Audio-tactile maps as a means to increase competence in spatial orientation of people with visual impairment

(overview essay)

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Abstract: *The following post aims to introduce a project supported by the Technology Agency of the Czech Republic, which dealt with the production and testing of audio-tactile maps. These maps are used to help people with severe visual impairment explore space. The project focused on the 3D printing of map bases and their connection to tablets through conductive map parts. This resulted in aids that were not only based on touch but also on hearing. These aids continue to serve not only adults with visual impairments but also pupils with visual impairments and are intended to convey the space in a particular location and orientation within it.*

Keywords: *audio – tactile maps, spatial orientation, mobility, people with visual impairment*

1 Introduction

The independent movement of people with visual impairments is influenced by many variables, including not only the personality of the individual, but also the compensatory aids and the educational process the person has undergone or is undergoing. In the project TAČR TL01000507 Development of independent movement through tactile-auditive means, we have tried to show that modern technologies help not only to increase the feeling of independence when moving on the trail, but also to increase other literacy of the target group.

The aim of the project was to adapt people with visual impairments to modern technologies and make these technologies accessible through newly developed teaching aids and didactic methods. The project focused on the development of 3D tactile maps created with modern 3D printing tools, the development of a software tool to connect the maps with a tablet and the subsequent training in working with

3D tactile-auditive maps. The connection between the 3D maps and the tablet was made possible by 3D printing technology where the technology used connected the tablet with the conductive part of the map.

At the beginning of the project, an extensive expert research was carried out, which was necessary for the effective implementation of the project, where the current scientific knowledge and approaches have to be used. Both the Institute of Special Education Studies of Palacky University and the Department of Geoinformatics of Palacky University carried out the expert research for their respective areas. The output of this partial objective are conference papers and related publications. The results of the analysis of the state of the problem and the proposal for further progress of the work could be discussed with the general public, where a number of expert opinions helped the next progress of the work. The comments of the special educators were very helpful in terms of the proposed didactic approaches. The comments from geoinformaticians and cartographers were beneficial for the design and implementation of the tactile maps.

2 TouchIt3D Technology and 3D Haptic Mapping

Based on the obtained knowledge and with the knowledge of TouchIt3D technology developed at the Department of Geoinformatics of Palacky University, an initial draft of tactile maps was created for user testing in 2018. The issue of appropriate methods of typhlography and typhlocartographic semiology was tested on samples with differences between layer heights, line thicknesses, point feature sizes, line structures, textures of area map features, etc.

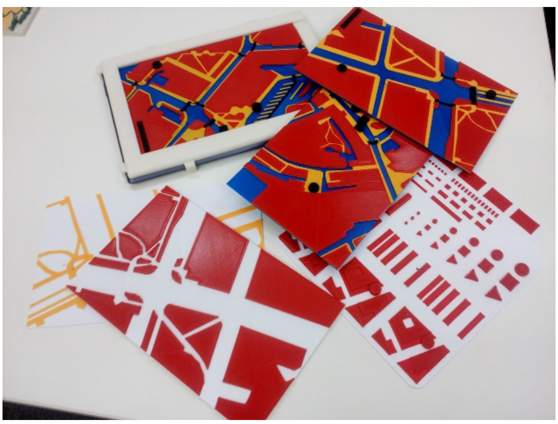


Figure 1: *Tactile maps 1st generation including one of the templates*

The process of manufacturing tactile maps and their technological solution was optimized several times during 2019. The various settings and nozzle sizes were tested, and the character key was modified based on the findings from the user testing. The main aim was to reach such a high level of detail that the individual 3D structures could be distinguished tactilely in the form of point marks that serve as activation points for the audio component. According to the obtained knowledge, new prototypes of the tactile map were continuously created for user testing and used for working with the target group during training of movement in space. For the second generation of tactile maps, the signs for pavements and streets have been extended to a minimum width of 5 mm, and instead of different layouts of interactive signs, the categories of marked points of interest have been differentiated by the style of the surface of these signs (peaked, sloping, flat).

