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A new approach to making 3D-printed geographic models interactive for people with visual impairment

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Abstract:

Achieving geospatial awareness has been important for mankind since early settlements. Modelling features of geographic objects and phenomena has helped us to understand their regularities, specifics, problems, and beauties. However, not all people have the same opportunities to reach such awareness. According to the World Health Organization (2022), there are hundreds of millions of people with visual impairment including tens of millions of blind. Vision loss can affect people of all ages disabling their access to traditional geospatial aids.

Luckily, smart technologies of the modern world can provide us with innovative geovisualisation aids to reduce the information deficit of people with visual impairment when aiming for geographical knowledge and spatial imagination. 3D printing is one of these technologies making the production of tactile maps and other models in 21st-century technology significantly more accessible than ever before. Moreover, 3D printers with multiple extruders together with the TouchIt3D technology linking 3D-printed models with mobile devices (Barvir et al., 2019) present an efficient way of producing interactive models.

In the early stages of our research, we started with designing simple models verifying the functionality of the technology and the connectivity of the 3D-printed models with a touchscreen of a smartphone. In this stage, models of different scales were designed including a small-scale terrain model as well as a large-scale representation of a single factory and a transmitter tower (figure 1). Relevant elements of the models were designed as a separate part of the digital model and made of conductive filament when 3D printing it. Consequently, touching these elements results in an electric impulse passing through the conductive segments of the models down to the touchscreen and inducing a reaction of a preinstalled mobile app, such as an auditive description of the individual model parts.

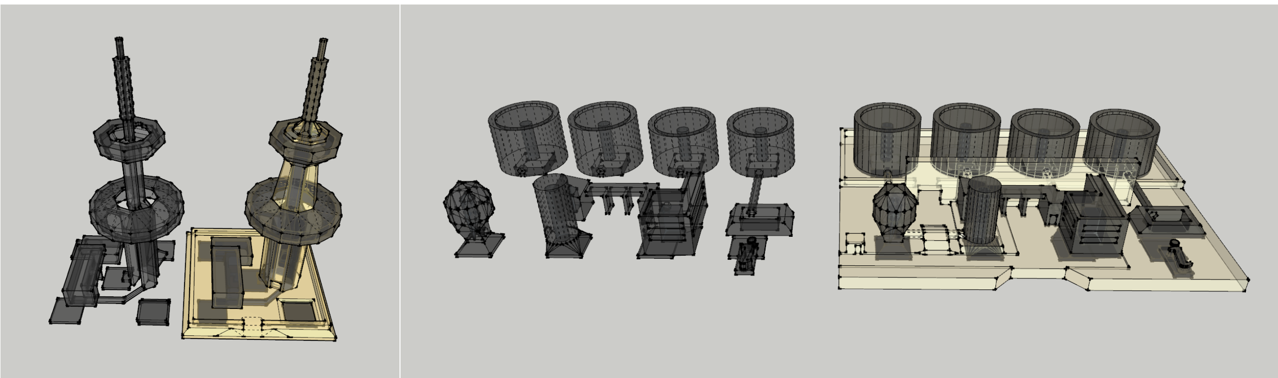

Figure 1. Models for verification of the TouchIt3D technology.

Subsequently, the same principle was applied when designing interactive tactile maps linkable with a tablet. Moreover, these maps feature from multiple colours of the non-conductive parts differentiating mapped topics presented busing positive and negative relief in order to support the use of residual vision (figure 2). Interactive map symbols for points of interest were made of the same conductive material by perpendicular projection from the top surface down to the model base. Such tactile maps capturing various urban areas were repeatedly tested with visually impaired people (Barvir et al., 2021). In this case, users easily distinguished interactive symbols as these were consisting of either a typical cylindrical shape differing only by their cap style according to the presented object (public transport stop, orientation landmark, services), or of an oblique symbol for pedestrian crossings. Both the symbol types contrasted

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noticeably (at least 3mm) with the three flat background layers at different heights representing roads, pavements, and buildings (figure 2). After every 1-second-long touch, a vibration was launched immediately followed by an auditive description of what the touched element represented. Interactive controls by the edge of the map enabled switching between short and long descriptions.

