Interaction with Media Façades

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Abstract:
Media façades are a prominent example of the digital augmentation of urban spaces. They denote the concept of turning the surface of a building into a large-scale urban screen. Due to their enormous size, they require interaction at a distance and they have a high level of visibility. Additionally, they are situated in a highly dynamic urban environment with rapidly changing conditions, which results in settings that are neither comparable, nor reproducible. Altogether, this makes the development of interactive media façade installations a challenging task.

Over the last years, urban environments and public places emerged as prime locations for deploying digital technologies, which increasingly affect the daily life [16]. For example, they optimize heating systems in buildings, balance the flow of electricity through the power grid, and keep autonomous public transportation networks moving [16]. Hence, urban environments are on their way of being turned into dynamic and programmable surfaces [11].

The notion of *Smart Cities* increasingly enjoyed popularity over the last decade. There are enormous efforts by the European Union, governments and cities to make them smart in different domains by utilizing information technologies (IT). Some parts of this technology are visible, for example when long serving artifacts such as analog billboards for advertising are being replaced by digital displays. The computer chip manufacturer Intel[1] estimated in a recent case study on digital signage that the number of digital public displays will reach 22 millions screens worldwide by the year 2015[2]. As a consequence one of the main goals when planning and building urban environments is to achieve that the residents identify with it [14]. Architectural principles state that an effective way of achieving identification is to focus in the design process on the communication between people and buildings [17]. Besides large scale digital displays, an increasing number of *media façades* are embedded into the urban landscape (compare Figure 1), becoming more and more ubiquitous. In a common sense, the term media façade describes the idea of turning the façade of a building into a very large public screen by equipping its outer shell with interactive, light-emitting elements [12,14]. However, untill now, there is no clear definition that sufficiently delimits *media façades* from urban media architecture and large-scale digital displays, which are embedded into the urban environment. In this case the display appears as a *second skin* of the building.

Media façades can be classified based on different characteristics and properties. Among others, these might include their technical composition, as well as the main principles of how content can be displayed. Along with media façades, the manifold use of light and light-emitting elements in general plays a more and more important role in the architecture of urban environments. In this sense, we have to note the differences between lighting architecture, media architecture and media façades. Haeusler [12] distinguishes these terms as follows: Lighting architecture subsumes the illumination of a building using daylight and artificial light in order to underline parts of the building to create a certain atmosphere. This also holds for media architecture, whereas media architecture also includes all aspects of dynamically displaying media, such as dynamic graphics, dynamic text and spatial movement, but with a strong focus on dynamic content. Media façades build on this by including media to transform the building façade into a communicative element.The transition between lighting architecture, media architecture and media façades can be seamless. While media façades enable communication via technologies onto a façade in the form of digital media, and media architecture describes the cultural, social and economic implications of these façades for the immediate

[1] http://www.intel.com
[2] https://aimsuite.intel.com/sites/default/files/resources/growing-the-digital-signage-economy-case- study.pdf

environment [12]. The aforementioned notions of media façades are created from a rather architectural perspective. When dealing with media façades as large-scale digital screens from a human-computer interaction perspective, we can define the term media façade as follows: Media façades are digital public screens with arbitrary form factors and of arbitrary resolution, which are created by either equipping the outer surface of an architectural building with controllable, uniformly shaped, light emitting elements or by projecting digital content onto it. They are embedded into the architectural structure of a building.

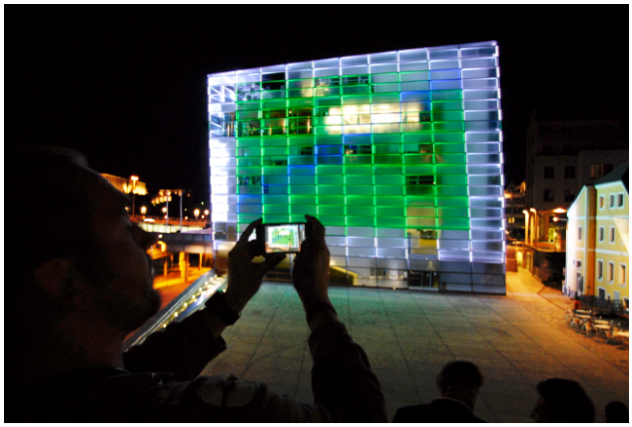

Figure 1. Interacting with a media façade utilizing a mobile phone as an input device

