Sense Viz

Qualitative Data Analysis in Architectural Education via Senses, Sensors and Scripted Visualization.

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ABSTRACT
Over the last decade digital tools became an integral part in architectural design practice and teaching. A variety of software and algorithmic methods enhance our possibilities in advanced building design. Yet our build environment is perceived with our body and senses. In this paper I present an information visualization course, which gives students an analysis method to interlace and understand the complex relationship between physical phenomena and qualitative evaluation of space. The tools and methods to achieve this aim were a combination of sensor technologies, algorithmic data visualization and phenomenological inquiry. A detailed description of the course objective, methodologies and students work are provided in this paper.

KEYWORDS: Information Visualization, Senses, Perception, Qualitative Data Analysis

Introduction

In architectural education students are by now very well trained and skilled in the use of software tools and also increasingly in regards to scripting languages, algorithmic shape grammar, generative and parametric design methods. They also learn about building physics, construction and statics, all three subjects related to material performance, which can be again calculated in specific software programs. Besides this digital part of materiality and space the architectural education also provides classed were the actual phenomenological perception is in focus.

But in general these two realms remain separated in education, even though they could benefit from each other and be combined to a powerful design tool and methodology.

In this paper I am presenting an information visualization course, in which a method was elaborated, to interlace physical phenomena and qualitative evaluation of a space, with the potentials of physical computing and programming techniques. The course title *SenseViz* (Pohl, 2011) derived from the objective to visualize our sensual perception. The fundamental idea was to make students aware of physiological aspects of spaces and how this sensual experience and analysis can be combined with the benefits of information design as the digital method. The subsequent sections explain the course objective in more detail and describe its' structure. The featured student works showcase the work process and merit of the developed design method. In conclusion I will discuss the major findings of the course and possible future course adaptations.

Course Objective: Digital Design Practice and the Senses

Nowadays digital design tools are well established in common architectural practice. They provide the possibility to create complex shapes, parametric models and are used to optimize static and energy consumption of future buildings. Apart from this virtual design and optimization process architects are depending on physical material properties to complete design decisions. Material decisions are not only made in regards to building performance but also in terms of corporal and sensual perception. Phenomenological aspects (Merlau-Ponty, 2005) influence the well-being in an architectonic space and its' qualitative evaluation by the inhabitant in a crucial, although often unconscious manner. From a phenomenological perspective there are many factors which constitute the personal spatial and sensual evaluation. Besides surface materials also the geometrical shape, the proportions and dimensions of a room, the natural and artificial lightning, temperature, humidity, sound and many other elements influence the perceptive process.

This exemplifies how complex the interplay between these factors can be and what professional architects should embrace in their design and its materiality, because this influences the wellbeing and also productivity of users and inhabitants in the build space (Pallasmaa, 2005). Nevertheless in the education of architecture students digital design processes and physical experience are often kept separated. Therefore the objective of the presented course was to integrate these phenomenological experiences in the evermore digital design process, thus in the daily work of future architects. In this course I also raised the question how this mixed media approach can then be used to improve the examined space by a conversion. In order to give the students a sense how to improve environmental working and living conditions I used qualitative data analysis and information visualization techniques as an instrument to turn the data set in a understandable and itemized overview of the underlying perception and influence factors and to bridge the gap between digital and sensual tools.

