# Haptic Paintings

## *Using rapid prototyping technologies to grant visually impaired persons access to paintings, sculptures, graphics and architecture*

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**Abstract.** *The paper describes an ongoing cooperation of architecture students with museum educational services and visually impaired persons. The project aims at conveying non-haptic art like paintings or graphics in public exhibitions to visually impaired people (blind or partially sighted). The concept combines rapid prototyping technologies with art interpretation and strategies for transporting visual information by haptic expressions. To reach this goal the students produce small and haptic explorable exhibits of the paintings by using rapid prototyping technologies and manufacture hand-outs, which can be touched by the blind people during guided tours at the exhibition.*
**Keywords.** *Rapid prototyping; haptic experience; design parameters; inclusive design.*

## DIDACTICAL BACKGROUND

As an important aim in today's curriculum for architecture students the in-depth study of rapid prototyping technologies (RP) could be appointed. These technologies should not only be used and teached as a set of new tools to produce highly accurate models, but as an important and current development with great influence on planning processes, cooperation concepts and architecture itself.

Therefore it is even more necessary to introduce these technologies in a way to animate students to get in deeper contact with their principles, consequences, potentials and constraints. Our project tries to accomplish this by an uncommon combination of art and technique. By choosing this approach, we try to explore and evaluate possibilities to give architecture students a closer, more directly and more intensive understanding of RP.

The project is divided in three areas:

1. Exploring potentials and limitations of RP
2. Background and interpretation of a specific artist's work on exhibition
3. Classification of requirements of blind and partially sighted people

### *Rapid prototyping*

As a well-introduced chapter of modern methodology in most architectural facilities the potential of RP concerning model making seems to be obvious. But

the education is mainly focussed on reaching visual effects in detailed and precise models. Regarding our project it is more important for the involved students to be able to use a wide range of different materials which can be handled by RP machines to transport as many distinguishable haptic information to visually impaired persons as necessary. Another important aspect seems to be the developing of competences, which allow the students to decide at which point handmade solutions will lead to better results. In our project we therefore use a lasercutter, a 3D-printer and a 3D-scanner in combination with handcrafted parts.

## THE SPECIFIC ARTISTS

As our project first concentrated on a single specific exhibition, the students had to be introduced into the background and vocabulary of a specific artist. They must be able to extract the main components of his work, understand the specific time and environment and need to make a solid interpretation of the specific painting or graphic. Since these interpretations are always individual, the chosen view of the artist's work by the students should be identifiable as a possible but not an exclusive view to the painting itself. Experiences from special guided tours for visually impaired people were collected by especially produced haptic exhibits in wood since 2009 concerning pictures of the artist group "Blauer Reiter", Georg Baselitz, Joan Miró and Neo Rauch at the Museum Frieder Burda at Baden-Baden, Germany.

The first exhibition which has been supported by introducing RP was the 2011 retrospective of the German painter Neo Rauch (*1960) at the same museum. The process has been attended by a group of blind and partially sighted scientist of our university. This cooperation is of a very high importance for the students, because they learn to recognise the haptic possibilities of blind persons whether they are blind by birth or got blind later in life. Also the exhibits should be useful to persons with a strong sight disorder but a rest of ability to see.

## ENVIRONMENT

The Study Centre for the visually impaired Students (SZS) at the Karlsruhe Institute of Technology (KIT) exists since 1986 as a pilot project of the federal states Commission for Educational Planning and Research Promotion. The innovative scientific approach consisted in using modern information and communications technologies and an integrated consulting and care concept in order to open new study and occupation possibilities to visually impaired persons, in fields which were so far more or less inaccessible to them. These were all those socially increasing important fields of natural sciences, engineering and economic sciences. Until 1993 the pilot project "computer science for the blind - studies for blind and partially sighted people in computer science and economics" was able to grow to a holistic concept, in order to get institutionalized in the faculty for computer science of the KIT as a university-wide centre.

The successful establishment in 2011 of the professorship of "IT systems for visually impaired students" supplements the previous fields of activities of the SZS with new key research topics. In the meantime visually impaired students study among other things computer science, economic science, biology, physics, meteorology, geo-ecology, philosophy, literature sciences and sociology.

