INTRODUCTION

Digital representation of architecture is not the choice, but a natural consequence of the widespread use of CAD. Each project being prepared with the use of computers is carried out in a virtual environment. You can ignore this fact, or benefit from it. In basics - by exploring cheap training ground, which - through the use of appropriate apparatus - simulates the effects of future construction. More broadly - as an individual expression in unique environment. Through implementing digitally represented objects, architectural message gains the ability to transfer not only appearance, but also functionality (Mitchell, 1998). Thanks to the Internet and devices of virtual space, users “live in buildings” remotely, in parallel space or before construction.

Architectural Work represented digitally achieves the aspect of execution. Depending on particular demands - generates signals transmitted to the various senses or creates complex simulations. By utilizing the functionality of digital medium, architectural idea approaches the specificity of the score. The composition of space, like a musical composition - defines the boundaries of freedom determined by the author. Digital realization - provides a multiplicity of representations and generates room for interpretation. By spatial simulation, non-existing buildings, gain a new implementation or an extension.

Society of control, thanks to digital representation can change the nature of the interaction within the work space. People will not only be able to create and use objects in a linear sequence of events. Through telepresence, remote participation, and advanced communication means they will get the ability to develop “controlled” architecture, which interactively modifies its forms and usage scenarios. It will also reconstruct the relations of the architect and client. Industrial specialization replaces integration competence. Prosumer will gain the possibility of independent creation (control) of buildings. The

Low-Tec Sensor Concept for Reactive Space Programming

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Abstract. This paper presents a case study of the pavilion built with the participation of students during experimental design course of ASK studies, master program in Warsaw. The installation was developed to research programming behaviour of augmented space. Pavilion generates acoustic signals in relation to user actions. It does so, according to the rules stored in a program that can be changed through the user interface. The pavilion serves both as a didactic and experimental installation. Therefore, a single low-tec sensor was invented, which operation can be easily understood. Optical mechanism analyzes the image of a shadow to obtain information about interior use. Components of the experiment are used to control process and establish rules. Mode of action is defined by independently designed system procedure.

Keywords. Interactivity; behaviour programming; shape recognition; camera obscura.
Architectural communication has changed in the age of information. Materiality of space as well as human responsiveness are exposed now to the impact of digital messages and representations. Mixture of physical and virtual components construct augmented three dimensional context. Multiple interpretation came into architecture in the sense that it exists in aleatoric music. As a replacement for definite building image, new architecture offers numerous alterations dependent on parameters. Environmental constraints as well as user demands influence spatial solution in real time. Interactivity catalyzes architectural creation and perception (Saggio, 2010). Society of control is our present day. Contacts have here non-linear character - parallel and relational (Deleuze, 1997). Principles and behaviour patterns are replaced by passwords and codes providing access to particular contacts and functions. Position in global connections network depends on fulfilling certain conditions. Man of control does not use machines dedicated to specific tasks, he uses computers and Internet. Contact with them does not consist in management, but interactive control.

Since interaction has become component of the message, architects have started to develop creation techniques embracing feedback features. Consequently – architectural education needs to address interactivity as it complements professional workshop. However, creating interactivity differs from traditional space shaping as it is constructing process rather than any permanent structure. It demands programming and interdisciplinary knowledge.

ASKtheBOX pavilion, described below, came into being as a learning environment built by students to interact with digitally augmented space. In particular - to program behaviour of 3D object, research multiple architectural representation, distinguish between initial setup and temporal architectural state of reactive space and to integrate various artistic expressions (music, architecture, visual art) within common digital medium environment. Implemented methods tended to incorporate any components needed (space, material, process, program). However – infrastructure and tools were limited to allow full understanding and participation. During two weeks of intensive workshop whole installation was designed and constructed from scratch. Final installation - interactive “instrument” -
was equipped with tuning mechanism, which enabled to calibrate its behaviour and functionality.

SPACE AND EDUCATIONAL CONTEXT
The pavilion named ASKtheBOX was built at the Department of Architecture, in Warsaw and was open to the public on April 19, 2011. It is the result of experimental design course of master program Architecture for Society of Knowledge co-founded by EU.

