FACHHOCHSCHULE TRIER
Hochschule für Technik, Wirtschaft und Gestaltung
University of Applied Sciences
Informatik

Informatik-Bericht Nr. 2011-2

Schriftenreihe Fachbereich Informatik, Fachhochschule Trier

Treehugger

A holistic approach, combining architecture and interactive media installation for the federal horticultural show in Germany[1]

Daniel Gilgen
University of Applied Sciences Trier
Schneidershof
D-54293 Trier, Germany
+49 651 8103 825
d.gilgen@fh-trier.de

Holger Hoffmann
University of Applied Sciences Trier
Schneidershof
D-54293 Trier, Germany
+49 651 8103 451
holger.hoffmann@fh-trier.de

Georg Schneider
University of Applied Sciences Trier
Schneidershof
D-54293 Trier, Germany
+49 651 8103 580
g.schneider@fh-trier.de

ABSTRACT

This paper describes the design and realization of a pavilion for the chamber of skilled crafts in Koblenz, Germany as part of their contribution to the federal horticultural show. The pavilion should not only correspond to the idea of an innovative and sustainable construction, it also had to show a strong relation to the ideas of the horticultural show and reflect the stylistic vocabulary of nature. Furthermore the building should be augmented with media elements in order to emphasize the architecture and to offer another approach to the visitors for discovering the organic fusion between architecture and nature. In our case we have highlighted the pentagonal comb structure of the pavilion using a diffuse illumination of the combs and we have adapted the idea of watering and flowering as user interface

[1] Authors contributed equally, names in alphabetical order

metaphor within the pavilion as reflection of the natural growth process. For doing so, we have built tangible interaction elements that are familiar to the users in this context, i.e. watering cans with integrated sensors for location and orientation. Visitors can pick up the cans, chose their color by rotating the can and virtually pour the color at this position in a way that starting from the very point on the ceiling is colored accordingly like a blooming flower.
The interactive media system has been realized using the Arduino platform together with several sensors, RFID readers and wireless communication in order to control the ceiling illumination consisting of LED strips over the DMX protocol.

The project has been realized as an interdisciplinary project between the departments of architecture, intermedia design and computer science, including students of the aforesaid departments together with external partners.

Keywords

Interactive Media Augmented Architecture, Tangible Interfaces

1. INTRODUCTION

The federal horticultural show takes place every two years in Germany. The show consists of extensive landscape architectures and gardenings, which transform the area and give it "a new, green visual identity. The transformation is taking place on three sites covering a total of 48 hectares at the Electoral Palace, the Blumenhof courtyard and Ehrenbreitstein fortress" [1], which is part of the landscape of the UNESCO World Heritage Site “Upper Middle Rhine Valley”. Besides, many recreational and cultural attractions will take place as well during the opening of the show, which is usually between April and October. Several million visitors are expected for this period.

The Koblenz chamber of skilled crafts participates in the horticultural show and wanted to display the technical excellence of their member enterprises as well as the innovative power of craftsmanship.

The Treehugger concept shows the fusion of the stylistic vocabulary of nature, i.e. a wooden pentagonal comb structure, with an organically shaped interior, which additionally integrates a tree in the architecture that has grown on the premises of the pavilion. Furthermore an interactive light installation has been integrated in the concept in order to emphasize the structural elements, i.e. the combs. The installation uses the idea of natural growing and blooming as a metaphor. For this reason we use a watering can as tangible interaction element which is a familiar instrument in the area of gardening. The watering can is used to select a color and to virtually pour it out so that the surrounding area starts blooming, i.e. the surroundings combs on the ceiling are illuminated with the selected color and the illumination continues at the neighboring combs. This way the organic pentagonal comb structure of the pavilion is highlighted even further in the course of the illumination process.

In the following we will first describe the ideas of the architecture of the pavilion. Afterwards we will talk about related systems and installations in neighboring fields and highlight the philosophy behind the interactive light installation. Then we will emphasize the realization of installation. We will close the paper with a resume and an outlook to our future work.

