A CONCEPT OF CARTOGRAPHIC SOFTWARE FOR DESIGNING DATA VISUALIZATION IN MOBILE SYSTEMS

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Abstract

The developed prototype cartographic application was initially tested and it confirmed the correctness of the concept and usefulness of the proposed solution. Besides software development, the project will resulte in construction of the laboratory and environment of testing the visualizations in mobile systems. At present, further works aiming at specification and final testing the developed concept and its widening with visualization performed basing on various types of projectors, have been continued. The MobiKart application functionality is also developed and the final format of the presentation description in the xml format is prepared.

Keywords: cartographic methodology, geographic data visualization, mobile GIS, mobile cartography, car navigation systems, GPS, LBS

1. Introduction

One of the main objectives of the project, which was implemented at the Department of Cartography, the Warsaw University of Technology (Project No. 0129/B/T02/2008/35 of the Ministry of Science and Higher Education) was to define the methodology of development of cartographic presentations (visualization) using mobile devices, as well as to propose and design new cartographic tools and determination of impacts of new technologies and conceptual solutions on the theory of cartography.

Analyses and experiments performed by the author of this paper allow to define preliminary methodological guidelines for that process. Those guidelines refer to rules of data visualization, and, on the other hand, construction and utilisation of cartographic tools. This paper discusses, first of all, the concept of construction of new cartographic tools.

The methodological bases of designing cartographic presentations were discussed in the papers (Gotlib 2008) and (Gotlib 2009).

2. Basic conceptual assumptions of the visualization system

Development of modern cartographic visualization for GPS navigation systems cannot be performed without consideration of technological issues. It is similar to the case of printed maps, where the major role is played by the knowledge and experiences related to the technology of printing. In distinction from the process of development of conventional maps, different technologies should be recognised, and, thus the conventional methodology of preparation of cartographic presentations should be modified.

Unlike in the case of the conventional map, the concept of a navigation map must be usually tested for many mobile devices. Therefore a set of at least several test devices should be methodologically selected. The final number of devices, which may be used by the users of the navigation system, is usually high and utilised devices considerably differ between one another. It happens even within the group of devices which meet the same nominal parameters, such as resolution, the number of colours or the anti-reflective covers.

Some systems of visualization of the mobile systems apply the antialiasing techniques (which considerably improve the quality of the graphic presentation). Therefore, in the process of creation of the visualization system, a set of at least several, representative testing devices should be methodologically selected.
Tools for preparation of cartographic visualization should allow for simulation of the layout of a map for devices of different resolution, size, contrast. However, its practical implementation is not simple.

The aspect related to optimisation is very important. Although the power of devices constantly grows, the volume and complexity of data, which should be made available to users, also grows; the methodology of cartographic visualization (3D views, pseudo-realistic views, displaying aerial and satellite images, photographs of objects etc.) becomes more complicated. Mobile systems must operate with high speed and without any breaks. One of the key elements, which influences the operation speed, is cartographic data presentation, (which requires that large numbers of objects are read-in the device memory). Therefore, optimisation of the amount of the displayed data is required. That is why tools, which support cartographic presentation, should include embedded statistical modules, which – for a given data set – can calculate the number of objects presented at particular scales. This will ensure the efficiency expected by the creator of the navigation application.

Cartographic presentation should be strictly defined and described using a specified forma language. It is proposed to separate layers of definition of the cartographic visualization from data. It is also proposed to describe the method of the cartographic presentation as XML files. Development of a uniform standard in this field is required.

Cartographic tools should simplify preparation of correct cartographic visualization, which are effective in various illumination conditions (in day and night, in sunny and cloudy weather, in conditions of artificial and natural illumination, in a car and outside), and for various parameters of monitors of mobile devices (high differences in projection of colours and resolution) and projectors (displaying information on car glasses or with the use of the HUD - „Head Up Display” – type devices).

Those and other aspects of the cartographic presentation designing process were considered in papers (Reichenbacher 2004, Nagi 2004, Gotlib 2008, Gotlib 2009).

Within the project, a prototype system of designing the cartographical presentation system for mobile navigation and location based systems (first of all, car systems) was developed, which includes the following components:

1) Prototype software tool (under the working name MobiKart) for creation of mobile cartographic presentations, which considers the methodology of operations defined in the work,

2) Stationary environment for analyses and testing visualization of mobile applications,

3) Mobile environment of analyses and testing visualization of mobile applications.

