TRAN(S)QUILLITY: THE DYNAMICALLY MEDIATED FAÇADE

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Abstract. Media façades grant infinitely many faces to a building and can change the architectural meaning of what a façade is. They can also help to transform the face of the building into an over-size communication device for public (Borras, 2010). Contemporary media façades mostly rely on the content of their screens, and only a small number of them physicality of the screen itself. Precedent building façades that incorporate moving components are unable to function as displays. In this paper we present a media façade design, titled “Tran[s]quillity”, in which we fuse reconfigurable building components with display technologies to achieve a unique design. As well as fulfilling the function of a regular media wall -as a crisp screen- we imagine Tran[s]quillity as a transformable kinetic sculpture that can act as a screen of physical depth to introduce greater functionality and interactivity.

Keywords. Media; façade; kinetic; LED; image processing; digital; design; architecture.

1. Introduction

This paper introduces a commissioned experimental media façade project, called Tran[s]quillity. The project aims to grant maximal visual transformability to Pandora, the building on which it will be functioning. Pandora is a proposed building to be located on the gateway to the City of Venice, and thus it requires in depth architectural investigations. We discuss the architectural aspects in relation to building’s location and function. Tran[s]quillity consists of a physically-reconfigurable array of display screens, so it also requires detailed technical investigations. For development of this unprecedented façade configuration, we utilize computational design techniques and incorporate mechanical parts. We benefit from CAD simulations and animations. We build a scale prototype to test feasibility of our design. The documentation about our fully-functioning scale prototype reveals both the potentials and limitations of our proposal.
2. Project Background

Tran[s]quillity was developed mostly during our course work at the Media LAB at Massachusetts Institute of Technology in the fall 2011 semester. An innovation company, VEGA (VEnice GAteway for Science and Technology), located in the City of Venice, was our project partner. They commissioned a series of innovative projects to be implemented for their proposed office building, Pandora. Projects varied in scale, physicality and target user. A media wall was in the list of requests; however, it was not imagined to be something beyond a conventional flat media façades made of LED lights. From the very beginning of the project, we sought a media wall that would not merely act as a surface to adorn the façade. We conceptualized the media wall as a transformable object that would become a space defining element on the façade (Haeusler, 2009). We started with a concept we called “greater than 2D” (>2D) and explored ways to generate a physical depth via use of simple components and simple geometric transformations (Figure 1). Our aim was to stimulate the north-facing blind façade of Pandora. This façade measures approximately 16 meters in width and is 39 meters tall. The media façade is planned to cover the top portion of the wall, leaving 12 meters of clearance from the ground.

Figure 1. Collage of the concept [>2D].

3. Precedents: Contemporary Designs of Interest

We analyse a wide spectrum of media façades and compare and contrast their visual features and technical specifications. Here we discuss the media façades that inspire us as well as the ones that help us elaborate on limitations.

To start with, the media screens that adorn the façades of the buildings in Time Square in New York City represent cutting-edge examples of bright, crisp and flat media walls. Although some of these screens are curved and they envelop the
corners of buildings, they are still flat in nature; they can only display 2D visual content without any hints of physical depth.

At the other end of the topological spectrum, we examine Heatherwick Studio’s UK Pavilion, which was constructed for the Shanghai World Expo in 2010. Sixty thousand 7.5m long transparent fibre-optic rods protrude from the pavilion façade to create a gentle, soft fur around the building. UK Pavilion demonstrates how physical depth can create striking visual effects that contribute to the architectural manifestation of a building. With its subtle colour scheme and gentle patterns that emerge with forces of nature (such as wind or sunlight), the UK pavilion features an organic skin.

DECOI’s renowned HypoSurface renders the most compelling example amongst all contemporary full-scale dynamic wall designs. Although the surface performs beyond any of its predecessors, the cost, maintenance and application scale reduces its applicability as a façade installation. Staab Architect’s Flare Façade, which is a larger scale application, suffers from complexity and cost of its individual components.

Simon Heidjens’ “Shade”, which is an installation that was exhibited as a part of the Hyperlinks Exhibition at the Chicago Art Institute (Heidjens, 2010), inspires us with its potential to capture the forces of nature and to use them in generating ever-changing real-time light effects for interior spaces. It is a very lightweight installation that benefits from deviating material properties of special films on glazing. It cannot be used for displaying any sort of digital content.

Although not a façade installation, the interior hybrid-material installation of the Greenhouse Nightclub in NYC by Bluearch inspires us with its success in merging materials.

We incorporate our inspirations to work with simple geometrical configurations that can create sophisticated results. Our first attempts concentrate on fibre-optic rods (Figure 2).
4. Re-thinking Media Wall

Our media façade, Tran[s]quillity, will be similar to conventional LED media façades only in the way that it will consist of individual panels. The panels will aggregate to create a larger single screen. This single screen will function as a flat display surface when desired. However, each individual panel will have the capability to sweep about two axes to create motion. We are aiming to use this motion to generate dance choreographies and geometrical configurations (Figure 3). The panels will be capable of displaying content while moving, so the choreographies can be designed by taking both capabilities (rotational actuation and displaying) into account. When the display screens are off, the façade can become a pixelated pattern.