Experimental projects bring important component to the concept of ASK. They allow to focus attention on the method of research. Require to determine the observation environment (laboratory), conduct tests and the objectification of observations and records. Implemented technique descriptions, measurements of spatial simulation, functional remarks - enable to construct student’s semester project.

Work on ASKtheBOX project lasted over two weeks. In the first step teamwork was based on the division into five groups: sculptors, developers, builders, composers, and coordinators. The crews worked on specific tasks independently, but always bearing in mind the common concept of the pavilion and the final vision of installation. Sculptors designed the interior of the building as a background for action based on the relationship of light, shadow and music. The developers have scripted a program that controls the operation of the installation. Builders checked in practice capabilities and limitations of the concept implementation; selected a suitable material for the inside and for the screen. They also built the pavilion prototype in 1:1 scale, which required cutting about 600 unique items. Manufactured items were labelled, sorted and assembled. After that builders installed the equipment necessary to operate installations: the speakers, projector, screen, wiring. Construction of the pavilion lasted continuously for 7 days and claimed more than 300 plates of polystyrene. Composers created components for sound reaction of the pavilion. Coordinators watch over the whole organization of the workshop, cared for effective communication between groups and supplies. In addition, they designed visual identity of the workshops and published it as a blog, video and website.

ASKtheBOX was meant as testing ground for the programming of space research, in particular - for the study of the phenomenon of interactivity. Cuboid with dimensions 2.5 m x 2.5 m x 3.75 m was assembled with wooden boards as a boundary of experiment. The interior was shaped to provoke

Figure 2
ASKtheBOX design: computer model, digitally fabricated model.
various behaviours - moving, sitting, touching the highlighted points. Authors strived to create a mood of immersion in the alternative, detached environment. Initial “cave” shape was given by recording a cloud of human activity, which served as a negative template for curved walls and the ceiling. Sequential pictures were taken periodically and mixed together to map probability of use of the space. Than modelling process began. It involved three parallel procedures:

- traditional moulding in clay,
- sculpturing voxel space with haptic devices (Sensable phantoms),
- defining the geometry directly - using the 3D editors.

Experiment was developed to test in 1:1 scale. Computer model needed to be transferred to real scale and produced with implementation of durable material. Sliced NURBS shape was divided into pieces to match the factory size of styrofoam plates. Fabrication process required application of digitally controlled thermo cutter.

By the time all labelled pieces were mounted together, our laboratory was ready to put digital substance in it.

**SENSOR AND OUTPUT**

In order to expose the mechanism of interaction, we wanted to avoid technically complex devices. Hence the concept of a low-tec sensor, that implements mechanism of perspective reconstruction of the shadows.

A strong light source was placed at the entrance, while the opposite side was constructed as a translucent screen. Any person or object placed between the light source and the screen casted shadow. Shape and darkness of the shadow depended on person/object location and size.

The camera placed outside the pavilion recorded the shadows (performed by users) from the screen, and provided regularly refreshed images to the computer. The mechanism of projection has replaced distance sensors and provided synthesized information about the distribution and movement of people.

The reaction of pavilion could be anything that brings signals for human senses - movement, light, smell or sound. For our needs, acoustic signals were most suitable - fitting low-tec concept of the system. Speakers plugged into computer fulfilled equipment requirements producing sound that came directly from Processing libraries.

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*Figure 3
ASKtheBOX behaviour: installation in use, scheme of sensitive zones.*
INTERACTION

ASKtheBOX plays (creates) music that corresponds to human behaviours inside. Images were captured by our low-tec sensor several times per second. Sequence of shadow maps, transmitted to the computer managing the system, contributed coded information about movements inside the box. Detection was then performed in the course of comparing pixel status (in time and in relation to programmable matrix).

Music played as output was composed in the real-time. Two different procedures were applied. First combined predefined elements - phrases, instruments synchronized in time. This allowed to strictly control the rules but limited variety of output. Second - generated acoustic signals, gave unlimited sound diversity, but demanded highly complicated system of rules.

