Union of Chambers of Turkish Engineers and Architects
Chamber of Surveying and Cadastre Engineers

First National Workshop on Generalization and Multiple Representations

12-13 September 2009,
İznik, Turkey

Abstracts

Dear Researcher,

The National Workshop on Generalization and Multiple Representations was organized on 12-13 September 2009 in Turkey. The workshop was organized by the Standing Commission of Cartography and Spatial Informatics which belongs to the Chamber of Surveying and Cadastre Engineers. The aim of this workshop was to share and discuss the results of ongoing or completed MSc and PhD studies related with generalization and multiple representations in Turkey for determining the scientific capacity of the Turkish Cartographers. During the workshop 11 invited speakers were presented their studies from National Universities, General Commander of Mapping and Organizations to the attendees. This document including the abstracts of presented studies was prepared to share the results of the workshop with cartographic community from all over the world.

Thank you very much for your interest in advance.

Sincerely yours,
Organizing Committee

AUTOMATED PRODUCTION OF 50K MAPS FROM 25K MAPS

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In this reseach, it is tried to demonstrate practically how to produce 1:50 000 scale maps from 1:25 000 scale maps via automatic generalization by making use of traditional generalization principles and rules.

Definitions related with automatic generalization and factors effecting the generalization are discussed. Studies performed before are presented in a historical order. Generalization methods which differ according to the being (human and/or computer) that will decide what, when and how to generalize are presented. Among methods of generalization, first traditional generalization is explained and then automatic generalization methods are presented. Automatic generalization functions and algorithms which are the major topic of the thesis are investigated, related with the model "automatic generalization with digital maps" ("automatic generalization of digital maps") an application is realized.

NEW APPROACH to SIMPLIFICATION of CONTOURS

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In this research, the requirements for the simplification of contours are explained, and existing approaches for the generalization, i.e., simplification and smoothing, of contours are briefly summarized. Skeleton lines, i.e., drainage and ridge lines, are supposed to provide information for the determination of characteristic parts of contours. Characteristic points are automatically determined during the process of derivation of skeleton lines from contours in accordance with the method developed by Aumann's group. Three widely used algorithms for the simplification of contours, i.e., *n*th point, distance tolerance, and Douglas-Peucker, are examined. They are analyzed with respect to the retention of characteristic parts of contours based on case studies. Finally, the algorithms are modified in a way that they consider the determined characteristic points. A new simplification criterion is included included in the algorithms, and thus it is made sure that they retain the characteristic parts of contours.

GENERALISATION OF BUILDINGS AND ROADS IN SCALE RANGE 1:1000 - 1:25000

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Digital techniques have been widely used in cartography since the 70s, and a rapid development in computer technology has taken place in the last decade. In generalization, however, which is one of the major topics of cartography, there is still no adequate solution in a scientific and/or practical sense. On the other hand, these new technologies have led to a rapid development in the field of data capture in cartography and related disciplines. In developed countries in particular, the era of data capture is almost complete. National Mapping Agencies have built large data bases that include mostly large-scale data, i.e., in base map resolution. For applications in smaller scales, existing large-scale data should be used through digital generalization, to avoid redundancies in data capture and to ensure consistency between different data sets that represent the same geographic area.

Although generalization is a complex and subjective process, some important solutions to problems of generalization have been developed. Prominent studies, which are recognized worldwide, have been undertaken at the Institute for Cartography of Hanover University, especially in the generalization of large-scale data. Based on these studies, the CHANGE software product was developed, which is capable of processing building and road objects.

The main subject of this thesis is to apply and to expand the approach of Hanover to Turkish map data. For the case study digital large-scale maps produced by the mapping service of the Municipality of Metropolitan Istanbul were selected. These maps include almost all possible settlement structures that can be seen in the city. Not only the possibility of applying the Hanover solution is investigated, but also the expansion of this approach. This latter aim is realized in the study through the development of substitute programs. A further innovation is the integration of CHANGE, which has no interactive component, with an interactive CAD-GIS system, namely AutoCAD MAP. Here, a universal data exchange standard, DXF, is used, which makes it possible to integrate CHANGE, the kernel system, with most of the CAD-GIS software. Considerations of the quality of generalization and GIS applications after generalization, the topological and semantic consistency and adequate graphic quality of the digital data before and after generalization are important issues. In order to meet these requirements, substituting programs developed for this study expand the approach proposed here. Moreover, a new approach, namely building generalization in separate logical regions, is realized.

