Multi-User Painting on Media Facades through Live-Video on Mobile Devices

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Abstract
Media facades in urban spaces offer great potential for new forms of collaborative multi-user interaction. We present a way to directly interact with facades at-a-distance *through live video* on mobile devices. We extend the *Touch Projector* interface to accommodate multiple users by showing individual content on the mobile display that would otherwise clutter the facade's canvas or distract other users. To demonstrate our concept, we built an application that allows for simultaneous painting on a facade. We gathered informal feedback during the ARS Electronica Festival in Linz, Austria and found that our interaction technique is (1) considered easy-to-learn, but (2) may leave users unaware of the actions of others on the same canvas.

Keywords
Mobile, media facades, interaction techniques, input device, interface distribution, multi-user interaction.

Introduction
More and more media facades can be found in urban landscapes. Their size, visibility, and naturally large audience offer a great potential for collaborative interaction. However, due to their size, interacting with them directly is impossible. Common interaction techniques include controlling pointers on the facade's canvas [1] or pushing content to it through multimedia messages [2]. Techniques that make use of virtual pointers, however, restrict the number of simultaneous

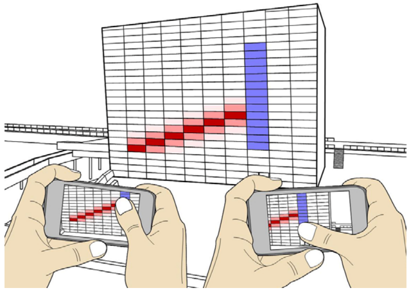

Figure 1: Interacting through live video allows multiple users to manipulate a media facade. Changes (also those of other users) are shown immediately on the facade and the mobile device. Colors denote actions from other users.

users as each pointer occludes a portion of the facade. Sending multimedia messages allows larger numbers of users but in turn does not allow for direct interaction.

One approach to solve these issues is to use an absolute and direct technique such as interaction *through live video* [3]. We extended this technique to allow for multiple users by distributing user interface elements on both the facade (*canvas*) and the mobile device (*tools*). Based on this, we developed a painting application that allows multiple users to interact simultaneously on a facade. We deployed our prototype at the ARS Electronica Festival in Linz, Austria to observe how people are interacting simultaneously on a facade at-a-distance. In this paper, we (1) present the design and development of our prototype and (2) describe the findings of our deployment in more detail.

Related Work

Haeusler describes the term "media facades" as the idea of designing or modifying the architecture of buildings using their surfaces as giant public screens [4]. In addition, more and more media facades are embedded in the landscape of cities [5]. Recently, researchers explored the social potential of such media facades: multiple users can view or even design them simultaneously [6,7]. Dalsgaard et al. described eight key challenges when designing such novel interactive systems and – most importantly – when offering users new, distributed interfaces [8].

Several techniques have been proposed to interact with distant displays. The most prominent techniques are relative and indirect pointing as well as augmented reality approaches. Relative and indirect pointing can be used to distant displays by turning a camera-equipped mobile device into a mouse-like device [10]. However, such techniques may hinder multi-user scenarios due to the required virtual pointers. Recent advantages in mobile augmented reality allow absolute pointing on displays [7]. For tracking purposes, their system relies on a marker shown on the remote display. Since *Touch Projector* allows direct interaction with a distant display shown in the viewfinder using touch in real-time without relying on fiducial markers [3], we decided to take it as the basis of our prototype.

Interaction Design

Our goal was to implement a system that allows multiple users to interact simultaneously on a media facade. As mentioned before, relative and/or indirect techniques may limit the number of users to the number of distinguishable pointers on the remote canvas. Techniques that use a world-in-miniature representation overcome this limitation at the expense of macro attention shifts between both the mobile and target display (here: facade). Thus, we decided to use the concept of *Touch Projector* [3] where users aim their device at the facade and observe it in live video. Touch input on the mobile device is *projected* onto the facade, giving the impression that users directly touch it (see Figure 1).

The large size of such facades allows multiple users to interact simultaneously on them. The original idea of *Touch Projector* only transforms input occurring on the mobile device to a facade's canvas. Thus, all interaction elements (i.e., *controls* and *feedback*) reside on the facade, which is not an optimal solution: Tool palettes waste screen real-estate and decrease the size of the actual interaction canvas. The resolution of the facade (in combination with the viewing distance) further requires a minimum size of such controls. In addition,

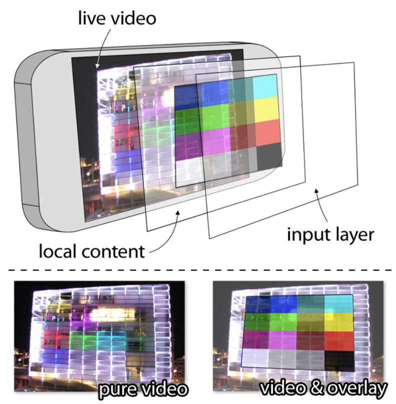

Figure 2: Inserting a local content layer allows for showing pure or augmented live video for each user.

