MAP DESIGN FOR NAVIGATION PURPOSES

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ABSTRACT

Small display cartography is one of the most important subjects of the cartographers since the microcomputer technology develops. Navigation map design for different purposes is considered in this concept. In this paper, map design requirements for navigation and its constraints were explained in terms of small display cartography. Maps used for navigation purposes examined in terms of Multiple Representations because of the scale factor effects. These effects were examined in detail and sample navigation maps are designed for different levels of application.

1. INTRODUCTION

Technological developments occurring in time affect cartography as much as the other disciplines related with computer technology. Especially developments in this technology and the use of the Geographical Information Systems (GIS) made significant changes in map production and generalization processes. Managing full automation of these processes considered as one of the main tasks of cartographers and related researchers. As a result, all developments on map design and presentation technologies have added new vision to cartography. However, it has made new discussion points in cartography (Ulugtekin and Dogru, 2004). Stated developments affected automobile industry and navigation systems recently became a part of this market. Thus, use of maps by the driver has evolved from the classical roadmaps to the screen maps presented in car navigation systems while traveling.

Map design for navigation purposes is one of the most important and current discussion point of cartography. It needs different and special design considerations in addition to conventional cartographic methods (Dogru, 2004). Symbol selection, feature sizes, map scale choice, memory limitation of the hardware can be considered as only some of these important subjects. On the other hand, the type of the navigation should be considered as a determining parameter while designing these kinds of maps.

This study firstly consists of a general overview of cartography and generalization. Map design requirements for navigation and its constraints were explained in terms of small display cartography. Especially scale choice for different stages of the navigation was examined. Finally sample navigation maps were designed with in the context of this study.

2. CARTOGRAPHY AND GENERALIZATION

Cartography is the science, art and technology of making, using, and studying maps. As a result of the technological developments, significant changes on cartographic process occurred in time. Digital map production became more important than classical methods with its eases introduced to map production process by the development of computer technologies. Moreover Internet brought a new perspective to the cartography so web cartography became an important and discussing subject for cartographers (Kraak, 2002). Nowadays, mobile mapping technologies and methods, which aim to design maps for mobile devices such as mobile phones or pocket PCs, introduced mobile cartography or small display cartography.

Generalization, which is considered as the spatial equivalent of simplification by Bertin (1983), can be defined as selection and simplified representation of detail appropriate to the scale and/or purpose of a map**.** It is one of the most important and problematic subjects of cartography. It remains problematic, however, for although the widespread use of GIS and spatial databases - and the subsequent need for visualization of spatial data over a huge range of scales - has stimulated much research and development effort, success in the automation of generalization has been limited.

Spatial data obtained from the real world is generalized in model and cartographic generalization steps. As stated in Kilpelainen (1997), model generalization is the simplification of the abstract digital model represented by the geographic information, and this stage contains no aesthetic components. It is applied in database and considered as a

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preprocessing stage for cartographic generalization. On the other hand, cartographic generalization consists both of these components as a complementary part of generalization process so it is one of the reasons why cartography is considered as an art. Cartographic generalization deals with symbolized features in map space and resolves symbol conflicts. For example, a point typification process needs to take into account the point symbol dimension and to satisfy a minimum spacing between the point symbols; a line simplification process needs to consider the width of the line symbol (Lee, 2004). As a result, cartographic generalization has the leading role in the transmission of the data by using symbols to represent geographic reality and it is a significant stage of the map production process.

Although the generalization is achieved in two main stages, the whole process uses several methods called generalization operators. Shea and McMaster in 1989 were defined these operators. Ten of these operators (simplification, refinement, smoothing, displacement, amalgamation, exaggeration, aggregation, enhancement, merging, and collapse) are defined for spatial transformations. Besides, classification and symbolization are considered for attribute transformations.

3. MAP DESIGN COSIDERATIONS FOR NAVIGATION

Map design for navigation purposes should be considered in terms of two different approaches, because the map on which mathematical calculations are performed is different from the map used as the user interface. Network analyses for finding shortest path or optimal route are executed in navigation systems. Therefore, especially road networks should be geometrically accurate in the first type of maps so it is essential to depict the nodes and roads connecting them, whereas the precise locations or shapes are of much less importance (Mooney and Winstanley, 2003). Besides, the topological consistency should be maintained while designing these maps. Topology is the mathematical concept of spatial structure, sometimes defined as characteristics of geometry that do not change when the coordinate space is deformed. In other words, topology is a structure that defines geometrical relationships between objects. If any model is tried to be constructed for roads, first its topological relations should be defined then this topological structure should be formalized by using an appropriate method (Dogru and Ulugtekin, 2004; Hardy et al., 2003). Standardization of this process is one of the most important current issues of the related specialists. Today Geographic Data Files (GDF), a data format based on planar graph theory, is considered as a standard for database and map design for navigation. (GDF3.0, 1995) by using topological relations.

