Ambient Interactive Architecture: Enriching Urban Spaces with Low-cost, Lightweight Interactive Lighting

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ABSTRACT
We investigate how an existing urban space, a pedestrian tunnel under a busy road, can be enriched using low-cost, lightweight sensors, digital technology, and lighting equipment. Our installation utilizes bars of LED lights placed in a pedestrian tunnel and connected to and individually controlled by a microcontroller. When vehicles pass overhead, a laser sensor detects the movement and passes on this data to the microcontroller that processes the data and changes the lighting within the tunnel in various ways according to our custom-made algorithms. The purpose of the installation has been to convey meaning in an ambient, non-prescriptive way to the pedestrians, bicyclists, and others passing through the tunnel about the traffic situation on the busy roadway overhead. In carrying out this project in a public space not originally designed for installations and events of this kind, we have encountered a large number of practical concerns that need to be dealt with, including issues of access to the power grid, changing weather condition, stakeholders and gatekeepers with different perspectives, and issues of safety and vandalization.
Keywords: Ambient interactive architecture, Light Installation, Urban Spaces, Tunnels

1. INTRODUCTION

In urban areas, large numbers of people use passages and tunnels on a daily basis as crossing points to traverse busy roadways, separating pedestrians and vehicles. We are interested in how such an existing urban space, a pedestrian tunnel under a busy road, can be enriched using sensors, digital technology, and lighting installations that convey meaning in an ambient, non-prescriptive way to its users. This can be thought of as lightweight 'interactive architecture', i.e. architectural solutions that demonstrate responsive behaviors with respect to the interaction between humans and their surrounding urban, almost entirely artificial environment.

In this paper, we investigate and report on a light installation that ran for ten days as part of a lighting festival in Umeå, Sweden, during which residents, daily commuters, and visitors traversed the tunnel on a daily basis. Umeå is a city in northern Sweden, an area known for its bright summers—when it is daylight more or less day and night—but also for its dark fall and winter. The light festival, named the *Umeå Autumn Light Festival*, rather naturally took place in the late fall of 2009 and included about a dozen different light installations, all within close proximity to Umeå city center, that ran for a full 10 days and were entirely open to the general public at all times.

With our pedestrian tunnel installation, we were primarily interested to see if this transitional space could be used to create ambient awareness of the traffic situation overhead, i.e. to convey meaning and a sense of 'being there' in a subtle, abstract way, using only light and without resorting to quantification of data, information displays, and written explanations about the purpose and aim of the installation. The design goal was to create a light installation that were interactive and informative in the sense that it responded and changed over time according to the traffic situation above, while the representational link between the two would remain open and somewhat unclear, at least for pedestrians and bikers rapidly passing through the tunnel. These brief visitors would perhaps only note that the lights changed subtly or abruptly when they passed by, but not care for or spend enough time there to understand the link between the way the light changed and the other subtle cues as to what it represented or modeled, i.e. subtle vibrations from large trucks passing by overhead, occasional horns sounding, and other subtle, multimodal, and ambient sensory experiences that would allow visitors that took the time to 'see' the overhead traffic in the tunnel's changing light.

2. INSPIRATION

In the current literature on interactive architecture, there are a number of interesting projects where researchers, designers, and architects have explored various aspects of the notion of pliable and responsive digital environments. Typically, these concern man-built environments such as airport or hotel lounges, museum spaces, 'smart' homes, hospitals, care facilities, or other high-tech buildings or public spaces (for some examples, see e.g. [4]). With this project, we however sought to explore how an existing, decidedly low-tech, urban concrete environment could be enriched with ambient interactive behavior using lightweight, low-cost sensors, computers, and light equipment. We were interested in which lessons we would learn from carrying out such a project, all the way from ideation and conceptual work to actually designing, installing, and running the installation for multiple days in a real-world outdoor environment, hostile to electronics and computer equipment.

Inspiration has been found in some previous projects that have visualized energy and movement and which have also been re-using urban spaces in various ways, including Nuage Vert's Green Cloud project in Finland [1] and Bar & Shay's altered lighting in Tel Aviv's open underground tunnels [3]. Similarly to these projects, we have also taken an existing urban space as a starting point and through the use of sensors, digital technology, and light tried to enhance this rather dark and hostile urban space by subtly connecting the tunnel to the busy street above.

