Cartographic systems visualization in mobile devices: issues, approaches and example cases

Iván Colodro Sabell [1], Javier López Ruiz [1], Borja Vicario Medrano[1], Antonio Moratilla Ocaña [1], Eugenio Fernández [1]
[1](*Computer Science, University of Alcalá, Spain)*

ABSTRACT : *Visualization of cartographic systems in mobile devices is a challenge due to the its own limitations to show all the relevant information that the user needs on the screen. Within this paper we review current state-of- the-art technological solutions to face this problem and we classify them in a novel typology. In addition, it is shown an example case of a developed system for a logistic company specialized in dangerous goods. The system is able to calculate optimal routes and communicate the drivers the best path in order to achieve a great management of the company resources*

KEYWORDS *-Smartphones and tablets, Visualization, Cartographic Systems, Big Data.*

I. INTRODUCTION

The concept of visualization can be understood as an interface among two powerful information processing systems. The human mind and the modern computation. (Gershon et al., 1998). The visualization is the process of transforming data, information and knowledge to a visual shape making use of natural visual skills of the human being. With efficient visual interfaces is possible to interact with huge volume of data in a quick and effective way to discover hidden characteristics, patterns and trends. In a society more and more rich in information, research and development in visualization has changed the way of seeing and understanding the set of massive data. The impact of the new visualization techniques has influenced on the generation of new knowledge and on a better decision making.

II. Information Visualization

Taking the best choice to the get the maximum information broadcast can be hard with the current collection of visualization techniques. (Muzammil y Sarwar, 2011). The main target must be the easiness and efficiency to interpret the visualization.

In (Muzammil y Sarwar, 2011) is collected all the visualization techniques and a brief introduction as well as definitions relative to the visualization, how the can be the processes of visualization, problems in this task, techniques classification from different point of views and advantages and disadvantages of each visualization method.

An entire research about information visualization can be found in (Liu et al., 2014), where is exposed the last discoveries in the state of the art as well as the next challenges to resolve.

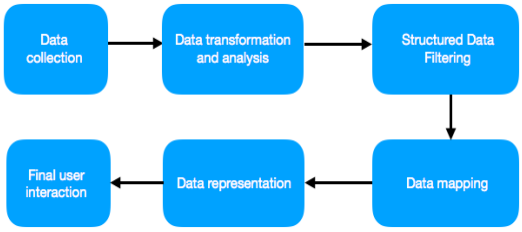

Fig. (1): Typical process of information visualization. Source: own elaboration

III. Visualization on Mobile Devices

Data visualization has become in an inherent part of our life. For example, to see the weather forecast on a map or to see supplying in the company's warehouses (Watson y Setlur, 2015). In as much as people use their mobile devices as main information source, the need of exploring new visualizations and interfaces appears to reach an optimization on smaller screens.

The technique of visualization called "Overview + Detail" is one of the approaches most used to show a big amount of information for computer's screens. Widely used in desktop applications, its viability on mobile devices has always been argued. In (Burigat y Chittaro, 2013) is introduced a detailed analysis of the state of art

about visualization of this technique, explaining and comparing the research's results in desktop and mobile applications with the final purpose of pointing out the advantages and disadvantages of each approach. In conclusion, according to the result of this research, the use of the descriptive and detailed view has a positive impact when the user makes use of the application.

IV. Analytic visualization of Big data

To transform the information of massive set of data in knowledge, in some specific cases, the data centers need the human intervention to be able of extracting valid knowledge (Schneiderman, 2014). Researches on the fields of statistic and algorithmic, recognize that the use of visual strategies for exploring complex data bring to a deeper knowledge in such data. Automatized analysis[1] can generate good results for structured data but a right visualization of these ones increases the expert's efficiency in the time of analyzing them.

The analytic visualization of Big Data can contribute in some profits such as (Gentile, 2014):

1. Acquire information in new and more constructive ways.
2. Visualize patterns between operational and business activities.
3. Identify and take advantage of emerging trends.
4. Manipulate and interact directly with data.

States of art, technologies, comparisons and other types of researches about Big Data and its visualization either direct, analytic or interactive can be found in (Zhang et al., 2012; Khan et al., 2014; Singh y Reddy, 2014; Tsai et al., 2015).

