PHYSICAL MODELS OF BUILT HERITAGE – MAKING ARCHITECTURE MORE COMPREHENSIVE TO THE BLIND AND VISUALLY IMPAIRED

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Introduction

Historical architecture can relate to an individual through all of the senses, which means that it has multi-sensory dimension. Architecture experiences are the results of perception and experiences are required via sensory systems. Contemporary architecture struggles with a impoverishment of the multisensory qualities, whereas historical buildings generate haptic, gustatory, olfactory, auditory experiences. Cannot be denied that architecture is contingent on visual language and practice, however the haptic sense, or the sense of touch largely contributes to the experience of architecture. Pallasma claims:

> All the senses, including vision, can be regarded as extension of the sense of touch – as specialization of the skin. They defined the interference between the skin and the environment- between opaque interiority of the body and exteriority of the world[1].

Referring to the tactual perception, visual impaired in comparison to sighted visitors have better and more accurate sense of touch, resulting from, among others, greater sensitivity and the ability to differentiate shapes[2].

Historical architecture are often visited by sight impaired and partially sighted people, whose perception of form and space is limited and mainly dependent on their sense of touch. Vision loss is compensated with the other senses and when dealing with the reality cognition it is the touch that dominates. Géza Révész defined this as the 'vicariate of the senses[3], or the quest for a substitute for the senses. Haptic perception entails direct interaction with an object. The perception of architecture is often extremely limited if not impossible due to the size of a building, an ornament position or a top-down prohibition against touching objects. It is impossible to embrace the entire building, touch the detail on a ceiling or learn items not permitted for tactual perception. Mock-ups are considered

[1] Pallasmaa, Juhani. The Eyes of the Skin. Chichester: Wiley-Academy, (1996) 2005, p. 42.

[2] Lai, Hsin-His, Chen, Yu-Cheng. *A study on the blind's sensory ability.* International Journal of Industrial Ergonomice. 36, 2006, pp. 565-570.

[3] Révész, Géza. *Psychology and Art of the Blind*. London: Longmans, Green 1950.

a suitable method to depict architecture and that is why they are increasingly being ordered by various cultural institutions. Museum of the City of Lodz owns a model of the dining room of Poznanski Palace created with the blind and visually impaired in mind.

The touch replaces the sight; the mock-up supports the perception of architecture

The study on the perception of the blind and partially-sighted exploring the dining room and its mock-up showed that the sense of sight may, to some extent, be compensated with enhanced sense of touch when dealing with the architecture. Fingers sense shapes and recognize geometrical relationships. The skin reads the surface texture, the temperature and density of materials. It is believed that the touch is a form of a human control and the ultimate empirical evidence of reality. A doubting Thomas refused to believe without direct personal experience. The touch is the sense that is always considered to relate to the physical, immoral and sexual.

However, the sight differs from the touch in many aspects. The sense of vision is tele- analyzer while the touch is a contact- analyzer. This means that the receptors respond to visual stimuli from objects located at a great distance, whereas touch requires a direct contact. The way of perception is also different. We look at a number of objects or phenomena at the same time (simultaneous impression), by touch we learn step by step (successive impression). Haptics perception is characterized by discovering from general to specific, and the visual the other way, from the specific to the general. It translates into fragmented remembering and creating the whole picture. For example, a blind person gets to know a car through touching door handles, mirrors, trunk, later bumper and then creates the imagine of the entire car. Naturally, in the case of architecture the opportunity to trace the source of information is limited, and it is not possible to embrace the whole building by hands. A fundamental difference is how senses work. Stimuli operate at the sight continuously, in contrast to the touch, which seeks, and then detects the appropriate stimuli. Sensory receptors of sight and touch carry other information. Through vision people get to know the color, light and perspective. The touch informs about the texture and density of objects, however it is difficult to detect the movement understood in a traditional manner.