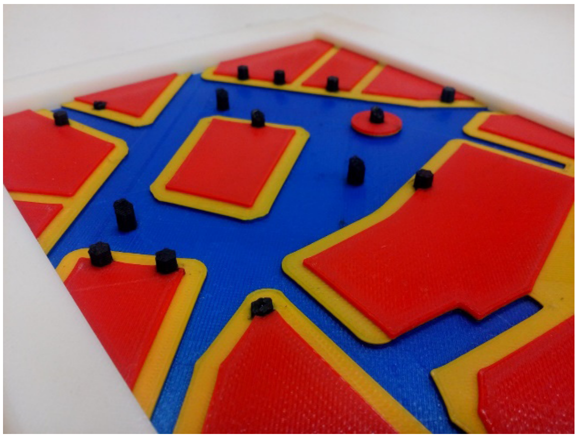
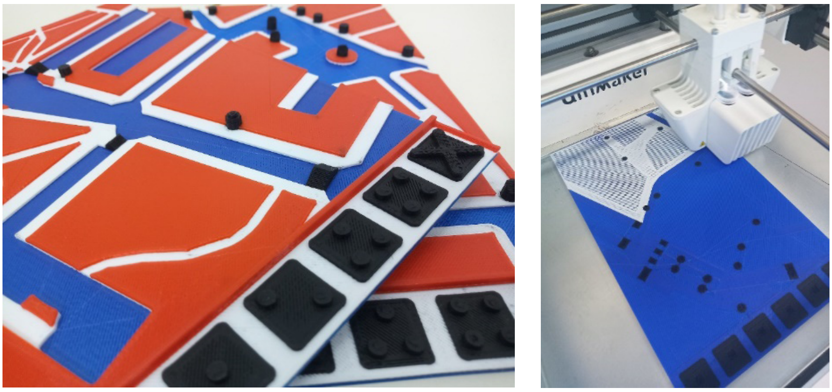


Figure 2: *Detail of one of the 2nd generation tactile maps with a different character key*

The functionality of tactile map was also extended during 2020. Following new findings, the yellow colour has been replaced by white, which offers better contrast and increases the readability of the maps. At the same time, all pedestrian crossings were tangibly depicted. This led to the creation of the 3rd generation tactile maps with the addition of buttons for switching the modes of voice accompaniment. All original maps of the 2nd generation were updated with them.



The different Figure 3a and 3b: *Colour and technological equipment of 3rd generation tactile maps and their production*

All interactive maps were accompanied by partial non-interactive maps depicting only one of the mapped topics. This was appreciated by users as a suitable teaching tool for learning how to work with tactile maps. The 3rd generation tactile maps set included tactile maps of Prague, Brno, Olomouc, Ostrava, Opava (each in 3 versions – interactive, sidewalks only, buildings only) and a fictional map with a legend, all in several pieces. The functionality of tactile maps has also been extended with modes allowing short description of characters, long description, task and route description between two points. The required functions were simultaneously implemented in the software application.

Figure 4a and 4b: *Detail of height-resolved pedestrian crossings and partial non-interactive tactile maps*

A set to explain the differences in the different scales was also produced, ranging from the interior of the building to the campus, the city, the Czech Republic, Europe, the World and the Solar System. This set was produced in the form of fuser maps on microcapsule papers, as well as in the form of 3D printing in the form of non-interactive and interactive TouchIt3D maps. Also, the web configurator was programmed for easy creation of documents for the TactileMapTalk mobile application.

Figure 5a and 5b: *A set of maps for understanding scale: different levels on the left, different versions of one level on the right*

Figure 6: *Tactile maps modelling and compilation of the basis for the mobile application*

3 Web Configurator and Software Tool

Based on the obtained knowledge and specification of the necessary functionality, a beta version of the TactileMapTalk mobile application for Android devices was created in 2018. For this test version of the application, templates containing the layout of the controls of the first trio of tactile map of 1st generation were subsequently created by measuring individual interactive features. Then the application was used for user testing. In the application it is possible to define buttons under appropriate interactive characters containing parameters about their position, dimension and text, which is then converted by the application into spoken word by the TTS function. Each template designed for one tactile map is then accompanied by an optional name and identification parameters. The manually written (in code) templates in JSON format could be added and deleted to the application according to the current needs of user testing.

The TactileMapTalk mobile app was significantly updated in 2019. The possibility of using different modes was introduced, which was subsequently used in the new generation of tactile maps. A function has also been added to evaluate the sequential pressing of a pair of buttons to call up a route description between two points. There was also work on the creation of a web configurator that will allow easy and user-friendly creation of valid JSON templates for the new tactile map application.

http://hmatovemapy.upol.cz/service/tactilemaptalk/. The web configurator is available at: The TactIleMapTalk application is available at: http://hmatovemapy.upol.cz/konfigurator.