Media façades come along with a set of typical characteristics, which raise various challenges to be faced when developing interactive installations for them: in contrast to situated public displays, they are usually very large in size. The size of a media façade can vary from very small media façades with $50m^2$ like the Academy of Fine Arts[3] Saar in Saarbrücken, Germany, to medium ones, such as the ARS Electronica Center[4] in Linz, Austria, with $5000m^2$, or very large ones, such as the Allianz Arena[5] in Munich, Germany, with a total surface area of $25.500m^2$. As a result of their enormous size, media façades can be visible from great distances. This leads to a wide exposure of the content displayed on the façade. In most of the cases, media façades also cover more than one side of a building's façade, and in some cases even the roof of a building. This gives them a three-dimensional (3D), non-planar form factor. A further very important aspect is their technical specification: media façades are usually individually designed and unique creations. Since media façades are created using a wide range of industrial components, they usually strongly differ in their technical configuration and therefore, in how to access and control them. Furthermore, they also provide various screen resolutions and hence, their capability of displaying a particular content.

In their ability to display highly dynamic, digital media content, media façades might be comparable to situated public displays. On the other hand, due to their size and unlike situated public displays, media façades require a certain viewing distance to view and perceive the displayed content. Situated public displays are a great source of interactivity. People can interact with the display in various ways and for different purposes, like for example, browsing information, exchanging content or simply for pleasure stimulation. Media façades represent a potential gateway between the personal and the public domain and offer great potential for interactivity. To establish media façades as an information gateway, media façades need to provide possibilities for user interaction. When designing interactive installations for media facades, the highly dynamic and public environment in which they are situated, and their physical properties need to be addressed in order to create a successful and enjoyable interaction and exploit the full potential of media facades as computing surfaces and large-scale urban displays. In particular, the design and development of interactive installations needs to address a diversity of situations that dynamically change, as well as the characteristics of urban public spaces. Furthermore, we need to develop suitable techniques for interacting with media façade as a shared urban screens of architectural scale.

[3] http://www.hbksaar.de
[4] http://www.aec.at
[5] http://www.allianz-arena.de

Media Façades versus Public Displays

Although media façades and situated public displays seem to be closely related as they share the purpose of being information displays, there are elementary differences between both. In order to clarify the varying approaches for designing content and applications for both, we highlight four key differences:

Integration into architecture

The integration into architecture is not only important from an aesthetic point of view. It makes a crucial difference between public displays and media façades. While Schoch distinguishes between dedicated media façades and buildings designed with media technology as a main element [14], Tscherteu combines both [17]. However, Tscherteu and Schoch both clearly distinguish light and screen elements integrated into the architecture of a building from so-called *urban screens* as add-on displays, such as situated public displays. Tscherteu draws the boundary where it is no longer the screen on a building that communicates with its surroundings, but rather the building as a whole [17]. The integration of screen elements into existing architectural structures often also results in uncommon, irregular form factors in contrast to the usually rectangular shaped situated displays with a 2D form factor.

The spatial setting

As reported by Fischer and Hornecker [5], the spatial aspects of media façades have a strong impact on the installations. Describing discrete spaces around an interactive media façade, they clearly distinguish media façades from situated public displays. Diniz et al. [4] investigated territoriality and behavior within the scope of interactive media façades and indicated that the spatial setting around the screens as an important difference between situated public displays and media façades. While for situated public displays people usually are within an arm length from the display when interacting, for media façades, the interaction is performed within a wide, distributed space in front of the façade. Interactions in such a case are shown to have different characteristics with a strong focus on territoriality and personal space [5].