Meaning of historical architecture to the blind

Historical architecture, as part of the cultural heritage, plays an important role in the development of civilization, having an impact on social identification and tradition. Not only is it a source of knowledge in, among others, historical, social and engineering fields, but it is also a space. A number of historic buildings are often adapted to museums, concert halls, theaters, libraries and other cultural institutions. Being public utility facilities, they must meet legal accessibility standards for people with disabilities, however there are no requirements as to their perception. In order to show the architecture to the blind and partially sighted, the space and the

form are described in the following manner: Braille alphabet, audio description and occasionally through a mock-up. Physical models provide information, whereas the interpretation itself entirely belongs to the recipient, unlike the description which is often subjectively characterized. This article presents the process of creating a mock-up and its application as a proof of the usefulness in improving and providing information about architecture to the blind.

The subject of study – the dining room

The dining room is the most representative room in the palace built in stages from 1898 to 1903 by Israel Kalmanowicz Poznański and his heirs. This manufacturer's residence is one of the largest industrial palaces in Europe. The author of the first draft was Hilary Majewski. Its final form however, similar to the current one, was reconstructed according to the project of Adolf Zeligson in years 1901-1903. The palace is Neo Stylish with some elements of Art Nouveau decoration. All important business meetings, events and decision making processes would take place in the dining room because of its magnificence. Next to the design, the room dimensions are as strongly impressive. The hall is 10 meters wide, 20 meters long and 8 meters high. The interior is represented by a big fire place with a painting of Samuel Hirszenberg hanging above it and vast china closet decorated with allegoric sculptures and semicircular pediment, both integrating with oak-paneled walls. Sculptural decoration in the upper part of the room creates a three-dimensional frieze which surrounds a number of elliptical windows. The sculptures are the size of a man, and the frieze is 3.5 meters high. It surrounds all the walls forming the esthetic culmination of the space of the room. Rich stucco covers the entire surface of the ceiling. In the center of the room there is a large five meter long table with 8 chairs in the Neo-Renaissance style.

The dining room as the most representative space of the Museum of the City of Lodz is frequently visited. Once a month, the museum organizes special guided tours entitled 'Museum on at your fingertips' for the visually impaired visitors. The meetings are attended to by about 30 people on a regular basis in order to visit the hall of mirrors, Poznański cabinet (office), palace garden and the dining room, the latter being considered the most difficult for non-visual perception. The room space is not possible to be fully perceived due to the location of decoration and large dimensions.

The process of making mock-up

"Science (for) Art" project was launched by the Museum of the City of Lodz, which through the efforts of the Department of Dissemination and Education, had received a grant for the purpose in question. It is within the project that, inter alia, the model of the dining room was made. The purpose of the model was to teach visually impaired about proportions, shapes, scale and interdependencies in architecture. It is also a source of knowledge about the decor of the room. The mock-up is now available in the hall for an unlimited period and for all visitors.

Fig. 1. Mock-up in comparison with the interior of the dining room
Source: photo by author.

The model of the dining room was designed within four months in 3dsmax computer program by students. The final mock however lasted 5 months. Students of the second year of Architecture and Urban Planning (two groups - 30 persons) under the leadership of prof. Anetta Kępczyńska-Walczak, modeled the room in a scale of 1:1 with high precision. Previously, students had made an inventory and photographic documentation.

The process of preparing and creating mock-ups was divided into four stages:

- STEP 1: analysis of perception of visually im-|paired basing on visiting the dining room.
- STEP 2: the selection of scale, materials and technology to perform the mock-up.
- STEP 3: prototyping (mock fragments) –in-terpretation of the reality.
- STEP 4: the combination of prototypes and other elements, and the creation of the whole mock-up.

The project, at different stages, was participated in by six blind and partially sighted experts in the age group 27-70 years: 4 men and 2 women from the Foundation for the Blind Chance who participate in 'The museum at your fingertips' meetings on a regular basis. The group had different stages of vision loss. Two men were partially sighted with a limitation to recognizing shapes from a few centimeter distance. The third man was completely blind (congenital blindness) and the fourth one had lost his vision at a certain stage of adolescent life. The two women had also lost their vision at a certain stage of their adolescent life. The direct contact with a group of people with various visual impairments who shared their insights during the tour as well as making the mock-up prototypes provided lots of significant information.

