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Planning local public transport: a visual support to decision-making

Stefano Pensa[a,]*, Elena Masala[a], Maurizio Arnone[a], Andrea Rosa[a]

[a]*SiTI- Higher Institute on Territorial Systems for Innovations, Via P.C. Boggio 61, Torino 10138, Italy*

Abstract

This paper describes a visual tool for data analysis applied to a case in public transport. Our tool is based on geo-referenced dynamic maps, created with free Web GIS applications, and allows users to visualize data and interact readily with a large database of public transport service information. This tool will support decision-makers in detecting issues of inefficiency and ineffectiveness related to the public transport services of a given area. The paper focuses on the visualization system, its features, and its use, detailing the indicators utilized and the analyses it may be employed for.

Keywords: Visualization; public transport; dynamic maps; reorganization; decision support systems.

1. Introduction

Public administrations face increasingly tight budgets and, more than ever, must make the most of available money to provide public services. When tackling budget limitations in public transport provision, informed decision makers may do better than resolving to undifferentiated service cuts. However, good data sources and analysis tools are crucial in making smart choices.

In Italy, Provinces and Regions are responsible for planning and contracting the interurban public transport. Regions are also in charge of financing the services -using government funds and, if necessary, topping them up- and coordinating the planning activity of the different Provinces. In 2012 the research institute SiTI carried out a study analysing the whole regional interurban public transport of the Piedmont region. Such work was conducted for the regional administration to find the main inefficiencies and optimize service provision to comply with reduced public budget. Within this work SiTI elaborated an assessment methodology (Isabello, Arnone, & Rosa,

* Corresponding author. Tel.: +39-011-1975-1569; fax: +39-011-1975-1122.
E-mail address: stefano.pensa@polito.it

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2013) and a web-based interactive visualization tool, discussed here. The content of this paper is based on the final report of the study by SiTI (2012), which the authors contributed to.

This visualization tool has been realized to give to the contracting bodies a decision support system useful to visualize the main issues, both locally and looking at the whole regional public transport network, characterized with the aforementioned assessment methodology and also develop different scenarios, e.g. given different budget constraints.

The choice of a web-based interactive visual tool was also due to the size of the task: the analysts had to work on a database of some 70 indicators each detailed for about 4000 bus routes. While working with a large dataset we aimed at ensuring the user-friendliness of the tool -to allow a quick deployment in planning and contracting bodies-, limiting development costs, and obtaining something that could be applied to other areas and, eventually, able to include real-time data feeds.

The paper focuses on the decision tool to be provided to the regional planning and contracting body in order to support the assessment process of the Piedmont public transport system. In the next section, an overview on current available tools is discussed, while section 3 describes the working framework of the Visual TPL tool. The conclusion proposes some possible implementation of the research in the field under investigation.

2. Low-cost technologies for supporting decision-making processes

In the context of Piedmont region, in which data are gathered following different procedures by a significant number of operators independently managing their own transport lines, the evaluation of the current status of public transport system was a difficult challenge. First of all, the differences in data collection generated a large number of reports with no common terms of comparison. Secondly, many available data were referred to territory only by the name of the path or line, which was not sufficient to understand their actual geometry, their catchment areas or possible overlapping with other lines. Thirdly, possible inefficiencies and inconsistencies of the transport system were not readily recognizable.

Due to these reasons, there was a strong need to make the data homogeneous, even though the dataset available was fragmentary and incomplete. In order to analyse, manage and evaluate such data, a new framework with two key requirements, related to each other, was required. The data structure should allow clear reading and easy understanding of the data, avoiding possible misunderstandings in readings.

Several commercial tools have been designed to manage data related to transport issues. In particular, there is a large number of simulation models which aim to provide useful information on efficiency of transport systems. Nevertheless, to use these tools, input data have to respond to specific requirements of homogeneity in graph representation, a condition that is sometimes impossible to obtain with real data. The data available for the application discussed did not have those desirable features and new opportunities were to be found in other fields.

Therefore, a research started to understand the state of the art in managing large geographical databases coming from different sources and structured with different typologies of attributes. The obvious choice would have been to use GIS applications, which are conceived to manage geographical information from different sources, merge tables and represent data visually. However, GIS were not suitable for achieving the main task of the research, which was not just identifying solutions for reducing transport system costs, but providing a decision tool to the planning and contracting bodies. This tool should support decision-makers in analysing and evaluating data related to the current status of the public transport system in order to investigate the whole network, with particular care to its dynamics and efficiencies. To that end, the new tool should be able to show the key elements of the system, independently of the fragmentation of the system among about one hundred companies. Elements such as overlapping lines, low value of average ridership on lines needed to be clearly visible.

GIS require specific users' skills, which are not necessarily those of the decision makers involved, thus resulting complex for end-users. Moreover, GIS tools have often significant license costs, a fact that may reduce the possibilities to access to their use. At the same time, even the Web-GIS tools provided by ESRI had graphic interfaces which are often unknown by the main part of decision-makers, so that they result not so easy to be used in exploring data and communicating information.