V. CARTOGRAPHIC SYSTEMS VISUALIZATION

In the context of the manipulation of cartographic data, it is considered that a cartographic visualization process is the conversion of space data of a database in graphics (Kraak, 1998). Geographic data manipulation is defined as the acquisition, storage, processing and visualization of space data in the context of specific applications. During the process of visualization is applied cartographic techniques and methods.

The use of mobile devices for the visualization provide an extended environment for the access to the information and the efficiency in the decision making. These visualizations are fundamental to satisfy the knowledge needs of the experts in diverse areas such as education, business, law, medicine, transport, energy, scientist discoveries…For example, in (Kim et al., 2007) is developed an efficient and interactive visual analytic system for mobile devices, for a better decision making in response to emergency situations. The proposed system elaborates visual analysis with location data of scenarios thanks to a simple interface which is adapted to the features of the mobile devices. Especially is focused in process and show data in a sensor network.

The aim of the map design is to create an abstraction of the real world taking in consideration the purpose of the map (Nivala y Sarjakoski, 2007). The success of the design depends of not only the cartographer skills but also the capacity of the user reading the map and the particular circumstances in each case of use. If the user does not understand the meaning of the symbols on the map, Frustration and misunderstanding can be produced. In the context of cartographic maps on mobile devices, adapted symbols required in each situation and even to the user's preferences can be provided in real time, in this way, an effective read of the map is achieved.

The mobile devices used widely in navigation task with maps have produced researches about the problems in the usability in relation to the limited area of the visualization on devices and the conditioned interaction for these small screens. In (Paolino et al., 2013) is analyzed the strategies most common suggested by the state of art for resolving these problems.

VI. Typology of technological solutions

There are many technological solutions related to the cartographic systems visualization on mobile devices, each one giving one or several characteristics to the final cartographic system which will be used by the users.

[1] The results produced by Deep Learning are being very promising on this field. (Najafabadi et al., 2015)

Due to the particularities of each one, emerge the need of establishing a typology to be able of catalog all the current technological solutions, and given the lack of state of art in the scope of the academic researchers, it is proposed the next classification:

1. Map suppliers

These are the technological solutions which supply cartographic images of maps (known as tiles).

2. Visualization libraries

These solutions are the ones which offer to software developers visualize maps and other elements typically used on maps such as markers, polygons, paths, etc.

3. Web services

These solutions allow to get relative information to geographic data such as geolocation, times, distance between 2 points, coordinates description, etc.

4. Analytical tools

These ones use techniques of artificial intelligence on geopositioning data with the purpose of getting a deeper knowledge, visualizing the results on the own maps.

5. Comparison

A summary of the current technologies and the functionality that they offer according to the previous typology proceed as follows:

Table 1: Comparison of the relative solutions to the cartographic systems visualization.

TechnologicalSolution	Mapsupplier	Visualizationlibraries	Web Services	Analyticaltools
Google Maps	Yes	Yes	Yes	Yes
Apple Maps	Yes	Yes	Yes	No
Here (Nokia)	Yes	Yes	Yes	No
TomTom	Yes	Yes	Yes	No
MapQuest	Yes	Yes	Yes	No
MapBox	Yes	Yes	Yes	No
Esri/ArcGIS	Yes	Yes	Yes	Yes
Carto	Yes	Yes	Yes	Yes
Leaflet	No	Yes	No	No
OpenStreetMaps	Yes	No	No	No

The choice of a solution against another one, it can be differentiated not only for its functionality but also other characteristics such as the time which the product has been in the market, the type of license or the quality of the published documentation.

In the table 2 has been realized a brief comparison between the classification of technologies solutions and the characteristics which have been commented previously.

Table 2: Other important characteristics what should be considered to choose a solution.

TechnologicalSolution	Launching date	Documentation	License
Google Maps	2005	Verygood	Free/Premium
Apple Maps	2007	Normal	Free/Premium
Here (Nokia)	2012	Normal	Proprietary
TomTom	1991	Bad	Proprietary
MapQuest	1967	Good	Free/Premium
MapBox	2010	Good	Free/Premium
Esri/ArcGIS	1969	Normal	Proprietary
Carto	2011	Normal	Free/Premium
Leaflet	2011	Good	Free
OpenStreetMaps	2004	Normal	Free

VII. PRACTICAL CASE: LOGISTICAL OPERATOR

A practical case is developed in a logistic operator of transportation in tank trucks specialized in dangerous cargoes, mainly in petrol products. This kind of activity have a high impact in the Spanish economy, at the same time, have quite strict security levels and rules. It worth to pointing out from the point of view of security as well as the economy, the proper management of the transport and distribution due to the extreme dangerousness of these type of products.

