Blinking Lights and Other Revelations – Experiences Designing Hybrid Media Façades

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Figure 1: Examples of different media façade types in different locations: (a) Low-resolution light emitting façade type, (b) front-projection high-resolution type and (c) high-resolution screen embedded in a low-resolution light emitting façade. Image credits: (a) and (b): © realities:united, (c): © Jerry Dohnal.

ABSTRACT
In this work we present our approach prototyping and pretesting *hybrid* media façades. We utilize a combination of a low-resolution light-emitting diodes (LED) and front projected high-resolution content in order to create multidimensional information layers. Our implementation in the form of a purpose built toolkit empowers designers and architects to prototype *hybrid media façades*, using low and high resolution simultaneously, quickly and at low cost. We further share our initial experiences through a case study setup and investigated different content settings displayed at varying viewing distances.

Author Keywords
Media Architecture; Prototyping; Design Process; Toolkit.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

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INTRODUCTION
The consolidation of digital media and the built environment, commonly categorized under the umbrella term *media architecture* [3,14,15,21] has created strong research interest among the scientific community within the last few years. Prominent examples include the transformation of buildings into gigantic screens [1,2], as well as urban interfaces to improve cities [9,12]. Urban media façades have the further potential to act as an information *gateway* between cities and citizens [8,17,20].

As depicted in Figure 1, urban media façades can display any type of content depending on the resolution capability. In this vein Haeusler categorized façade types by their different technical capabilities and resolutions [11]. Light-emitting façade types, for example, presently include a common practice approach by embedding light-emitting diodes (LEDs) in the outer shell of a building and use the façade as a media display with high aesthetic qualities (see Figure 1, c). However, the problem with low-resolution LED façade types is their level of information density. If there is, for example, a demand for high-resolution content (i.e. text or images), the graphical output of these low-res façade types remains limited. This is based partly on the circumstance that these façades are built for long-range visibility in a city and, hence, for long viewing distances to recognize content or patterns (see Figure 1, a). On the one hand, this is a desirable goal as these buildings have the ability to become a landmark for a city, district, or region. However, passersby who are physically close to such a façade type are restricted from perceiving any content at all.

Large LED high-resolution screens and front projections, on the other hand, are capable of displaying content also for shorter viewing distances but are more expensive to maintain and operate (see Figure 1, b). This causes these solutions to be acquired and used mainly by large corporations to display commercial advertisements. Additionally, these oversized TV screens do not appear to be seamlessly integrated in the physical structure of a building and appear rather retrofitted onto existing infrastructure [14].

In the recent years a few architectural studios also experimented with the combination of different façade types integrated into a single building. One prominent example includes the building AAMP in Singapore, created by realities:united (see Figure 1, c). In this example a low-resolution light-emitting façade was combined with one area for high-resolution content.

Due to the aforementioned challenges in this domain, the scope of our investigation in this work was the exploration of a combination between low- and high-resolution façade types, we hereafter refer to as *hybrid*. We envision a future media façade type that is capable of displaying ambient information intended to be viewed from longer distances combined with an additional high-res layer projected "on-top" for closer viewing distances. Such a façade type can potentially display information as ambient low-res visualization with high aesthetic qualities but can also, when required, display high-res information at certain times on the same surface. Building such a media façade type from scratch, we faced a few challenges. First, the design process of a media façade is still unclear. In addition, how these systems can be prototyped and developed systematically and in close alignment with a city's population in order to receive wide acceptance before the final implementation remains an open question [13]. We therefore developed a purpose built toolkit to explore content and resolution for hybrid media façades in different configurations. Using our hard- and software components, architects and designers are able to explore the potential of hybrid media façades without dealing extensively with technical burdens and high cost.

In summary we consider it advantageous to provide architects with tools that enable them to prototype media façades on a smaller scale before a final implementation and investigate if the setup, content, or interactivity makes sense to the people. Due to the circumstance that these projects are still ranging at a very high price tag, merely large and renowned architectural studios are able to facilitate work in this domain. With our hard- and software toolkits we aim to empower smaller practices with a tight financial budget to join this novel and emerging field of architecture and develop their own creative solutions. We consider our tools "creative enablers" which can be used to exploit the full potential of urban media façades before their implementation and create these systems in alignment with the intended users following a co-design process.

