Designing Urban Media Façades:
Cases and Challenges

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ABSTRACT

Media façades comprise a category of urban computing concerned with the integration of displays into the built environment, including buildings and street furniture. This paper identifies and discusses eight challenges faced when designing urban media façades. The challenges concern a broad range of issues: *interfaces*, *physical integration*, *robustness*, *content*, *stakeholders*, *situation*, *social relations*, and *emerging use*. The challenges reflect the fact that the urban setting as a domain for interaction design is characterized by a number of circumstances and socio-cultural practices that differ from those of other domains. In order to exemplify the challenges and discuss how they may be addressed, we draw on our experiences from five experimental design cases, ranging from a 180 m^2 interactive building façade to displays integrated into bus shelters.

Author Keywords

Media facades, urban, public space, interaction design.

ACM Classification Keywords

H5.2. Information interfaces and presentation.

General Terms

Design, Experimentation.

INTRODUCTION

Urban space is emerging as a prominent arena for information systems design and presents a unique set of challenges and potentials for the design of interactive systems and installations. Under the umbrella term of *urban informatics* [11] researchers and practitioners are exploring the particular challenges and potentials that this domain presents. As examples of the particular challenges for designing for urban space, designers must to take into account the integration of digital technologies into large scale structures like city squares and high rise building, address multiple and intertwined social practices, balance the need of multiple groups of stakeholders as well as take

into account for the need for robustness of systems in changing weather and light conditions, etc.

In addition to employing well-established design methods and techniques, new approaches that take into account the particular characteristics of the cityscape are being developed (e.g. composite urban sketching [20]). On a more theoretical level, the nature of designing for the city has been addressed by for instance Greenfield & Shepard [15] and McCullough [25] who calls attention to the importance of understanding the urban situations in which interactive systems are introduced. McCullough proposes that an offset in situational awareness can serve as grounding for designers operating in the intersection between architecture and interaction design.

During the past four years, we have explored this intersection through the design, implementation, and real-life testing of a number of urban installations, as well as through participation in four international architectural competitions. On the basis of this research, we outline eight challenges for urban interaction design, and discuss how we have addressed those challenges in our experimental design cases. Within the field of urban computing, we focus on a particular category, namely, *media façades*. Media façades is an umbrella term for installations in which displays are integrated into architectural structures [17]. This is often accomplished with LED displays and digital projectors, but the term also covers the use of mechanical displays such as that at l'Institut du Monde Arabe in Paris. Although media design is an emergent field, certain genres are forming: In addition to *ornamentation* of architecture, *advertising* and *news*, as seen in Times Square in New York, are the most widespread. Media façades are also being increasingly employed within genres such as art (for instance Rafael Lozano-Hemmer's *Body Movies* [7]), games (e.g. *Blinkenlights,* www.blinkenlights.de), public service and community media (e.g. *BBC Big Screens*, www.bbc.co.uk/bigscreens).

Several researchers have chosen to systematize their discussion of issues and concerns prompted by the spread of computer use by listing a set of *challenges for HCI*. Among the prominent contributors, we find Grudin [16] who has identified eight challenges for developers of computer support for cooperative work (CSCW). Bødker [3] addresses the challenges of moving from what she calls

'second wave HCI', which is group work in well-established communities of practice, to 'third wave HCI', where HCI is increasingly being used in private as well as public spheres, and in situations calling for a concern for the emotional and experience aspects of human life. Her analysis primarily revolves around third wave HCI challenges concerning the work place, drawing on areas like information technology support for tax officers, for building construction supervisors, and for municipal case workers, but also touches on borderline situations between work life and leisure time, as exemplified by the use of mobile phones. Various sets of challenges for HCI have also been discussed at a number of research workshops, addressing, for instance, HCI challenges in multi-cultural environments [26], in health assessment [27], in non-traditional environments, for instance the military [4], and with regard to methods and tools used when designing mobile technology [28].

In this paper, we proceed down the same avenue of research as Grudin [16] and Bødker [3], but focus on the challenges of urban computing, with a particular concern for media façades. As the main platform for the identification and discussion of eight specific challenges, we draw on five of our own experimental research cases, which we first introduce.

CASES

During the past four years, we have developed a series of media façade installations in urban settings. The installations have been developed in collaboration with a variety of external stakeholders from both the public and private sectors. Our involvement in these experimental design cases has been motivated by an ongoing interest in exploring the potentials and challenges of designing for and in urban settings, and in examining how to address these issues in the design process. In the following sections, we present five of these cases. We have selected this set of cases to represent the diversity of urban media façades. In the main part of paper, we combine the insights gained from working with them with surveys of related installations and academic work in order to establish a general understanding of the challenges to media façade design in the city.