STEP 1: Analysis of perception of visually impaired based on exploring the dining room

The process of creating the mock-up of the hall was preceded by the analysis of the perception of the blind and visually impaired. The impact of historical architecture on human experience proved to be useful and had an impact on the form of the model. While visiting the dining hall, the blind experts said that the historic buildings had multi-sensory dimension and interacted much better with their senses than the majority of contemporary buildings. People, who had lost their vision in childhood and subsequently developed other non-visual senses above average and do not have such abstract view of the world as those with congenital blindness, noticed that non-visual senses had a great impact on the uniqueness of perceiving the space and the form. They appreciated in particular the historic architecture that evoked emotions with the use of simple measures.

Pallasmaa and Rasmussen also stated that historical buildings appealed to all senses and build the tension in one's mind[4]. Strongly stimulating sensory stimuli created an experience that would remain in the visitor's memory for longer. Stimuli usually appeal to particular senses to varying degrees and intensify the sensations. The receptors of sense organs may be activated by the play of light (feeling of warmth), by the relationship between spaces (impact of acoustic wave), by using appropriate forms and finally by applying adequate materials (haptic elements). Materials, which are well applied in the specific context of architecture, have sensual features and are sense-making. Zumthor said that the suitable form and meaning compounds need to be generated in a concrete object[5].

Fig. 2. Exploring the dining room with blind experts
Source: photo by author.

The dining room has been described as sensual. Blind experts were touching wooden wall paneling, which has a different structure and temperature than commonly used plaster. They paid attention to varied raised coffers, which give the character to vertical surfaces. Richly decorated fireplace in the form of faces of four women representing the four seasons, located on each of the pillars of the lower part of the furniture, startled the blind experts and evoked their positive emotions. Carved in wood garlands composed from fruits grapes, pears, apples and pomegranates placed in the wall panels and in rounded corners of china closet were quickly recognized and aroused great

[4] Pallasmaa, Juhani. *The Eyes of the Skin.* Chichester: Wiley-Academy. (1996) 2005. Rasmussen, Steen Eiler. *Experiencing Architecture*. Cambridge, Mass: MIT Press. (1964) 2001.
[5] Zumthor, Peter. *Thinking architecture.* Baselin. (1999) 2010, p. 10.

interest. The decoration was easily perceived tactually because of its clear layout, adequate distance between the fruit and the scale that was close to the actual size. The key aspect in the tactual perception (in the context of information providing) whereas the texture and temperature played crucial role in sensing pleasure from the act of relishing alone.

Contrary to the ornament, the scale and the symmetry of the room were difficult to determine because of the proportions. Distortion of auditory perception, caused by the attenuation of the echo signal through the window curtains, was one of the reasons why people with visual impairments found the examined object vague. Earlier, in the middle of the room there had been a carpet, which would reduce the spreading footstep noise. Items such as furniture can be a helpful addition in the size assessment process, however in the case of the dining room it was a question of one table and chairs. Basing on the table width, the blind experts were able to identify the dining room as a large hall by determining its proportions with number of steps. The amount of windows seemingly simple was often given in inaccurate number. Two pairs of doors placed between evenly spaced windows, fully integrating with the interior, with the same width and decoration as windows, were often not distinguished by the visitors. The fireplace and the dresser would not have been recognized at all by blind experts if it had not been for the tips from a museum guide. The problem is about the aforementioned span. Hall elements are larger than the standard ones and above all, they are difficult to be fully embraced with arms.

The mock-up consisting of three walls (excluding the ceiling) aims to complement the information about the dining room which visitors are not able to notice.

