

3D-printed models of Czech architectural monuments for people with severe visual impairment

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Abstract:

The role of cartography is to capture reality in a simplified form for diverse user groups. Most people can easily perceive basic topographic structures and dimensions using their sight when moving across a landscape, and maps can provide them only a generalised and well-arranged overview. However, people with severe visual impairment are strongly limited in perceiving distances and dimensions. Therefore, scaled 3D models may allow them to compare and understand spatial distribution and differences in size and shapes. While tactile maps provide simple schemes of areas where two dimensions dominate, these maps cannot easily capture the shape of buildings and their height structure. Conversely, real models manufactured using a 3D printer provide a more complex representation in both horizontal and vertical directions.

Our research was aiming to investigate and provide people with visual impairment and blind with a set of 3D models capturing the most interesting cultural monuments from various regions of Czechia, helping the people to perceive:

- a) diversity in monuments' dimensions and shapes
- b) characteristic features of architectural styles and building solutions of the monuments
- c) spatial distribution of each monument

In a close cooperation with historians, a set of valuable monuments was chosen from all parts of Czechia, including one or two monuments from each of the 14 administrative districts. The set contained important cathedrals, palaces, castles as well as both traditional rural and modern architecture (Figure 1). The importance, uniqueness, and size diversity of each monument were considered to result in a useful set of 3D models to provide spatial awareness and be useful in educational processes at the same time.

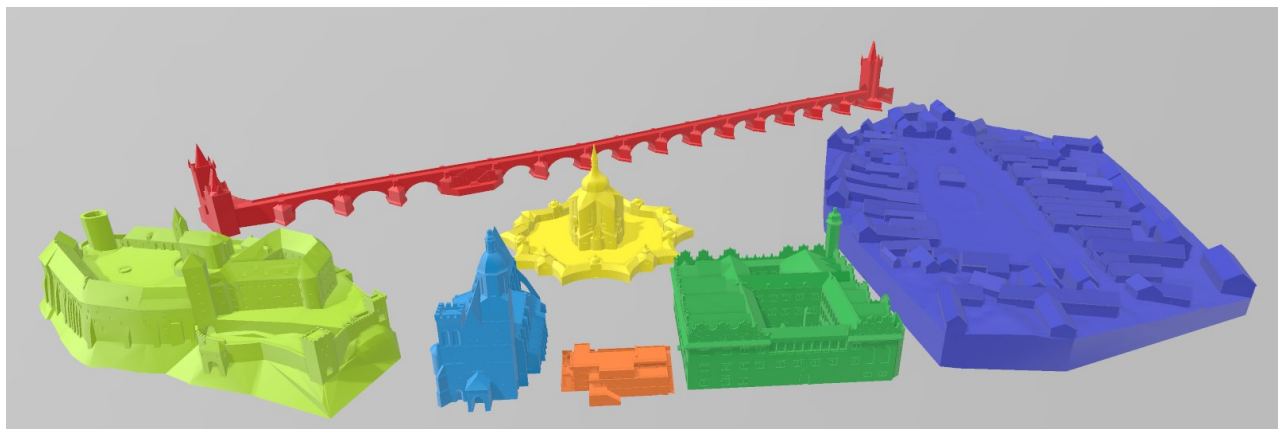


Figure 1. Several of the designed monuments differing in architectural style in the same scale factor: Charles's Bridge (red), Bitov Castle (lime green), Opava Cathedral (cyan), Villa Tugendhat (orange), Church of St John of Nepomuk (yellow), Litomysl Castle (green) and Holasovice Village (blue).

Special conditions were also considered when modelling to achieve 3D models usable for blind and people with severe visual impairment. The monuments were designed in a simplified form to avoid shapes that could possibly be dangerous for the users and get easily broken by touching the 3D-printed model (Figure 2). Therefore, thin structures were either slightly enlarged or fully omitted. Otherwise, the models were designed from available sources with the priority of preserving the dimensions of each monument and their relations to not deform the overall look of the monuments. While most of the models represented the current look of the monuments, few were designed to show how the monuments looked in the past.