Each of the five cases is visualized on the short video enclosed with this paper. We recommend reading each of the short descriptions, and then watching the corresponding video snippet.

Aarhus by Light

Aarhus by Light [6] was an interactive media façade that engaged local citizens in new kinds of public behavior, in order to explore new possibilities of digital media in urban life. The 700 m^2 glass façade of the Musikhuset, the city concert hall of Aarhus, was fitted with 180 square meters of semi-transparent LED screen, which was distributed in a non-rectangular pattern behind the surface of the Musikhuset, facing an adjacent public park. Visitors to the

park were met with a view of animated creatures crawling around the structure of the glass façade, along with a constantly moving outline of the Aarhus skyline.

Figure 1. Visitors interacting with Aarhus by Light.

When visitors walked through the park, they passed through three interactive zones marked with coloured carpets. Once someone walked onto a carpet, a camera, together with custom designed software, identified the outline of the person's body, thereby creating a silhouette on the screen. This silhouette encouraged a curious and playful investigation of the façade among the users, while enabling them to interact with the creatures, by pushing, lifting, and dropping them. The motivation behind *Aarhus by Light* was driven by research interests and curiosity, but was also supported by the concert hall management's interest in challenging its own rather conservative image. They did not, however, in any way wish to influence the actual design.

The Climate Wall

The Climate Wall [12] was an interactive generator of climate statements that used as its backdrop Ridehuset, a prominent historical building located at the corner of two busy streets, directly across from the City Hall of Århus. The Climate Wall was in operation during the climate conference, Beyond Kyoto, and provided citizens of Aarhus with the opportunity to takepart in the ongoing climate debate.

Figure 2. The Climate Wall.

The design of the interactive wall found inspiration in the familiar refrigerator magnets with words on them, which people use to put together short sentences. On *The Climate Wall*, words in speech bubbles drip down from above. The speech bubbles contain words related to the ongoing climate debate, like 'more', 'less', 'cars', 'trees', 'people', 'like', 'ice', and 'climate' (our translation of the actual words in Danish). People passing by the building could 'grab' a word with their body, and move it around, thereby participating in the process of forming a climate statement, for instance "more trees less cars".

The Climate Wall was made possible by four webcams along the façade providing input to customized software, which identified people stopping in front of the façade, enabling them to grab words and drag them, by moving along the building. All the scenery was displayed on the façade by two projectors in temporary towers across the street.

Dynamically Transparent Windows

A *Dynamically Transparent Window* (DTW) [8] responds to the movement of people passing by. The window is fitted with so-called electro-chromatic foil that can change from opaque to transparent when an electric current runs through it. By using strips or rectangles of the foil, narrow bands on the façade change and reveal what is on display in the store, in order to draw the passers-by closer, and encourage them to explore the display. The DTW have been developed as a part of an effort to explore interactive technologies for marketing purposes [24].

Figure 3. Dynamically Transparent Windows in shop façade.

Once again, the interaction is enabled by a webcam positioned high above the shop window, providing input to software, which interprets the changes in the video signal as people move along the façade. The computer running the software is connected to a custom-built control unit, which, combined with a power converter, enables the control of the individual strips of foil. For a five-week period, we installed a custom-developed version of DTW in the high street façade of *Salling*, a large department store in the centre of Aarhus, Denmark.

The Confederation of Danish Industry

This case concerns an architectural competition regarding an extension of the headquarters of the *Confederation of Danish Industry* (HCDI) [9]. The headquarters are located at the corner of two main streets in centre of Copenhagen, the Danish capital, and has neighbours such as Tivoli, the most visited Danish amusement park, as well as Rådhuspladsen, Copenhagen's main square, in front of the City Hall.
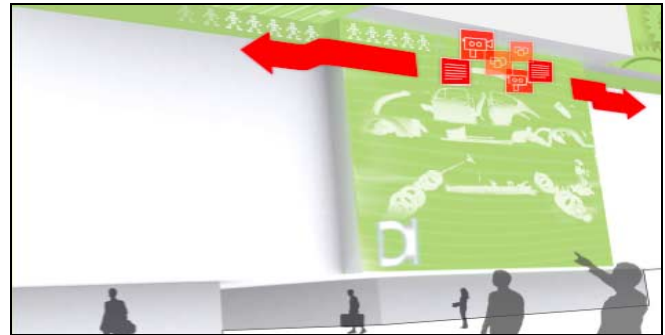

Figure 4: Scenario from the HCDI proposal.