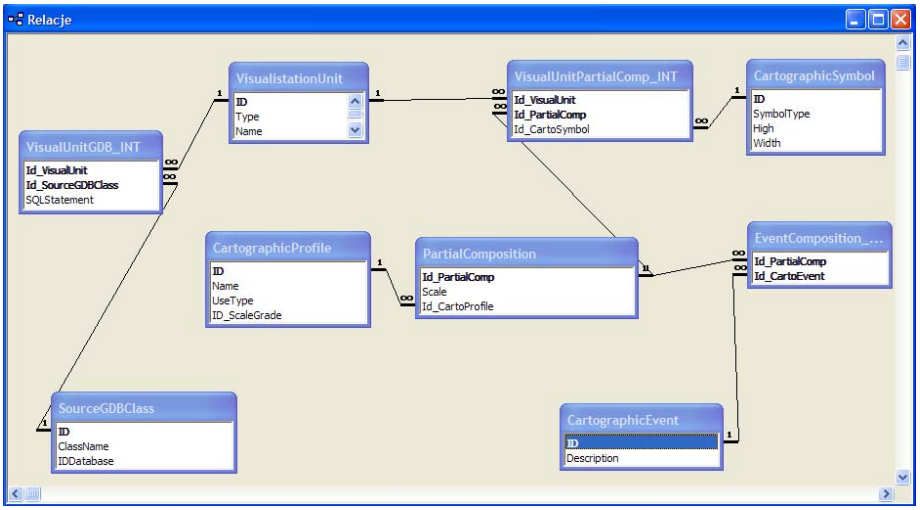
Only examples of solutions have been proposed in described investigations, which are the proposals of directing operations for manufacturers. The success of such solutions is important only in the case of introduction of official standards. The author aims, among others, at focusing on the needs of standardisation in this field. The cartographic presentation, which has been once developed, could be used for controlling – at least to the basic extension – the way of displaying data in various mobile systems, which utilise the same GIS database. This would also allow for wider creation of individual cartographic presentations by the users and for developing the amateur society of users, amateurs-cartographers.

After performing the initial tests, development of the cartographic tool of the following features has been proposed:

- Separation of the system of designing the cartographic presentation from the module of visualization of the navigation system, which allows for the possibly abstractive description of the cartographic presentation (in practice, today, all existing tools are fully integrated with the environment of the navigation application), with additional extensions for particular navigation applications (such as, for example, selection of scale thresholds, co-operation with converters),
- Visualization prepared basing on a carefully selected, test spatial data set, representing areas of various geographic characteristics – an area of a big, complicated road junction, a motorway, a city centre, rural areas, forested areas, a sea-coast, mountains,
- The possibility to perform tests of the application in conditions of simulation of various parameters of mobile devices and conditions of their utilisation,
- Simultaneous preview and possibility to compare several versions of a map (“cartographic profiles”),
- The possibility to optimise the cartographic presentation (the navigation system) by giving statistical data for particular components of the cartographic visualization, which inform about the number of displayed lines, points, polygons, labels, the number of vertices, time of readouts etc.,
- The possibility to have a mobile module which allows for connection to the system of mobile devices and simulation of utilisation of the cartographic presentation.

3. Characteristics of the MobiKart software

The software prototype is based on the Cartographic Presentation Model described in (Gotlib 2009). It allows for development of the, so-called, “Cartographic Profiles”, which are composed of many “Partial cartographic compositions”. The “Visualization Unit”, selected from the source GIS database is the basis of visualization. Data which describes the presentation, being a specific type of metadata, is recorded in the format of the selected database (the prototype has been based on the MS Access database – see Fig.1), and then it is finally exported to the XML file.



CartographicEvent : Tabela

	ID	Description
+	1	Speed > 90 km/h
+	2	Speed > 60 km/h and < 90 km/h
+	3	Speed < 60 km/h
+	4	Manoeuvre in 600 m
+	5	Manoeuvre in 300 m
+	6	Manoeuvre in 150 m
+	7	Built-up area entrance
+	8	Built-up area exit
+	9	Zoom to route function
+	10	Zoom to selected object
+	11	Speed < 10 km/h
+	12	Speed = 0 km/h

VisualisationUnit : Tabela

ID	Type	Name
1	1	Autostrady
2	1	Ekspresowe dwujezdniowe
3	1	Ekspresowe jednojezdniowe
4	1	Główne dwujezdniowe
5	1	Główne jednojezdniowe z poboczem twardym
6	1	Główne jednojezdniowe bez pobocza
7	1	Drugorzędne dwujezdniowe
8	1	Drugorzędne jednojezdniowe
9	1	Lokalne
10	1	Szlak pieszy czerwony
11	1	Szlak pieszy zielony
12	1	Szlak rowerowy żółty
13	1	Obszar zabudowany do 1000m2
14	1	Obszar zabudowany powyżej 1000 m2
15	1	Lasy poniżej 5000 m2
16	1	Lasy powyżej 5000 m2
17	2	Nocleg
18	2	Ambasada

Figure 1. A logical model of data and examples of data tables, used in the prototype solution for describing the cartographic presentation.