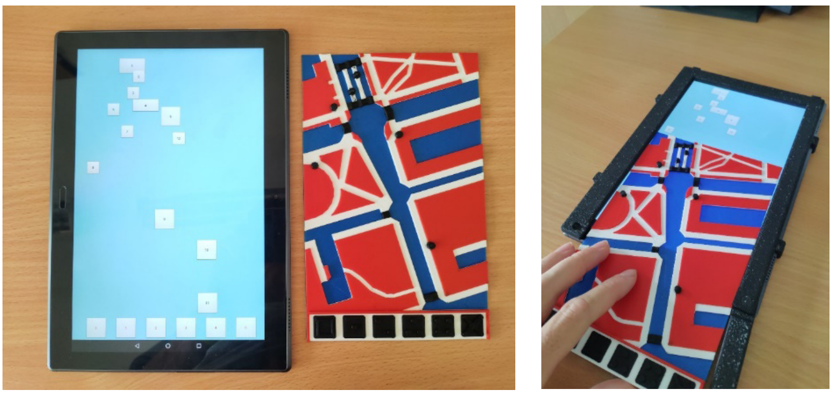


Figure 7: *TactileMapTalk application template environment with its corresponding 3rd generation tactile map*

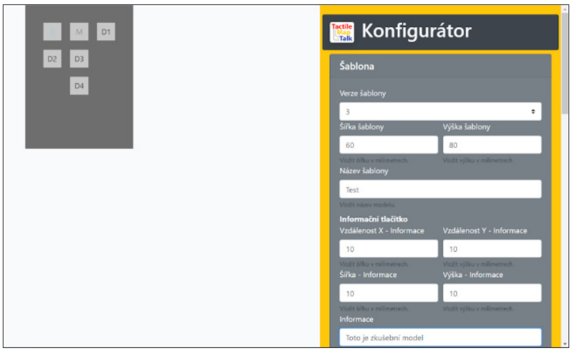


Figure 8: *The window of the web configurator*

4 User Testing

User testing with representatives of the target group is necessary to validate all proposed procedures. This testing was conducted with the participation of the staff of the Institute of Special Education Studies as well as the staff of the Department of Geoinformatics, students of doctoral programs in special education and other geoinformatics programs. Throughout the project, the aim was to gain insights into the proposed didactic approaches and the design of appropriate teaching materials, as well as insights into the proposed technologies and the associated templates, layers and appearance of maps and plans.

User testing was divided into several logical successive stages, which were supplemented in the last testing stage by Kateřina Bečicová, a student.

This testing took place both in the individual centres of the application partner and in primary and secondary schools for pupils with visual impairment, as well as in SONS branches.

In the first phase, only templates and maps representing each thematic layer were tested with several respondents from Olomouc and Kafira branches. The aim was to adapt to the needs of users without having to work with a completely new concept of audio-tactile maps. The results of the user testing were favourable and only the colour scheme was modified to a blue-yellow-red composition. The design of the signs otherwise suited the majority of respondents with individual reservations. Immediately after this testing phase, the testing phase of TouchIt3D tactile maps followed with minor modifications. For each of the three selected test sites, interactive map features were modelled into the map. These include a graphic scale indicating a length of 50 m (height of 4.5 mm from the base, line width of 5 mm), pedestrian crossings (at a height corresponding to the base layer of pavements and streets, i.e. with a height of 2 mm or 1 mm), the start and end point of the crossing (circle with a diameter of 10 mm, height of 5.5 mm) and public transport stops (square with an edge length of 8 mm, height of 5.5 mm).

On the base of the information acquired, a second prototype was created to meet the set objectives and requirements. All sub-products were consulted with representatives of the application partner, who provides services for the target group and is therefore very familiar with their needs, with experts on the subject and with selected representatives of the target group. Based on the specification of the required features, a beta version of the TactileMapTalk mobile app for Android tablets was also created. For this test version of the application, templates containing the layout of the controls for all three areas of interest (tactile map) were then created by measuring the individual interactive features. This application was then used for user testing of the created tactile map set. For the application, the buttons can be defined under appropriate interactive characters containing parameters about their position, dimensions and text, which is then converted by the application into spoken word thanks to the TTS function. Each template designed for one tactile map is then accompanied by an optional name and identification parameters. Templates in JSON format can be added and deleted in the application according to the current needs of user testing. Almost the entire group of researchers took part in the second phase of testing – Dr. Růžičková for the Institute of Special Education Studies, Dr. Brus for the Department of Geoinformatics, Dr. Barvíř and Dr. Vondráková, PhD candidates from the Institute of Special Education Studies, and for the application guarantor, the Kafira Public Benefit Society, employees of individual branches. Since these were individual consultations and testing with representatives of the target group of users, testing took place throughout 2019.