Course Modules: Digital and Phenomenological Methods

The course *SenseViz* had two technical sections, one was the technical challenge to capture and process data with the open source platform Processing and Arduino and the second was to analyze and interpret the collected data and to transfer it into a comprehensive information visualization. The course structure can be defined in three subsequent phases, which also outline the methodological background: In the first phase students made a phenomenological analysis from a first person perspective of an architectural space. The examined space could be indoor as well as outdoor, thereby the students should be aware of the distinct function and physical requirements (light, sound, humidity etc.) of this space. They should consciously feeling and experiencing the selected space with all senses. Apart from the onsite work and the discussion about their findings in the class, the students got a profound introduction into programming data visualizations in Processing. Also theoretical information and practical examples about different forms of presenting qualitative data (Tufte, 2001) were shown furthermore diverse methods were introduced to analyze such a set of data (Groat, Wang, 2002). To apply these theoretical skills in a practical design, they had to design and program a visual representation of sensual data The used data for this exercise were online sensor data from the *Pachube* (Cosm, 2012), now known as Cosm.com platform. On this platform a large variety of different sensor data from all around the world are available. All data could be obtained as comma separated values (CSV), which students than imported in Processing to create a graphical representation.

The conscious examination of the space made them aware of what the essential factors are which give significance and meaning to these special build environments and prepared them for the next step. The students had to decide on what physical aspects they want to focus and how they could measure and record them. In regards to the technical solution the students had different approaches to collect the required data. They could access the sensors from their devices, like laptops and mobile phones, use sensors from the Arduino hardware assortment or build their own sensors. The majority of the students decided to build their own sensors, since I introduced them to Arduino hard- and software and provided also a basic knowledge about electro-technology. Students started to design and build their own sensor prototypes to chase the important physical phenomena. This practical approach was part of the engagement with physical phenomena and their possible effects on the lived environment.

The Arduinoboard was used to record the data from the sensors, which acted like the technical counterpart of their own corporal sensor system. Apart from gathering data via sensors, they documented their own experience throughout the collecting process in order to evaluate the data set afterwards. In the last module the students had a large, abstract dataset and should transform it into useful and readable information. Moreover the information should not remain an isolated data set, but have lead to qualitative valuation of the utility of the space, which was part of the last phase. Due to static and dynamic visual representations of the dataset, students produced an understandable visual image of the complex interplay of diverse factors and phenomena. These results could be used further to redesign the spaces. How students developed their visualization and examination concepts will be described in the following section on the basis of two student projects.

Students' Work Progress and Results:

In our living and working environment sound is a crucial factor for the concentration and productivity as well as for our personal wellbeing. How sound and sound pollution can influence our habits during a day is shown in the first student project *Good Vibration*. The student decided to analyze his apartment in regards to the noise from the surrounding apartments and the urban area.

He investigated how this noise affects his productivity but also his relaxing during the observation and data recording. To record the sound he used a piezo element, which doesn't detect common frequency of sound but the vibration, hence the structure-borne sound, which we can not only hear but also feel with our body. For the vibration recording he developed his own highly sensible and precise sensor (see Figure1). During the first test with the sensors, it became obvious that the sensor is not sensible and precise enough; therefore he improved the prototype by putting an additional weight in form of a tin-solder spool. This elements enhanced the sensor capacity and the structure-borne sound was measured every tenth second over several days. The time and the vibration data were stored in a CSV file in order to document the arrangement and to reproduce it in form of the visualization. Visualizing the overlap of vibration and time in form of a qualitative significant form was a process which was not only focused on the graphical solution. In fact during this process the students got a grasp on the cause and effect of physical phenomena in a building. The data were connected to the time as well as to his personal observation and notes.

The graphical result in this case was an interactive data visualization, whereby the user plays a central role in the graphical representation. A grid of small spheres creates a three dimensional sound landscape, thereby the x and y coordinates represent time, and the z position of the elements is indicating the intensity of the vibration (see Figure1). The user can navigate through this landscape and also select via graphical user interface (GUI) different dates, times and places in the apartment in order to compare them. This form of graphical sound - interpretation and its effect on the user indicates the critical stage when the structure-borne sound is disturbing. Focusing on this special characteristic of sound he could detect when the peaks of impact and localize them, this could be used as guideline for sound improvement in the apartment when it is renovated (see Fig. 1).