The scale

A further fundamental difference between media façades and situated public displays is the physical dimension of the screens. While the size of public displays ranges from TV- to billboard-sized screens, media façades usually achieve architectural scale. For example, the earlier mentioned media façade of the Allianz Arena in Munich. Such enormous form factors have an impact on the visibility of the content and the way people might interact. It requires a certain minimal viewing distance to perceive the displayed content, which introduces gap spaces [5]. However, as in the example of the Allianz Arena, media façades can be so large that it is impossible to perceive the whole façade at once. Furthermore, people interact differently: while for situated public displays users can see each other since they are close to the display,in the context of media façades, users can be distributed among large spaces and not always be aware of other users. This circumstance also influences the social protocols on how people behave [10].

Diversity of situations

Just like media façades, public displays are usually situated in a dynamic public environment. While the space around the display is rather limited, the number of people around the display, as well as the general conditions of the environment can vary. However, for media façades the diversity of situation is way more distinctive. Due to their size and the fact that they are located in outdoor urban spaces drastically increases the number of variables in the setting. Changes in weather and lighting conditions, population of the surrounding space, traffic are only a small number of factors influencing the whole situation. They have an impact on how people approach, perceive and interact with a media façade. Hence, it is barely possible to reproduce a complete setup or a particular situation. This diversity of situations needs to be addressed when designing content and interaction for media façades, as when providing supportive development tools.

Interaction with Media Façades

As previously highlighted, media façades offer great potential for interactivity. However, this potential is mainly still neglected. Nowadays, media façades are mainly used for displaying pre-produced content, like advertisements or digital animations. In order to unlock the full potential of media façades, we need to develop interactive systems, which allow people to interact with media façades and engage and mediate the interaction between people and architecture. As a outcome the scientific community can gain more awareness on the constraints and opportunities of this emerging design and research domain. In [15], Struppek investigates the urban potential of public screens. She investigates how the growing infrastructure of digital displays and media façades can be broadened with cultural content. She believes in interactivity and participation as the keys to bind digital screens to the communal context of the space and to create local identity and engagement. Regarding interaction with situated public displays, the most common input modality is direct touch input. Besides the fact that large multitouch screens have become less expensive and direct touch input being an easy to use modality that does not require further hardware or technology efforts for a user, one important reason for this comes with characteristics of the displays and their deployment context. Situated Public displays allowing interactivity are very small, compared to media façades and they are usually installed within the grasp of potential users standing in front of the display. Hence, the displayed content is within arm reach of a user and it is only visible for people in the direct proximity of the display. For multiple users interacting with the display in parallel, there are spatial constraints for the interaction. First, since a user occupies space in front of the display while interacting, the number of users is delimited by the available space in front of the display. Hence, the interaction is also visible for bystanders besides the display and in particular selected areas of the display. This can engage social interaction between users and spectators in several ways. As a result, conflicts concerning the parallel access of the shared display can be resolved by directly interacting with each other.

Due to the characteristics of media façades, we cannot transfer the previously described concepts without further efforts. As mentioned before, media façades are very large in size and they therefore require a certain viewing distance. Unlike situated public displays, media façades are not suitable for direct touch input, requiring interaction at-a-distance. Their size furthermore leads to a great visibility. As a result, the displayed content is visible from great distance and therefore highly exposed to the public. This raises the need for tailored interaction approaches and an adapted design process to address the issues raised by the characteristics of media façades. Along with the technical aspects of media façades, the context in which they are deployed, as well as the exposure of their content have an enormous impact on how users interact with a media façade. Since situated in a highly public context, our assumption is that people will adapt their behavior and react differently when interacting with a media façade than with a situated public display, since they are interacting in front of a large audience and the result of their interaction are highly exposed. Goffman analyzed the behavior of people in public places [10]. He investigated the interaction between people with respect to what happens when two or more people meet. He found that when people meet in public, a system of social rules unfolds, which dictates the interaction and which cannot be lead back structural factors of the society. The interaction spans its own realm of interaction. Hence, in this domain we should not understand behavior as behavior per se, but as a part of an interaction. As further described by Goffman, whenever two or more people meet in a public place, a social situation evolves, in which people tend to behave in a communicative manner, as if they were interacting with other members of that social situation. This behavior is independent of whether they are interacting or not. This behavior has a significant impact on the way people use interactive systems – like media façades – in a public setting and it therefore needs to be taken into account when designing such systems. In [9], Gehl categorizes activity in public environments into necessary, optional and social activities, which come along with slightly different behavior. Since the belonging of an activity to one of these groups frames people's behavior, the type of activity needs to addressed when designing interactive systems for public spaces. Furthermore, technology should be designed to enhance and support these types of activities.