A general goal of the SZS is to support blind and partially sighted students at the beginning and during their studies as well as during the transition to the working life. Each first-year university student went through an intensive consulting program before beginning their study, completed mobility training and received domestic technical equipment. Integration and thus to study, to live and to work like and together with their seeing fellow students is the central message of the SZS.

## REQUIREMENTS OF VISUALLY IMPAIRED PEOPLE

In assessing and evaluating the requirements visually impaired persons have concerning the exhibits,

*Figure 1*
*Neo Rauch "Start" (1997, Detail), rapid prototyping element and haptic painting.*

one has to consider the reasons for their impairment, whether it is blindness from birth, or later, or a partial visual impairment which makes the situation even more difficult. The very different competences in using tactile materials belong to the following facts:

- Starting time of the disability: Birth blind have in general more experience in using tactile materials and Braille. This is due to the special education for the blind in their special schools. In most cases birth blinds are not able to recognize three dimensional and perspective graphics. Persons who got blind later in most cases may have more problems to recognize tactile materials because the tactile sense of their fingers is not trained well. Later on, when their perception gets better, they can use their graphical memory. From that point they are very successful in using tactile materials.
- Degree of the visual disability: Many partially sighted persons are not able to view three dimensional things. For example if they only have partially sight on one eye. Another reason for that phenomenon is a tunnel view. In this case the person has a very restricted view as from within a tunnel, where the outer parts are not visible. The main problem is that they might get lost in viewing large things.
- Colors and light: If someone wants to produce materials for those who still have some remaining sight, one has to take colors and contrasts into account. Especially if the clients use magnifiers with negative/color inverted presentation the correct colors and contrasts are very important. Partially sighted persons are generally not as experienced in using haptic or tactile models as completely blind persons; therefore they might need some additional information. At this point in time they hold the picture directly in front of their eyes and try to identify the colors. That's why it is important to use high contrast colours on each individual part of the exhibits to provide an optical guidance. Even if it is just black and white.

Independent of the individuals the ability for haptic sensitivity could vary in a wide range and must influence the level of detail of the exhibits itself. Therefore the exhibits or tactile/haptic materials need as well a detailed explanation (written or spoken) to provide the necessary background information for the haptic experience. With this base all visually impaired persons are able to explore the exhibit. Additionally the haptic models can consist of different haptic materials (wood, metal, plastic, cloth, wool, etc.) to describe different parts of the exhibit.

## EXPERIENCE

Since more than 20 years, the Studycentre for visually impaired students of the KIT provides besides textbooks – in Braille, audiorecordings and nowadays electronic versions – tactile print outs of all kind of graphics. The experiences reach from simple sketches up to complex mathematical or electro technical charts (examples figure 2 & 3).

Today all fields of study – as well the normal life – include a great extent of media and graphics, which should be available to visually impaired users, too. But it is not natural that visually impaired students can work with tactile or haptic materials. Thus the students or persons get trained by experienced blind scientists how to read and work with this kind of tactile material. By the daily use of the tactile graphics, the users even help to improve the future material and objects. Even were it would be helpful to have an 3-dimensional model for a deeper investigation.

During the last years it has been shown that the transcribtion of graphics has to be done on three levels:

1. Textual solutions: figures / pictures / drawings which are easy to understand or serve as visualized summary of context developed before and can be transferred in a textual way.
2. Textual and tactile solutions: the graphic is complex and combined with text. First, the process is a reduction of the graphic: removing caption, marking, legend, etc. In short removing unnecessary and confusing lines and information, broadening the important lines. A summary of context developed before can be transferred in a textual way. Secondly, we describe the graphic in simple words, easy to follow and understand. Type and structure of the graphic as well as the arrangement of the elements are explained. Deleted elements are mentioned. The graphic will also be printed by a tactile Braille embosser in a tactile and visual way so the sighted and visually impaired students can use it in the same way.
3. Tactile graphics: there are pictures and graphic information not to be described verbally and