As the module of visualization the software component NavigoX by PPWK S.A has been used, which is the ActiveX type component. It is possibly to build the similar software basing on another database and another component of visualization.

The relation between the MobiKart software and components of the navigation system is presented in Fig.2. Basing on the GIS database content or on information from the converter of the navigation system (CoNVerter – CNV), the cartographic visualization system (CVS) generates “The list of Visualization Units”. After assigning visualization parameters to particular units in the MobiKart editor, information is transferred by means of the XML format to the module of the navigation application (VM) and/or the CNV converter. In the latter case information may be used for controlling the conversion process in order to obtain the appropriate cartographic presentation (if the converter designer decides to utilise those data).

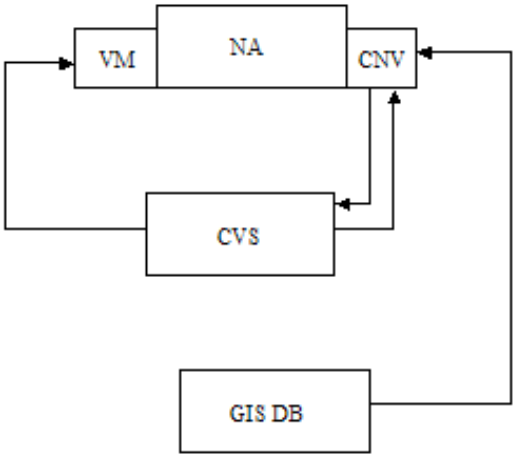


Figure 2. Relations between the cartographic system of visualization designing (CVS) and components of the navigation system. NA – navigation application, VM – visualization module of the navigation application, CNV – the converter of the navigation application, GIS DB – the source GIS database

The design of the graphical interface of the application is presented in Fig.3. The prototype application has been developed basing on this design; it has been currently developed. In the course of preparation of this paper, the graphical interface has undergone the complex reconstruction, therefore only the design version is presented.

Development of the cartographic visualization comprises the creation of a specified „cartographic profile”:

- selection and description of the visualization units,
- assigning the identifiers of cartographic symbols to particular classes of objects,
- selection of a symbol representing the planned travel route (including intermediate and destination points),
- selection of a symbol which represents the mobile object,
- selection of patterns and proportions for presentation of the horizon,
- definition of a method of labelling particular objects,
- determination of scale thresholds (the scale series), which will be maintained for the specified visualization,
- assigning the events resulting in changes of scale thresholds (e.g. approaching a cross-road at a given distance, entering the built-up area, exceeding the specified speed, etc.,
- defining priorities of displaying objects,
- defining sets of objects of the highest hierarchy for the given type of the profile (maintaining the context in the mobile application),
- performing tests and correction of visualization,
- recording information which defines the presentation in the XML format.