RELATED WORK

Media Architecture

Under the umbrella term *urban informatics*, Foth described modifying the build environment with sensors, actuators, and screens [9]. The notion of urban interaction design was further examined by [6]. One subdomain under this umbrella term involves the idea of turning buildings into screens using digital media as a *new material* for creating architecture [4,20,22]. These so-called *urban media façades* are the main focus of our research activities, which involve investigating their design process, integrating them into physical structures, and exploring evaluation techniques.

Media Façades

Urban media façades describe the consolidation of digital media and the façade of a building in order to create gigantic urban screens [2]. Media façades can be created using different technical means and differ from regular public displays in several ways [24]. Haeusler presented a global collection and described six main categories to differentiate media façades [11]. In the investigation presented here, we focused on two categories and possible ways to merge them in order to create an additional category and exploit possible advantages:

- ***Low-Resolution Light-Emitting Façade Types:*** These façade types are created using LEDs or fluorescent light bulbs directly embedded in the outer shell of a building's façade (see Figure 1, a). Computer-controlled lighting systems are often integrated in custom-built glass elements that represent the individual "pixels" [11]. The main advantage of these façade types is that the lighting elements can be integrated throughout the whole building [24] (non-planar form factors) and allow daylight to pass through glass elements when not in operation. In this domain Seitinger et al. explored an approach to distribute pixels on any façade using prefabricated elements [18]. As previously indicated, issues often arise when a demand for high-resolution content occurs due to the limited scalability. Considering the limitations of low-res media façades, researchers emphasized the challenge to develop content that suits the medium [5]. Offenhuber and Seitinger discuss the issue of information design for low-resolution media façades. They investigate different strategies to convey information, inter alia, the use of a mobile interface as an additional layer for annotations [16].
- ***High-Resolution Front Projection Façade Types:*** This façade type utilizes high-power data

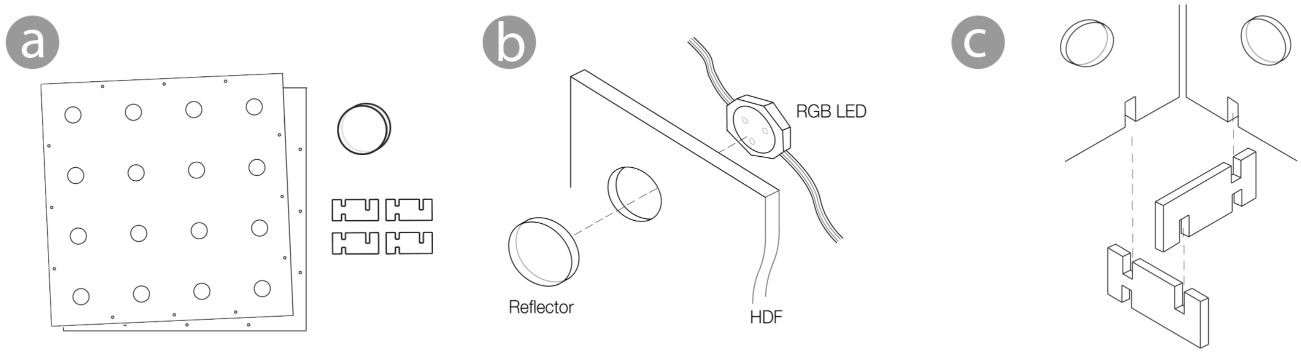

Figure 2: Construction manual for hybrid media façade toolkit: (a) laser cutted wooden façade panels, acrylic reflectors and joints for assembling (b) attaching the reflectors ahead (gluing is recommended) and inserting the RGB-LED chains from back (c) assembling the modular panels with the joints.

projectors facing a building's façade from a distance and projecting directly onto the physical structure. These systems are capable of displaying any kind of content and creating novel experiences with architecture using live video (see Figure 1, b). Additionally, these types are highly mobile and can be implemented also on a temporary basis on nearly any surface as long as the data projectors are powerful enough. However, a long-term utilization, as in the case of the previously described light-emitting façade type, is often not feasible due to the very high maintenance and energy costs.