A similar approach in an indoor environment had the second project *Workspace*. In this case the student benefits from the build in light sensor a microphone of his Mac Book Pro. He examined three working spaces, which he is using very often and observed his productivity while noise and natural lightning are changing over time. The timeframe of the data gathering for each place was an entire day, from eight a clock in the morning until six a clock in the evening. During this time three values were continuously saved in a CSV file: time, light value and sound volume. In order to generate a qualitative data analysis the student designed a static representation of his data, which is updated over time with the new sensor data from the CSV file, hence the user can not interact with the visualization. The presentation is split up in three segments, which shows different, juxtaposed levels of information details (see Figure 2).

From a graphical perspective he used three very classical presentation modes: the bar, pie and line chart. Within this graphical breakdown of information, he shows current data values of light and sound with a line chart. The pie chart is the central and most complex data visualization element, since it represents both elements during the last hour with the exact numeric value. This chart also contains the qualitative evaluation presented as an inner ring. Light values within this ring, presented as bars, are optimal for working, as soon as they exceed this marking ring; the light is too bright for working. The same occurs to the second ring indicating the sound values. In the three line charts the entire three days are presented separately and can be compared to each other. In conclusion the student stated that in a next step he would also integrate the exact geometry of the room in his data set and then observe all three locations over a longer timeframe.

These two projects exemplifies how students applied the technological but also the phenomenological tools showed throughout the course. Other projects were focusing on outdoor environments in different scales,

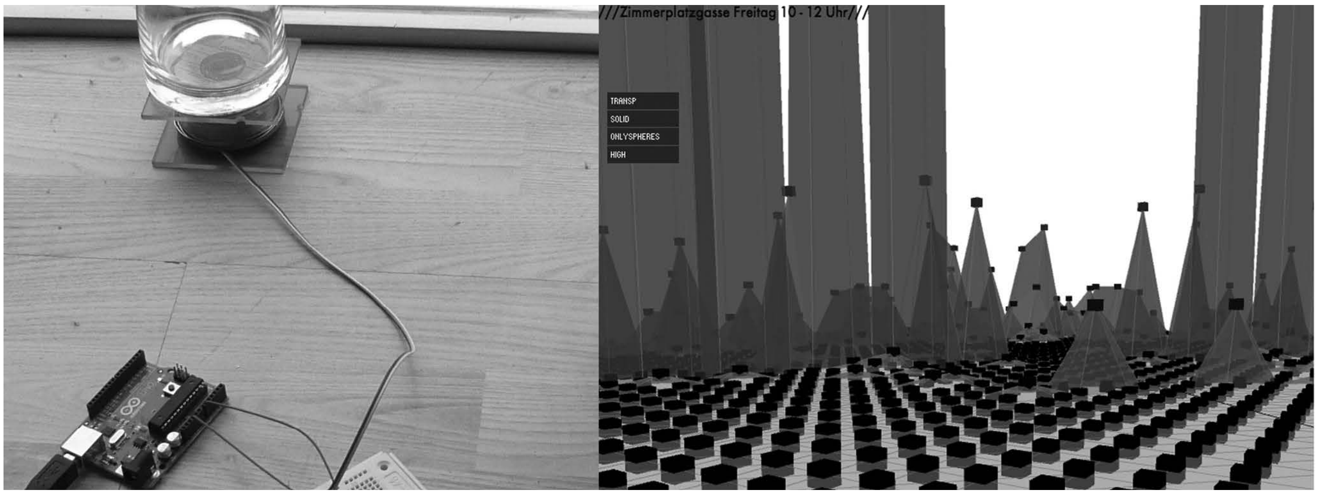

Fig. 1. Left: Sensor prototype connected to the Arduino board. Right: Sound landscape fly-through sound data.