The findings were evaluated and incorporated into the design of the final tactile map. Despite taking into account the results from the first phase of testing, the colour scheme was changed to blue-white-red to suit more respondents. Different signs were also tested in terms of their vertical shape design (tip, sloping surface, horizontal surface), correct conductivity (touch point triggering), user friendliness and user evaluation within the Map Use concept. Testing results included, for example, defining a new parameter setting for the width of the pavements to a minimum of 5 mm for proper tangibility and understanding of the presented layer. The application can be installed on any Android device. However, the size of the maps should be adapted to the size of the display. This proved to be essential, although in the first phase of testing a minority of respondents commented on this issue. As testing progressed, the final designs were then tested with the new colour scheme. Here it was confirmed that the changes made led to better working of the respondents with the tested tactile maps.

During the testing, it was very useful to gradually introduce the concept of the map, the individual "layer maps" and only afterwards the TouchIt3D map, where the user already knew which points would be touchable and that he should expect an audio response. From an educational perspective, a proven concept were the multiple modes for a single map, which was proposed in the second half of 2019 and this functionality was fully implemented and tested in 2020. In terms of using audio-tactile map content, the plan for multiple ways to trigger the audio track (tapping, long hold, etc.) was dropped based on user testing. One long hold for the whole map proved to be the suitable trigger, which was understood by the users easily.

The testing also clearly showed that a slight difference in surface texture is not enough and, given the printing technology, the texture of the individual layers is not very desirable. It was also found that all conductive parts of the map must be raised, ideally with their own characteristic features, otherwise the user finds them very clumsily on the map and the audio tracks are triggered by touch when viewing the map without the user wanting them to be.

In the first two phases, testing was carried out by adults, while in the second phase, primary and secondary school pupils were also involved in the testing. For them, tactile map kits were created for geography lessons (details in the next chapter). The testing of the final version of the maps, including the accompanying materials (on the creation of the maps and on the didactic procedure for their use), was planned for the first quarter of 2020, but due to the global pandemic of Covid-19, this phase was extended until July 2020, when the modified maps, the final form of the configurator and the TactileMapTalk application, and last but not least the aforementioned sets of maps for teaching in primary schools were tested.

The project also included the creation of a set of tactile maps for teaching geography. Under the guidance of Dr. Alena Vondráková from the Department of Geoinformatics, student Kateřina Bečicová wrote her bachelor thesis on the topic of Creating Tactile Maps for Teaching Geography. The motivation for this thesis was based on the observation that respondents from the user testing who had previous experience with tactile maps of different types were able to understand TouchIt3D tactile maps very quickly and work effectively with them much earlier than respondents without such experience. It is therefore important that geography teaching aids reach schools specifically targeting pupils with visual impairments. More than anywhere else, this was the case when this modern technology was attractive to the target group of users.

5 Conclusion

The project "Development of Independent Movement through Tactile-Auditive Means", which was funded by the Technology Agency of the Czech Republic, has been successfully completed and all its outputs and other information are available on the project website. The most important results are:

- Sets of tactile-auditory maps;
- Didactic set – teaching materials;
- TactileMapTalk – SW;
- Project web portal (http://hmatovemapy.upol.cz/en/about-the-project/);
- 2 Monographs (Růžičková, V.; Kroupová, K. (2020). Typography: relief graphics and its role in the lives of people with visual impairment. Olomouc: Palacký University. ISBN 978-80-244-5732-1; Vondráková, A. (ed.) (2020). Tyflomapy–Tyflografika–Tyflokartografie: Percepce prostoru prostřednictvím 3D audio-taktilních map. Olomouc: Univerzita Palackého. ISBN 978-80-244-5788-8).

In addition to the above documented outcomes, however, as a team we see the achievement of the goals of the work as the main outcome of the project. These were the adaptation of people with visual impairments to the new 3D maps, working with the new teaching aid and also, and above all, working with the map. The work with the map and map materials then leads to a better grasp of space and spatial relationships and thus increased independence in orientation.

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