The Danish architectural firm, 3XN, was the leading partner on a team offering a bid for the competition for the extension of HCDI, where we contributed to the part of the proposal concerning the idea of furnishing HCDI with an interactive media façade.

Confession Booth

The Confession Booth [23] was a video installation that put a face on the struggle for climate improvements and offered the citizens of Aarhus a voice to be heard – and seen – throughout the city. The installation was part of the Municipality of Aarhus' campaign CO2030, dedicated to engaging citizens in the efforts to achieve carbon neutrality by the year 2030.

Figure 5. Confessions on display at an urban info stand.

The installation was in two parts, one being part of the exhibition space of Ridehuset and another in urban space. In Ridehuset visitors could enter a booth with a camera proving the visitors the opportunity to record a short

statement about climate change, for instance confessing that she or he is taking long and hot showers every morning hereby contributing to excessive Co2 omission. The video statements were subsequently edited and distributed to displays integrated into bus shelter and info stands at four locations in the city.

Design processes

Before we proceed to the identification and discussion of the eight challenges, we briefly outline the generic design process that led to the installations.

In all cases, we started by carrying out field studies, in order to establish an understanding of the specific potentials and challenges relating to the part of the urban space of which the installation was going to be integrated into. Likewise, we did a general review of interesting technologies that might be applicable to this domain. This research is partially available in a condensed form at http://www.digitalexperience.dk. The domain and technology knowledge was subsequently piped into various workshop formats, including inspiration card workshops [19]. The outcome of the workshops, in terms of loose concepts and ideas, are then visualized and refined through a number of different visualizations [18], representations, and physical manifestations, prior to prototyping experiments, which provided input to the final implementation and subsequent final installation in the urban setting. The full-scale installations lasted from 50 days of around the clock operation in the case of *Aarhus By Light*, to approximately five hours for four consecutive evenings, in the case of *The Climate Wall*.

Each installation was video documented and supplemented with in-the-field observations, and, in the cases of *Aarhus By Light*, *The Climate Wall*, and *Confession Booth*, we also based our evaluations on qualitative interviews. Moreover, in the case of Aarhus By Light we used the technique of overlaying time-lapse recording, in order to produce still images representing activity in the park facing the façade. In the same case, our media façade software had the feature of logging activations in the interaction zones.

CHALLENGES FOR URBAN MEDIA FAÇADE DESIGN

In this section we present eight challenges encountered when designing media façades in a city. This set of challenges is based on our concrete experiences with the experimental design cases described above, as well as a thorough review of related projects and academic publications. Each challenge has a specific focus, although in practice they are often intertwined.

Several of the challenges can also be encountered in other domains; when we explore them in this paper, it is because we have found them to be particularly prominent in the urban setting. For instance, robustness and stability are common concerns in software development, but are accentuated in an urban setting when designing installations to stand the wear and tear of weather and

public use. For each challenge, we thus emphasize and discuss what makes it particularly interesting with regards to media facade design in an urban setting. We then provide examples of how we have encountered and addressed the challenge in our design cases. This includes pointers to theoretical perspectives and references that yield further insights for each challenge.

Eight challenges for urban media façade design

1. New interfaces: urban setting prompts new forms of interfaces or alternative assemblies and uses of existing ones

2. Integration into physical structures and surroundings: New installations and systems must be integrated into existing physical surroundings.

3. Increased demands for robustness and stability: Shifting light and weather conditions over which designers often have little or no influence must be taken into account.

4. Developing content to suit the medium: The content has to fit the format of the display and the kinds of interaction intended to be supported.

5. Aligning stakeholders and balancing interests: Exploring, negotiating, transforming, and balancing stakeholder interests can be critical to the success of a system.

6. Diversity of situations: A very wide variety of situations occur and overlap in the city - how does the media façade fit into the assemblage of situations in a given location?

7. Transforming social relations: The introduction of new technologies can cause disruptions and transform social relations and protocols.

8. Emerging and unforeseen use of places and systems: Media façades will likely be used, perceived and appropriated in different ways than designers intend.

Table 1. Eight Challenges.