Finally, CHANGE, AutoCAD MAP and the substitute programs are components of an integrated system that can be used by National Mapping Agencies and similar institutions. Consideration of the case study of this thesis shows the evident applicability of this system.
The thesis summarized above was discussed in the workshop on generalization and multiple representation

10 years later. Some issued from the discussion is given below.

The thesis focuses on the generalization of building objects with area geometry. The geometry is the same after generalization. The scale ranges from 1:1000 to 1:25000. In the production of 25K topographic maps of Turkey, most of the geometry of buildings is point. It is questionable that the approach of thesis is applicable in the production of 25K maps in Turkey. In contrast to this approach in Turkey, the European 25K map sets contain many building objects with area geometry at this scale. The main concern of the Turkish approach speed production. On he other hand, the point buildings are mostly scattered objects in rural areas. In urban areas, there are many areal buildings even in Turkish production approach. Therefore, the approach of the thesis is applicable in urban areas.

Another issue arises in the discussion is the production of 1:5000 map sheets, where no generalization is applied. These sheets are directly reduced from 1:1000 maps. The approach of the thesis should be applied here.

Finally the thesis stayed at theoretical level like many other dissertation in Turkey.

AUTOMATED GENERALISATION OF BUILDINGS AND BUILT-UP AREAS FOR MEDIUM SCALE TOPOGRAPHIC MAPS IN AN OBJECT-ORIENTED GEOGRAPHIC INFORMATION SYSTEM ENVIRONMENT

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Different application areas require modelling and visualisation of geographic space at various scales and themes. Two approaches, data acquisition and generalisation, can be used for this purpose. The general trend is in the direction of constructing one master spatial database and deriving many other products from that database via generalisation owing to the reasons such as high data production costs, updating and revision problems, the activities for national, regional and global spatial data infrastructures, increasing demands of society for geographic information and maps. In this study, it is aimed at developing automated generalisation solutions for buildings and built-up areas in deriving medium scale topographic maps and cartographic databases from master (base) geographic database, regarding short and long term requirements in Turkey. Topographic data were modelled within object-oriented geographic information system and map production software Gothic LAMPS2 prior to generalisation. Generalisation solutions are dealt with in two steps: individual generalisation and contextual generalisation. First roads are simplified and smoothed since they delimit buildings in general. Then manual/interactive selection operation is performed for

road networks considering the criteria such as road type, graphic limits, connection to main roads, continuity, minimum building size (if a building exists in the block surrounded by roads). A variety of methods (granularity, rectangularity, compactness, convexity, elongation, orientation, number of corner, centre of gravity, distance to nearest road) that reveal geometric and structural properties of individual buildings were developed in order to assist the determination of proper generalisation operations and (static or dynamic/iterative) parameters for them. Individual building generalisation consists of those steps: squaring of buildings, enlargement of simple and complex shaped buildings, changing the elongation of buildings, simplification of buildings, collapse and symbolisation of small buildings. In addition, built-up areas are also simplified. After that blocks are created by means of buffers of roads. Then built-up areas are smashed according to blocks. Next built-up areas are constituted in dense blocks since it will be impossible to apply any other operation. Then a strategy is developed that strengthen the decision-making mechanism in contextual generalisation in blocks. In this strategy, building clusters are created through the buffers of buildings that are of graphic conflicts according to target scale and more related than the others owing to nearness according to first law of geography. Delaunay triangles and hence Voronoi polygons are obtained based on the corner points and the additional points interpolated on the contours of buildings and blocks. Voronoi zones are created for each cluster by combining Voronoi polygons that the buildings belonging to it intersect with and trimming them in regard to graphic limits. Thus

generalisation problem is reduced to producing a proper generalisation solution within each zone.

