The Augmented Video Wall: Multi-user AR Interaction With Public Displays

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Abstract
The *Augmented Video Wall* is a compelling showcase application demonstrating a novel collocated interaction technique for public displays beyond traditional competitive or collaborative multi-user scenarios. By utilizing means of augmented reality on personal mobile devices and applying animated video overlays accurately superimposed upon the public display, we create the illusion of literally private views to a shared public display. Besides this concurrent viewing mode, the demonstrator features a competitive mode and a concurrent mode enhanced with social features to highlight the characteristics of this novel display interaction techniques. During a first preliminary study, the *Augmented Video Wall* attracted lots of visitors and created highly entertaining experiences for groups.

Author Keywords
Large display; smartphone interaction; multi-user; mobile augmented reality

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces: *Input devices and strategies, Interaction Styles, Prototyping*

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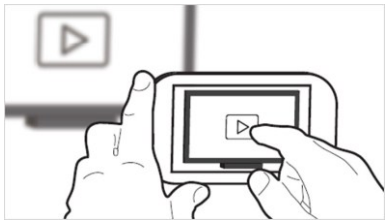

Figure 1. Touch-based interaction with a public display through a 'smart lens'.

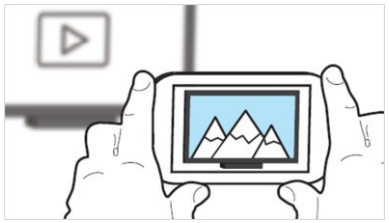

Figure 2. Private feedback as AR overlay instead of publicly visible content on the remote display.

Figure 3. The final design of the *Augmented Video Wall* shows preview images to start respective video clips.

Introduction

Over the last few years, our urban environments have been increasingly populated with large ambient screens, projections and entire media facades. Such public displays can be found in shopping windows, subway stations and town squares. In order to enable promising interactive applications for such installations, feature-rich mobile devices equipped with various sensors and multimodal features have been investigated as sophisticated remote controls [3]. Mobile multi-user interaction is one very obvious use case for public displays which are typically installed at busy locations with lots of passers-by.

This paper presents a compelling novel device-based interaction technique for public displays which allows for the concurrent but separated remote controlling of one shared public display by several collocated users. To realize this multi-user interaction approach we make use of augmented reality (AR) technology to provide each user with a private view on the public display on his personal mobile device.

AR-based display interaction

Previous research on multi-user interaction with shared displays mainly focused on traditional collaborative and competitive application scenarios. Typical examples include early research by Rekimoto who investigated the usage of handheld devices for manipulating private notes and sharing them on public displays [8].

One first preliminary step towards private views on a public display is the concept of *visual multiplexing* [7]: up to three texts or pictures in primary colors are multiplexed into one image which is then shown on the public display. The corresponding smartphone application applies suitable color filters and makes the information visible. However, this approach results in distorted screen content on public displays.

In order to enable the separated interaction with one shared public display by several interested users, we propose the creation of literally private views on public displays by utilizing a mobile augmented reality approach. Users may both intuitively control and watch the feedback entirely through the camera viewfinder of their mobile device:

Control. For simply controlling the public display we adopted a touch-based interaction approach operating on live video [1][4]: A user simply points his mobile device towards the distant public display and observes the content through this 'smart lens'. Interactive elements such as buttons can now be simply triggered by tapping them on the camera viewfinder (Figure 1).

Feedback. In contrast to showing the actual reaction on the large display, the feedback is shown as an animated AR overlay superimposed on top of the public display (Figure 2). This approach creates the impression of an updated distant display while still leaving its actual content unmodified for the interaction by other users.

Following this approach, a public display may serve as a common entry point for interested passers-by while it enables detailed and personalized private views through personal devices. In contrast to previous research which investigated methods to 'grab' digital content from public displays for later consumption (cf. [6]), this approach based on AR overlays for the public display preserves the users' connection to the public display and thus enables

Figure 4. The *concurrent mode* presents the videos as AR overlay superimposed on top of the display.

Figure 5. The *socially concurrent mode* extends the *concurrent mode* by offering a 'like' feature and activity indicators.

Figure 6. The *competitive mode* shows the video on the public display in full-screen while the mobile application just shows the viewfinder.

novel group experiences for users collocated in front of a public display.

Demonstrator

For showcasing and studying purposes we implemented a fully functional prototype illustrating the proposed interaction concept. Our *Augmented Video Wall* allows passers-by to concurrently watch short movie clips on a public display. Its user interface (Figure 3) shows preview images of movies. By selecting one of the preview images the corresponding video clip is started. The clip then can be stopped by simply tapping the mobile display again.

Our *Augmented Video Wall* demonstrator comprises a *Windows* application executed on a standard desktop computer which serves the large public display and an *Android* application for smartphones and tablets. The AR features were implemented using *Qualcomm*'s *Vuforia* toolkit. Remote control commands between the mobile devices and the desktop application are exchanged via a simple custom protocol over plain TCP sockets via 3G or Wifi. To study the impact on the novel AR video views, our demonstrator features three distinct feedback modes:

The *concurrent mode* (Figure 4) implements the pure AR display interaction approach as described above: users point their devices towards the public display, tap one of preview images visible through the camera viewfinder and then watch the corresponding video as an animated AR overlay superimposed over the large display.

To convey an impression of previous and current interactions with the *Augmented Video Wall*, the second mode, the *socially concurrent* one (Figure 5), extends the previous pure AR mode by social features: it integrates *Facebook*'s well-known thumb icon into the mobile applications to 'like' a watched video. The corresponding counters are shown on the large display for each video. Further, blinking red borders highlight videos currently watched by collocated users.

Finally, to emphasize the characteristics of the concurrent modes, our demonstrator also features a *competitive mode* as a more traditional interaction technique with a shared display. Here, a selected video is started on the public display in full-screen while the mobile application stays in camera mode, i.e. without any AR overlay (Figure 6). By tapping, any user may stop the video and choose another one from the menu.

Experiences

We gained first experiences with the described demonstrator only recently during an informal public science event [2]. At our booth, we had installed a flat screen acting as public display and handed out several smartphones and tablets to interested visitors. Throughout this event, our demonstrator attracted more than hundred visitors who tested each feedback mode in groups of two to five people (Figure 7).

The general feedback for our novel AR video approach was very positive. While the *competitive mode* often caused irritations due to interruptions and kept newly arriving visitors from spontaneously interacting with the shared display, the private AR views were well appreciated: Users described them as *very easy-to-use, amazing* and *impressive*. The activity indicators of the *socially concurrent mode* were regarded highly since 'shoulder surfing' was a very common phenomenon in

Figure 7. Collocated visitors watch two different video clips on one shared display through augmented reality views.

order to see what others are currently watching in the purely *concurrent mode*. Overall, we observed that the AR video views created various kinds of interactions, not only with the display but also within the group and resulted in very playful experiences for the collocated users.

Conclusions

In this paper, we presented our *Augmented Video Wall*. This demonstrator illustrates the novel concept of private views on public displays enabled by means of mobile augmented reality. It features a concurrent, a socially concurrent as well as a competitive playback mode making it an interesting study and showcase application for venues with lots of passers-by. During a first preliminary demonstration, it proved to attract lots of interested visitors and showed that the proposed multi-user AR video views provide highly playful and entertaining, yet provocative group experiences for the involved users.

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