Challenge 1: New interfaces

The perhaps most salient challenge for interaction designers is that the urban setting prompts new forms of interfaces or alternative assemblies of existing ones. The displays used for media façades differ from many traditional displays in terms of properties such as scale, resolution, brightness, exposure, and shared use. Lessons from the design of small mobile devices such as PDAs indicate that the best design solutions rarely consist of making carbon copies of desktop software, only on a smaller device. The same considerations hold true when moving dramatically upwards in scale, as is often the case with media façades in which traditional design heuristics might not be applicable. Adding to these concerns is the fact that many urban media façades are located in environments in which people naturally pass by, and may not have been exposed to the installation before, leading to two oft-used strategies for designing the interaction with the system referred to as 'pass-by-and-use' and 'walk-up-and-use'. Furthermore, many installations cannot rely on users to employ dedicated input devices, but have to employ other means of input.

Aarhus by Light is an example of how media façades prompt new forms of interaction. People arriving to Musikhuset or merely passing by the façade on their way to some other location in general had no expectation that they had the opportunity to use an interactive installation. Therefore they did not carry along with them any interaction devices, perhaps except for their mobile phone, and due to concerns for robustness (see challenge 3) it was not feasible to provide interaction devices for potential users to grab. For those reasons we decided to employ camera tracking which brought the users' silhouettes onto the façade as avatars that could interact with other elements in the façade. Thus, there were no traditional input devices available to users, who instead used their bodies to control interaction. Together with three very visible interaction zones the use of silhouette was a very easily comprehensible way of establishing an understanding among users that they deliberately or unwillingly could interact with the façade. On the large screen covering the concert hall, the silhouettes interacted with the luminous creatures, a pre-programmed but reactive part of the installation, as well as the diagrammatic representation of Aarhus, which shape-shifted autonomously and independently of user input. The large display was in itself also a new form of output device.

The Dynamically Transparent Windows (DTW) installation is another example of a new form of interface for use in media façades. The installation was developed specifically for a high street shop front. Whereas *Aarhus by Light* turned out to be very successful, the DTW installation for the most part failed to attract extra attention to the storefront, despite successful pilot tests carried out in other settings, including an indoor IT expo. One of the key findings from our analysis of the installation was that many users simply did not notice that the rather subtle installation was in fact interactive. Passers-by instead expected the shop window to function as a regular window – or in other words, the installation lacked affordances that would invite interaction. This highlights the importance of ongoing experiments with new types of media façade interfaces, and analyses of their use in practice in order to inform future interaction design processes.

The mobil phone, a device that many people carry along with them in public space, is an interaction device that has been used in connection with several other media façades. For instance in the case of the light installation *Colour by Numbers* (www. colourbynumbers.org) people could call a dedicated number and used the keypad as a remote control to change the colors of in the windows of the *Tower of Perdigones*, Seville, Spain.

Challenge 2: Integration into physical structures and surroundings

New installations and systems must be integrated into existing physical surroundings. This includes both the landscape and the architecture, such as buildings and shared

spaces. Because of its size a media façades is a very drastic intervention in the city and its architecture, which calls for a concern for not only the architecture of individual building but also neighboring structures, including plazas and streets. Choice of resolution of the displays needs to take the dominant viewing perspectives(s) into account and concerning the layout of interaction zones designers need to consider viewing positions as well.

In some cases media façades are designed as part of the design of the building itself, but in the case of *Aarhus By Light*, the media façade had to be integrated into the existing building structure and at the same time the LED modules available for the project had a standard size. Luckily, in this particular case, the dimensions of the modules fitted the size of the window frames of the building.

In our work, we often strive to keep the display from standing out as a huge rectangular display and instead seek to make the display an integrated part of the façade. In the case of *Aarhus By Light*, this was achieved by fitting the LED panels into the existing steel framing of the building, and geometrically configuring the panels in an irregular and elongated shape. The integration of the display into the building was also supported by having the content relate to the building, for instance by having the luminous creatures crawling up and down the steel framing, or entering or exiting doors at vertical frames. Moreover, the design of the media façade had to take into account that not only would it be visible from the outside, but also from the Concert Hall foyer.

The Climate Wall consisted of two projections on the façade of a red brick building, an old military riding hall with rounded of windows. The two projections were aligned in such a way that the common edge of the two projections was right at a natural edge of the building's structure, a drainpipe, thus eliminating the need for edge blending. Moreover, the dripping speech bubbles bounced off the top of the windows.

Figure 6. Musikhuset with the Aarhus by Light installation.