Various methods (mean elongation, mean granularity, mean distance, mean nearest neighbour distance, standard distance, Voronoi density, block density, maximum area, median area, minimum area, number of complex shapes, number of different shapes, number of rectangular shapes, number of square shapes, number of semantic types, number of different buildings, number of official buildings, number of residential buildings, number of total buildings, total density, position) have also been developed to reveal spatial properties and/or relationships of buildings and/or built-up areas within group objects (block, Voronoi zone or cluster). The clusters in the Voronoi zones that are formed with nearness criterion are divided into sub-clusters, regarding semantic, shape and size criteria. After that, amalgamation, aggregation or typification operation is applied in the zones, depending on the density and some other spatial properties and relationships. Generalisation parameters are dynamically or statically determined depending on one or more clusters that a zone contains. All processes were automatically performed by means of KartoGEN generalisation interface and methods in database level developed using Lull programming language. It concluded with a case study for cartographic generalisation of medium scale topographic cartographic data set and an evaluation of obtained results.

The contributions in this study can be summarised as follow:

- Examination and original interpretations of some concepts concerning multi-resolution/representation spatial databases and generalisation (geometric, semantic and graphic resolution, geographic model, cartographic model, topographic data, thematic data etc.),
- Examination and schematic representation of different conceptual levels in a geographic database from automated generalisation perspective,
- Developing a general conceptual model of roads, buildings and built-up areas for a geographic database oriented to medium resolution/scale topographic data production in Turkey,
- First application of object-oriented approach for generalisation in Turkey,
- Making a proposal for the selection operation in inner-city roads,
- Determining spatial (geometric, structural and semantic) properties and/or relationships of buildings, groups of buildings and group objects (block, Voronoi zone or cluster), and developing database level methods for revealing them so as to use in generalisation,
- Determining proper generalisation operations and (dynamic/iterative or static) parameters,
- Enabling dynamic and hence more effective utilisation of an existing building simplification algorithm,
- Single axis positive/negative scaling algorithm for buildings,
- Single criterion clustering and multi-criteria

progressive sub-clustering of buildings for generalisation,

- Developing a structure recognition technique based on Voronoi diagrams (published in an ISI journal),
- Developing a typification algorithm, based on hierarchical clustering that usually suit to the buildings with irregular distribution called "Basaraner-Selcuk typification algorithm" (cited in an international scientific book),
- Developing an interface for automated generalisation of buildings and built-up areas.

The parts of the study in improvement/to be improved and complementary studies in development/to be developed are as follows:

- Advanced spatial analysis in Voronoi zones and/or re-arrangement of the zones for more proper generalisation decisions and results,
- Displacement of buildings,
- Clustering of buildings,
- Typification or elimination of buildings in complex zones,
- Analysis of different building configurations (patterns) and their preservation during generalisation,
- Interaction of Voronoi regions
- Meso level evaluation of generalisation quality
- Multi-resolution spatial database design and automated updating

Interconnected studies are as follows:

- Building generalisation at large and medium scales,
- Generalisation of delimiting object types (transportation and hydrography).

CARTOGRAPHIC APPROACHES FOR DESIGNING CAR NAVIGATION MAPS BY USING MULTIPLE REPRESENTATIONAL DATABASES

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Geographical Information System (GIS) is a multi disciplinary work so various users with various requirements use these systems. This situation complicates the organization of the data and increasing density of the data appears as a problem that is needed to be solved. Optimization of the map data and its visualization depending on the aim of the application are the other important issues related with data organization. Modeling the physical reality as multiple representations is provided by the use of zoom levels in GIS applications. Maps with different levels of detail are created for each zoom level. These maps are entitled as multiple representations and currently modeled based on Multiple Representation Databases (MRDB) approach, which is used to store the same real world phenomena at different levels of accuracy and resolution. The use of MRDB also provides the automation of the generalization and updating processes of the maps.

Navigation, which aims at wayfinding especially in the foreign environment, is a fundamental human activity and an integral part of everyday life. Advanced navigation systems integrate positioning and communication techniques, digital mapping, computer and handheld device technologies to cover the aim of navigation application. In addition to the accuracy of the

data used in these systems, efficient communication of the system based information with the user is also important for the success of the system. Maps are used for the communication of the information together with the use of multi media technologies supported by the system. Since navigation maps are the basic visual tools for information communication in car navigation systems, they should be designed depending on the aim of the application for increasing the efficiency of the implemented system.