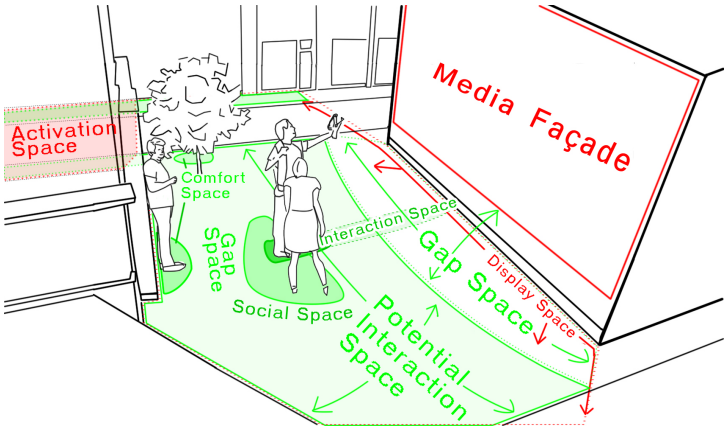

Figure 2. (Image appears in [5]) Space types for interactive media façade installations according Fischer and Hornecker [5]

Providing the *Urban HCI Space Type Model*, Fischer and Hornecker analyzed the spatial aspects in the design of shared encounters for interactive media façades [5]. They reflected on various urban technology interventions by analyzing their spatial configuration in relation the structuring of interactions. For these types of interactions they introduced the term *Urban HCI*, which focuses on urban settings where the context is not only set by a location point but also activity. Urban HCI is utilized to emphasize situations composed of the built environment, the interfaces and the social context. Fischer and Hornecker identified the following seven spaces (depicted in Figure 2): the *Display Spaces* are all spaces from which a media façade is visible. Considering the enormous size of media façades, compared to common situated public displays, the *Display Space* can be also enormous, ranging from a plaza in front of the façade to whole parts of a city. As *Interaction Space*, they describe the space from which a form of communication with the media façade installation is carried out. Size and placement of the *Interaction Space* depend on the applied interaction techniques and whether it is stationary or mobile, allowing users to walk around and to interact from various places. The *Potential Interaction Spaces* are the spaces from which a person could potentially interact with a media façade. The size of the *Potential Interaction Space* also depends on the properties and the range of the applied interaction technique. *Gap Spaces* can create distances and gaps, either between people or between people and façade. The gaps in this case can be introduced by natural or artificial obstacles (e.g., trees, streets or benches) and also by the required minimal viewing distance to perceive a sufficient part of the façade's content. Spaces where people gather and where they can have shared encounters without necessarily interacting with the façade are denoted as *Social Interaction Spaces*. In *Comfort Spaces*, people can find physical or psychological ease. *Comfort Spaces* can occur around objects like trees or walls of surrounding houses, where people can opt out of the social setting and blend into the environment in order to observe. Finally, *Activation Spaces* are the areas, from where the media façade is visible, possibly causing curiosity and triggering passersby to approach and participate. For the remainder of this article, we use the terminology introduced by the *Urban HCI Space Type Model* [5] when describing media façade installations. Understanding the spatial configuration of the spaces around a media façade is an important factor for the design and development of successful interactive installations for media façades. When creating such systems, the spatial configuration of the media façade's environment further influences the appropriateness of certain content and it further restricts the applicability of different interaction techniques.

Interactive Media Façade Installations

Researchers, artists and designers have been exploring interactivity for media façade installations in various different ways. On the one hand, they experimented with different input modalities and interaction techniques in a playful and artistic manner. On the other hand, they shared their valuable experiences and lessons learned as a solid ground for developing novel, universal interaction approaches in this domain.

Figure 3. Left: (Image appears in [2]) The design intervention *Aarhus by Light* at the Concert Hall Aarhus [2]. Right: (Image appears in [8]) The *Climate Wall* at the Ridehuset Aarhus [8].

