International Cartographic Association
Association Cartographique Internationale

Building Accessibility Maps: Cartographic Solutions to Assist Mobility of People with Disabilities

Dariusz Gotlib [a,*], Hubert Świech [a],

[a] *Warsaw University of Technology, Faculty of Geodesy and Cartography, dariusz.gotlib@pw.edu.pl, hubert.swiech@pw.edu.pl*

* Corresponding author

Keywords: maps for blind people, LBS, indoor navigation, indoor cartography, virtual acoustic map, geo-descriptions

Abstract:

Creation of building accessibility maps is part of a grant "Warsaw University of Technology as an Ambassador of Innovation for Accessibility." The basic project idea, from the cartographic perspective, is to create a Spatial Information System pertaining to the accessibility of the university's buildings by making digital twins of dozens of WUT buildings along with their surrounding areas. Building Accessibility Maps will be made in such a way that they can be used in navigation and location applications, and other applications supporting presentation of the university's campus (such as web services). Building Accessibility Maps will be integrated with the WUT Property Information System. In 2020 the research and implementation team received an international award for the conception and pilot implementation of this system from the ESRI Special Achievement in GIS Awards (SAG).

The models, which are currently being developed, contain a range of information that allows advanced assessment of a building's accessibility to different user groups (employees, students, visitors, emergency services), with a particular focus on people with disabilities. These models include information about the architecture of the building, people's potential main routes of movement inside the building (including evacuation routes), the main architectural barriers for people with disabilities, the infrastructure assisting people with disabilities (such as elevators for the disabled), and selected building equipment. The Building Accessibility Map will be a valuable tool for regular monitoring and reporting on the fulfilment of the requirement to adapt the buildings for people with disabilities.

Such solutions have been or are being implemented in various places worldwide to varying extents and levels of complexity, and using different technologies. The originality of the concept in question is in the particular emphasis on the use of textual description and sound/voice as important media for the transmission of geo-information (in addition to graphics), something not yet fully utilized in cartography. It was decided that the basis of the system would be the use of so-called geo-descriptions, i.e., site-related descriptions (text with georeferencing), which are later read out by a speech synthesizer or voiceover. Geo-descriptions refer to the architecture of the building itself, the architectural barriers, and the possible routes and points of interest inside the building. Geo-descriptions can be created by a human editor, as well as, ultimately, being automated, using advanced geospatial analysis and artificial intelligence algorithms. Descriptions will be displayed on a mobile device, read by existing speech synthesizers, or listened to in the form of recordings made in a recording studio by professional voiceover artists.

It was proposed that the? our? Building Accessibility Maps should become the basis for many different types of applications: from location-based applications, to simulators using game engines to assist space trainers in teaching the blind. These could range from mobile applications to desktop PC applications. At the same time, maps of this type will be the first step in the process of implementing a dedicated navigation system throughout the university. Due to the problems and inadequacies of current indoor positioning technologies, the full implementation of a high-quality navigation system is complicated and sometimes impossible. The development of Building Accessibility Maps, including the vital role of geo-descriptions, will enable the development of applications that provide simplified but effective navigation by supporting human spatial orientation in a way that is natural. It also involves production of an interactive audio map that will enable blind people to receive spatial training before visiting a university.

Abstracts of the International Cartographic Association, 6, 78, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa.
https://doi.org/10.5194/ica-abs-6-78-2023 | © Author(s) 2023. CC BY 4.0 License.

A separate, but equally complex issue is the methodology for developing cartographic visualizations of the buildings' interiors adapted to the needs of visually impaired people, and others who also need various forms of assistance when searching for destinations in the university, for instance, during conferences or other events. Such people will be provided with modern 2D and 3D visualizations of building interiors. At the same time, the 3D models for selected buildings will allow development of virtual walks using game engines to provide spatial training. A possibility of using Building Accessibility Models in combination with modern virtual and augmented reality tools (VR and AR goggles) is also envisaged.

This ongoing project has both production and implementation aspects, in addition to research. The first stage of the project consisted of the development of the prototypes of the system's various components and the first tests. This was followed by the designing of the target solution. Literature research was conducted in parallel with this, as well as tests with potential users of the system. A group of testers who are disabled is of particular importance, as they will help develop the most useful solutions.

The concept and implementation of the solution are not standard. The most significant element of this original concept, and the one that has the greatest research potential, is in the question of how to properly make a geo-description, and then how to make smart algorithms to read it at the right place and time, regardless of the positioning method used. Although the use of geo-descriptions was originally implemented for the blind, the first preliminary studies have shown this technique to be very useful in assisting fully sighted people as well. How to classify geo-descriptions and the relationship between their various types is currently being studied. A challenging task is the selection of locations, both points and areas, to which the voice message applies. Finally, the content of the message itself, which touches on linguistic issues, is crucial. The message must not be too long, and it must, in a clear way, provide spatial awareness of the place where the person is and their destination. The content of the message should deliver spatial learning and build situational awareness. The matter is complicated by the fact that the message will be addressed to people with different needs: sighted and blind, hearing and deaf, physically fit and mobility impaired. Geo-descriptions at different levels of generalization are also needed. Studies have shown that the messages need to be divided into the following categories: the characteristics of the entire building (giving spatial context), then its zones (floors, zones, the wings of the building), followed by detailed descriptions of characteristic places (e.g. entrances) and rooms. The problem to be solved then becomes the length of the message. At the research stage, the various concepts of linkage between the basic geo-description (e.g. common to all users), and its additional variants, are also being considered. If we additionally take into account the need to develop different language versions, the situation becomes even more complicated. An important issue in this context, for example, is the development of an appropriate model for storing this information in the database.

Currently (at the turn of 2022 and 2023), the project is in its implementation phase. The architecture of the system, a database model, 2D and 3D models of several important university buildings, a mobile application for blind people (assisted by a space trainer) to test the developed geo-descriptions, several hundred geo-descriptions, and a prototype of a location application using QR-code and RFID technology for positioning, have all been developed. GIS technology supported by ESRI software, in conjunction with an Oracle database, has been adopted as the base technology for building the system. In parallel, work has begun on an indoor navigation system based on BLE (Bluetooth low energy) beacons and sound actuators. The navigation system will be fully implemented in five Warsaw University of Technology buildings with a total area of over 100,000 m^2. The process for converting Building Accessibility Models into a form that can be used by the game engine has already been developed. Unreal Engine technology has been selected, and the first functionalities for performing virtual tours have been made.

Experimenting with systems that assist people with disabilities provides additional motivation for the study. Previous research and experience indicate that finding solutions for this group of people is challenging; but, at the same time, solving these problems can increase the quality of solutions for other people as well. Thus, we can look at this type of work in the context of dual-use solutions. So far, the work has demonstrated the adopted concepts' validity and feasibility. The project is scheduled to be completed by the end of 2023.

Abstracts of the International Cartographic Association, 6, 78, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa.
https://doi.org/10.5194/ica-abs-6-78-2023 | © Author(s) 2023. CC BY 4.0 License.