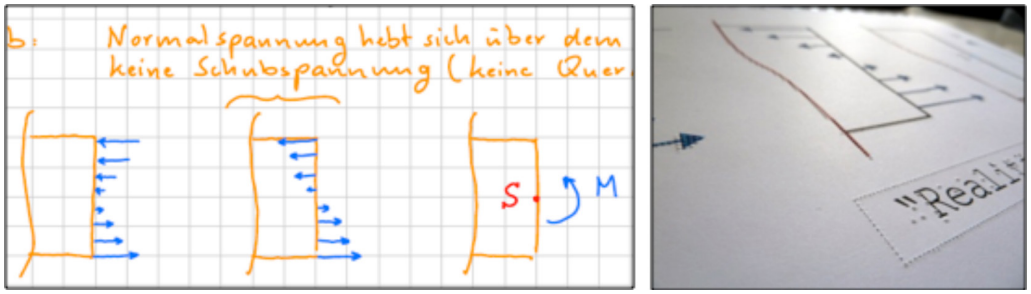


*Figure 2*
*Left: handwritten lecture notes, Right: transformed tactile print out in black & white and braille.*

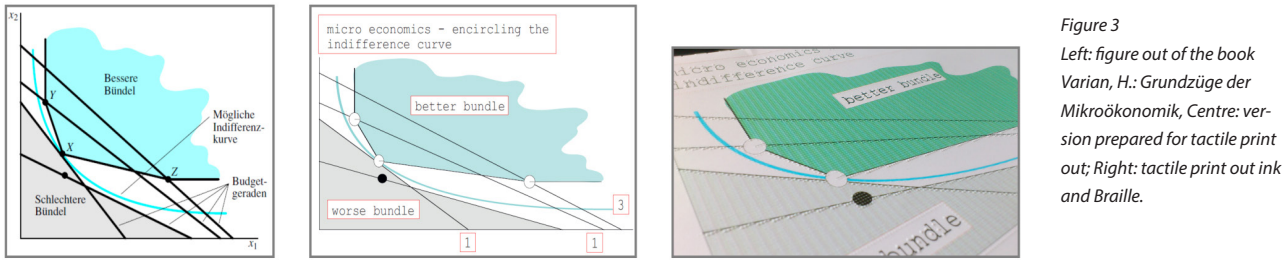


*Figure 3*
*Left: figure out of the book Varian, H.: Grundzüge der Mikroökonomik, Centre: version prepared for tactile print out; Right: tactile print out ink and Braille.*

written down, e.g. geographical maps, plans of public transportation systems. In this case one to one tactile versions are produced.

The whole work is not only done for academic users. It is even important to provide information to everyone who wants and needs the information.

An example for the way to reduce information and prepare the design for a haptic model is shown in figure 4. The text around the woman in the leaf, which can be interpreted as a reference to Ovid's "Metamorphoseon libri", contains too much information for the visually impaired observer and is just part of the written or spoken description of the picture.

The reduced version in the center is the basis for a 2-dimensional tactile / haptic printed version of the picture, which can be reproduced and handed out to the visually impaired persons. For light sensitive persons, there is as well a version with inverted colors. The picture shown above was part of a museum tour where the tour guide descriped the exhibits in detail to the participants of the tour.

This previous example is a quite easy ascertainable exhibit, but there are many more complex objects, that need more dimensions to transmit the information to the visually impaired. Not even the third dimension is enough, even another dimension by material or surface structure is necessary. Exactly here the research started with the exhibits by Neo Rauch.

## IMPLEMENTATION

Museum tours especially designed for visually impaired people with detailed explanations or models that can be experienced in a haptic way, are still rare. There is little literature on the subject, and there is a lack of widespread experience. Even the museum tours for visually impaired people described in the manuals of Fröhl (2007), Candlin (2003) and Rambert (2011) only take into account experiences with sculptures and furniture.