2. ARCHITECTURAL CONCEPT

The pavilion, which had to be designed for federal horticultural show had to serve many purposes. On the one hand it had to show a close relation to nature. Furthermore the peculiar location of the pavilion next to basilica St. Castor should formulate a subtle link to Romanticism’s enthusiasm for the mystique and the transcendental. So it is a rather anticlassical "as well as" approach that drives the structural, formal, material and spatial configuration of Treehugger.

The pavilion has been designed in the shape of an extruded pentagon (see Fig. 1) instead of a square-box – a simple geometrical "plus" that changes the building’s appearance significantly in relation to a beholder’s standpoint. The partly screen printed glass curtain blurs the interior construction and superimposes it with reflections of the surrounding trees.

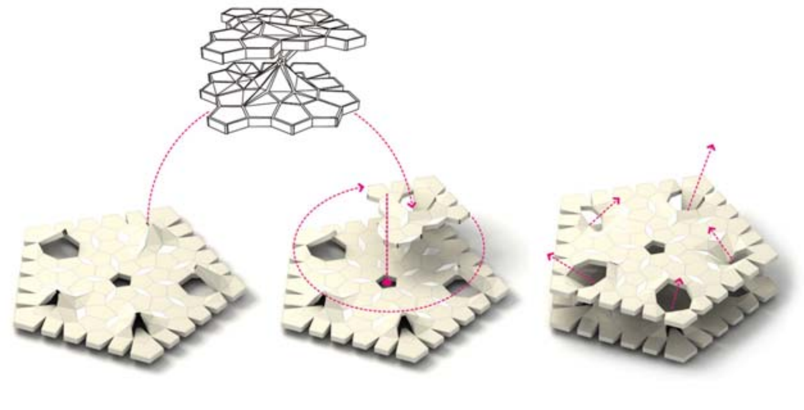

Figure 1. Geographic Pentagon structure.

The polygonal geometry and manifold symmetries of nearby St. Castor’s stellar vault have been a major inspiration for the project. Together with a rotationally symmetrical order a system of interdependent geometrical relations was defined that was resilient, yet rigorous enough to adapt to specific structural and functional needs. Furthermore the "branching" and inherent "porosity" of the trees' leafy canopy above has been abstracted into the similarly "porous" pentagonal and rhombic tessellation of the surfaces.

Treehugger has to serve as a place for exhibitions, lectures, workshops and similar events. Thus a circuit, a one-directional space and a row of cubicles had to be implemented within in one spatial configuration – which normally results in a claim for flexibility that would then be answered with as little spatial or structural determination as possible. In this case however we have decided to rather blend the three main programs. By rotating one structural element (the tree-like column) around a pivot in the center of the pavilion different regions of possible action emerge. This fairly simple geometrical operation then allows for all three conditions to take place at the same time: the exhibition pieces of the circuit are shielded by the tree-like columns that again create in between cubicles for work-stations in a workshop scenario. Lectures take place in a "Totaltheater"-like central space.

For sustainability reasons Treehugger will not only be erected once and then disappear, but it will be relocated in October 2011. Therefore the decomposability of the timber-structure has been of great importance from the beginning of the project. It will perform as a platform for diverse events during summer 2011. In October 2011 Treehugger will be dismantled to then be re-erected on the premises of the Chamber of Skilled Crafts, Koblenz.

In conjunction with the initial research project we have designed and constructed Treehugger entirely with the help of Rhinoceros 4.0, Grasshopper and Visual Basic/Rhinoscript - this mainly to find an efficient balance of technologically advanced as well as common low tech production methods. Thus the timber-works have mainly been factory machined by an automatic cutting machine that is normally used for standard timber roof structures. All steel knots have been lasercut and then been assembled with the tailored woodworks to mid-size prefabricated components.

3. RELATED WORK

The general idea to blend architecture and illumination has been already realized by several architects (e.g. [2] and [3]). In these installations the outer face of the buildings has been used to display information or to display animations for creating a lively impression of the building. The interactive light installation of Treehugger rather aims at the interaction of the user. However similar as in these projects, for the nighttime when the horticultural show is closed, automatically generated animations are displayed in order to attract the attention from outside of the premises of the show.