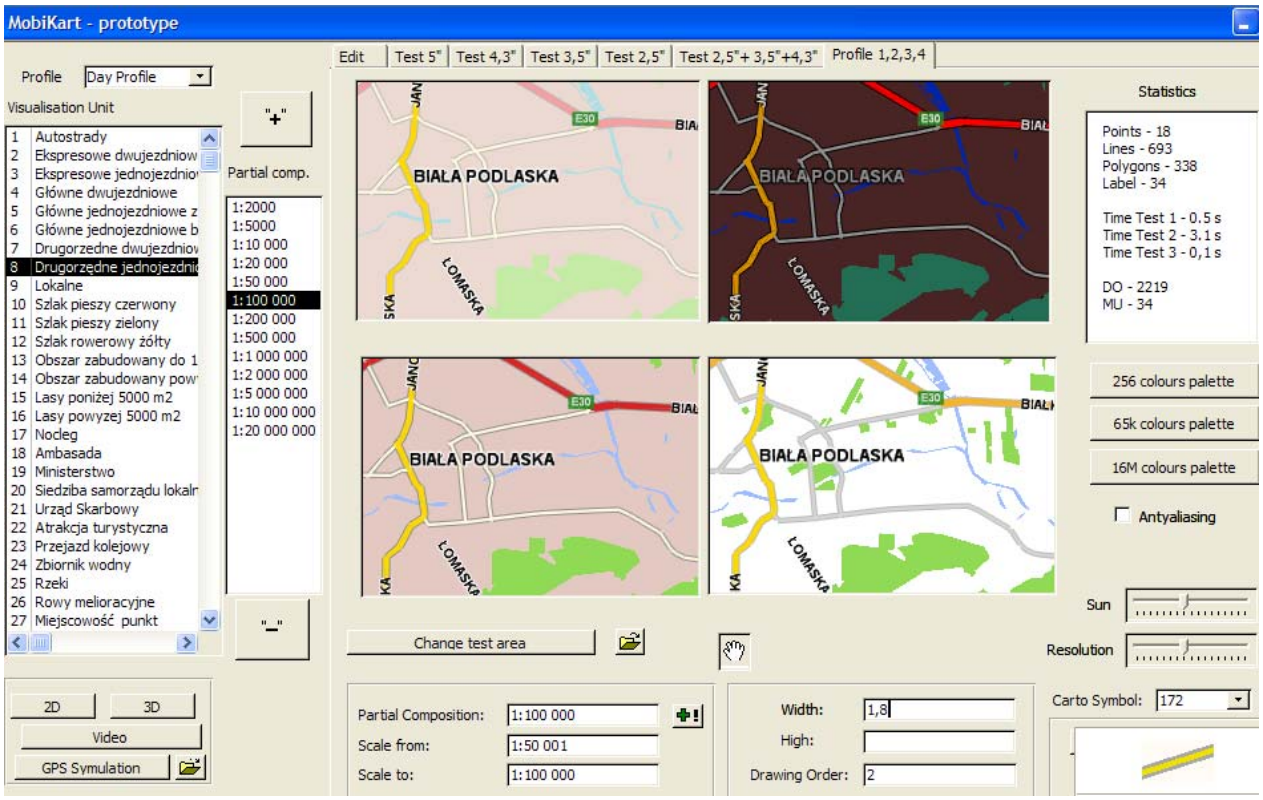


Figure 3. The user's interface sample of the the prototype aplication MobiKart.

Development of a full, modern cartographic presentation means that at least several cartographic profiles must be created, which consider such features of the system environment, the user and the objectives, as, for example:

- a cloudy day, low illumination intensity, high illumination intensity,
- spring, summer, autumn, winter,
- morning, noon, evening, night,
- business, pedestrian tourism, tourism by car etc.

Below a short discussion of selected, basic functional features of the designed MobiKart application are presented:

1) Selection between the „Professional" and „Average User" modes,

In the „Professional" mode it is possible to arbitrarily modify graphics of particular objects. It differs in the case of the "Average User" mode. It was assumed that this mode would be used for creation of presentations by non-professionals (the system end-users) when personal preferences differ from supplied, ready to use, professional visualizations. In such a case the user selects colours, patterns or scale intervals of presentations,, only out of the sets, which are available in the application. Selection of a way of visualization of particular components of presentations is not independent. Selection of the specified way of visualization of a road network, for example, influences the available palettes of colours and patterns for built-up areas or waters, and vice versa.

2) The possibility to preview the visualization effects in various sizes

The application allows for viewing the map with such scope which corresponds to the size of typical displays of mobile devices: 5”, 4.3”, 3.5” and 2,5”. This allows for appropriate evaluation of differences in perception of prepared cartographic presentations. Depending on the display size of the navigation device, this may be the need to modify the size of object descriptions, etc.

3) The possibility of simultaneous preview of several cartographic profiles

This function allows for simultaneous displaying up to 4 cartographic profiles at the size of 2.5”. This allows for evaluation of consistency and comparison of various solutions, and, in particular, it facilitates implementation of user tests.

4) The possibility to switch between 2D and 3D visualization

This function allows for adaptation of the prepared cartographic presentation to map display modes, commonly available in navigation systems.

5) The possibility of previewing visualization results in the dynamic mode (simulation of movements of the mobile device).

This function allows for reading-in from a file the recorded GPS logs and for simulation of the user movements, and, therefore, results in changes on a map (the scale change, display „refreshment”, change of the content, rotation, overlapping the route symbol and the moving user with other content elements), the user will face in the course of the system utilisation. This allows, in the laboratory mode, for testing the correctness of the cartographic presentation in conditions similar to the real conditions of its utilisation. This function allows for evaluation of the influence of dynamic visualization elements on perception of the developed map.