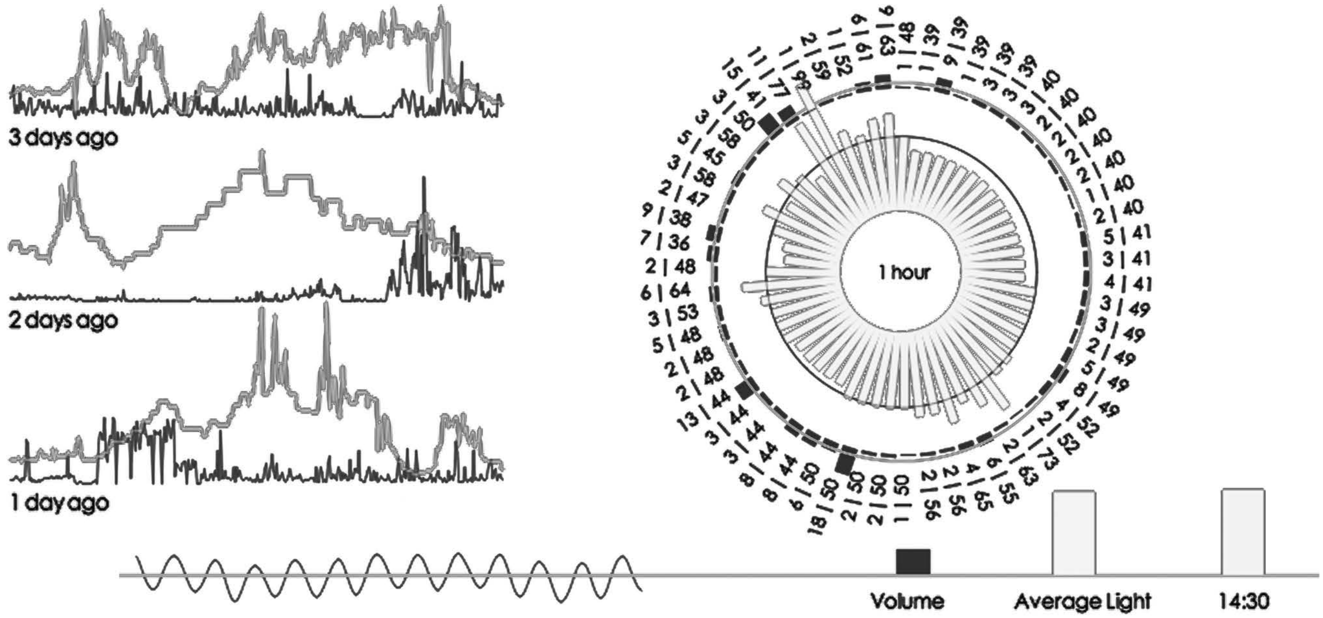

Fig. 2. The student project Workspace investigates how natural light and sound in a room are influencing the productivity. These factors were observed and recorded over three days.

for example examinating different sound areas in a housing complex, using a network of microphones . The student developed a sort of sound mapping as graphical solution, whereby also the sound sources were recorded and used in the interactive visualization.

Discussion and Conclusion:

This course showed how students are benefiting from combining their personal sensual experience with digital technologies. We can benefit from the ever increasing amount of available and cheap sensor technology and the physical computing platform Arduino, which has already opened up new interactive design direction for architects and students. Within the information visualization course one focus was on the graphical presentation of gathered data, informed by our senses. This visual interpretation of other non visual factors was an important part in solving and understand the complex interplay between these factors and the spatial experience. Thereby the data gathering was a central aspect in tackling the disconnection of digital and bodily fields.

All students gathered a deeper understanding how strong the examined space is affected by the special physical aspects. The majority of the students wanted to develop the project further in terms of examine the spaces over a longer period of time, including more physical factors to compare them and make user surveys with other persons. Many students are still working with Processing and Arduino on other projects. As far as the author knows the students are benefiting from the methods presented in the paper in regards how to analyze their environment and how to integrate this techniques in similar design challenges. To build their own sensors or hack existing ones and to design a visual representation of the findings turned out to a very effective technique to analyze the space and to see were design improvements could be made. In a further step these findings could be transferred into a design proposal.

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