Having to keep in mind end users' skills on the one hand and to quality of input data, on the other, we considered the use of free web interfaces. In recent years, from the advent of Web 2.0, the increasingly widespread use of personal devices able to correlate different types of data to its geographical localization, generated a collaborative mass of users, who constantly create huge amounts of data with spatial attributes. This phenomenon, that Goodchild (2007) has defined as volunteered geographic information (VGI), is also known as "social mapping" and is opening new frontiers in managing and visualizing spatial information datasets. Among these innovations, an important step is provided by the Application Programming Interface (API) released by Google Inc. since June 2012, in order to combine "Google Maps", "Google Spreadsheets" and "Google Charts" (Google Inc., 2012a).

These new technologies provide free web tools for both managing and visualising data stored in spreadsheets or tables by means of dynamic maps and charts. A number of applications have already been produced worldwide (Google Inc., 2012b) for different purposes such as the visualization of the spatial distribution of submarine cables (PriMetrica Inc., 2013), the localization of bikes accidents (Elinsion, Lupkin, Shifflet, Suriano, & Raja, 2011) or the mapping of census data (Murphy & Stiles, 2011). In the latest months, such tools have been applied to more mobility related issues, such as the interactive data on the street congestion of Toronto (Thompson & Merringer, 2012) or about the streets plowed after snowing in Chicago (Eder, Gregg, Velez, Smithgall, & Bhaskar, 2013). We were able to find no published examples concerning their application to the analysis of public transport systems and their evaluation.

Combining these technologies with public transport issues can be achieved only by the exploration of new research paths, which involve multidisciplinary skills in the fields of web coding, transport systems and visual analytics. The path followed in the work reported here led to build a decision tool, named Visual TPL (TPL is the acronym commonly used to indicate public transport in Italy), which is currently ready to be applied for the analysis of Piedmont interurban public transport services.

3. Visual TPL: a web-based visual tool for supporting decision-making processes

The visual TPL decision tool has been conceived to analyze and evaluating the large amount of data related to around 4000 bus routes of Piedmont public transport system. Due to the fragmentation and heterogeneity of data, the Visual TPL tool needed to overcome the strict requirements demanded by common transport analytical instruments. If data are not precise and graphs do not have the same nodes and coordinates values, common transport system evaluation tools cannot be used. Thus, the Visual TPL tool is a web interface for visually analyse a geodatabase related to public transport, which may be seen as innovative in different fields of research.

Firstly, it makes use of very recent web technologies which provide a new approach to spatial related questions, both conceptual and instrumental. In fact, these technologies are highly accessible because free and open. More importantly, they are constantly developed and improved by a self-built global community, who freely offer information and knowledge on their use.

Furthermore, the proposed tool approaches decision making problems related to the public transport by means of visual, dynamic, interactive and easily updatable instruments, which can be considered as an innovation in transport planning practice.

Finally, the use of maps for examining data offers the opportunity to use graphs with no precise overlap and also to exploit the intuitive perception of users, who can more easily understand where conflicts and problems are localized.

3.1. Structure of the tool

The Visual TPL tool has been built on a web platform by the use of Google Fusion Table (2012a) free applications. Through these technologies, the tables, shapefiles, database and geodatabase related to a public transport network, have been merged with one another and visualized in a customized Google Maps Interface. Through the Visual TPL tool, data can be analysed and assessed on the basis of a number of indicators, whose threshold value can be changed in real time by the user. The study carried out by SiTI (2012) provided for each indicator a threshold value that, once entered in the interface, generates a general scenario for the evaluation of the bus network. However, the tool allows users to interact readily with data and introduce new threshold values so to work with new "what if" scenarios.

The interface of the tool has been organized in three different horizontal frames, see Fig 1.