Map design for navigation purposes should be considered in terms of small display cartography, since navigation systems use small display devices as hardware. Small display map design requires additional constraints in comparison with traditional map design. The common aim of these maps is to communicate the optimal data on a small display media. This task requires a special map design process including the intensive use of the generalization methods. Additionally databases used to design navigation maps need systematic updates in the case of changes in road geometries or attributes. All requirements of navigation map design process coincide with the context of the MRDB.

Generalization is certainly one of the most important issues of the cartography which is the science and art of visualization of world reality on paper, screen or similar media. Particularly researches on automated generalization, data base design for multiple representations with very huge amount of data currently became a research base of Cartography. Similar to GIS

applications, current car navigation systems use predefined zoom level and selection strategy to generalize the map content for the use of different levels of representations. Although this method covers several needs of car navigation, its static structure on data derivation and visualization issues should be improved for the use of 3 dimensional and real-time navigation applications. These applications are the new trends of current navigation technology.

In this study, an automated system were designed and implemented for deriving the data, which will be used for car navigation map design, from the base data by considering MRDB. The base data only includes navigable road network data and buildings with their geometries and attributes. Concurrently with the system design works, current commercial car navigation products were examined depending on the technologies that they used for map design. In this context, deficiencies on the optimization of the map content were determined as a problem that can be covered by using user centered generalization approaches. Optimization of the road network data and the land use information of areal data were considered as the problems to be solved in this study and a user centered approach for navigation oriented generalization was proposed to add value of current navigation systems in use. This approach covers generalization processes applied on both areal and linear objects for optimizing the data presented at detailed level. The constraint that makes it user centric is to consider the calculated navigation route as the main component of the data while generalizing it. Both areal and linear

generalizations are realized by using calculated route geometry. Therefore this process is applied whenever a route calculated and it gives different results for each application.

As the second part of the study a classification approach processing on road interchanges was proposed for reducing the visual complexity of the small scaled road maps. The aim of this proposal is to determine and classify road interchanges for the use of generalization. In this context, interchanges were first derived from the road network data by using semiautomatic way then they were identified as matrices and tree structures. These identifications enabled the user to classify interchanges depending on their common characteristics. Classification results were proposed to be used for automated symbolization of interchanges on small scaled road maps.

A NEW SELECTION/ELIMINATION APPROACH FOR THE GENERALIZATION OF URBAN ROAD NETWORKS

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Road objects which build a network structure are important artificial objects of topographic maps. They are directly and effectively related to other map objects such as buildings. Cartographic generalization of road networks begins with the selection/elimination process.
The aim of this study is to contribute to the solution of generalization problem for roads that still remains unsolved in cartography, by developing a more qualified, objective and heuristic selection/elimination approach in urban areas. In order to achieve this aim, it is determined to handle the problem in object-oriented geographic information system environment, and to make use of urban blocks formed by road networks. Although the scope of study is limited to the selection/elimination for road networks, urban blocks and their specifications are also analyzed to obtain more useful results from the view of building generalization. These specifications are derived from geo-spatial information of the urban blocks such as their size, whether they include buildings or not, the lengths and connectivity values of roads forming an urban block, and the numbers of buildings to be showed in an urban block at target scale. In the light of them, the urban blocks are amalgamated for the realization of the developed conditions and thus the roads that are unnecessary for the target scale are eliminated.

In this study, the source scale is determined to be 1:25,000 and target scales are to be 1:50,000 and 1:100,000. An experimental testing is realized in object-oriented Gothic database via a series of commands put into Radius Clarity as a menu and coded in Java programming language. The results of tests are compared in terms of formal and quantitative features with the results of selection/elimination process carried out by an experienced cartographer.

Since the selection/elimination approach is designed by considering roads, urban blocks and buildings in this study, it can be say that it deals with the other generalization studies on buildings and urban areas. Also, the selected road networks used to design navigation maps, and to create multiple representation databases for the road networks. However, the test results shows that the new approach developed in this study should be redesigned in future including displacement and caricature operators to be able to make an appropriate cartographic representation of a road network. In addition, when the measures used for weighting road segments are extended to create an objective hierarchy in future, the urban blocks are going to be amalgamated more accurately and precisely.