Toolkits and DIY Media Architecture

Supporting the HCI design process [7] of interactive media façades has been described by Wiethoff and Gehring [24]. Toolkit support for the creation using simulation and miniaturization was exemplified by [10,23]. Caldwell and Foth pointed out an opportunity space for do-it-yourself (DIY) media architecture using rapid prototyping techniques [4]. In this vein Hoggenmueller and Wiethoff presented an approach to creating media façades in a co-design process involving urban prototyping [13]. In the present work, we aimed to substantiate these approaches further and (a) explore the interplay of different façade technologies and (b) provide a supportive toolkit for making our approach available to others.

TOOLKIT

Our toolkit is a modular construction kit (see Figure 2) for prototyping hybrid media façade types using off-the-shelf soft- and hardware components. The aim of the toolkit is to further contribute to the development of a standalone DIY media façade prototype. The required construction units (e.g. façade panels) can be easily fabricated from low-cost materials using a laser cutter. This allows fast replication and the construction of a miniaturized prototype within a few hours. Due to miniaturization, the toolkit is transportable for evaluation *in the wild*; however, the spatial dimensions differ from the actual media façades mentioned above.

In this work we provide a step-by-step description on how to work with our tool supplemented by the source code, published via github[1]. The CAD drawings to our toolkit are freely available for download, replica, and further development.

Hardware

Our provided laser cutter template consists of square panels with a size measuring 30x30 centimeters. In our setting the panels were cut from white high-density fiberboard (HDF), providing slots for LEDs (see Figure 2, a). Each panel can be equipped with a 4x4 matrix of LEDs. To create a diffuse light distribution, an acrylic diffusor was mounted in front of each individual LED. Aligning the notches to the dimensions of the LEDs, one can quickly and easily insert the pixels without additional mounting equipment (see Figure 2, b). The vertical and horizontal spacing of the pixels in our case was measuring 5x5 centimeters. In our setup, we utilized a total of 672 pixels distributed among 42 panels covering an area of 3.78 m^2. The density and arrangement of the pixels was chosen due to prior research investigating low-res media façades [13]. Thus, the amount of LEDs is in accordance with the rough classification of a low-resolution media façade with just a few hundred pixel elements. The utilized LED modules were manufactured by the company AHL[2]. To address the LED modules, we have used a standard off-the-shelf LED controller CP950 (AHL). The controller can be connected to a computer via a standard CAT5 cable.

By using white HDF panels, we noticed that the surface provides an optimal color rendering for the additional frontal high-res projection. For the frontal projection, we utilized a standard full HD projector (1080p) with 3000 ANSI lumen. Using one projector for covering the whole

[1] https://github.com/HoggenMari

[2] https://www.ledahl.net

prototype setup implied a resolution of 150x150 pixels per panel. We acknowledged that the projected high-res content is not visible on the areas where the LEDs are positioned due to their intense brightness.

Our hybrid media façade system is expandable to any amount of panels. The panels can be assembled with cable fixers or custom-made joints enabling straight and right-angled arrangement (see Figure 2, c). Using the joints, the prototype of the façade is easy to assemble and disassemble, which means that more design iterations in less time are feasible.

Software

For mapping content onto the low-res screen, we coded a Java-based library that helps configuring the display settings in terms of resolution and orientation as well as sending RGB values to the connected controller. The library can be directly integrated in the Java-based scripting language Processing[3], a platform that we considered ideal for the fast development of prototypes. The content of the high-resolution projection can be generated within the same Processing sketch. In order to map the high-res content onto the flat panels, we used the freely available video projection-mapping library Keystone[4]. Having both low-res and high-res content generated within the same instance, simplifies bidirectional conversion and adaption of material, interplay between the two layers, and exploration of the content that suits the medium [5].

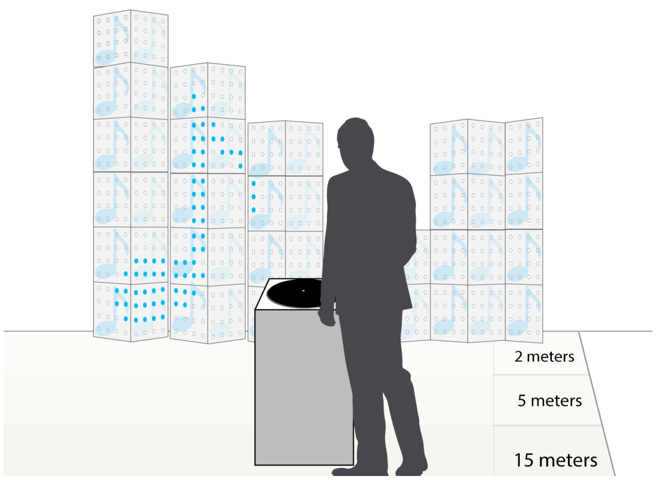

Figure 3: Setup of the preliminary field study exploring different aspects of the prototype setup.