Figure 3: Users are able to switch between the façade in live video (a) and their individual tool palette (b).

temporary feedback (e.g., highlighted regions) interferes with the interaction of others. Thus, we decided to utilize the mobile display as additional, personal output canvas for individual feedback (see Figure 2). In addition, we ensured a constant control-display independent of the users' viewing distance by automatically sizing the video to show the entire interactive area.

Example Application at ARS Electronica

To investigate the effects of simultaneously interacting through live video on media facades, we built an application that allowed users to paint freely on the facade. Similar to common drawing applications, users (1) choose a color and (2) select a tool from a tool palette. To do so, users perform a slide gesture next to the live video image. The mobile device then shows a tool palette (see Figure 3b). Due to the low resolution of the facade in our deployment, placing the controls on the mobile device was the only possible solution.

Once users chose their tool and color, they again performed a slide gesture to close the personal view causing the device to show the facade through live video (see Figure 3a). Each touch point on the mobile device is mapped to the respective pixels on the facade and can thus be lightened in the selected color. If the *fill tool* has been chosen, all pixels are lit in the same color, clearing everything that has been on the facade.

User Feedback

During the ARS Electronica Festival in Linz, Austria, we presented our applications to a broad audience. We handed phones with the application already running to users without any further instructions. By observing how others use the application, they immediately started to interact with the facade. Up to three persons were able to interact simultaneously, but we ensured that at least two did at all times. Out of about 50 users, we asked 15 for detailed feedback after interacting with the building. We found that this style of interaction is perceived as (1) easy-to-learn and (2) easy-to-use. We further gained insights regarding such technologies.

Changing urban landscapes

We received highly positive feedback about the general idea of our prototype. As most of our interviewees had a background in art and/or architecture, the fact that they could change (and observe) the facade in real-time was mentioned positively by nearly all of them. One remarkable statement about painting on a facade in general was made by one participant, stating: "Finally, I have control over a building."

Collaborative versus competitive use

We found that users liked both collaborative and competitive interaction. However, this strongly depended on them knowing each other beforehand. In terms of collaborative interaction, we observed an interesting interaction style: Two participants used the *paint bucked tool* to color the whole facade with different colors alternately to create a stroboscope-like effect. On the other hand, simultaneous interaction was also used for disturbing drawings of others instead. This disturbance was generally observed when these users did not know each other. Especially when two or three users painted simultaneously, they felt that the unpredictability of the outcome led to an interesting piece of art. One stated: "This is another layer of fun. You can spoil others drawings and you can draw together. So it's a new way to combine stuff." Another user stated: "It is really nice when you interact with someone else, you can destroy his drawing which is funny."

Multi-user interaction at-a-distance

A controversial statement regarding a collaborative use was made by a participant with a background in media design: "Well, it was good and bad, because it is good in a way to interact in a parallel way if you know the person, you are co-working together. But if you don't know the person, you are kind of fighting over the pixels and over the space to draw and it's kind of annoying." This type of interaction mostly occurred when users were unaware of each other which turned out to be a general problem of interacting at-a-distance.

Conclusion & Future Work

In this paper we presented the design and deployment of a multi-user application that allows painting simultaneously on a facade. Based on this prototype, we gathered informal feedback from a broad audience during the ARS Electronica Festival in Linz, Austria. While our technique allows for multiple users, we found limitations that apply to interaction at-a-distance in general.

In contrast to collocated scenarios in which users are next to or can see one another, larger facades may cause greater distances between users, so that they may not be aware of (1) *who* is interacting, (2) *where* others are, and (3) *who* owns which content on the facade. As this is a common problem of interaction at-a-distance, we plan to develop solutions to the awareness problem, by, for example, visualizing the location and direction of others as well as ownership of content.

We identified another issue being the parallel nature of interaction using our technique: permitting all possible interactions (i.e., no ownership of content, or first-come first-serve interaction) versus preventing undesired interactions on a large-scale, multi-user, public media facade. We hope to iteratively converge at least on a more appropriate balance, e.g., through partitioning time slots or sub-regions among users with the ultimate goal of maximizing enjoyment and minimizing frustrations for future users. We will evaluate our solutions to the awareness problem with more complex applications that require collaboration on the facade.

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