The works of [4] and [5] show several light installations, that either automatically create a certain impression within a room by displaying animations or reacting on bypassing users. In contrast to these installations, in our project we focus on the explicit interaction using tangible interaction objects in order to emphasize the topics of the show.

Several projects realized from [6] deal with a similar question as we do, which is complementing the architecture with a media installation, that emphasizes the architecture and refers to the theme of the "event". Especially the project "Spheres" deals as well with a specific theme, which is incorporated in the architecture as dynamic light surface, emphasizing in the same way the architecture and referencing the theme "mobility".

On the other hand, the idea of media installations in the context of gardening and plants has been discussed in [7] where virtual trees are constructed based on the emotions of the users and more significantly in [8], where lights show the biopotential activity of plants. In our case however we want to use direct input from the users and imitate the blooming using a light installation in the ceiling. In [9] watering cans are used as tangible input devices for a virtual garden. The experiments showed that the users can intuitively use the interface and show a high satisfaction since they can interact easily with the system.

Ceiling illumination in the public space using LEDs is presented in [10]. In this case however the display is targeted at displaying readable information. The Treehugger illumination is used to produce a visual effect rather than displaying additional information to the user.

In [11] a coexisting entertainment furniture is presented. The object interacts using light with the users. Here light is used on the one hand as illumination. It also is used in order to give feedback about certain states, like touching. We will use a similar mechanism in order to inform the user about certain states as well, i.e. the detection of certain dedicated positions for interacting with the light installation.

4. INTERACTIVE LIGHT INSTALLATION

The interactive light installation had to achieve two goals. On the one hand it should emphasize the innovative structure of the pavilion and it should use an easy to understand but innovative user interface in the context of the garden show.

Facing the fact that the visitors of the horticulture show covers a wide range of different users from families with children to mainly elderly people, the design of the human computer interface had to be intuitive and easy to use. Intuitive design means that we exploit previously learned knowledge. The watering can has a well known handling and relates to the metaphor of pouring the virtual color out and let it bloom over the users head by spreading it over the ceiling. However it is important that the modified watering pot can be distinguished from its standard appearance (to avoid a mystical interface). Therefore the hole where usually the water got filled in is covered with frosted plastic. If the watering can stands still for 2 minutes it switches into stand-by mode and starts to pulse in the lately selected color to catch more attention (see Fig. 2).

Figure 2. Two modified watering cans indicating a selected color by their orientation.

Once a visitor lifts up a blinking watering can the color in the can starts to change by rotating it. The instant visual feedback provides an explorative approach to find the desired color or to simply test one by tilting the can.

The interaction with the ceiling can take place only on specific locations, where RFID tags are integrated in the floor. In order to mark these places, the RFID tags are covered by a pictogram of a watering can. If the real watering can is placed onto this nonverbal sign, the can blinks white twice. Afterwards the animation starts above the lately selected RFID tag. In terms of interaction design this is a compromise to the technical possibilities because an explicit new action is needed (see paragraph 5.1).

There are 3 watering cans which can be used simultaneously from different positions. The selected colors will be blended in the ceilings modular elements when they overlap each other. This leads to an exciting interaction between different users and extends architectural perception by enriching it with an involving experience.

Figure 3. The pavilion and the interactive light installation at night (Photo by Roland Borgmann).

Finally the physical interface (watering cans) can be easily stored away at times when the pavilion is used for different purposes.

At night time when the pavilion is closed for public the system can be switched to a mode which simulates the use of the watering cans. Especially then, the seamlessly integration with the generative architecture has its full effect (see Fig. 3).

As it concerns the integration of the light installation several constraints had to be met. First of all the lights had to be installed in a way that they don't interfere with the building. For this reason the usage of spotlights was already impossible from the beginning. The idea of emphasizing the pentagonal structure of the pavilion could have been done by either highlighting the skeleton, i.e. incorporating the lights in the wood frames or by highlighting of the interior of the pentagonal combs. Finally we have chosen the diffuse illumination of the combs since it further contributes to the illusion of a blooming flower, where new petals appear over time.