![Figure 3. Choreographed panel rotations create 'textures' on the façade.](image)

5. Design Objectives

Pandora is planned to be an environmentally conscious building. It aims to incorporate state of the art sustainability technologies. The media façade should represent Pandora’s originality as well as its environmental sensibilities. The Pandora media façade should allow for a wide range of content to be expressed by its surface. As the screen itself must reflect Pandora’s originality and sensibility, so should the screen’s content. It should welcome people at the threshold of the City of Venice. The content and the actuation of the façade should be integrated together to hold the potential to transmit ever-changing messages on any given day (Burnett, 2004).

The Media façade should be visible to passers-by whether they are on foot, in a car, or on a train, even under the broad daylight. The façade should be similarly priced.
as a standard LED screen and last for a long time. Construction and maintenance should be feasible. Energy consumption should be one of the main concerns. The photo-voltaic panel array on the roof of the building should be used as one of the energy resources for operation of the installation. The media wall should be easy to implement and it should utilize existing technologies. Finally, the media wall should in itself be optically complex and intriguing, even when no image is displayed.

5.1. ENGINEERING ASPECTS

- Screen Size and Shape: The screen must be high enough on the wall that it is not obscured by the surrounding trees and structures. Using a standard aspect ratio (such as 4:3 or 16:9) will allow a greater range of media content that can be efficiently displayed. If the full width of the wall is used for the long dimension of the screen, the screen will be 16m X 9m, or 144m^2.

- Resolution: One of our fundamental concerns is the resolution of the media façade, to enable legible text display over the span of the screen. A regular definition screen has 43,000 pixels and a high definition screen has 60,000 pixels (“Outdoor LED Screens, LED Displays and Advertising Signs”, 2010). Many large media screens have a larger number (150,000 or more) of pixels to increase the brightness of the screen as well as to decrease the minimum viewing distance at which the screens pixilation is no longer apparent (GKD, 2011). For a high definition screen that is 144m^2, the minimum distance between pixels should be 5.4cm in both the vertical and the horizontal directions.

- Brightness: The minimum brightness of a screen that is visible in daylight is 2000 cd/m^2, and up to 5000 cd/m^2 if it is to be viewed in direct sunlight (“Outdoor LED Screens, LED Displays and Advertising Signs”, 2010). Our façade faces mostly north which will limits its exposure to direct sunlight (with exceptions only during sunrise and sunset during parts of the year), making 2000 cd/m^2 a sufficient amount of brightness.

- Viewing Distance: The minimum viewing distance for a screen that is 16mX9m will be on the order of 35m (“Outdoor LED Screens, LED Displays and Advertising Signs”, 2010). For the Pandora building this means that, if the screen is atop the building, centre of the screen will already be at 24m; the screens should be viewable to any person 24m away from the building.

- Screen Technologies: The screen technology must balance the many design objectives ranging from originality to cost. This is discussed below in greater detail.

5.2. ANALYSIS OF SCREEN TECHNOLOGIES

We investigate the properties of LED panels as well as two other technologies. One competing technology is the Mediamesh LED screen manufactured by GKD in the UK. This media façade suspends LEDs on a transparent wire mesh. These
screens feature a low surface weight and benefit from reduced wind loads (GKD, 2011). The transparency of the screen opens up the potential to use the space behind the screen as another design parameter. The other competing technology employs the movie theatre projectors (at 30,000 lumens a piece).

We compare the potential core technologies to a standard LED panel screen (Table 1). These results are inferred and scaled from other projects using similar technologies or are taken from manufacturer specifications. The dimensional numbers are collapsed into a Pugh chart in the second table, which allows us to holistically compare the technologies.

In summary, the installed cost of the screen will likely be similar independent of the technology employed. The competing technologies weigh less than LED panels, and while the maximum resolution of the media mesh is slightly less than an LED screen (though sufficient for high-definition) the resolution of the movie projectors is unparalleled. The LED screens, both panel and mesh, are expected to last 10 years, while the projectors will likely last comparatively more with proper maintenance. However, the projectors will consume 8 times the amount of power of an LED screen of similar brightness. The environmental impact of the projectors’ inefficiencies is reflected in the large annual energy cost. The projectors are also more complex to install. Custom engineering will be required to integrate multiple projectors, and an external housing will be necessary for their accommodation. Digital projectors for large scale projections are available on the market, but they are three times more expensive. Finally, the projectors’ brightness falls short of 2000 cd/m², a number easily achieved and surpassed with either of the LED screens.

Table 1. Key Properties of Competing Screen Technologies.