When designing the maps as the user interface, other constraints such as the dimensions of the presentation media (6x8 cm on an average), viewing distance, memory limitations, and etc. come on the scene. Especially representing the world reality in limited dimensions makes the highly generalized maps consisting exaggerated road networks and point of interests (POI) necessity. Thus, world reality (transportation network, important centers, and etc.) is tried to be represented very well to the users traveling in an unfamiliar environment so that, it can be reconstructed later on by using cognitive maps in their minds. Nivala and Sarjakoski (2003) made detail research on categorization of context in mobile map applications, following information should be considered while designing maps for car navigation purposes. Illumination and the brightness of light were found to be somewhat critical in certain situation for physical surroundings. When using mobile map during the day or at night, the map colors and background illumination should be adapted to be surrounding brightness. The map should then be displayed in the right position with respect to the user's line/direction of movement in terms of orientation context. On the other hand, time is an important factor for especially the car navigation systems. However, the system should not only consider the navigation but also ensure the confident travel to the user. Therefore, the data used in these systems should be up to date. One social context awareness application, implemented already, is in some car navigation system; the routes for drivers are suggested utilizing traffic information on traffic jams etc. Besides the culture of the nations using the navigation systems should be taken in to the consideration. When using navigational products, local conventions of navigational symbols as well as the colour should be used. Furthermore, the names of places and streets and address formats can also be presented in many different languages in this context.

Although texts are the descriptive components of the maps, they are not wildly used for navigation map design because of the limited display media and its negative effects on the concentration of the driver. Orientation by using voice is generally used in this manner, but lettering should be used on large-scale maps for especially roads and POIs. Road names can either be permanently viewed, or in the case of on overlay, the road names appear by clicking on depending on the user. Besides the all text and the symbols used in the maps should be represented with a legible size and font type with respect to the viewing distance estimated to be about 50cm. Based upon this distance, minimum widths of 0.24mm, 0.48mm and 0.72mm should be chosen for the different linear signatures. For the optimal readability, the 10 and 12-point fonts of Verdana, Trebuchet, and Geneva are recommended (Wintges, 2003). In addition to these, text placement is still a conflict problem. Related works are performed on this subject (Zhang and Harrie, 2004).

Users need various types of maps in different situation and when usability of maps is concerned, one of the main issues is that the user has the right type of map, at a suitable scale and with the symbology adapted for the specific usage situation (Nivala and Sarjakoski 2003). The user needs may be totally different in various map usage situation (e.g. city or road navigation in national or international scale). Therefore, all maps are designed for different purposes. Aim of the map mainly affects its content and symbolization techniques that will be used in terms of generalization. Generalization has always played an important role in map production. However the scale is an important and determining concept for map contents so it is generally agreed that the scale is the most important constraint of the generalization (Bildirici, 2000). As the map scale reduces, the representation of the mapped features becomes more and more symbolic. That means the level of generalization increases. Although the visual scale of the maps are changeable during the application, it can considered in five main levels according to their application purposes while designing car navigation maps (see Table 1). These levels can also be considered as the levels of the Multiple Representational Databases (MRDB), which aim to produce maps (database) from a single base dataset by using automated generalization (Dogru, 2004). For international applications small scale maps are used based on coverage area. These maps can only be used for general overview and only consist national boundaries and international motorways. If the nationwide navigation is considered, national road maps consisting international motorways, state roads and city boundaries should be visualized for general overview. It means both of these levels use more abstract maps offering a cartographic overview of a wider area, with symbols.

Table 1.Map details for navigation depends on application

Application Levels	**Scale**	**Detail**
International	Depends on coverage	National boundaries, international motorway, related text.
National	1 : 8 000 0000	National boundaries, international motorways, state roads, city boundaries, related text.
City	1 : 250 000	Administrative boundaries, motorways and the state roads, railways, airports, related text.
County	1 : 25 000 - 1 : 50 000	POI (with symbols), motorways, state roads, arterial highways, land use (settlement or green area), related text.
District	1 : 5000 - 1 : 10 000	Land use (buildings, green area) POI, district and building block boundaries, all roads (all roads are represented by aerial symbols, and related text.