STEP 2: the selection of scale, materials and technology to perform the mock-up

The model was constructed in a scale of 1:25 considering the comfortable model size of 40 cm x 80 cm x 32 cm (height). A smaller scale (1:50) would cause the reduction of details and furthermore simplify the whole design. Too big mock-up, could in turn split the perception into fragments. By reason of the existing scale, the entire object can be easily embraced by hands. The choice of the scale has an influence on the understanding of the room proportions , the sense of symmetry and rhythm as well as on understanding the relationship between the details. At 1:25, the upper frieze made on the Makerbot Replicator 2 printer with working area of 28.5 x 15.3 x 15.5 cm was printed in its entire height, which did not generate any additional joints. That would introduce unnecessary divisions in the model sensed by touch.

The mock-up was divided into two parts in terms of materials, and thus technology. With regard to the dining room space, the bottom part of the model is made of wood and the top one of white PLA plastic. For the purposes of its execution, the top part was composed of 8 fragments / PLA prototypes and the bottom part was divided into 3 wooden walls and a floor with additionally-cut and printed details. You can freely put your hands inside the model and conveniently grasp each element.

The top part was made in Fused Deposition Modeling Spatial 3D printing technology where PLA (poly lactic acid) filament diameter is 1.75 mm.

The potential of 3D printing technology was fully exploited when creating architectural models of historic buildings as they are rich in details. The building of soft shaped forms on a small scale would be very difficult, and its execution time-consuming and would additionally generate high costs. An alternative solution could be wood or clay carving and then mold casting or coating with fiberglass and resin. All these technologies however would delay the process of making so called prototypes which have been extensively modified following the consultations with blind experts. The printed elements in 3D printing technology from PLA plastic can be printed a number of times and successfully improved. They are also more durable as compared to other PLA plastic materials. They can be cleaned and disinfected and therefore they make an ideal material for the tactual perception.

The bottom part is made of birch plywood reflecting the oak paneling. The interior birch plywood class 2/3, 3 mm of thickness, size 1525 mm x1525 mm is the best to succumb to laser cutting. The dimensions of plywood were so large that there was no additional joints. The choice of thickness resulted from the scale of the model and the haptic perception of blind experts.

The laser cutting technology is indispensable in terms of complicated shapes and faux wood finish laminate sizes. It is about introducing energy of high-energy cutting jet. Manual cutting would be laborious and imprecise, even with the wooden elements. Smooth edges without the loss of veneer on the surface and in the core were achieved with the use of laser. It is vital for the comfort and safety of the blind.

STEP 3: prototyping (the mock-up fragments) – interpretation of the reality

The first step was to simplify the computer model and to create the basis prototypes. It was important to modify or eliminate all details that do not contain any valuable information and that cause confusion in the haptic perception. When making the mock-up the clarity of forms and the choice of appropriate size are crucial. Human fingertips are not able to detect some of the details, while the eyes will see even minor differences. In some cases, the form needs to be specially enlarged to emphasize its importance, and sometimes it should be omitted. Taking into consideration the clarity of the tactual perception, the prototypes were repeatedly consulted with blind experts. The main problem was either too intricate or too simplistic message. Some blind experts pointed out the unnecessary depletion of models in order to eliminate interference. People with visual dysfunction found interesting to explore different planes. Discovering forms and relationships of the formerly unknown architectural decoration is a great pleasure in discovering.

According to the guidelines of blind experts various elements of the model of the dining room, which are composed of reoccurring geometric plant and figural motifs, have evolved the strongest. Garlands of leaves and fruit such as: pomegranate, pear, apple and grapes have been simplified to irregular hemispheres and positioned in a manner allowing the fingers to easily distinguish their shapes. In this case, the model is not a projection in full, but only an indication of a detail existence in a particular location. Area designated for the garland was not big enough to present the plant theme meticulously. Referring to the above, a blind