In many cases, and in particular when it comes to interactive media façades, the design has to take into account the multiple viewing perspective and distances: at close range, for people approaching the building, and for people passing by on the busy city street along the park.

The scale of the content and the layout of the interaction zones in *Aarhus by Light* ensured a successful handling of this challenge, see Figure 6. *The Climate Wall* was a less successful set-up, because the interaction zone was the pavement along the building, whereas the projection on the façade was best viewed from the pavement on the opposite side of the street. M.H. Hauesler [17] offers in his book on media facades a survey of 36 media façade projects and provides a rich source of inspiration for ways integrating media façades into physical structures.

Challenge 3: Increased demands for robustness and stability

In the urban setting, shifting light and weather conditions present distinct challenges, as designers have to consider these conditions over which they often have little or no influence. Moreover, depending on the type of installation, users may not feel a sense of ownership, and may therefore be less gentle in their use of the system than when using personal systems.

During the initial prototyping test of *Aarhus By Light* in its actual physical context, it turned out that reflections in puddles from the LED display during and after rainfall were in some cases identified as shadows of people by the camera tracking software. This problem was solved when colorful carpets, indicating the three interaction zones, were introduced. Reflection was also encountered during the implementation of the *Dynamically Transparent Window*. Not only did varying light and weather conditions have a negative impact on the quality of the camera tracking of the surface of the street, but reflection from windows on the opposite side of the street also interfered. Based on a series of on-site tests of the camera tracking, some of the problems were resolved by incorporating various dynamic calibration features in the tracking software – but the reflections from across the street were never handled satisfactory.

Vandalism and theft may also present challenges. One Saturday night, someone tried to remove one of the colorful carpets that formed part of *Aarhus By Light*. The vandal might have thought the carpet was enabling the interaction, but he or she most likely was unaware of the camera sitting in a protective casing on the light pole next to the carpet. One of the information stands showing the Co2 confessions videos in the city was smashed up during the night, and though there is a recurrent problem of bus shelters being targets for vandalism, it seems likely that monitors integrated into the information stands and bus shelters may have added to risk of attracting the attention of vandals. *The Climate Wall* was in operation only for a few days, partly because the tower with the projector on the opposite side of the street had to be guarded, to protect them against vandalism, and to reduce the risk of theft of the very expensive projectors.

Challenge 4: Developing content to suit the medium

A key challenge concerning content is striking a balance between supporting the communicative goals or intentions of the media façade, and taking into account the format of the urban installation as well as the situational circumstances. The content has to fit the format of the display and the kinds of interaction intended to be supported.

The actual scale of the media façade, and the fact that media façades exist in public spaces, making them very visible to many people, places a specific responsibility on the shoulders of those who provide the content.

When it comes to interactive media façades, highly complex content may put people off, and fail to support the communicative goals or intentions. *Aarhus By Light* was a purely image based installation, with no text at all. The content was relatively fixed, only providing passers-by with the opportunity to contribute their own silhouette to a visual world populated by luminous creatures in a line art representation of the skyline of the city of Aarhus.

The Climate Wall went a step further in terms of complexity by adding text elements as content. The collection of text bubbles of *The Climate Wall* had a fairly large vocabulary, and no support for grammar, which made it hard or almost impossible to create well-formed sentences. So, even though the intention behind *The Climate Wall* was to provide passers-by with an opportunity to make a climate statement, the effect of the installation was instead one of creating an opportunity for a playful experience.

At *Blinkenlights* [17] low-resolution animations could be uploaded to a server for display on the building. In few cases, erotic animations were displayed, but to our knowledge, none of the content on the *Blinkenlights* building sparked controversy. In the case of one of our own installations, *The Confession Booth*, in one instance a user made a very visual statement by making obscene gestures in front of the camera, probably meant more as provocation than as a language act about the climate. The video recorded in the booth was edited before it was shown on the information stands around the city, and the mooning sequence was not shown to the public. In the case of *The Climate Wall*, we considered providing people with the option of texting their own words for the text bubbles by mobile phone, but this part of the installation was not implemented, thereby avoiding the challenge of handling rude or inappropriate language. What determines acceptable content is very much a matter of balancing freedom of speech and ethics, which depend on the culture and values of the context of the media façade. The issues regarding content and new types of media in the urban setting are explored in more detail by Klingmann [22] with regards to branding and the experience economy. In some cases, advertisements are not acceptable, as in the city of São Paulo, which has imposed a ban on commercial signs

in public spaces, and the city of Paris, which has banned commercials within 300 meters of monuments and other major cultural landmarks. As we discuss in the next section, challenges concerning content are closely related to the stakeholders who are either directly or indirectly involved or affected, for instance who provides the content, and who controls it.