THREE DIMENSIONAL CITY MODELING AT DIFFERENT LEVELS OF DETAIL AND THE INVESTIGATION OF ITS APPLICABILITY

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Digital maps, which are produced to use for Geographic Information System (GIS) contain geometric and semantic information of spatial objects and provide a basis for operation and communication among the data groups. Cartography has had, and continues to have, important and indispensable roles in spatial data acquisition, processing, and visualization. Primary objective of cartographic visualization is properly, easily, and quickly perception of spatial information for the map users. The developments in computer technology made 3D representations more popular tools for visualizing information.

The needs for 3D city models are growing rapidly and the applications of those models are appearing in a variety of fields in recent years. In parallel, the speed of the internet communication is being greatly improved by the fast and wide spread of broadband infrastructure. Nowadays, those web3D applications are waited to desire that make possible interactive fly-through and walk-through manipulations in detailed 3D city models on the internet. For the recent few years the researchers have developed techniques for automatic generation of 3D city model using 3D LIDAR data, 2D digital GIS (Geographic Information System) maps and satellite images.

The newly developed 3D urban information system use semantic data, provide transmission and reception of a great amount of urban information with interactive manipulation of detailed 3D city models linked with GIS. New techniques developed for this purpose, include; reduction of data, Level of Detail (LoD) modeling and streaming, and linkage between 3D city model and GIS.

Digital Terrain Models (DTMs) and 3D building models at different LoDs can be unified in order to create 3D city models at different LoDs. Communication, dissemination and presentation of large buildings with complex structure can be performed more rapidly by modeling 3D city models at different LoDs. They contains at different levels of detail of a city from interior of an individual building to built-up areas. These levels are usually denoted with LoD0, LoD1, LoD2, LoD3 and LoD4 from coarser (lower) to finer (higher) respectively.

This research includes information about 3D data handling and 3D data modeling techniques also examines 3D DTM generalization, 2D and 3D building generalization. Besides it contains 3D spatial visualization of city models, virtual reality and web based dissemination of 3D spatial models by using modeling and mark up languages. In this study, LoD, which is actual and newly developing domain for 3D city modeling was examined. Sufficiency of existing data in our country was tested for LoD-based 3D city modeling and its deficiency was introduced. Then recommendations were made for data acquisition. In the

case study part of this study LandXplorer Studio Professional™, 3D city modeling and GIS software, was used. The data, used, was provided by Istanbul Metropolitan Municipality and the Beyoglu Municipality. Sultanahmet and Beyoglu districts, which are the most historical places of Istanbul, were selected as application area. Models of this region were developed at four different levels of detail. Digital terrain model (LoD0) was created by using 5 m resolution raster DEM (Digital Elevation Model) data. LoD1 model was created by using block buildings, which were generated from 2D GIS data. And then building facades, roof types, and 3D detailed building models were integrated into the LoD1 model so that LoD2 and LoD3 models were created. LoD4 was not created because this LoD contains interior building objects. Finally, it was observed that generalization criteria suggested by Open Geospatial Consortium (OGC) was not appropriate for the data used in the application and more appropriate generalization criteria were determined.

CARTOGRAPHIC GENERALIZATION OF BUILDINGS FOR THE RANGE OF MEDIUM SCALES

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A geographic phenomenon is represented by cartographic symbols on maps. These symbols have the geometry of point, line or polygon. Point and line sizes are same for maps having same standards but different scales. For instance; for the 1:25000, 1:50000, and 1:100000 scale maps produced in our country, point building symbol size is 0.5 mm. When all features represented in basic map also preserved in derived map, conflicts occur. The same point and line symbol size for all three scales is the reason for this.

Settlement areas consist of point buildings especially in rural areas. When point building in source map symbolized in target scale, they overlap. For this reason, while producing derived maps, appropriate buildings that represent settlement best should be selected.

In this study, it is aimed to realize the selection/elimination process of building features in digital data and to develop algorithms and program these algorithms for the production of 1:50 000 and 1:100 000 scale maps from 1:25 000 scale basic maps. In scope of this research study, two algorithms, angle and range algorithms, are developed for the selection of buildings which represent settlement area.