With the design intervention *Aarhus by Light*, Brynskov et al. created an interactive installation for the concert hall in Aarhus, Denmark [2] (see Figure 3). The installation was installed on the glass façade of the concert hall building, which was fitted with 180m^2 media façade consisting of semi-transparent LED screens. The goal of this installation was to engage local citizens into new kinds of public behavior to explore the potential of digital media in urban life. Within three interactivity areas in front of the façade, which where marked with colored carpets, the silhouettes of people standing on he carpet were tracked. Their movements were *mapped* to playful creatures on the media façade in order to encourage a curious and playful investigation of the expression among the users. The movement of the virtual characters further served as visual feedback on the users' movements. Brynskov et al. revealed valuable insights around the themes of interaction patterns, re-occurring behaviours, initiation, how people engage with an installation, interaction styles, as well as relation, denoting social interaction patterns. In [8], Fritsch and Dalsgaard presented the Climate Wall, an interactive design intervention utilizing a *whole body interaction* approach from the *Aarhus by Light* installation (see Figure 3). The *Climate Wall* was an installation at the Ridehuset (an historical building) in Aarhus. It was installed and running during the climate conference *Beyond Kyoto*. The installation displayed generated, fragmented climate statements, giving passersby the opportunity to take part in the ongoing climate debate. People could *grab and move* around individual words with their body movement, forming new climate statements. While interacting, the users received visual feedback on their input by the movement of the triggered word. In summary, the focus of these works was not the actual interaction technique itself. Instead, the key aspects from the *Climate Wall* and *Aarhus by Light* installations were that the creators delivered insights into how people interact with such novel urban interfaces and how they can be engaged. They utilized media façades to create engagement, where the particular interaction technique supported the playful character of the installation. Gutiérez et al. showed how whole body interaction can also explicitly enhance the experience of a user while interacting, taking the interaction to a spatial level. With *Lummoblocks*[6], they created an interactive *Tetris* Game, running on the media façade of the Medialab Prado[7] in Madrid. The aim of the installation was to provide a playful interactive, space located experience, as well as engaging social interaction between users and spectators. It was created in the context of the Open Up workshop in Madrid, Spain in 2010. The façade showed the visualization of the game, combined with a live video feed, displaying a birds-eye view of the users in the two interaction spaces in front of the façade as visual feedback. The goal of the game was to *rotate and move* the digitally visualized blocks to create lines. The installation mapped both actions to two separate interaction spaces: two players had to collaborate, where one had to *rotate* the block, while the second player *moved* it to the right spot, both by running around within the boundaries of the particular interaction space. The aforementioned installations show that interaction by body movement usually has a playful character and it comes with certain performative elements. Hence, whole body interaction can be well suited for playful and performative installations but its applicability as a general interaction technique to interact with complex content on distant screens is very limited.