The system which has been described in this practical example have as aim to allow a suitable management of these works through the development of a solution for an environment what use mobile devices inside of the trucks. This way is possible via calculations of optimal routes, to communicate in the real time the best ones for a specific service. All the developments have always considered the limitations that these types of products must respect to carry them on the roads.

VIII. General system architecture

The system designed for the development of this work has been based in a web architecture, specifically client-server, making use of a main server which contain the business logic and a relational database PostgreSQL as well as additional servers for other types of services such as route optimization or communication with the vehicles fleet of the logistic operator.

The main part of the graphic interface of the system has been developed with SmartGWT, an extension of GWT which makes easier the codification in the client part using the programming language of JAVA, translating this code automatically into HTML and JavaScript. The Server side is implemented in Java 8, making use of different frameworks as Spring or persistance solutions as Mybatis. Services as route calculations and route optimizer use Matlab as well as OSRM libraries.

The communication between the client and the server is performed via AJAX requests, where the server provides a API REST. The data format follows the standard JSON and also its extension GeoJSON for geographic data.

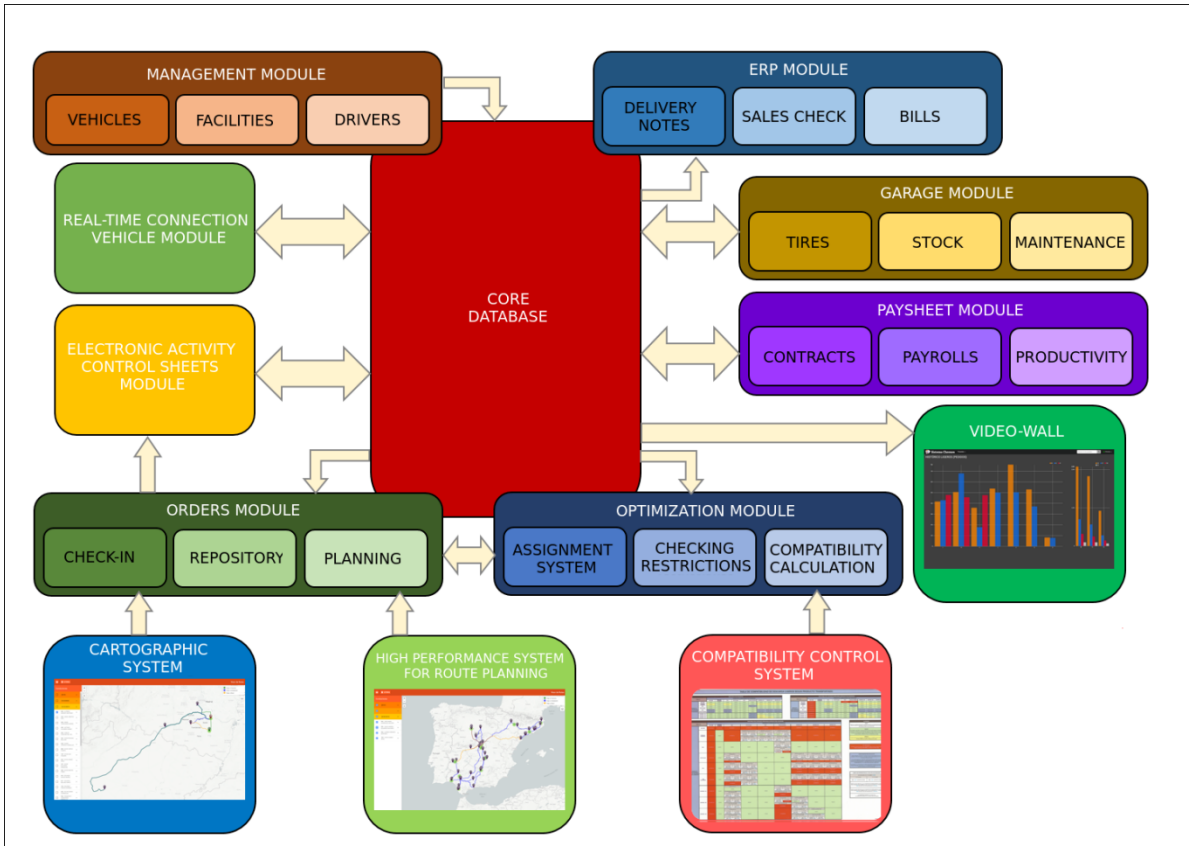

Fig (2).Diagram of the system architecture. Source: own elaboration.