5. REALIZATION OF THE LIGHT INSTALLATION

The interactive light installation needs to detect different information of the watering can concerning the location, the orientation, which serves to adjust the color of the watering can and the tilt. Furthermore the user has do be provided with a feedback about the selected color as well. In order to detect these parameters several sensors has to be integrated.

The so collected data has to be transmitted to a server were, data coming from different cans have to be processed in order to realize the light animation on the ceiling.

Finally the different sections, i.e. pentagonal combs have to be illuminated accordingly.

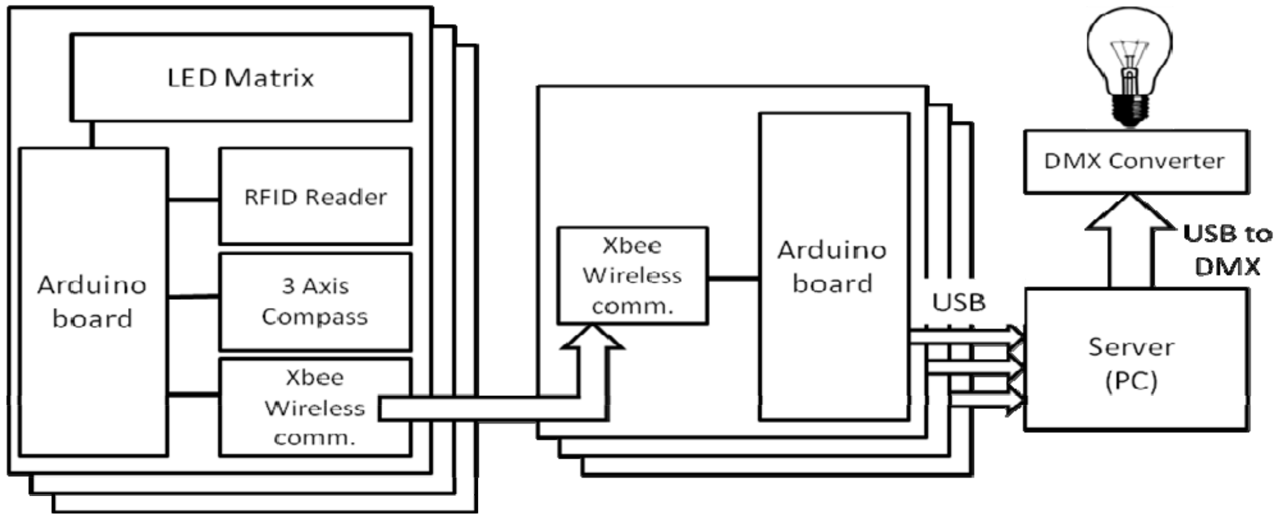

Figure 4. System architecture.

Figure 4 shows the system architecture. The Arduino board with RFID reader, 3 axis sensor, Xbee wireless communication and LED matrix in order to provide visual feedback to the user, are integrated into the watering can. Right now we have installed three different watering cans, that can be used simultaneously. For each can, we have a dedicated receiver connected to a PC via USB. The reason for multiplying the Arduino boards on the server side is, that experiments with multi threading on one Arduino board have shown that it is more reliable to perform the computation on a more powerful platform.

The server calculates the animations of the ceiling illumination and controls the lights using a DMX converter, which is connected to a USB to DMX interface.

In the following sections we will discuss the single parts of the system in more detail.

5.1 Watering can as tangible input device

As mentioned above the watering can has to collect certain sensor data about position, orientation and tilt. It has to provide feedback concerning the selected color and communicate the information to the server. We have chosen the Arduino platform [7] in order to realize the required behavior. Notably we used the Arduino Mega 1280.

Figure 5. RFID Reader and Tag.

As it concerns the position of the can, we first experimented with the signal strength of several Xbee modules, which we have integrated in the environment. This procedure would have had the advantage that we could determine the position of the can within the whole pavilion. Whereas this approach worked nicely in the lab, it was too fragile for an environment with many moving people (possibly with cell phones). Therefore we have decided to use an RFID reader and to embed RFID tags in the floor of the pavilion. Therefore slots have been milled into the floor and the positions have been labeled with a sticker. As a consequence the interaction with the ceiling can only take place at discrete positions. Once the RFID tag is recognized the watering cans signals this by blinking twice in the color white. As hardware we have used the ID-20 module [8] and a passive tag (see fig. 5).