ASKtheBOX depends on program that runs the installation. Each component - physical shape, spatial environment, projection mechanism, computer infrastructure - takes part in cyclic process of grabbing, analyzing, projecting information and formulating rules. The way installation works, is defined within system procedure that is individually designed and coded.

System managing the installation consisted of several modules realizing the tasks performed by ASKtheBOX:

- image recognition - formalization of the observation by creating a matrix of points, the analysis of contrast, changes in illumination and defining fields of activity/movement;
- triggering reaction - definition of active zones and the configuration of performed actions;
- creating musical effects;
- coordinating the system;

To ensure that the manipulation does not require programming intervention, the pavilion was equipped with a “Control Panel” utility that provided access to the internal mechanism of behaviours. One could use the system configuration files (.txt sheets), manipulating selected musical motifs and defined modes of operation. One might also add, move and change shape of the fields that trigger effects. As a result - pavilion could be tuned as musical instrument - adapting the configuration most appropriate for achieving the desired objective.
THE PROGRAM
Processing environment was implemented to script program performing all ASKtheBOX functions. Image recognition was based on preparation of images grabbed by camera. Images coming to the computer were simplified and interpreted. Finally, transformed into matrix of 36x24 pixels of greyscale. Gray contrast factor (darkness) contributed information about presence of user and distance from the screen, while changes in greyscale measured for particular pixels - information about the movement.

Trigging reaction depended on the procedure of comparing picture states with user-defined matrix of sensitivity. Particular image sectors were defined to be active. Exact grey amount detected in the sector, triggered the acoustic component. Several sectors were programmed differently - to switch between predefined modes of operation or to activate functions.

Music played by ASKtheBOX was composed in two ways. Analog music – was predefined outside the system, in Logic application, as synchronized loops. ASKtheBOX program managed loops, just like musical sequencer does. Using global time system switched on and off loops performing needed fades and transitions. Choice of motifs depended on calibration sheets uploaded by Processing at the beginning. Digital music was generated within Processing program (through MIDI libraries). “Touching” sensitive zones - trigged MIDI instruments on proper volume and frequency.

CONCLUSIONS
Testing of ASKtheBOX pavilion started during experimental design course. The guests explored the interior allowing students to tune the parameters of logic. During the opening of the pavilion over five hundred visitors interacted with it. Their behaviour was recorded and analyzed as well as personal impressions.

Since opening to the present, pavilion ran repeatedly. It was exposed not only to those who are interested in architecture. ASKtheBOX was presented during the Museums at Night – cultural event and exhibition organized periodically in Warsaw.

Observations of users’ behaviour indicate that contact with the pavilion is different for different age groups. Older people sought to know the rules before entering the interior. They strived to research poster explaining pavilion concept and only then verified functionality. Children - the opposite - they learned through the interaction with space. The fact confirms the discrepancy described by Deleuze (1997) - a society of control implements alternative cognitive methods.

What did we learn experimenting with ASKtheBOX? To begin with, we explored new medium of architecture. Medium that Bill Mitchell described as augmentation of space that changes rules. According to typology given by Lev Manovich (2001) new medium is obviously: digitally represented, modular and automatic. What stroke us much more - it is also variable and transcoding. After insertion of information genes - space becomes undefined. It is the population of possible physiognomies rather than finished form. Digital medium translates signals itself. Location in space, image, music data, are on the level of bits identical. Transcoding information we are now able to switch between different languages of artistic expression. Strong correlation between space and music was not accidental in our experiment. And it is not only output format that benefits from musical methodology. Long time before computing became crucial technique for organizing processes, music researched algorithmic composition using analog or semi-analog tools. One can find signals of this direction in medieval Guido d'Arezzo Micrologus and in Mozart's Musikalisches Würfelspiel (where composer sets rules and playing dice contributes needed entropy to the system).

Design object has changed. As Kas Oosterhuis underlined - we do not design objects anymore. Through the evolution of interests we focused on the subjects which are in most cases processes of getting shape, functioning, falling apart, recycling. To design the process, ability of programming is needed. As a matter of fact - it is new competence of artistic correspondence that catalyses interaction from both sides - author’s and user’s.
REFERENCES


Saggio, A 2010, The IT Revolution in architecture; thoughts on paradigm shift, New York.