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City center tactile map produced by 3d printing

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Abstract:

3D tactile maps can serve as tools to enhance spatial ability and environmental perception, allowing people with visual impairments to interact with a tactile representation of their surroundings. The use of 3D printing technology is considered an innovative and essential initiative that supports the movement and spatial perception of people with visual impairments at the city level. Creating a tactile 3D map of the city centre's key landmarks, main roads, pedestrian streets, etc., can help people with visual impairments understand the city's structure and geography through touch.

The tactile map described in this paper depicts the Athens city centre as defined by three major squares, Omonoia, Monastiraki and Syntagma, that define the so-called "Commercial Triangle" of Athens, where the city's main cultural and historical landmarks are situated. A scale of 1:2000 was chosen, resulting in a mapped area of 60 x 60 cm, which supports touch within the area covered by the user's hand (Wabinski et al., 2022). The city map portrays the road network (roads and pedestrian streets), building blocks and important landmarks (e.g., buildings, squares, metro stations, churches, archaeological sites), as well as the location "You are here" corresponding to the Athens City Hall, where the tactile map will be placed. Several buildings and squares that record the city's cultural heritage are considered important landmarks. Specifically, 13 buildings and 12 squares are portrayed and annotated with numbers, which are linked with their names in the map miscellanea. Numbers were assigned following the spatial distribution as closely as possible. Important roads and pedestrian streets are also annotated. Geospatial data from the Municipality of Athens' geoportal (http://gis.cityofathens.gr/) is used.

The amount of information in a tactile map is less than that in a printed map because it is read by touch (Touya, 2025). The symbols are larger, greater distances are required between them, and, at the same time, the use of Braille for annotation requires more space on the map than the standard alphabet. Cartographic Generalization plays a very important role in tactile maps. For the road network, the main roads and pedestrian streets were selected, while less important roads and pedestrian streets were eliminated. Furthermore, they were simplified to facilitate perception by touch and the application of symbols. Squares and buildings were simplified, and sometimes enlarged to facilitate annotation in Braille. Finally, they were displaced and reshaped to ensure a 3 mm gap relative to the road network (Wabinski et al., 2022).

Tactile map symbols were formed according to literature (Wabinski and Ungar, 2025), utilizing haptic variables such as shape, texture and height. Symbol choices were evaluated experimentally using a questionnaire, a part of the tactile map and the legend. The NTUA Ethics and Deontology Committee approved the questionnaire before data collection, ensuring the protection of participants' personal data and their informed consent. People with vision problems from the Lighthouse for the Blind in Athens and the Panhellenic Association of the Blind were recruited voluntarily and anonymously. The questionnaire tested understanding of the point, line and polygon symbols in the legend, the ability to read Braille printed by the 3D printer, recognition of the symbols on the map and identification of the geospatial entities they represent. The map symbols use different heights provided by the 3D printer. Therefore, differentiation is enhanced, and the tactile perception of the symbols is improved. The heights of the data were chosen so that the building blocks, which are rendered indirectly from the space created by roads and pedestrians on the map base, have a height of 0 mm and serve as the starting point for height values. The road network follows with 1 mm. Roads, pedestrian streets and building blocks form the map's basemap and provide the geographical context for the landmarks that constitute the map's main theme. The symbols for the point data are 2 mm high but ultimately appear at different heights depending on their location. Based on the above, the “You Are Here” symbol, which indicates the user's position on the map, is the tallest. The symbols were finalized based on the survey results (Table 1). Roads and pedestrians were portrayed with lines 13 mm wide, equal to the braille character height plus a 3 mm gap on each side (Wabinski et al., 2022).

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Thematic layer	Symbol	Size (mm)	Height (mm)	Haptic Variables	Thematic layer	Symbol	Size (mm)	Haptic Variables	Height (mm)
Road		13	1	Shape	You are here	●	5	Shape	2
Pedestrian Street		13	1	Shape	Metro Station	▲	5	Shape	2
Square		various	4	Texture	Church	✚	5	Shape	2
Building		various	5	Texture	Archaeological Site	■	5	Shape	2

Table 1. Tactile Map Symbols

The final map consists of 3 parts (Figure 1): a. the map (in the center), b. the legend and explanation of the landmarks codes (right) and c. explanation of the abbreviations of the names of streets and the pedestrians (left). The dimensions of the final map are determined by the dimensions of the structural elements, combined with the distances between them, at 128 cm width and 68 cm length. ArcGIS Pro was used for map composition and symbol creation. The map was extracted as a GeoTIFF and converted to STL using the "DEMto3D - DEM 3D printing" plugin in QGIS. Blender was used to add Braille annotations in Greek with a custom script. When printing the individual parts of the tactile map with the 3D printer, the printer's maximum printing dimensions (35 x 35 cm) must be taken into account. This limitation necessitates dividing the map, the legend and the abbreviation explanation table into smaller parts (30 x 30 cm). The 3D models were split into smaller parts in Blender, and bases that allow connection via a "puzzle" mechanism were added. To ensure optimal communication of the map's content and format, three audio descriptions in QR Code format were added: a general description of the map, the legend and the landmarks' numeric codes with their explanations and the abbreviations and the names of the roads and pedestrian streets. Additionally, another QR audio description includes the haptic description of the map following a route from north to south, then east and north again.

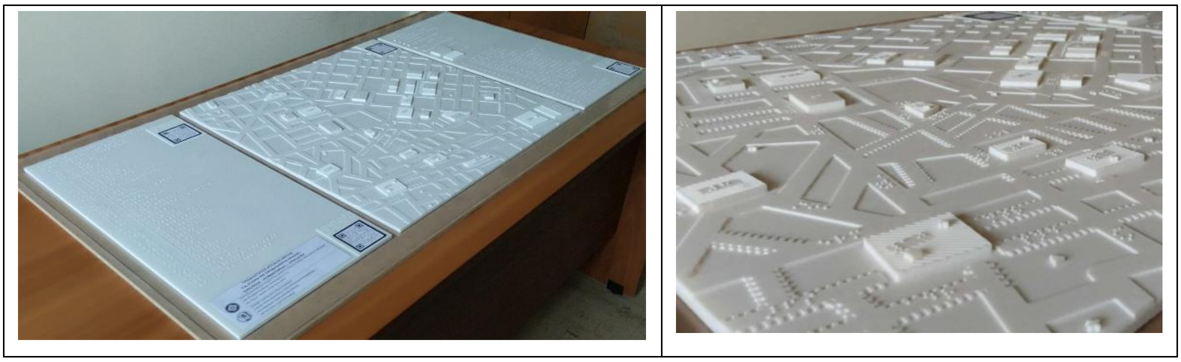

Figure 1. Athens city center tactile map made with 3D printing.

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