype use the user perspective to know on which axis to rotate the 3D object. Depending on the view the object will rotate with that face on top.

3. ***Content creation:*** users can create content in the private layer. With our proposed 3D mobile interaction, users can visualize their new content in the public and virtual layers. In this way users can experiment new approaches for their content in private, but at the same time have a preview of the result.

For public displays feedback not relying on visual feedback is important, because the space around them can have changing lighting conditions. Therefore, in addition to the visual feedback described so far, our prototype utilizes the mobile device sensors to provide a user with audio clues and haptic clues after the user perform an action. Equally important, it is to give user feedback about the ownership of the content on the screen. In our prototype the server assigns a unique colour to each user and change the opacity of the content in the public layer so it is not mistaken as being part of the private content of the user.

4. INTERACTION CASE SCENARIO

Up to now, we have described the interaction techniques for our proposed 3D mobile interaction for Public displays. One case scenario of its future use could be to jointly order food in a restaurant.

We have three friends, Olivia, Ruby and Jack, who decided to have dinner at a restaurant in a city. Once they are assigned a table they found a large wall poster (public display) on a wall nearby their table. On the public layer they see the special order of the day, discounts offer in the restaurant and other information related to the place they are in. Utilizing their own mobile devices with a previously installed App they see the menu of the restaurant in the private layer. Olivia and Ruby utilize the 3D representation of the food in real size to see if that's enough food for them before transferring the food to the virtual layer to share with the others what they are ordering. Jack decided to select the special of the day from the public layer and transfer it to the virtual layer. Then the three friends comment about the others food, and Jack notices that Ruby food has onions, which she dislikes. Therefore he rotates the 3D content to show this to Ruby, while at the same time laughing about her reaction. While Ruby is selecting a new food, Olivia suggests ordering an entry, to which all agree. Every time one of them transfer an item to the virtual layer, they can see in their private layer the total cost of their individual order. This let them make decisions more informed. Once they finish selecting food they call the waitress by changing the image on their public layer of the display. When the waitress arrives she utilize her own mobile device to see the plates selected. All the plates are in front of the person that orders them, so she can know where to bring the food and which one is the entry as that is in the middle of the table.

5. CONCLUSION

We proposed 3D mobile interaction for public display, which provides tools to help users collaborate with one another as a way to engage them with the content on public displays. The use of 3D content to increase collaboration, which takes advantage of the use of natural skills that 3D user interfaces provide, is explored in our prototype and our case scenario. Previously proposed interaction for public displays focus on giving the user tools to control 2D content. In this scenario 3D content is rarely used, thus for the user public displays still try to mimic their private desktops, which remove their motivation to use them and prevent their popularization. Our future work is to investigate CSCW aspects such as spatial awareness and to do a user evaluation of our proposed 3D mobile interaction for public display.

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