As it is stated, coverage area is the core element for determining the scale for international applications. In this study scale factor was examined for other four application levels and the study area for the urban navigation was chosen as the city of Istanbul, which is the most crowded and complicated metropolis of the Turkey. For obtaining a general overview of the whole Turkey 1:8 000 000 scaled maps should be used. City maps with an approximate scale of 1:250 000 is used for viewing the general structure of the city and origin and the destination of the navigation.

More complicated maps with the lower level of generalization represent the last two application levels. These maps are frequently used during the navigation in urban. POIs should be considered as significant elements for orientation and structuring the mental map in the drivers mind as close as the world reality. Although the scale was chosen in a range of 1:5000 and 1:10 000, the content of these maps are much more generalized than the 1:5000 scaled map details. Elimination is highly used for this process. In this concept the maps with the scale of 1:5000 should be considered as the zoomed view of the 1:10 000 scaled maps. Consequently it can be said that a detailed map is included in advance, containing all necessary information and covering the selected area. It means that the content of the maps is not classically related with the scale. All detail maps are designed for a user-dependent display of information.

In this study sample navigation maps were designed in terms of the criteria stated in Table 1. Generalized maps to the scale of 1:10 000 by using CHANGE software produced in Hannover University (Bildirici, 2000) from the 1:5000 scaled maps of the Istanbul Great City Municipality (see Figure 1) were used. Navigation maps as the user interface were derived for the application performed in counties and the districts. In this concept, some buildings eliminated and roads were represented as area for the district level. The geometrical edits were performed manually at this stage. As it is seen in Figure 2 POIs such as schools, hospitals, and places of worship were represented with their generalized geometries. Much more generalization is needed while deriving the maps for county level. POIs were selected and

represented with their symbols while the other buildings were eliminated (See Figure 3). Land use classes were determined as the density of the buildings in the building blocks. It is obvious that all map design considerations cannot actually be implemented yet, especially automated generalization could not be fully succeeded in this context but studies continue as a part of an MRDB application for navigation systems.

Figure 1. 1:5000 scaled base map (the frame emphazies the dimensions of the Figure 2)

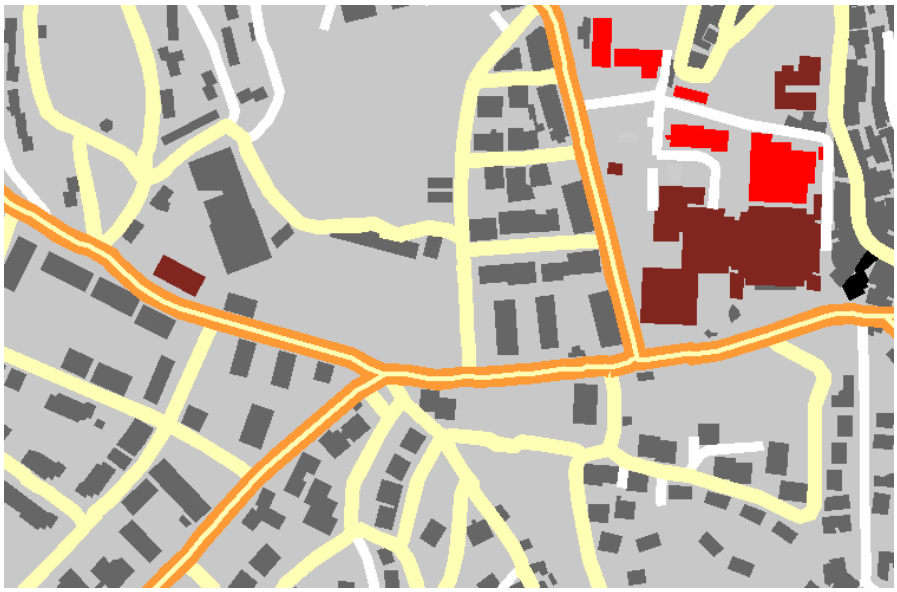

Figure 2. The map produced for district level

4. DISCUSSION AND CONCLUSION

Navigation map design is very troublesome process with its constraints. It needs high accuracy on road networks while performing generalization. On the other hand, final outputs of this process should have spatial characteristics for representing the world reality best. Firstly, all essential components of the route, especially the roads, lines, etc. should be visible and easily identified. Routes must be clearly marked and readily distinguishable at a quick glance. The map should only contain the amount of information necessary to highlight the chosen route. Map content should cover the all information needed for navigation.