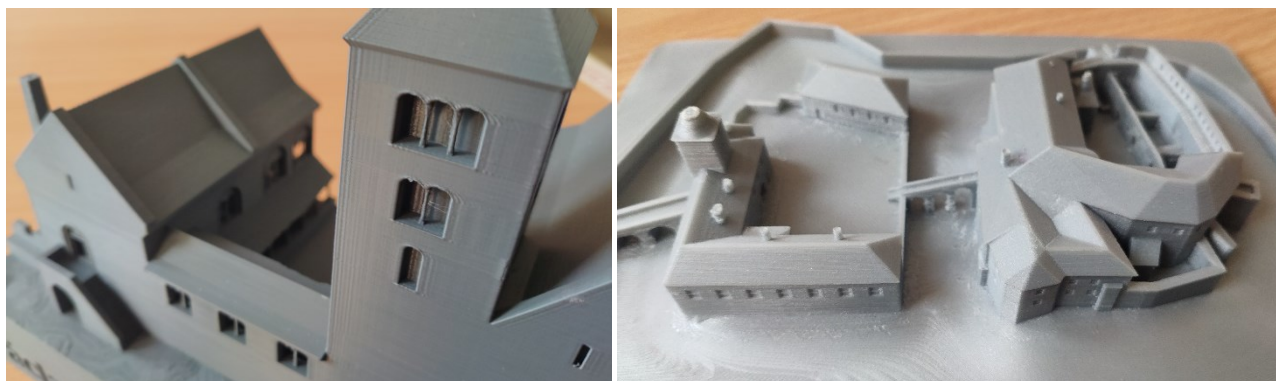


Figure 2. Thin structures, e. g. columns and chimneys etc., may get broken when touching by fingers, and, therefore, become dangerous for the users (left), simplified solid model (right)

The models were designed in SketchUp software (Figure 3), suitable for architectural designs and easy to use. Some of the models were also designed to be interactive, implementing the TouchIt3D technology (Brus et al., 2019). To achieve this, the model had to be split into two separate parts – one for 3D printing with non-conductive and another for conductive elements. Various data sources, including maps, photos, and field measurements, were used when modelling the shape of the monuments.

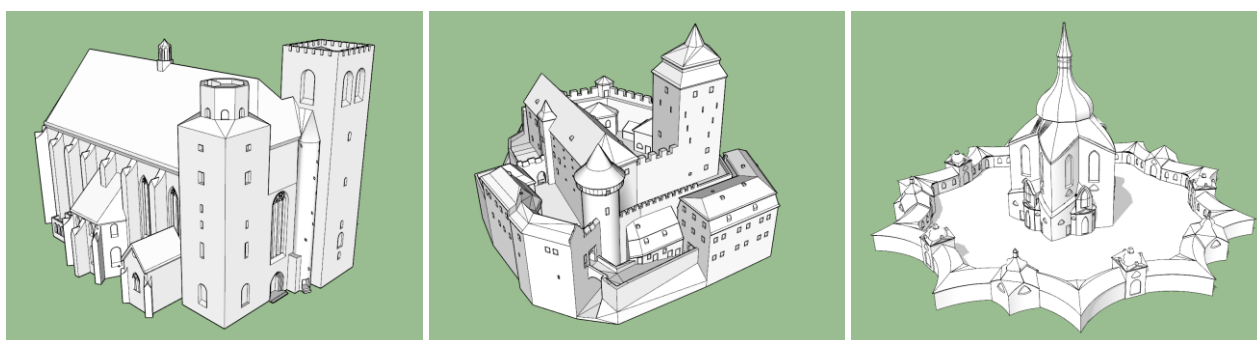


Figure 3. Church of Saint Maurice (left), Kost Castle (centre) and Church of St John (right) designed in SketchUp

To provide both size comparison and specific shapes' perception, all the models were manufactured in two collections:

- a) in a united scale (to enable comparing sizes)
- b) in the maximum size, the 3D printer Craftbot FLOW IDEX XL make in one piece (up to 425×250×500 mm)

Prusa i3 printer was also used for manufacturing smaller models (Figure 4). In both 3D printers, PLA (Polylactic Acid) filament suitable for large-size models was used. Support structures needed to be generated for few models (Figure 4), while most of the models were designed in a way they do not need any supports. Basic postprocessing of the models was performed to avoid unwanted relicts from the manufacturing process on the models' surface. Manufactured models were then used in user testing with people with severe visual impairment.



Figure 4. Small model of Villa Tugendhat with support structures manufactured using the Prusa i3 3D printer (left), large-size model manufactured using the Craftbot FLOW IDEX XL printer (right)

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