Field Study

As previously indicated, our hybrid media façade toolkit should enable the fast prototyping of both a façade display type combining ambient information intended to be viewed from longer distances with an additional layer for closer viewing distances in a higher resolution. In order to receive initial insights we conducted a preliminary study in the field investigating (a) the visual *recognizability* at varying viewing distances and (b) the perceived aesthetic qualities of our prototyping setup.

Setup and Tasks

Within the scope of a symposium on urban screens, we recruited a total of 13 participants (4 female, average age 29.8 years). First, they received a 5-minute introduction about the context of our investigation (media architecture, hybrid media façades, and supportive toolkits). Then, each participant had to individually perform a given task consecutively from three pre-defined viewing distances (2 meters, 5 meters, and 15 meters, see Figure 3). Each participant had to *browse* through a set of 10 different pictograms (e.g., triangle, circle, square, etc.) and *select* a specific one by verbal confirmation. For the low-res representation, the icon was displayed on the entire surface; for the high-res, the icon was scaled down and duplicated on each panel (see Figure 3). For the set of icons, we have chosen simple and ambiguous symbols (e.g., a musical note) that were suitable for a representation in both high and low resolution. The interaction was carried out by means of a tangible user interface (TUI) in the form of a scroll wheel and chosen due to an easy-to-use and barrier-free access (see Figure 5).

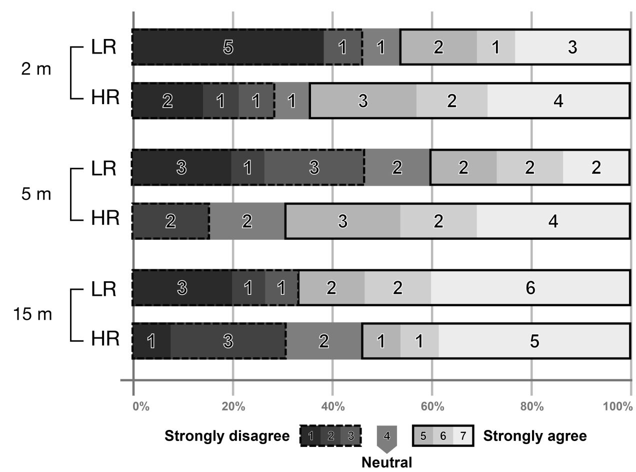

Figure 4: Response frequencies to the prompt "The presentation was helpful for solving the task" at distances of 2 meters, 5 meters, and 15 meters to the façade (LR=low-res, HR=high-res).

Preliminary Results

After finishing the tasks, we asked each participant to fill out a questionnaire including items on a seven-point Likert scale (ranging from 1 "totally disagree" to 7 "totally agree") and open questions comparing the low-res and high-res representations.

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[3] http://www.processing.org/

[4] http://keystonep5.sourceforge.net/

In the first part of the questionnaire, we wanted to know the overall perception of the low- and high-res layer in terms of *recognizability*. Asking for the most appropriate representation for solving the task, the majority, 10 out of 13 participants, opted for "strongly agree" for the high-res layer. In order to receive a more detailed distinction in relation to the varying distances, we asked the same questions for 2 meters, 5 meters, and 15 meters (see Figure 4). Whereas the high-res layer was perceived as helpful with a mode of 7 for all three conditions (4 times, 4 times, 5 times), for the low-res layer, the data revealed the expected distinction for the varying distances: for 2 meters, the low-res presentation was ranked lowest with a mode of 1 (5 times). Conversely, for 15 meters, the low-res presentation was ranked highest with a mode of 7 (6 times).