The orientation of the watering can controls the color that will be poured by the can. The sensor that is used provides us with data about the three axis. The values concerning the heading control the color that is selected from the user. The tilt data are responsible for activating the light animation once they exceed a certain threshold. A Honeywell HMC6343 Three-Axis Compass is integrated for this purpose [14], which we have accessed using the Arduino wire library.

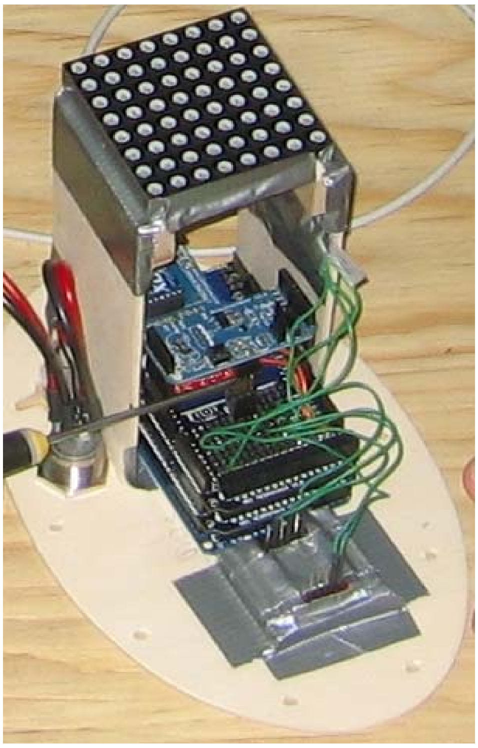

Figure 6. The assembled interior of the watering can.

As communication technology we have used an Xbee module together with an Xbee shield.

The LED matrix is integrated in the hole of the watering can, where the user normally fills in the water, i.e. on top of the can. This matrix displays the currently selected color and likewise gives a visual feedback. Furthermore the matrix is used for informing the user if an RFID tag, identifying a position for starting an animation has been detected. For this purpose the device blinks twice with a white color. In our case we have used an 8x8 LED matrix [15].

The complete hardware setup is shown in figure 6.

5.2 Server side hardware setup

On the server side we have used a similar hardware setup as in the watering can with Xbee wireless communication and an Arduino board. The Arduino boards are connected to the server over a USB connection. The server processes the input from the watering cans and calculates the belonging animations. The color information is sent over a USB to DMX cable to a DMX converter and then to the attached LED strips (as shown in fig. 7), which are able to display the RGB color spectrum.

Figure 7. LED strips.

5.3 Lighting control

The server takes care of the control of the different lights. Different situations have to be taken into account. First of all there was a non interactive mode, that had to be implemented for presentations and other events. For this case all lights had to be switched to the color white in order to provide illumination.

As it concerns the interaction with the watering cans the animation with the color, a user has selected by turning the can, shall start as soon the can is tilted. The animation shall start at the user's position and propagate to the neighboring combs. Since the three different cans can be used at the same time collisions may take place when the animations start to overlap. In this case the combs at the edges between the areas will be set to a blended color. This idea is illustrated in figure 8.

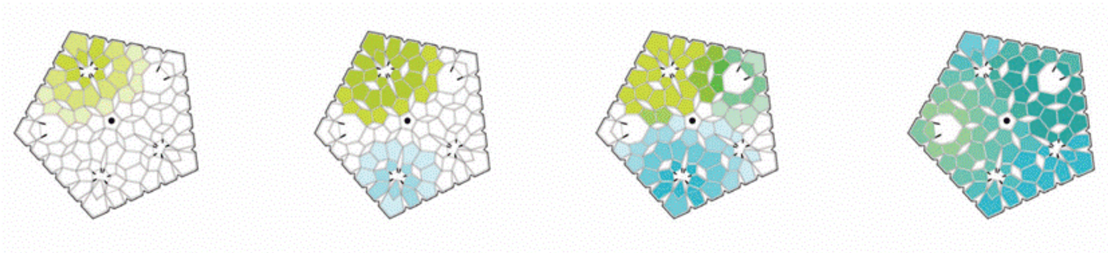

Figure 8. Light animation.