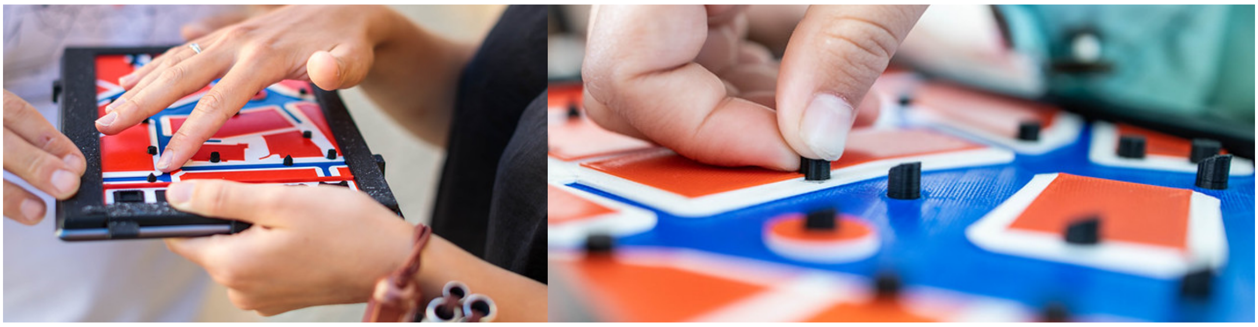

Figure 2. Tactile maps with easy-to-distinguish thematic interactive symbols: overall look (left) and detail (right).

Both the previous concepts were merged when moving from tactile maps to large 3D models of architectural monuments and landscapes. A relatively small smartphone was used instead of the large tablet, so the conductive channels were necessary to be designed properly in order not to meet, to stay inside the model and to connect the signal from all conductive surfaces to a relatively small area on the bottom part of each model, where the mobile device was inserted. This solution involved separating each model into two parts – the top one capturing the landscape model (consisting of the conductive and non-conductive parts), and the bottom base serving as a case for inserting the smartphone (made only of the non-conductive material). Both the parts were then connected using magnets (figure 3).

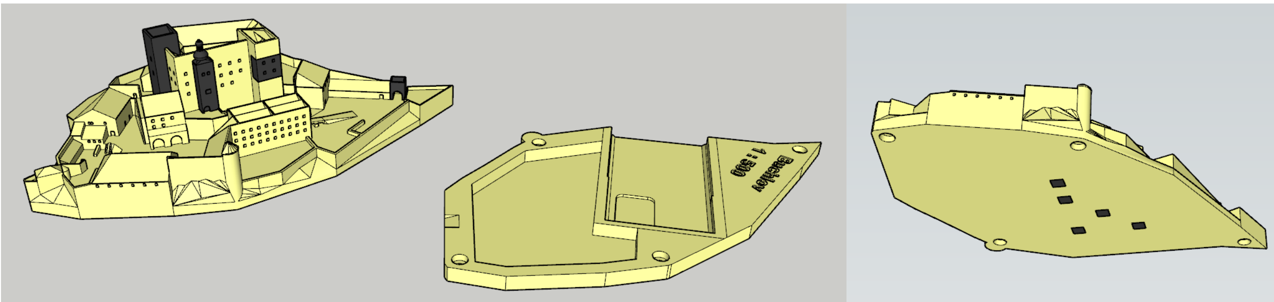

Figure 3. One of the large-size 3D models with the landscape part (left), smartphone case (centre) and a view from the bottom side of the landscape part showing the end of the connection channels (right), the conductive elements coloured in black.

However, in the case of 3D models, users with severe visual impairment and those suffering from blindness failed in recognising which elements of the model were interactive. Contrary to tactile maps, where all the interactive symbols were easily distinguishable only by touch, in this case of a complex surface consisting of terrain, multiple buildings and various architectural features, the border between conductive and non-conductive segments was not recognisable at all. Users were, therefore, unsure which part of the model was touched and which the description was related to.

User testing suggested a change of the mobile app to vibrate immediately when touching any conductive part to inform the users they had just touched one of the key elements. Following up a 3-second-long continuous hold, the auditive description was launched. This change was implemented into the mobile app and prepared with a set of 3D models for further user testing to determine if this update would result in a more user-friendly solution for interactive 3D models.

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