Challenge 5: Aligning stakeholders and balancing interests

Exploring, negotiating, transforming, and balancing the interests of stakeholders is a general challenge in interaction design. With respect to the specific challenges concerning the urban setting, the introduction new systems in this domain very often affect a broad range of people and institutions with different agendas and interests. These range from traffic authorities, local businesses and shop owners, cultural institutions, and of course a variety of citizens and citizen groups who inhabit and make use of urban spaces.

In the case of the headquarters of the *Confederation of Danish Industry*, this diversity of stakeholder interests was highly evident. Stakeholder concerns and interests included the building owner's (The Confederation of Danish Industry) goal of maximizing floor space utility, the individual members of the association's concern for obtaining exposure for their own business (e.g. in the shape of logos displayed on the façade), the architect's interest in creating an iconic building, the concerns of the public authorities to use the centrally located building to brand the city, while at the same time adhering to the traffic authorities' guidelines.

On the more practical side, the manager of Salling's food section lowered the sun-blinds to protect the wine in the window of the food section in the basement below the *Dynamically Transparent Window*, thereby obstructing the camera's the view of the pavement in front of the installation. A similar instance of local stakeholder concern also emerged in relation to the people at the ticket office at Musikhuset, who were affected by the light and noise from the LED panels.

In order to address these concerns, and to establish a shared understanding of the project at hand among stakeholders who would be directly or indirectly affected by the building's new media façades, we systematically developed a number of scenarios as part of the architectural proposal, each addressing specific aspects and uses of the building, and of how it would affect stakeholders in the city. In order to manage and communicate the scenarios, we developed a *design space explorer* [9] a structured overview in which the different potential users and use situations were listed alongside proposed interactive features and technologies of the facade. Although it was, of course, not the only method employed, the design space explorer was productive in establishing an overview of the situations of the use domain

and their interrelations and communicating this among designers, architects, building owners and decision makers from the city. As such, the method played into the larger decision making process regarding the future building. The complexity of this process is representative of many urban design cases, in which designers must understand and navigate within the frames of public decision-making processes. This is a difficult discipline to master; however, the field of Participatory Design is rich with examples of how to approach such situations [30]

Challenge 6: Diversity of situations

Thoughtful design is based on an understanding of the use situation. Some design projects primarily address one or few relatively stable situations; however, the urban setting is often characterized by a diversity of situations. The same physical space may be the setting of diverse and overlapping situations that may be perceived differently by different inhabitants. Furthermore, these situations and the use practices they entail may change over the course of time, e.g. as the flow and rhythm of the city changes over the course of a day or a season, or in accordance with specific events. The introduction of media façades into urban places inevitably transforms these situations. Thus, a challenge for designers is to explore the existing practices and preconceptions of the setting and, depending on the aim of the project, to determine whether the installation should conform to the existing situations, extend or augment them, or introduce an alien element that may disrupt the situations, for better or worse.

In the case of *Aarhus by Light*, the concert hall and the surrounding park is host to a number of situations: It served as a public recreational area, as a transit space for cyclists and pedestrians, as arrival area for concert hall guests, as host to seasonal sport activities, etc. In order to address these situations, we conducted field studies and explored through participatory sessions how and why it could be fruitful to alter them or to provide opportunities for new situations to occur. As a recommendation for future design projects, we had success in designing the installation in a way that provided *'situational interaction flexibility'*. In its main mode *Aarhus by Light* could be interpreted and used in different situations (passing through, arriving for a concert, observing others, interacting with the creatures, creating social connections etc.), but it could also serve as a platform for specific events, like when we collaborated with a dance theater to develop and carry out an innovative dance performance (http://www.digitalexperience.dk/?p=361).

Further insights into the complexities of diverse and overlapping situations in the urban domain are addressed by for instance McCullough [25] who defines and explores a number of 'situational types' and their implications for interaction design. In addition, several of Alexander's patterns provide a nuanced language for understanding urban situations [2].

