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Interacting with Digital Public Displays using a Video See-through Head Mounted Display

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ABSTRACT
Public displays are widely used for displaying messages to large groups of people, such as advertisements, wayfinding or warnings. The proliferation of public displays has also lead to them being ignored either through people assuming the content is irrelevant to them or they get lost among other objects in the public space vying for attention. Adapting or personalising the content could make the displays more relevant. However, inherit privacy issues are then created. This workshop paper presents an initial prototype that demonstrates the concept of interacting with public displays with video see-through augmented reality and its potential for individuals to have private and unique experiences with public displays.

Author Keywords
Public displays, Smartphone Augmented Reality, Privacy.

ACM Classification Keywords
H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems – Artificial, augmented, and virtual realities

INTRODUCTION
According to recent research, more displays that are out in public spaces are embracing interactivity instead of being completely static (Fortin et al. 2014). Public displays in general are becoming more widely available as the cost of electronics is falling (Michelis & Müller 2011). Despite this, there are still a number of issues in the literature that continue to persist: (1) making content relevant to individuals while ensuring their privacy (Davies et al. 2014); (2) potential for social embarrassment while interacting (Alt et al. 2011); (3) displays ultimately being limited by their screen "real-estate" (Kaviani et al. 2009) and therefore only being able to hold so much information.

Public displays can be good mediums to display content to large audiences but they have an inherent issue of being public, and therefore any information displayed can be seen by everyone that walks past, providing no privacy to the people who are interacting with the displays. This issue of privacy is discussed in research by Baldauf et al. (2012), where they presented "private public displays". Through a smartphone augmented reality (AR) users could view augmented content overlaid on the digital screen and interact using the touchscreen on the smartphone. This allowed the user to have privacy and it can also accommodate multiple users.

Through a follow-up study by Parker et al. (2016) testing a similar system for viewing personalised information, it was suggested that users were still concerned with being linked to the display's content and that the perception from passers-by was that they were taking photos, affecting the flow of the busy area. However, the potential issue of "shoulder surfing" (Brudy et al. 2014) could still occur with smartphone AR.

Potential exists to overcome this issue with see-through head mounted displays as they give the user a private view. The Google Glass is an example of how this can be achieved, however, the technology is still inaccessible to most researchers, developers, and the general public. Therefore, testing this technology's viability as a method to interact with public displays is difficult. Recent advances in the Vuforia SDK have allowed developers to create smartphone AR apps for the Google Cardboard. We created a prototype video see-through display app for the Google Cardboard, where a digital display could be interacted with through the head mounted display (HMD). Although this setup may be considered cumbersome and potentially embarrassing to wear in public, it was created to demonstrate the potential of the technology and how interactions can be designed to facilitate interaction with existing infrastructure in urban environments, such as public displays. Therefore, this paper builds on previous research by demonstrating the potential of interacting with public screens with see-through AR. We discuss our prototype system and future directions.

PROTOTYPE
The implementation of our prototype consists of two main components: (1) a large digital public display; (2) the smartphone HMD.

OzCHI '16, November 29 – December 2 2016, Launceston, TAS, Australia
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http://dx.doi.org/xx.xxxx/xxxxxxx.xxxxxxx.

Public Display The public display hosts the web app and the websockets server to send data between the HMD and screen.

The interface consists of a navigation bar, content area, and arrow buttons to sequentially navigate the different content categories.

The content in each tile consists of live tweets sourced from Twitter. The system refreshes the displayed tweets every five minutes. The tiles will display the image (if it exists) and part of the tweet. There are nine different Twitter feeds that can be sequentially navigated.

Smartphone HMD The system is composed of a modified Google Cardboard V2. We cut a small hole where the smartphone's camera is located so the camera feed is unobstructed.

Tiles can be selected by aiming the on-screen reticle at a tile, controlled by simply looking around. The tile is selected when the switch is pressed on the HMD while aiming at the tile (Figure 1).

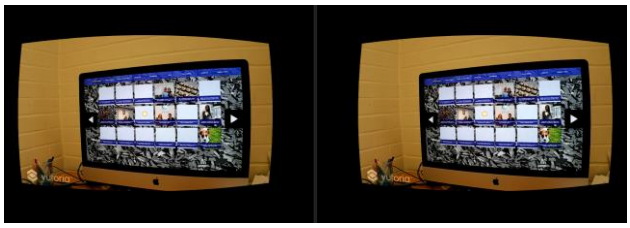

Figure 1. View from the HMD – Items can be selected by aiming with the reticle and pressing the HMD's switch.

Navigation between the different categories can be achieved by aiming at the right or left arrow and pressing the magnet switch. Alternatively, a gesture (Figure 2) can be performed after pressing and holding the magnet switch while aiming at the screen and moving the head to the left or right quickly.

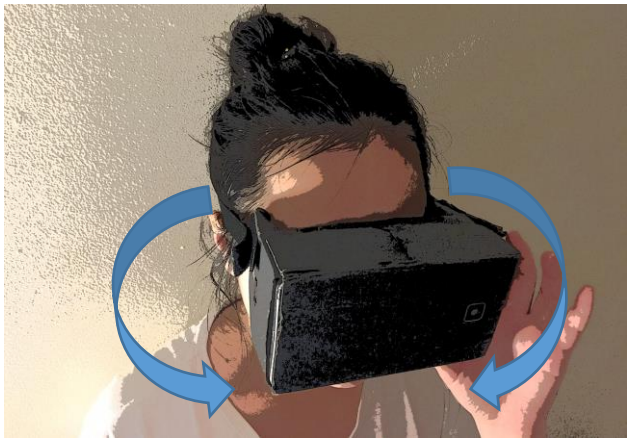

Figure 2. Head gesture simulating touch & swipe to navigate.

The screen is tracked by smartphone's camera achieved through an AR marker, which is set as the background behind the tiles. This is a modified version of the Vuforia woodchip marker for better tracking. After the screen comes into the view of the camera, virtual tiles will be overlaid in the same position as the tiles on the screen. These virtual tiles will not be visible to the user and send an ID to the screen when selected.

When the switch on the HMD is pressed, a raycast will be made in the 3D space. If it collides with a tile it will trigger the smartphone app to send a message to the screen with the ID of the tile selected. This will trigger the screen to display a popup, featuring more information about the tweet, such as a larger image, the twitter handle of the author, the time posted, and an uncut version of the tweet.

However, if an arrow button tile is selected or a head gesture is performed, a message will be sent to the screen which will trigger a traversal to the previous or next category, depending on the direction of the selected arrow or head gesture.

CONCLUSIONS AND FUTURE WORK

See-through AR has potential for individuals to have completely unique and private experiences with digital public displays embedded into the urban environment. Additionally, this form of interaction could make interactive displays more accessible, removing the need to physically reach and touch parts of the display.

Future work will further investigate the potential of this technology, particularly in regards to accessibility.

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