

Concept and realisation of the laboratory of indoor cartography with the support of computer game environments

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Keywords: indoor cartography, LBS, cartographic serious games, 3D building model, virtual reality, Unreal Engine

Abstract:

The indoor cartography is one of the newest branches of cartography. There is a high probability that the next few years will bring significant development of BIM systems, indoor navigation applications and building management systems (including energy optimisation and security assurance). To achieve these goals, appropriate building models are needed, including cartographic models understood as a kind of map. Tens of thousands of models are now being created worldwide, which is arguably a growing trend. However, research in this area is still relatively scarce. It is not easy to find guidance on data generalisation, the principles of using colours and patterns, the scope of content or how to develop thematic maps. The theory of cartography in this area is still developing. Therefore, according to the authors, further intensification of research in this area is needed. To this end, the concept of a laboratory to support research in the field of indoor cartography has been developed.

The use of game technology to create a simulation environment was adopted as a fundamental premise. This is due to several considerations, the most important of which include: limitations of moving around in most buildings, the need to take into account dangerous factors (such as simulating a fire or terrorist attack), diversity of buildings and the high level of development of game technology. On the other hand, the availability of technologies that allow creation of virtual twins of buildings (digital twins) was taken into account - from CAD technology through BIM to photogrammetric methods and laser scanning. At the same time, the concept assumes a possibility of conducting research in real objects (corresponding to virtual ones) in order to verify the research carried out in a simulation environment.

The laboratory's concept involves adapting two rooms, equipping them with a selection of gaming equipment, creating models of the test buildings and developing a simulation application. The setup lets people move around in a virtual world in a way that allows a high degree of immersion, and perform the tasks given by the researcher in different conditions and with a change to some parameters of the models. All study participants' behaviour is recorded for later analysis. In addition, a testing field was designed to test prototypes of applications using real positioning systems in a dedicated building.

At the concept stage, the following equipment was purchased and configured, among others: VR headsets: HTC Vive Pro Eye and Pimax 8K Plus; Omni-directional VR treadmills: Kat Walk Mini and Kat Walk C; Microsoft HoloLens 2, Vuzix M4000 device. Unreal Engine software, a professional-grade game engine, was used to create the simulation environment.

In preparation for the lab's work, several models of Warsaw University of Technology buildings were developed (using CAD, BIM, GIS technology and using a game engine), in particular, several variants of a highly accurate model of the building of the Centre for Scientific Geospatial and Satellite Analyses in Jozefoslaw, which was chosen to be the location of the labs.

The concept assumes the following main research scenarios:

- 1) The participant, using goggles and a virtual reality treadmill, moves around the selected building using a virtual mobile application to reach selected locations indicated by the researcher conducting the study;

- 2) The researcher changes the environmental conditions during the study - e.g., changes the way roads are marked in the building, changes the appearance of the interior of the building, turns on the simulation of heavy traffic of people, turns on the simulation of fire, etc.;
- 3) The virtual environment engine records the user's behaviour, e.g., the route and time travelled, places where the user uses the simulated navigation map, places where the user loses the route or makes longer stops, places where the user focuses his or her eyes, how the user uses the application, etc.;
- 4) The participant performs similar activities as in (1) but without the use of glasses, using only the treadmill and the image projected by the projectors. A setup like this is called a Virtual Reality Cave;

An additional research component is testing the prototype application in a real building (test field).

The building is equipped with various in-building localisation systems, such as a dense network of Wi-Fi routers, Bluetooth beacons and a professional UWB (Ultra Wide Band) based localisation system. With these systems, it is possible to analyse the accuracy and efficiency of indoor localisation. Additionally, participant behaviour in the test field is recorded on surveillance cameras for later analysis and comparison with the behaviour in the virtual digital twin of this building.

As the essential elements of the research agenda of the designed laboratory the following can be mentioned:

- 1) Evaluation of the quality of various navigation application prototypes;
- 2) Supporting the design of building maps;
- 3) Optimisation of models of building interiors from the cartographic perspective;
- 4) Performing building accessibility audits and improving signs systems in buildings (including building maps);
- 5) Supporting the design of indoor information solutions for people with disabilities;
- 6) Testing of in-building localisation systems;

The laboratories are currently in the preliminary stage of commissioning and conducting the first tests.

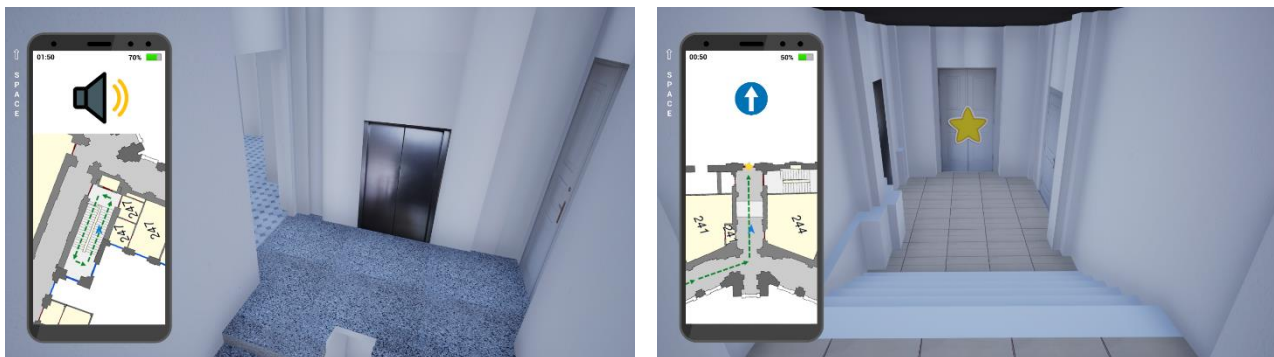


Figure 1. Screenshots from the simulator - research application.

The initial preliminary studies have shown that utilising gaming technology can be beneficial for studying scientific indoor cartography (indoor LBS) and implementing the proposed concept. An example of one of the applications used in the research is presented in Figure 1. The article will provide a more in-depth examination of the results of the ongoing research.

Acknowledgements:

The authors are thankful for the opportunity to use the CENAGIS infrastructure, developed under the project entitled "CENAGIS - The Centre for Scientific Geospatial Analyses and Satellite Computations including Laboratories for testing and authorising geomatic products," which is co-financed from the European Fund for Regional Development within Priority Axis I "Utilisation of research and development activities in economy" (RPMA.01.01.00-14- 9871/17 from 11.12.2018).