Angle algorithm is developed by using corner angles of the area which represents the cluster formed by building features. Range algorithm also firstly finds area representing cluster formed by building features and then uses the distance between the centroid of the area and features.

Onward part of the study, it is planned to try mesh optimization and polarization algorithms which are mentioned in literature. Additionally, to find out building clusters, cluster analysis used in statistical applications will be investigated and the possibility to use it and programming studies will be accomplished.

ENTROPY CONCEPT AND USE OF RESULTS IN CARTOGRAPY

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Entropy Theorem is the second law of thermodynamics. Entropy is the scientific name of indefiniteness in universe briefly. Although it is defined as the measure of indefiniteness of a system.

The studies for using entropy in communication area leaded to new researches in cartography including measuring the statistical information of map. The information defined using entropy is named statistical information.

In this study, entropy theorem which is one of the methods for quantitative measurement of statistical information of map is investigated. Statistical information of same scale maps is measured in practice and the results are compared. Moreover statistical information of maps generalized using different methods is measured and results are evaluated. Some practices are realized for defining the object numbers of object types automatically, that is the needed component of entropy calculation. Aimed at this purpose, some algorithms are studied in Matlab software. The studies mentioned are still being continued.

In the study, the success of measuring statistical information of map is investigated using the results obtained and improving a new criterion for evaluation of

maps is aimed. Thus the method can be effectively used in cartography for evaluation of different generalization algorithms.

SELECTION OF THE ROADS AUTOMATICALLY BY NETWORK STRUCTURE IN TRANSPORTATION GENERALIZATION

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Modeling and representing real world at several scales for the different purposes and requirements are the first goals of the cartography discipline. Therefore, generalization has been developed into one of the priority research topic for the cartographers and the researchers who involved in related disciplines. By means of the huge efforts of the researchers and the recent technology, hard working has been done and saticfactory results have been received about feasibility of the generalization automatic/semiautomatic in digital environment.

Because of the high production costs, updating problems, increasing geographical information and map requirements of the people and the associations, the thought of the constructing a basic geographical database and producing other products from this database by generalization method has been adopted by many map production associations any more.
In this study, the linear road data that must exist at 1:50.000 scaled map is tried to be selected automatically by using the data at 1:25.000 scale. Thus, saving time from production period and providing standardization in selection results is aimed.

In application, 1:25.000 scaled cartographic vector data are used. This data is stored in environment of Microsoft

Access Database (mdb.) as ESRI personal geodatabase. In selection process of the roads, junction points which not existing in database and positioned at the intersection points of the roads are created and selection is done by using these junction points.

It is understood that more complex and satisfactory queries and analysis can be done by adding to the database some informations like route, direction about junction points used in application.

AREA-LINE GEOMETRY CHANGES IN MODEL GENERALIZATION

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Reducing the real world reality to map scale makes generalization necessary. This reduction influences geometry and attributes of objects. In model generalization, area-line, area-point and line-point changes occur. In this study, area-line changes are handled. Area – line geometry – type changes are mainly required in two situations. The objects like roads, rivers etc. can be represented with boundary lines at most at 1:5000 scale. In smaller scales, centerlines, which represent the whole object in reality, are required. On the other hand, spatial analyses, which are very important for Geographical Informational Systems, make it necessary to have centerlines, even in large scales. Since area objects have different geometric properties, there is no universal solution that is applicable to all kinds of area objects. Therefore there are several methods applicable to certain objects under certain circumstances. Priorities of the methods are accuracy, processing time and optimal use of computer memory. We discuss five methods for area – line geometry change (triangulation, waterlines, maximal ball, straight skeleton and thinning methods) and double line – single line change method in detail. Finally an algorithm that is developed based on the triangulation method is explained in detail.

The results obtained are generally acceptable. In some cases post processing at junctions is required. After the

discussions at the workshop it has been observed that the centerlines of the roads created by using the methodology of this study can be a basis for generalization operations at smaller scales. Considering the geometric and topologic quality of geodata in our country, which is sometimes very problematic, this approach delivers acceptable road centerlines that are useable in a variety of GIS and generalization applications. This is an important merit of the study. The development of the methodology and the software is going on. In near future some post-processing tools will be added in order to obtain a better skeleton of the roads.