6) The possibilities to simulate the Sun illumination intensity

One of the most important factors, which decrease the readability of the cartographic presentation in the mobile system is intensive Sun illumination, which results in the decrease of readability of the map image. The bright environment results, on one hand, in the decrease of contrast of the displayed image, and, on the other hand, it causes reflections from the mobile display, which, in extreme cases makes the readout of the large part of the map impossible. The Sun illumination considerably changes perception of colours applied in the cartographic presentation; it limits the possibility to differentiate objects, to read names etc. Therefore, in the phase of testing the application allows for controlling the parameters of brightness and contrast within the area of the map preview window. However, further works are performed which aim at utilisation of more sophisticated algorithms of simulation of the display illumination by the Sun.

7) Simulation of changes in the display resolution

The application allows for simulation of changes of the display resolution. This allows for observing the influence of increased pixels of readability of some cartographic symbols (first of all, thin lines and labels) and on the general evaluation of the influence of low resolution on the perception of the designed cartographic presentation.

8) Preview of visualization effects in the case of available antialiasing functions

The quality of map is strongly influenced by the utilisation of the antialiasing function. Since not all navigation applications allow for utilisation of that function, in the course of designing the cartographic presentation, the possibility to watch the map with the antialiasing function, which are turned on and off, is very useful.

9) The possibility to evaluate the visualization effectiveness

Implementation of the efficiency analysis is possible, among others, by means of calculation of statistic data for objects and time required for selected operations. First of all, information concerning the number of objects of various geometric types and descriptions of objects, which are displayed at the given moment at the specified scale (the partial cartographic presentation). The possibility to connect a mobile device to MobiKart, with a special application module MobiKart, which will allow for transfer of information about the real time of implementation of selected graphical operations to the main application (e.g. map shift, zooming in/out). Results of such measurements will not serve for measurement of the efficiency of the final applications, but for relative measurements only – comparing of the influence of various versions of the cartographic presentations on the efficiency of the visualization module.

10) The possibility to record cartographic presentation in xml files

The application allows for recording all information resulting from the cartographic presentation designing process in the form of the xml file. At the first phase of the project, the xml format, used in the utilised NavigoX visualization component was applied. The final form of the file, which defines the cartographic presentation, is under development within the performed research works.

4. Test environment

Following the Author's opinion, the appropriate test environment of cartographic presentations is the required element of the spatial data visualization system for mobile devices. It is not possible to perform tests for all available devices. Therefore, a set of representative testing devices should be methodologically selected. Investigations concerning the rules of selection and definition of the test environment are performed within the discussed project. Below, the test environment, applied for testing in the first stage of the project, is shortly described. The methodology of selecting mobile devices for testing cartographic presentation and the final set of devices would be proposed on the next stage of the project.

4.1. Inistial selection of devices

At present, devices of the following characteristics are mostly applied in car navigation:

Display size: 2,5"; 2,6"; 2,8"; 3,2"; 3,5", 4,3", 4,8", 5", 7"
Resolution: 240x240, 320x240, 320x320, 400x240; 480x640, 800x480
Graphical mode: QVGA, WQVGA, WVGA, VGA
Number of colours: 65K, 256K, 16M

For LBS users, should be use large amount devices, besides listed above e.g :

Display size: 2" and less

Resolution: 128x128, 128x160, 176x220, 176x208,208x208

For the needs of creating the initial test environment, the following devices were selected in the discussed project:

1) PND:
   - INEX AutoNavi2000, 3,5”, 320x240
   - TRAK 425, 4,3”, 480x272
   - TRAK 550, 5”, 480x272
2) Palmphones with GPS:
   - ETEN M700 Glofish, 2,8”, 320x240
   - HTC Touch Diamond, 2,8", 480x640
   - Samsung Omnia, 3,2", 240x400
2) Phones without GPS
   - Nokia 6500, Samsung Z720

4.2. Selection of test sites

Following the initial assumptions, visualization should be prepared basing on the carefully selected, test data set, which represents areas of diversified geographic characteristics. After analysing available maps, aerial and satellite photographs for the area of Poland, nine sites were selected (four of them are presented on the Figure 4):

- an area of a big and complicated road junction,
- the motorways area,
- the city centre, the densely built-up area with traffic limitations,
- the city centre, the compact and relatively densely built-up,
- the rural area,
- the forested area,
- the seaside ,
- the mountainous area ,
- the touristic area.

Figure 4. Examples of data visualization from the test sites (source: Navigo visualization component).

Data from the test sites are the basis for the MobiKart application in the process of designing the cartographic presentation.

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