[6] http://www.lummo.eu/lummotetris.html
[7] http://medialab-prado.es

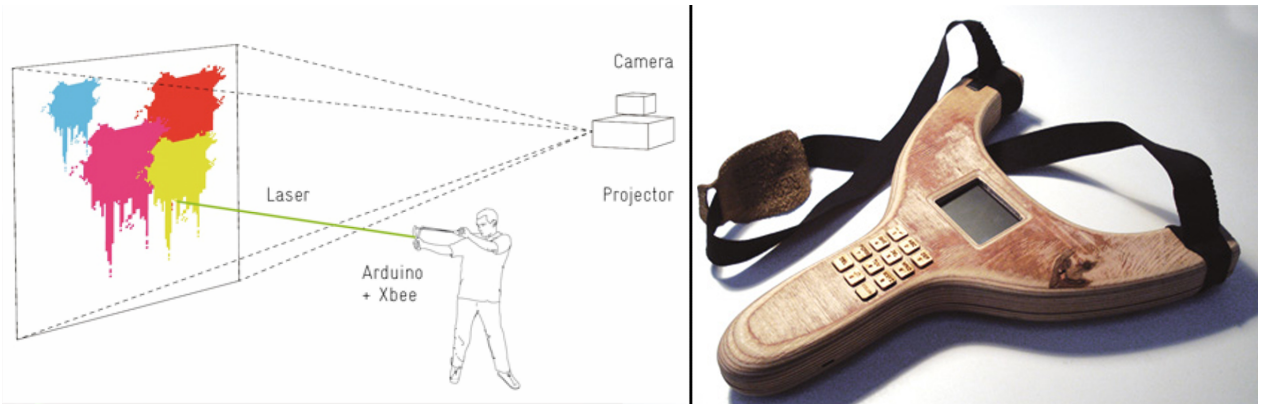

Figure 4. (Images appear in [7]) The SMSlingshot installation. Left: A user interacting with a media façade using the SMSlingshot. Right: The SMSlingshot device. A user can shoot a message onto a façade by aiming at a specific point [7].

A common interaction technique that was utilized in various interactive installations is direct pointing. With *Spread.gun*, as a part of the VR/Urban group[8], Fischer et al. presented an interactive shared encounter for media façades, inspired by established forms of graffiti culture [6]. The installation took place within the scope of the 2008 *Media Façade Festival* in Berlin, Germany. The aim of the installation was to create a digitally augmented forum in public space and to reclaim urban screens, which according to Fischer et al. are still dominated by commercial interests. The tangibility of the interaction is the most important part of their design work. The stationary interaction device — called *Spread:gun* — is a model of an ancient cannon: a user stands behind the cannon and rotates it to aim at a particular point on the façade. Additionally, a user can enter a text message through a digital touch screen. While aiming at the façade, a virtual red crosshair is displayed as visual feedback. The position of the crosshair is calculated with data from two potentiometers that are integrated in the canonlike interface for the horizontal and vertical axis. When *shooting* the cannon, a *color bag* is virtually shot onto the projected façade. The color spots on the façade are displayed enclosing the text messages of the particular user. While in general providing the possibility of interacting by direct pointing, this approach clearly has its limitations. In terms of design and interaction, the interaction device is highly tailored to the purpose of the installation and environment around the particular façade. In this vein, they point out the effect of the social and spatial setting and describe how the location and the surroundings may drastically alter the context of the installation.

As a conceptual enhancement of *Spread.gun*, Fischer et al. presented *SMSlingshot* [7]. Instead of using a stationary input device, they provided a mobile, custom-built input device, based on the metaphor of a wooden slingshot (see Figure 4). The aim of the installation was to create a digital slingshot with which people can utilize and *throw* digital information onto media façades. The slingshot device is based on the Arduino[9] platform and it is equipped with a ultra-high frequency radio unit, a small LCD display, a laser and a mobile phone keyboard, allowing a user to enter text messages. By *aiming and shooting* at a particular point on the media façade wit the slingshot, a user can shoot their entered message on the façade together with a virtual *color bag*, analog to the *Spread.gun* approach. Again, while aiming at the façade, a laser pointer mounted into the slingshot device was activated, which then was tracked on the façade with the help of a camera but which also provided the user with visual feedback on the pointing target. Since the interaction device in this installation was mobile and not directly connected to a larger system as the *Spread.gun* was, the messages were transferred to the computer steering the projection over a wireless radio modem. Additionally, the entered text messages were twittered in real-time. In comparison to *Spread.gun*, *SMSlingshot* has the advantage of providing a portable and flexible interaction technique.A well known and one of the first interactive media façade installations was the Blinkenlights project in Berlin, Germany, realized by the Chaos Computer Club [12]. Within the scope of the 20th anniversary of the Chaos Computer Club in 2001, the upper eight floors of an office building were turned into the world's biggest interactive computer screen. They created a window raster animation façade by equipping the windows of the building with 144 individually controllable lamps in total, which resulted in a display of 8x18 pixels. To control the content, users had to call a dedicated phone number with their mobile phones. Once connected, they could either control a virtual cursor on the façade or activate an animation with a code and utilizing the key pad of the mobile phone.