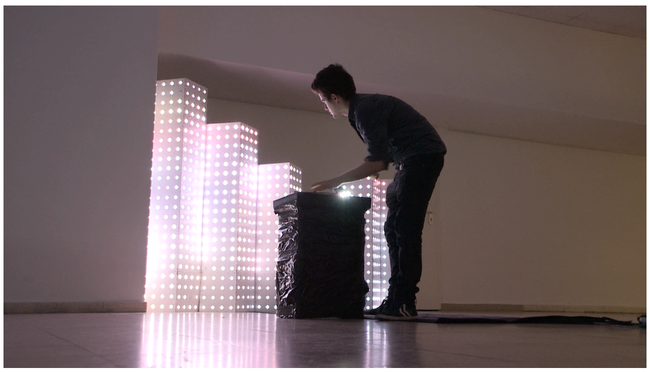

Figure 5: A participant interacting through a tangible user interface (TUI) with the prototype of a hybrid media façade.

These results correlate with the impact on the participants from an *aesthetic* point of view: for instance, one participant stated that when the distance was too narrow, the bright LEDs would disturb and "the experience was not very nice", adding that he "liked the impression of the prototype better from the largest distance". Five participants referred to the overall *aesthetic impression* as positive, with one participant appreciating the "ambient atmosphere". In total, the responses to the question, "I found the low-resolution aesthetically appealing" was opted with a mode of 7 (5 times), whereas the same question for the high-res layer was opted with a mode of 5 (4 times, see Figure 6).

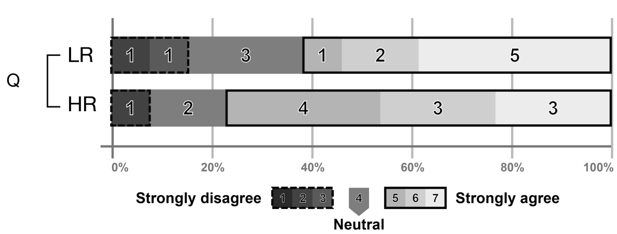

Figure 6: Results of Q: "The presentation was aesthetically appealing" (LR=low-res, HR=high-res).

DISCUSSION

In summary the collected data of our initial field study indicated the suitability of having a façade type that is capable of displaying both low- and high-resolution content simultaneously. Participants stated that the prototype proved more aesthetically appealing in a low resolution viewed form longer distances and in high resolution from shorter viewing distances. In our study we received preliminary results about the overall perception, the supportive use in terms of *recognizability,* and the general acceptance of such novel systems. The data indicated that the high-resolution content served its purpose as an additional information layer when interacting close to the façade. On the other hand, the low-resolution, light-emitting screen proved its strength as an ambient information layer when viewed from longer distances.

Limitations: Despite the limitation that we only conducted our preliminary field investigation with a small sample size, we present initial insights to judge general perception and aesthetical appearance of hybrid media façade prototypes. We also want to emphasize that the investigation of novel contexts as the one presented in current circumstances implicate results that are driven by *first five minutes of use enthusiasm*. In order to decrease this novelty bias, we recommend that long-term studies should be carried out to receive deeper insights and datasets.

Benefits: Our prototyping toolkit served its purpose to explore this novel façade type quickly and at low cost. The integration of our tools into a widespread programming environment allows content creation and exploration. Due to the modular system, which enables rapid assembling and disassembling, we were able to carry out a user study *in the wild*. We believe that a study culture out-of-the-laboratory fits this context best in terms of spatial and situational factors.

CONCLUSION AND FUTURE WORK

In summary we reported on our experiences exploring a combination of low- and high-resolution façade types, which we refer to as *hybrid*. By developing a purpose built toolkit using off-the-shelf hardware and software components, we aim to empower designers and architects to explore novel media façade types. Furthermore, we provide preliminary insights into this novel type by conducting a preliminary case study.

The development of media façades comes with several challenges and a design culture on how to build these systems from scratch has yet to be established. In this work, we presented a toolkit in order to create multidimensional information layers addressing the limitations of ambient, low-resolution media façades. In this vein, we (a) explored a purpose built toolkit to explore hybrid media façades and (b) received initial insights by the intended users.

To further substantiate the validity of our approach, we aim to carry out long-term user studies in the public domain.

There, we will explicitly focus on the information density that can be conveyed with our prototyping toolkit and investigate up and down scalability.

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