The software for the lighting control has been realized as a Java program. The main component loops over the following steps:

1. The Arduino module, which is responsible for the watering can provides the data for color and position at the USB port.
2. The data will be processed by the ceiling threads and written into the ceiling array, representing the individual illumination for each comb.
3. A DMX thread is notified about the new data.
4. The thread processes the arrays of the three cans and reads the color information. If there are different values for the same position, an arithmetic average is calculated.
5. The values are transmitted to the DMX controllers
6. The ceiling threads visit step by step all combs looping between step 3 and 6 until the animation is completed.

7. The ceiling threads wait for new data. Once new data is available the loop starts again at step 1.

In addition to this procedure, an automatic mode has been implemented, which can be activated by night, when the pavilion is closed and no more visitors are present.

6. RESUMEE AND FUTURE WORK

We have recently experienced the advent of a “digital modernism” in architecture. Hereby architects draw and integrate methods and aesthetics from computer technology which finally is having a significant impact on the current development of architecture: this architecture has become more complex in terms of its physical structure but also regarding its material and immaterial effects. Here the specific knowledge of media designers and computer scientists has proven to be necessary to develop projects beyond a classical architectural repertoire.

As a case study Treehugger has been the first collaboration of three disciplines at the University of Applied Sciences in Trier: architecture, intermedia design and computer sciences. We have aimed to develop a project that fully integrates these different professions in order to contribute to the current discourse, not only in the building industry, but also in relation to media design and computer sciences. Furthermore students from the different disciplines have been working together in order to realize Treehugger. The students had to take charge of their work package from the beginning until to the final product. They had to coordinate with the other teams, since all processes were strongly interrelated and they had to communicate with the external partners. This process has been a very challenging and instructive and rewarding experience for the students, reflecting ideas and decisions in the light of the entire project.

Until now the pavilion and the interactive light installation have gathered a great interest from the public. At the opening weekend of the BUGA, more than 5000 people visited the pavilion. Especially at night, when the lights are widely visible, the automatic light animations make the pavilion to a spectacular attraction for the whole city, due to the exposed location close to a road junction (more pictures from the pavilion at night can be found under: http://buga2011.tumblr.com/).

Furthermore special light events are planned, where the initiators of the pavilion will emphasize interactive light installation and invite the public to experience the interaction with the pavilion.

However we have not yet carried through a profound evaluation and user study of the interactive light installation until today. This is planned for later in the year, when the daylight time is shorter and when we have more time in the evening to gather user experiences.

7. AKNOWLEDGEMENTS

We want to thank the whole team that has worked on the realization of Treehugger: Our client, the Chamber of Skilled Crafts, Koblenz. Christoph Krause, director of the Center for Design, Manufacturing and Communication, Dipl.- Ing (FH) Hans-Ulrich Brink. The architectural design has been developed by the team of the department digital design at University of Applied Sciences, Trier: Prof. Dipl.-Ing. Holger Hoffmann with Dipl.-Ing.(FH) Jan Busemeyer, Dipl.-Ing. (FH) Frank Stolz, Jan Weber, Eva Ziegler, Gabriel Wüstner, and Peter Zock. The structural engineering has been made by the Office for Structural Design, Frankfurt am Main: Prof. Dr.-Ing. Harald Kloft, Jürgen Scholte-Wasssink, Florian Mähl, Peter Gerlach. In charge of the execution has been Ochs GmbH, Kirchberg: Christian Schiel (construction supervisor), Frank Schneider & Sven Schneider (CAD). The team of the Faculty Intermedia Design, University of Applied Sciences, Trier has developed the concept of interactive light installation. Prof. Daniel Gilgen heading the group of conceptual design with Thorsten Gätz, Jana Schell and Rebekka Thies. The hard- and software realization has been made by Prof. Dr.-Ing. Georg J. Schneider, Faculty of Computer Sciences, with Niko Schmidt, Julian-Marc Steffen and Christian Ternes.

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