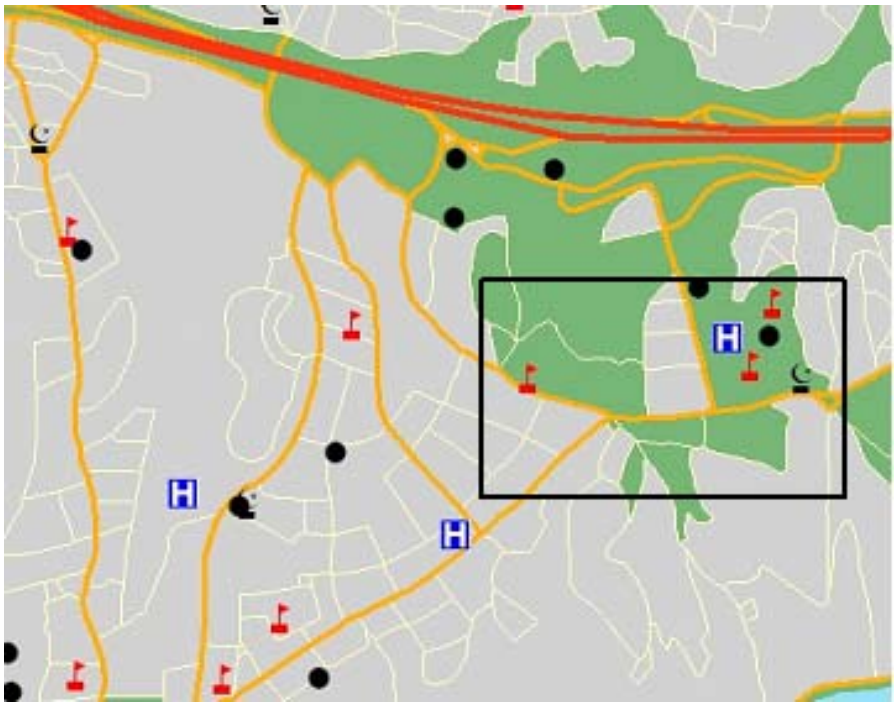

Figure 3. The map produced for county level (the frame emphazies the dimensions of the Figure 2)

There are significant problems while generalizing the maps such as maintaining the topology (nonintersecting roads can intersect as a result of scale change, etc.), smoothing the sharp and short edges of the lines resulted by exaguration. Therefore mapping process needs software with aesthetic concern. POIs are very important elements of the navigation maps for making the drivers mental map clear and obtaining better orientation. Solutions for should be found if is there is no POI in the application area. Expert systems should be used in this manner. In addition to these, software finding solutions to these kind of problems (navigation systems-this technology will be started to used soon in Turkey, not available yet-) should be examined cartographically and new approches shoul be developed for better presentation. It is obvious that the GIS tools are not sufficient for solving all of the visualisation problems. MRDB approach should be used in this manner.

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BIOGRAPHY

Assoc. Prof. Dr. N. Necla ULUGTEKIN is a senior lecturer in the Cartography Division of Department of Geodesy and Photogrammetry in Istanbul Technical University – ITU. Her main interests recently are cartography, visualization, GIS and small display cartographic design.

She was born in 1959 in Sivas/Turkey. She was taken her BSc. in the Department of Geodesy and Photogrammetry in Istanbul Technical University - ITU. In 1984 he began to work as a research associate in the Department of Geodesy and Photogrammetry. Thereafter she has achieved his MSc. degree in 1987 in the Institute of Science and Technology of ITU. In 1986 she was awarded with a fellowship from Netherlands for Post Graduated Education on Cartography. She has taken her PhD degree in the ITU in 1993 on Geometric Improvement of Digitizing of Cadastral Maps.

She is active member and there times she was taken the position in the executive board of the Chamber in Istanbul. She actively remains supporting chambers activities and taken position as a string head or a member in the technical commissions, like Cartography Commission Secretary from Standing Scientific and Technique Commission of Chamber of Surveying, members of Earthquakes and Natural Hazards Commission, Geographic Information System Commission, Education Commission and etc. She has steered the Regulation Commission of Council of Coordination and Planning of Mapping Works Among Ministries for the mission of preparing a law proposal for Turkish National Geographic Information System since early 2003 as represent of University. She is working on cartography in national and internationally as following activities.

- Active member of the Union of Chambers of Turkish Engineers and Architects, Chamber of Surveying Engineers, Istanbul Branch till 1983.
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