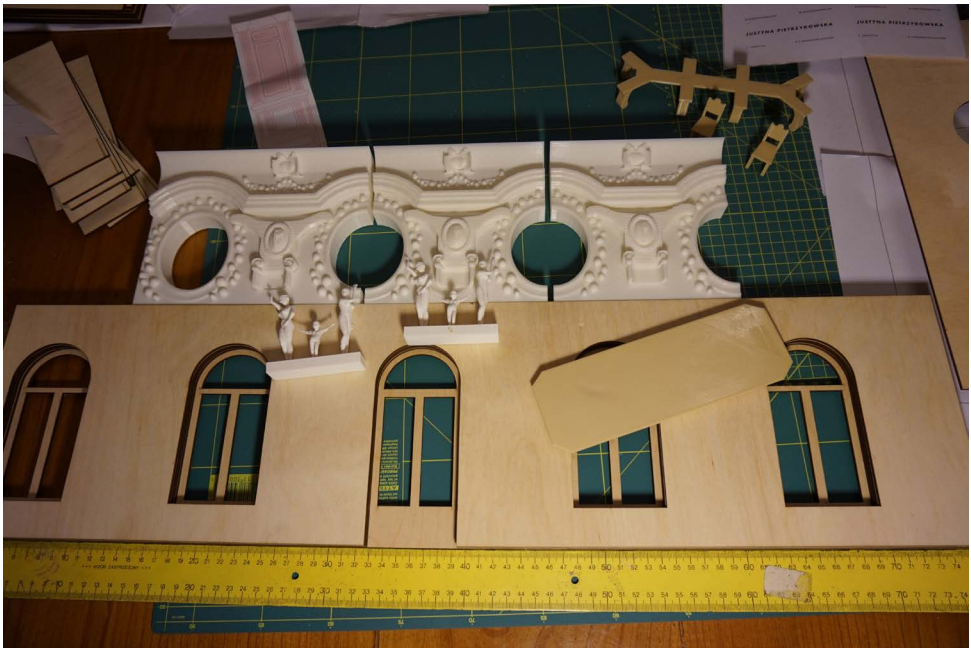

Fig. 3. Prototypes
Source: photo by author.

person is able to approach the real detail in the dining room through the touch. The palace mock-up sits in the hall and can be confronted abreast. Cartouche, which integrates the letter "P" for Poznanski, and is the background for the three allegoric statues, was also highly simplified. Some of the plant motifs and ogee, located by the sculptures of women, were omitted to the benefit of the communication transparency. What has also been reduced is the background scenery, which in the case of visual perception are visible, but obscured by the foreground elements are beyond the reach of touch. Cornice running around the whole space was highlighted to underline the continuity and link of all walls. Components such as oval windows, statues and some cartridges were not transformed or moved.

The bottom part made of birch plates was also consulted with blind experts. The thickness of a wall was obtained by combining 5 layers of plywood of 3 mm thickness. Three plates forming the walls were identical, whereas the fourth one included the division of window and door grilles. The fifth one, being the largest and external, was the support for the top part of the model. The wall coffers, doors leading to the next room and the fireplace were built by connecting properly laser cut wood plates. Changes made to this part of the mock-up were about reducing the coffers and the pilasters. Such elements as fluting were disregarded and the heads of pilasters reduced to a stroke. The form and proportions of the fireplace and doors were not simplified, yet without floral motifs. During the laser cut the laser beam burn off the plywood edges which resulted in their dark colour. The model

Fig. 4. The model 'seen' by the blind
Source: photo by author.

was designed for the blind, but quickly found interest among children and adults, so edges remain unchanged to emphasize three-dimensionality of the mock-up.

STEP 4: the combination of prototypes and other items, and the creation of the entire layout

The last step was to connect all prototypes and walls, and then laying them all out on the floor. In order to help visually impaired people to determine the scale of the model in an intuitive way, elements such as a table with chairs and statues of people were printed off for the purpose.

Conclusion

Is a blind person able to explore the architecture, which is commonly accepted as a form created for the eye? With a skillful combination of different media and basing on a properly created mock-ups the answer would be positive. The dining room mock-up in the Museum of the City of Lodz is an attempt of presenting the interior design to the blind and partially sighted. Through the mock-up the visual impaired can learn the detail of the frieze, which in reality is beyond the sense of touch. The model facilitates understanding of such details as the symmetry of the room, number of windows and the identification of the fireplace.