3. APPROACH AND IMPLEMENTATION

Our light installation utilizes bars of LED lights in a pedestrian tunnel that are connected to and individually controlled by a microcontroller. When vehicles pass overhead, a laser sensor measures the movement and passes on this data to the microcontroller that processes the data and changes the lighting within the tunnel in various ways according to our custom-made algorithms.

The actual installation consists of ten 240 LED RGB bars that are daisy-linked together using the DMX protocol, a standard for digital communication that is commonly used to control stage lighting and visual effects. A DMX playback/recorder unit was utilized to control the lights in addition to an Arduino Microcontroller tethered to an industrial laser distance sensor typically used in the forestry industry today.

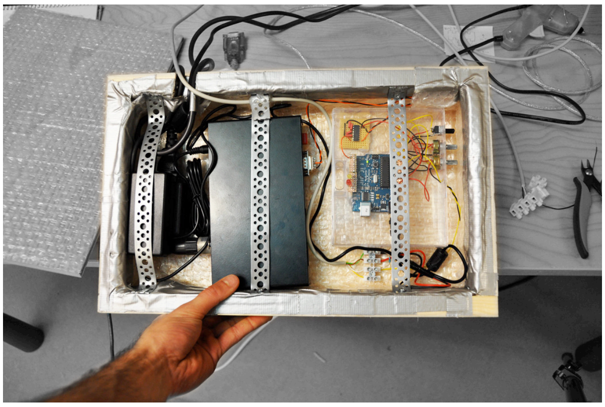

Figure 1. DMX playback device and Arduino Microcontroller

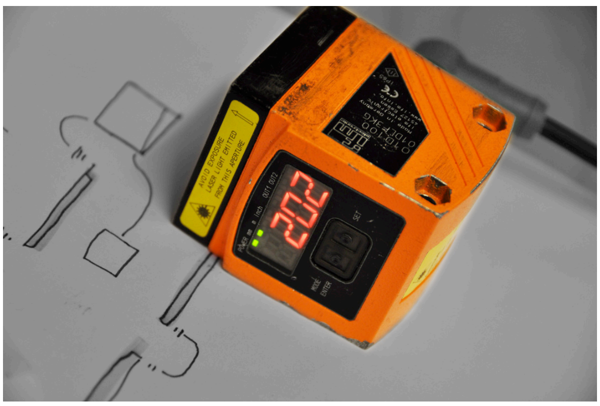

Figure 2. Laser Distance Sensor

The LEDs were sequentially programmed with a 'Northern Lights' effect reminiscent of the naturally occurring light phenomenon of the northern part of Sweden where the festival was held. The sequences switched gently between hues of blue, purple and green. When traffic passed the roadway above, the distance sensor would be triggered and the Ardiuino Microcontroller would communicate to the DMX playback to initiate another lighting theme. This theme was programmed with reds and oranges and had a more abrasive visual effect that would endure for a couple of seconds, depending on for instance the length of the cars passing by in front of the sensor and the frequency with which they were passing. When the roadway was clear again the installation would start to revert to the default Northern Lights effect again.

In order to program the behaviors of the lights properly, we brought some of the lights into the studio. Five LED bars were taken in and programming was conducted in the efforts of achieving the right effects. This allowed us to quickly sketch light sequences and downloaded them into the DMX playback device for viewing. With this method, our desired effects quickly materialized as the sequences were evaluated during the programming process.