In our project each visually impaired visitor gets an individual handed out model in about the size of a hand that can be experienced through tactile senses. When describing the picture the tour guide puts the fingers of the visitors to the specific location on the painting he is actually talking about. The main objects of the picture - such as humans - are separately shown on special haptic models, so that they can be explained separately. The background of

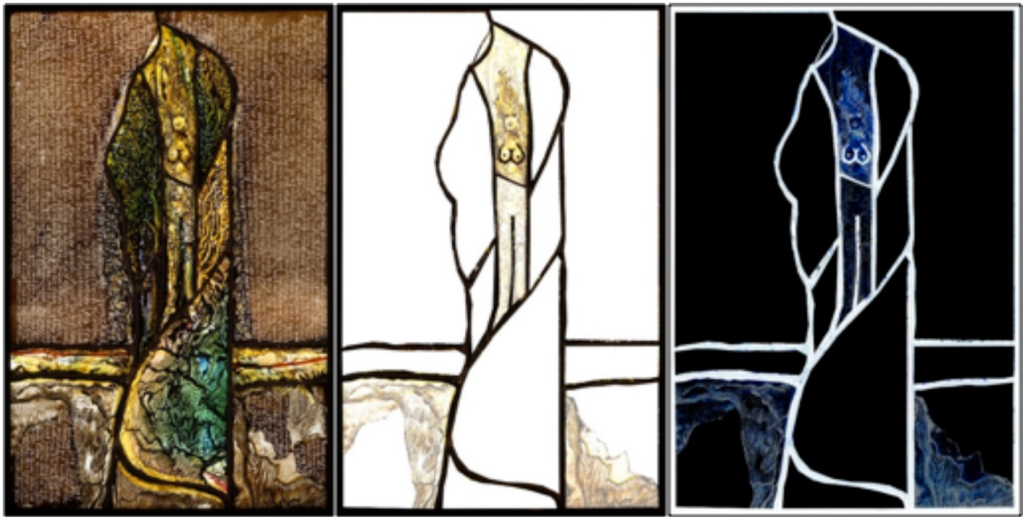

*Figure 4*
*Hans Gottfried von Stockhausen, glass picture "Daphne" (1984); Left: original version, center reduced version optimized for tactile print-out for blind, Right: colors inverted for partially sighted persons; prepared for an exhibition "Glasmalerei der Moderne. Faszination Farbe im Gegenlicht" of the Badisches Landesmuseum Karlsruhe (9.7.2011 – 9.10.2011).*

the picture is shown on a second haptic model and is explained shortly after the object itself. Therefore it is easy to understand detailed information in complex pictures made by an observer. Thus important aspects of the image description are experienced simultaneously by all. Only at the end of each description colours are considered. At this point in time partially sighted persons hold the picture directly in front of their eyes and try to identify the colours. The results with the models made via RP - especially with some examples of haptically implemented paintings of Neo Rauch - generally show a good comparable perception of the images by partially sighted and blind.

On this, analogue to models made out of wood – like woodcarving models –, the felt difference between single elements and areas of the objects in colour and shape (tactile differentiation) as well details of persons, e.g. where the details of their heads and fingers have to be worked out, have to be tactile. Our experiences with these museum tours show that exhibits especially designed with the distinctive features important to each artist in mind are very well understood and enthusiastically received by the visitors.

Modelling the image simply as an outline though is not optimal for the perception of the piece of art as a whole. The colouring of the model should be similar to the original so that partially visually impaired persons can experience an additional sensorial input. Thus, when using plastic elements in prototyping, pictures are to be preferred that show one color per element.

As a whole the design process used in this ongoing project shows that with the different Rapid Prototyping technologies used, i.e. laser cutter, 3D printer, and the large range of materials used for the modells, like textiles, leather, wood, the delivered outputs are able to capture and communicate a large amount of information relevant to the works of art. To study the use and benefit of different materials is a process which has just been started in this project and from which the production of the haptic models of paintings will profit enormously.

Apart from the use of new technologies, the applied working method is open to the possibility to produce parts of the modells manually, which sometimes offers advantages.

This takes into account that new technologies, have restrictions, as for example the 3D printer can only use one type of material.

It is important to highlight that each specific design of the haptic models is based on a indiviual interpretation of the art object. As the information that can be transported is reduced and based on indivual choice, the demonstration of an art object is the result of a subjective process. In spite of these objections and possible limitations inherent in the process of transmitting visusal information to visually impaired persons, this approach - with other similar projects - would actively help to open the world of paintings and graphics.

*Figure 5*
*Visually impaired visitors exploring paintings at exhibition.*

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