IX. Routes visualization in mobile devices

As previously mentioned, map visualization in mobile devices involve several challenges. Small screens or relatively slow hardware make more difficult the design and cause a disagreeable experience to the user (van Tonder y Wesson, 2008).

In relation to the technological solutions introduced in the section 2, a map viewer has been developed for mobile devices using Angular and Leaflet for the client side and OpenStreepMaps for the map tiles. In the figure 3 is shown the result of this project. The first image shows truck drivers selection to visualize the planned route, in the second one, the route is drawn on the map, establishing different colors according to the type of trip that has been done. In case there are several marks on the same point of the map, they are grouped just in one showing the real number of markers.

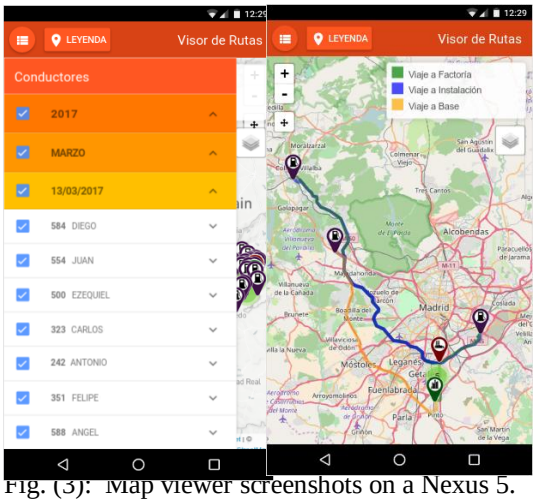

Fig. (3): Map viewer screenshots on a Nexus 5. Source: own elaboration.

X. Visualizing another type of relevant information on maps.

Never before in history has data been generated at such high volumes as it is today. (Sagiroglu y Sinanc, 2013). Exploring and analyzing the big volumes of data has become more complex. Information visualization and visual data mining can help to deal with this task. The advantage of visual data exploration is that the user is directly involved in the data mining process. There are a large number of information

visualization techniques that have been developed over the last two decades to support the exploration of large data sets. In (Keim, 2002), it is proposed a classification of information visualization and visual data mining techniques which is based on the data type to be visualized, the visualization technique, and the interaction and distortion technique.

Figure 4 shows a map developed with Carto, in which there is information by state, as well as points of interest through all geography, generated from more than half a million orders executed by the logistic operator for two years.

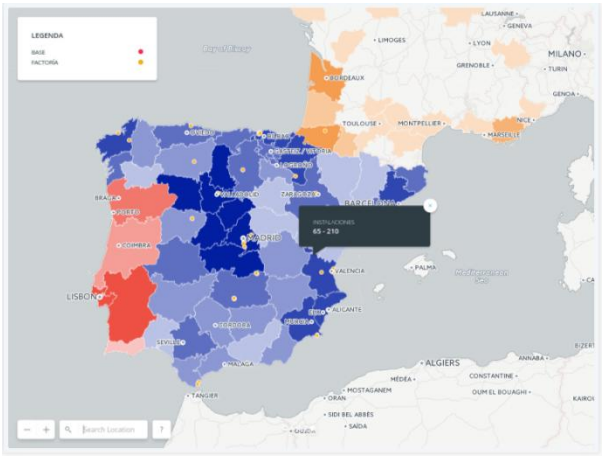

Fig. (4): screenshot on an iPad Pro tabletof a map made with Carto. Source: own elaboration.

XI. CONCLUSION

In this paper, a review of the different types of visualization has been carried out, within the context of cartographic systems.

Despite the growing number of mobile devices, there are still several challenges to face in order to do this process correctly. For this purpose, different technological solutions that address this problem have been classified, achieving a novelty typology. Finally, the system developed for this work has been described, and in detail, the modules referring to the visualization of maps on mobile devices.

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