Challenge 7: Transforming social relations

The introduction of new technologies can cause disruptions and transform social relations. Sometimes, this happens as an unforeseen drawback; at other times, the specific purpose of a new technology may be to transform social relations. With regards to design for urban settings, many spaces in a city are shared, and written as well as unwritten social contracts and protocols have been established in these spaces over the course of time to scaffold social relations, as explored by Goffman [14]. Some technologies (e.g. mobile phones) transform these social relations on a large scale; in their present state, media façades transform social relations locally (i.e. in the vicinity of the façade).

When introducing media façades in public spaces, there is the risk that people may become unwillingly involved in interaction, or be put in situations in which they appear in ways in which they did not intend to; this issue is explored in detail in [10]. The *Climate Wall* is an example of an installation in which passers-by could unwittingly become actors for others to observe, simply by walking down a familiar pavement, which for a weekend became an interaction zone for controlling the media façade. Some accidental interactors were too caught up in other activities to notice that they controlled the façade; others noticed, and hurried along, to avoid being the centre of attention; yet others were intrigued by the installation, and started exploring it. At the other end of the spectrum is *The Confession Booth*, in which users entered a specific, demarcated zone and sat down in front of a camera in order to convey a personal message regarding climate change. In this case, the installation played on established social conventions that gave users total control of how they appeared to others.

In dealing with these concerns includes considerations of entry barriers for observing and interacting, individual or shared control of interaction, possibilities for lurking or observing how others interact, ways of scaffolding discussion and interplay between users and observers, and ways of easing into and out of the interaction with the façade and co-present users. Depending on the specific situation, it may be beneficial to design for a variety of ways to relate to a media façade; in public spaces, people will most likely use it in a variety of ways, regardless. In the case of *Aarhus by Light*, we addressed the challenge of transforming social relations by designing the installation to exhibit a high degree of flexibility with regards to social situations. The installation provided a variety of possibilities for people to relate to the installation and the social life around it at different locations in park in front of Musikhuset, see Figure 6. The installation can be observed from afar; potential users can move closer and observe and comment on other people's interactions; they can approach it hesitantly, and gradually move from being observers to active interactors, by passing through the interaction zones along the pathway through the park; by standing in different interaction zones, they can interact with strangers

from afar; they can also share or take over an interaction zone; by moving inside the concert hall (which is traditionally recognized as the main attraction of the setting), they can vicariously observe and discuss the interaction and the mirrored façade, which from this perspective is now the main attraction. Our studies of *Aarhus by Light* [6] revealed that the installation spurred many social relationships throughout this range of use situations, among both friends and strangers.

Challenge 8: Emerging and unforeseen uses of places and systems

An almost inevitable aspect of designing for the urban setting, especially with regard to public spaces, is that media façades will be used and perceived in different ways than designers intended. Although designers and stakeholders may have an interest in establishing a narrow range of use situations, unforeseen use is a basic premise of media façade design. Thus, a design strategy that accounts for this is more likely to be more successful than one that tries to avoid it altogether.

Unforeseen use is not implicitly a negative. First, it indicates attention to the media façade and an interest in engaging with it. The *Dynamically Transparent Windows* were used much less by passers-by than we had hoped, and unforeseen use might have been better than no use at all. Secondly, unforeseen use can enrich the installation, as was the case with Lozano-Hemmer's successful installation *Body Movies* [7]), in which people were more interested in playfully engaging in shadow play with each other, rather than using it to uncover portraits, as was originally intended by the artist.

As important as short-term use may seem, an arguably more important issue, with respect to the development of urban life, is the long-term change that media façades may impose on the city. This issue presents designers with the challenge of considering the new patterns of use and socialization that may emerge over the course of time around a media façade. The initial attraction of an installation may fade, and an important design decision in this regard is whether the objective should be to design a finished work or a platform for further development. The latter strategy can be described as *designing for adaptation*. Since media façade design is itself an emergent field, there are few real-life examples of how new use patterns emerge over the course of time, and how strategies for design for adaptation may be formed. In the development of Aarhus by Light, we identified and developed a number of changing and emerging patterns of use. The installation was designed to follow a circadian rhythm, with the luminous figures sleeping during the night, but people's movement patterns and their rhythm of use also changed during the day – in the mornings, bicyclists would change their paths to work to pass through the interaction zones; during the day, school classes would visit the installation; in the evening, people dressed up for classical music

performances would observe, and hesitantly interact; at night, festive teenagers would play, dance, and sing with the creatures and each other. As a special event, we used the façade as backdrop and stage for a modern dance performance, *Running Sculpture,* performed by a nearby dance theatre, in order to explore how the façade could serve as platform for other types of content. The concept of using the media façade as an adaptable platform was carried over to the Confederation of Danish Industry case, in which we explicitly proposed a number of alternative use scenarios related to shifting situations. The media façade was intended to be a platform for content provided by Danish Industry, as well as the Municipality of Copenhagen.