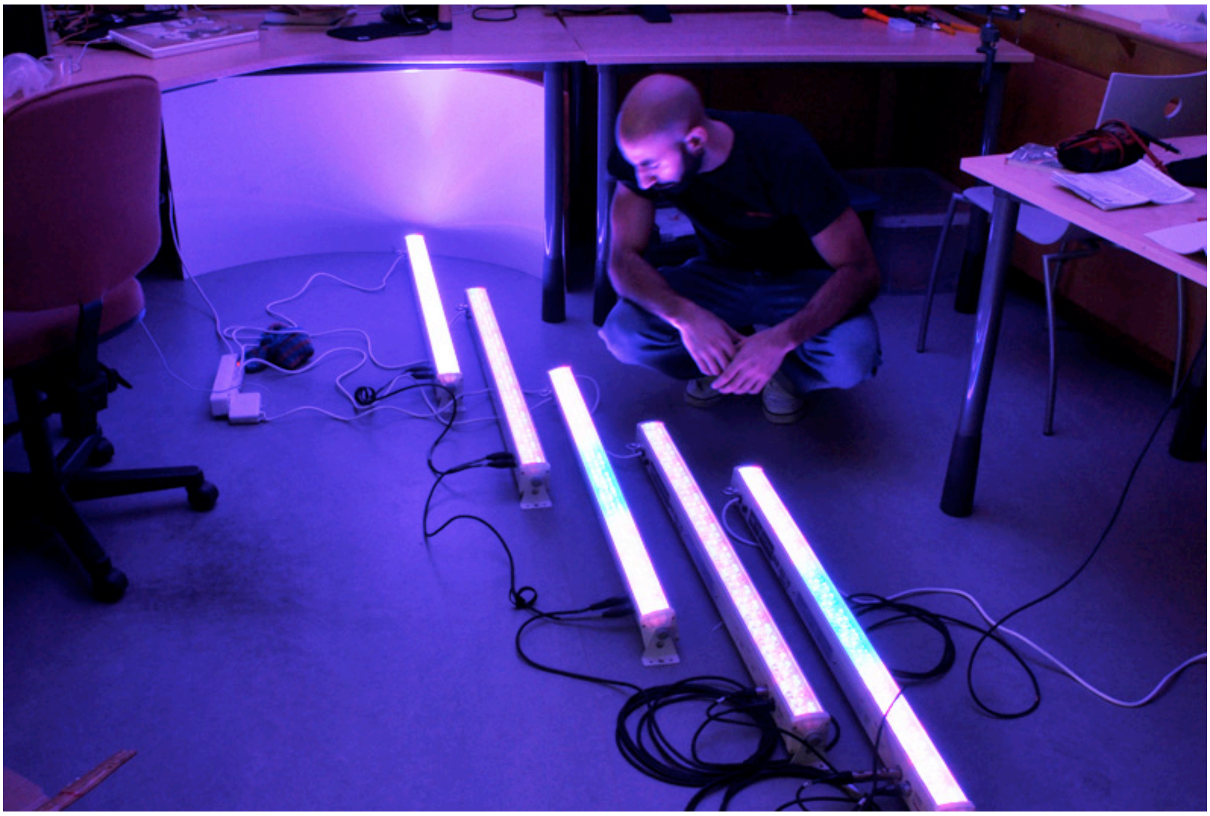

Figure 3. Testing light effects in our studio before deployment

4. SETUP

Permission was sought from the Umeå City Council to utilize a tunnel space and select an appropriate location, reserving it for the ten-day festival. As this was an event that would run 24 hours a day in a public space, without us there all the time to monitor its use, a professional lighting company was contracted to rent and install the required LED bars and work together with the local power company, plugging into the local power grid.

The installation was mounted inside the tunnel with a professional stage and outdoor lighting company. Electricity from the city grid powered both lights and control box. The control box was also encased in a water and moisture resistant box and mounted inside the tunnel roof to be out of public reach and be somewhat protected by unpredictable weather that may damage components.

Finally, the laser sensor was mounted to the back of a road sign and positioned facing the street to read traffic passing directly above the tunnel.

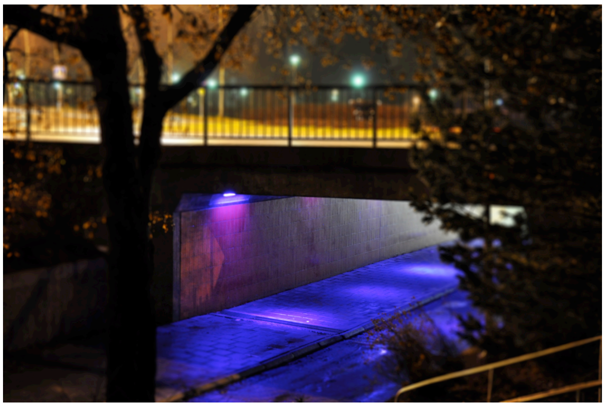

Figure 4 and 5. The LED lights installed on location showing the default effect

5. RESULTS AND DISCUSSION

The installation ran for a total of 10 days in close proximity to Umeå city center, during which numerous cyclists and pedestrians were able to experience it. Below, we summarize and discuss some of the most important lesson we have learnt in planning, designing, and implementing this project.

So-called “smart designs” and interactive architecture, i.e. responsive digital environments, used to be reserved primarily for museum and exhibition spaces. With this installation however, we build on the growing body of design examples demonstrating how various urban spaces can be transformed into ambient interactive spaces using low-cost, lightweight interactive lighting.