<table>
<thead>
<tr>
<th></th>
<th>16m by 9m</th>
<th>15.75m by 28m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Mediamesh LED</strong></td>
<td><strong>LED Display</strong></td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>5700X</td>
<td>51500K+ Inst.</td>
</tr>
<tr>
<td><strong>Brightness</strong></td>
<td>864</td>
<td>0</td>
</tr>
<tr>
<td><strong>HD Resolution</strong></td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td><strong>Max Viewing Distance [m]</strong></td>
<td>2K-6K</td>
<td>20-50</td>
</tr>
<tr>
<td><strong>Height [m]</strong></td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td><strong>Width [m]</strong></td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td><strong>Power Consumption [W]</strong></td>
<td>9125</td>
<td>12775</td>
</tr>
<tr>
<td><strong>Ease of Installation [5-1]</strong></td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td><strong>Ease of Cleaning [5-1]</strong></td>
<td>9</td>
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6. Mechanical and Architectural Simulations

We worked with digital models of Tran[s]quillity in various software platforms. We built a four panel CAD model in Solidworks and used it to simulate panel motions. These simulations helped us to address some crucial questions: if the panels are powered on, and we are not able to obtain feedback on each panel’s position (as is the case with conventional servos) how can we safely move the panels into a known state without making them collide? In building the ¼ scale prototype we identified a sequence that allowed for a safe recovery motion sequence from an unknown state. How far apart do the panels need to be spaced so that they do not hit each other? We found that the minimum spacing was on the order of the thickness of the panels, so that each panel could tilt forward without hitting the panels above and below it.

The models we built in Rhinoceros 3D and 3DS Max helped animate the panel kinematics. We used parametric modelling and scripting tools of these software platforms. In these models we included the whole VEGA site, Pandora building and all of the 432 panels, modelled in real-world scale.

We animated our media façade using bitmap RGB values extracted from images and videos. We worked with MAXScript to use the RGB and grey-levels values of individual pixels to determine the degree of rotation for corresponding panels. The resulting motions were rendered under realistic natural lighting conditions which helped us simulate the visual effects that could be achieved by a kinetic screen at the gateway of City of Venice (Figure 4). Animations shot from virtual cameras placed in street level gave us ideas about the perceptual qualities of the wall when observed from below. Although the depth created by the panels are planned to be a little more than 1 meter, the animations and renderings reveal the visibility and potential success of aimed effects.

Figure 4. Tran[s]quillity in motion: A frame from our animation reveals the potential visual effects that will be achieved.
7. Scale Prototype, Real Scale Considerations, and Further Development

Our ¼ scale prototype consists of four panels (Figure 5). Each panel is mounted to a servo controlled (Hitec HS-985MG high torque) pan and tilt mechanism (ServoCity SPT200H) that allows it to rotate about two axes. The servos are controlled by a microcontroller (Pololu Maestro 24 Channel) which stores scripted modular dance routines that are set into play by integrated motion sensors (triggered by passers-by). The dance routines are programmed using a scripting language (Maestro Scripting Language, Pololu Robotics) on a PC and transferred to the microcontroller via a USB cable.

As the overall envelopes of motion for each panel intersect in space, each panel should be informed about the position of the neighbouring panels. In the prototype this was achieved by specifying dance routines that carefully avoided collisions. We were able to create a variety of strictly specified motions by creating modular dance routines (Figure 6).

*Figure 5. The ¼ scale prototype features 4 servo-actuated 4 panel which we can perform various rotational choreographies.*

*Figure 6. Screenshots from the video of Tran[s]quility prototype dance sequence.*
Limiting the starting and ending configurations of each dance allows the dances to be strung together in any sequence. We can combine swift and slow manoeuvres with tightly controlled velocities and accelerations. In the future we are planning to simulate each panel’s motion envelope and develop a program to avoid self-collisions.

Later in the process we replace the laser-cut placeholders with small LED panels that feature 16 LED lights to demonstrate the display functionality of our wall (Figure 7).

The prototype provides the requisite intuition that must be obtained before designing and building a full scale façade. The prototype was not designed for the rugged requirements of a building façade in a windy climate with salt in the air. In the final embodiment, light-weight-mesh panels that are easy to move and have a low wind load, such as Mediamesh (GKD, 2011), can be used. Changing the actuators with fewer parts than servo motors will increase the durability of the construction and a parallel mechanism would provide more strength than a serial mechanism. These objectives could be met with parallel pneumatic or hydraulic actuators.

8. Contributions

In our project Tran[s]quillity, we propose a dual-function media façade: we merge a kinetic sculpture with a high-resolution display screen.

To achieve our goals we use emergent design techniques and carry the line of research via taking both the architectural and mechanical engineering considerations into account.

We do not merely rely on computational simulations. We build a fully-functional prototype. Our scale prototype becomes the proof of our concept, and it helps us to determine the potentials and limitations of our proposed system.
In the future development of Tran[s]quillity, we see interactivity to become the key concept to be studied. Once set as a fully functional interactive wall with environmental sensors, Tran[s]quillity can become an interface to connect the interior and the exterior of building Pandora. (Figure 8).

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