[8] http://www.vrurban.org
[9] www.arduino.cc

Designing Interaction with Media Façades

When designing interactive media façade installations, the unique properties and requirements of this whole domain need to be considered in order to create successful and enjoyable installations. First explorations towards designing such installation on a large-scale for public settings have been made by Fritsch and Dalsgaard [8]. While analyzing their two aforementioned installations *Aarhus by Light* [8] and *Climate Wall* [2], they identified affective experiences and engaging interaction as the two main perspectives in order to provide an interactive experience for the long run. One of the first systematic design process models creating interactivity between people and media façades was presented by Dalsgaard and Halskov. They then further expanded their work [3], identifying eight key challenges that need to be addressed when designing interaction for media façades in an urban context. These challenges consider a wide range of issues: (1) As already mentioned, existing interfaces cannot be transferred without further effort. Urban settings prompt for new or adapted forms of interfaces. (2) New installations need to be integrated into existing surroundings. (3) Changing light and weather conditions must be taken into account. (4) The content has to suit the medium. It has to match with the technical properties of the façade and it needs to support the intended interactions. (5) Stakeholder interests need to be balanced. This can be a critical issue, since the majority of media façades is owned by companies or public institutions, enforcing strict rules about their presence in public. (6) The diversity of situations in the highly dynamic urban space needs to be considered. (7) The introduction of new technologies might influence social behavior. (8) Technology might be used in a different way than intended, or even misused.

Following up on the fourth of the challenges Dalsgaard et al. highlighted (developing content to suit the medium), our own (research) agenda questions how to systematically develop interactive content for media façades. As indicated before, this domain bears several new challenges that are, in contrast to interactions on smaller personal screen sizes, visible to large audiences even before their final implementation. As a consequence, pre-testing soft- and hardware components plus interactivity remains a difficult task that designers, researchers and architects face when developing interactive installations in this domain. Hence, we investigated alternative means in the form of prototyping toolkits to support design teams and describe a more systematic yet holistic design process for the creation of these systems. As an initial process toolkit we introduced *Lightbox*, a fully interactive miniaturized version of a media façade system fitted into a steel suitcase [18]. The matter that this tool is robust, easy to transport and uses similar industrial components as media façades (DMX System, Hi-Power RGBW Leds, Wi-Fi Router) made it a supportive medium for envisioning, pre-testing and implementing interactive content for a particular media façade. In the context of a case study project we explored the toolkit in action and addressed the question on how to interact with content in natural and intuitive ways, a circumstance that plays an important role in highly dynamic settings with multiple users. By using the technique of *interacting through live video* [1] we presented an opportunity for users to *point and interact* with content using the live video image on the screen of their smartphones. In the context of an interactive media façade festival conducted in conjunction with the ARS electronica center in Linz, Austria [1], we provided the opportunity for users to select various colors on a *palette* shown on the interface of the mobile phone and then *apply* the selected colors to the building by *pointing* at certain areas on the video image of the building. The media façade then *reacted* in real time and changed to the desired output color. The creation of the system and the documentation of applying user-centered design methods to the domain of interactive media façade installations was presented to international audiences in a joint publication that proposes an extend design process with prototyping toolkits to explore the domain specific characteristics when developing interactive content in this realm [19]. Our initial case studies provided valuable insights into this novel and unexplored design and research context. However, the successful establishment of new technologies, such as interactive media architecture, may still be hindered by the sparsely documented case studies and practical applications in this domain. As pointed out by Shneiderman, in any emerging technology domain there is a demand for supportive toolkits [13]. These toolkits allow for replication while lowering the entry barrier for designers and artists with limited technical expertise to develop their own applications and solutions. One of our goals must be therefore to establish a tool-chain that supports the complete design process cycle. To do this we will investigate suitable design process tool-chains that co-exist in different media, such as virtual simulation, rapid prototyping techniques, electronic platforms, and instrumented spaces. These tools especially help artists, architects, researchers and designers to express their ideas, convince stakeholders in advance, and conduct pre-tests with users in order to judge which applications would possibly suit media architecture for individual use contexts.

We believe that by turning media façades into future interactive computing surfaces of urban environments, we can create a common platform for interaction, enrich the urban landscape and open up new perspectives for urban computing. By investigating the domain specific challenges and providing support though documented case studies

and prototyping tools we aim to strengthen a novell and emerging HCI-research domain in an interdisciplinary context.

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