Compared to a traditional exhibition event, the out-of-the-museum real-world nature of our installation has meant that we have had to take into consideration a range ‘new’ issues, such as: safety issues regarding the use of electricity and lighting equipment in a public space; issues of unmonitored computer and electronic operation in cold and wet weather conditions; and issues of theft and vandalization. Most of these issues are typically not major concerns when designing prototypes and installations for more controlled environments such as lab spaces, museums and indoor exhibitions. Here however, they become key concerns that need to be dealt with in detail.

One of the key lessons we have learnt from this project has to do with the large number of practical concerns that one faces when carrying out a project like this in a public space not originally designed for installations and events of this kind. For instance, even if you as a designer have ‘access to electrical power’ as minutiae in your project plan, it is not necessarily such a simple matter from the perspective of those granting access or those providing it. We were amazed (and at times frustrated) by the number of stakeholders and gatekeepers involved in what we first thought about as our fairly small and straightforward implementation. We found it important to have a good communication channel open with the local council and work closely with the power company to ensure a safe connection to the power from the grid as well as their trust in us. In addition, due to very unpredictable weather patterns, we had to ensure that the setup was rugged and could withstand great variances in temperature and humidity.

We have also found it critical to have access to the actual installation site well in advance, as it is difficult to know when your are designing the installation in the studio what to expect when the lights have been actually installed on location. Various aspects of the actual site will inevitably lead to changes and tweaks in your design, as no two tunnels look the same, no two places have the same geography, and so on. In this particular case, we for instance found out that there were some other lights in the area that were subtly conflicting with the LEDs, which we thought were making the whole installation less vibrant and ultimately dampening its effectiveness. Although inquiries were made on several occasions, at the end of the day it turned out that disabling these public lights was not an option as it was deemed ‘unsafe’ for the public. The installation thus had to be tweaked to fit the environment, not the other way around.

5.1 Future Work

Some of our future considerations concern the possibility of adding an interactive element in the set-up to prolong public contact to the installation. Connecting to actual data sets provided by the local power authorities could also provide richer, more meaningful data visualization possibilities to compliment the effect.

One of the areas hinted at by our installation but one which we would like to continue with and substantially deepen is the relation between the ambient visualization of traffic and how emissions from this traffic affects the air quality. By re-purposing a public cycling/pedestrian tunnel, we can hopefully provoke thought about how we can avoid motorized transport and consider alternate means of travel when possible.

6. CONCLUSIONS

Most current design examples of interactive architecture, i.e. responsive digital environments, are large, rather expensive projects carried out and displayed in high-tech buildings and museums.

With this project however, we have been interested in how an existing urban space, a pedestrian tunnel under a busy road, can be enriched using low-cost, lightweight sensors, digital technology, and lighting installations. We have reported on a light installation that ran for ten days as part of a lighting festival in Umeå, Sweden, during which residents, daily commuters, and visitors traversed the tunnel on a daily basis. Our installation utilizes bars of LED lights placed in a pedestrian tunnel and connected to and individually controlled by a microcontroller. When vehicles pass overhead, a laser sensor measures the movement and passes on this data to the microcontroller that processes the data and changes the lighting within the tunnel in various ways according to our custom-made algorithms.

The purpose of the installation has been to convey meaning in an ambient, non-prescriptive way to the pedestrians, bicyclists, and others passing through the tunnel about the traffic situation on the busy roadway overhead. In carrying out this project in a public space not originally designed for installations and events of this kind, we have encountered a large number of practical concerns that need to be dealt with, including issues of access to the power grid, changing weather condition, stakeholders and gatekeepers with different perspectives, and issues of safety and vandalization.

ACKNOWLEDGEMENTS

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REFERENCES

1. Nuage, V., “Green Cloud”, Retrieved November, 20, 2009, from http://www.pixelache.ac/nuage-blog/
2. Park, H., Burke, J., & Srivastava, M. B., “Design and implementation of a wireless sensor network for intelligent light control”, *Proc. IPSN'07,* Cambridge, Massachusetts, USA, April 25 - 27, 2007. ACM, New York, NY, 370-379.
3. Bar & Shay, “Adding Color to Tel Aviv's Underground Tunnels”, 2009, http://www.woostercollective.com/2009/05/adding_color_to_tel_avivs_underground_tu.html
4. Bullivant, L., “4dspace: Interactive Design Environments”, London: John Wiley & Sons, 2005.