The field of architecture, closely related to, and in many ways overlapping media façade design, can yield insights in this area. For example, both Brand [5] and Rudofsky [29] explore strategies for designing buildings that can be altered as occupants' needs change

CONCLUSION AND FUTURE WORK
In recent years, urban computing has emerged as a prominent domain for HCI. As part of this development, media façades are being developed in an increasing number of cities as production costs drop and stakeholders seek new ways of attracting and engaging people in the urban space. On the basis of our development of experimental design cases and surveys of related work, we have addressed eight prominent challenges that designers face in the emergent domain of urban media facade design. We have furthermore given concrete examples of how the challenges may emerge in practice, and how these specific concerns can be addressed in design. In our exemplification of the challenges, we have relied on five cases from our own research since we have deep insight into these projects. We have selected this particular set of cases because it represents the diversity of urban media façade design, and projects with similar characteristics are starting to populate cities around the globe. In terms of scale and the playful mode of interaction, the Japanese installation *Big Shadow* (http://www .bigshadow.jp/) is similar to *Aarhus by Light*; the British *Watermarks Project* (http://watermarksproject.org/) resembles *The Climate Wall* in its use of projected climate changes; the Belgian *iWindow* (http://www.iwindow.be/) uses shop windows as interactive displays as was the case with *Dynamically Transparent Windows*; *Kunsthaus Graz* in Austria (http://realities-united.de/#PROJECT,69,1) makes use of an interactive building skin akin to the one envisioned for the *Confederation of Danish Industry*; and *Urballoon* (http://urballoon.com/) allows users to present recorded video statements in public spaces as did *Confession Booth*.

Revisiting the similar types of HCI contributions outlined in the introduction, Grudin [16] has based his identification of eight challenges for groupware developers on more that ten years of research and practice in the field. Bødker's [3]

identification of changes and challenges in the shift between second and third wave HCI builds on several decades of findings. Media facades by definition intervene into urban architecture and it is evident that theory and practice of architecture is a resource when addressing the challenges posed by digital technologies. This discipline extends even further back in time, exemplified by Alexander's pattern language for architecture [1], which draws on almost the entire core history of architecture. Hence, the challenges outlined in this paper are tentative and reflect the fact that the domain of media facades is an emerging field of research and practice.

Whereas we have a fairly well-developed understanding of the *challenges* in the domain, it is yet less clear how the *solutions* to these challenges may be articulated. This is in large part due to the emergent nature of the field. We have briefly touched upon the design processes behind the main cases of this paper. However, an over-arching meta-challenge is to explore which well-known design techniques and approaches from previous domains of interaction design can be brought to the design of media façades, how the techniques and approaches may need to be altered to address the specific issues in this domain, and how they may need to be supplemented with new techniques and approaches. For instance with regards to *challenge 1: New interfaces*, the principles underlying the concepts affordances and constraints probably hold true in this domain, but they take on different forms than in previous types of interfaces. Similarly, with regards to *challenge 6: Diversity of situations*, HCI literature offers approaches to exploring the situations in the domain such as ethnographically inspired field studies and cultural probes [13]; however, a particular challenge in urban interaction design is that many locations for design consist of multiple co-existing and intricately intertwined situations which may prompt a more extensive or differently planned initial exploration than in other design domains. Since media façade design is still an emergent field, we find it particularly advisable that fellow designers and researchers include rich observations of the particular characteristics of the urban domain when presenting their findings in future contributions. For in-depth descriptions of the specific design processes and solutions pertaining to the five cases, we refer to our previous contributions [6, 8, 9, 12, 23]. In conclusion, the field is not yet as well developed, but it is rapidly evolving and expanding, and it will come to influence urban living in the years to come. On an experimental level, this calls for designers and researchers to actively engage in the development of media façades, to explore how it may be approached in design, and to discuss the wider implications of this development for urban living. On a theoretical level, it also beckons designers and researchers within HCI to establish dialogues with disciplines that have a much longer history of exploring the urban domain, such as architecture [2] [29], urbanism [21], studies of the experience of place [31], and sociology [14].

Recent contributions by McCullough [25], Greenfield [15], and Foth [11] have begun this dialogue, and we hope to continue it in our future research.

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