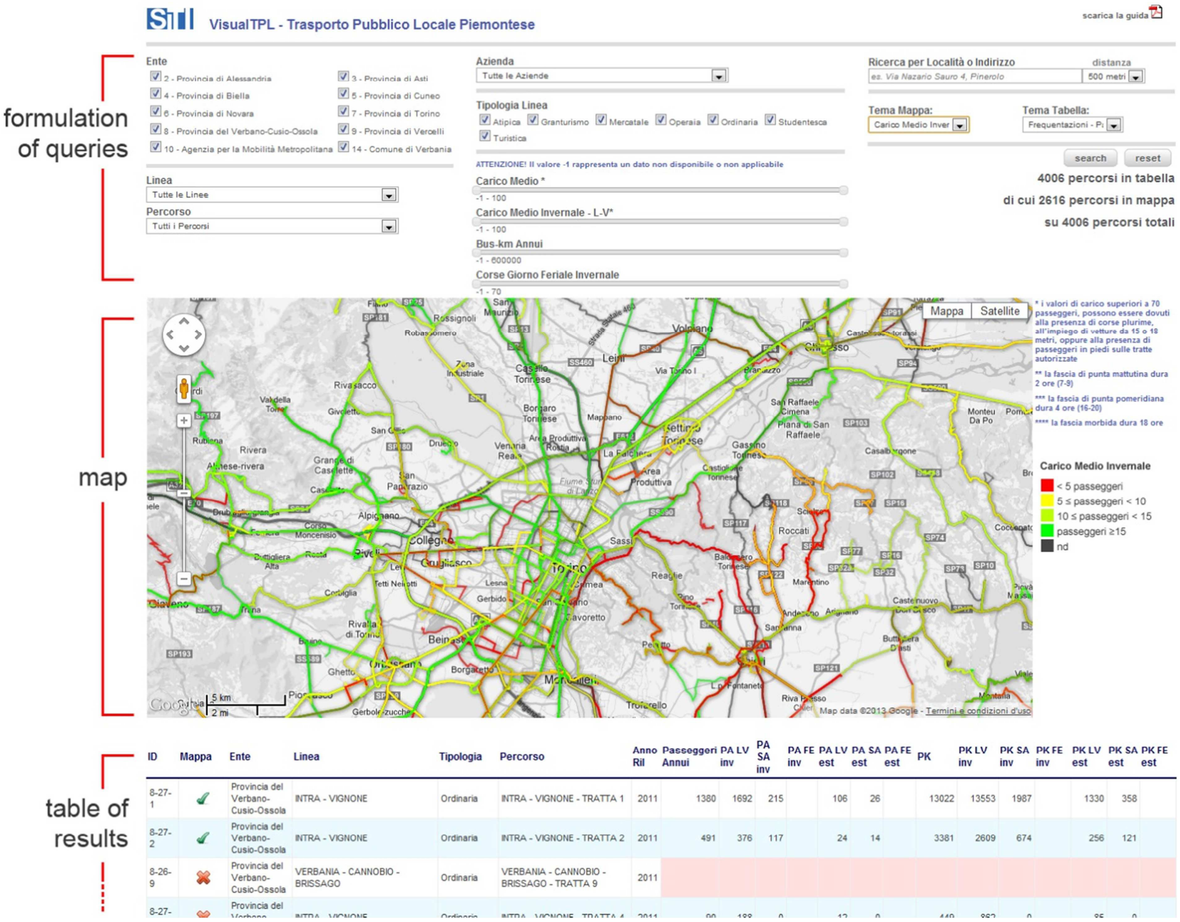

Fig. 1. Interface framework of the Visual TPL tool

The top side concerns the formulation of queries, where data can be filtered, the large database can be explored and specific attributes can be selected. In fact, using this Web GIS Application, analysts can characterize public transport lines on the basis of indicators of interest – e.g. ridership, number of services and km produced by time unit- or on the basis of characteristics such as route overlaps, reference public administration, type of services -e.g. daily, school services, market day only.

Data can be filtered on the basis of the following list of indicators:

- Planning and contracting bodies
- Bus line
- Single Routes (a line may be made up by several routes)
- Operator
- Typology of the route, classified as ordinary, school service, factory workers services, market, touristic, long distance touristic, and atypical routes
- Average ridership
- Average ridership from Monday to Friday during winter period (September to June)
- Bus-km/year
- Bus trips on winter working days (September to June)

On the right side of this top section of the Visual TPL tool interface, users can refine the search through other widgets. For example, they may restrict their search to a specific address or location and may choose which thematic map best fit with their purposes by selecting it among a number of possible ones such as the one depicting average ridership of buses or that showing commercial speed. This section of the interface includes:

- Search for location or address;
- Thematic map;
- Thematic table;
- Number of selected items, including items with no shape onto maps;
- Number of displayed items;
- Number of total items.

Lines may be characterized according to any combinations of attributes, defined by the user, thus enabling also the visualization of complex queries to the underlying database in the central frame of the tool's interface. There, the Google Maps window displays the data chosen in the first section, while the bottom frame, built by means of Google Charts, shows the table containing the filtered results. Visualizations available in the tool include charts and maps, which may be viewed along with the relevant tables. By the use of geo-referenced maps, the problems related to the imprecise overlap among data have been solved by using spatial data visualization features, which require just visual overlap without needing quantitative precision. The selection of a single item on the map generates a pop-up window which can contain both textual description or a chart.

In the bottom part of the interface, all the data which have been selected are listed in the table, while only data which have an associated shapefile can be visualized in the map section. The user is aware of possible non-displayed data also thanks to the fact the total amount of both displayed and listed data is showed in the first section.

3.2. Usability of the tool

The Visual TPL tool has been designed to be used by experts in planning and evaluation of transport systems with the purpose of identifying the critical points which could be studied in order to rationalize them and reduce the burden on the public purse.

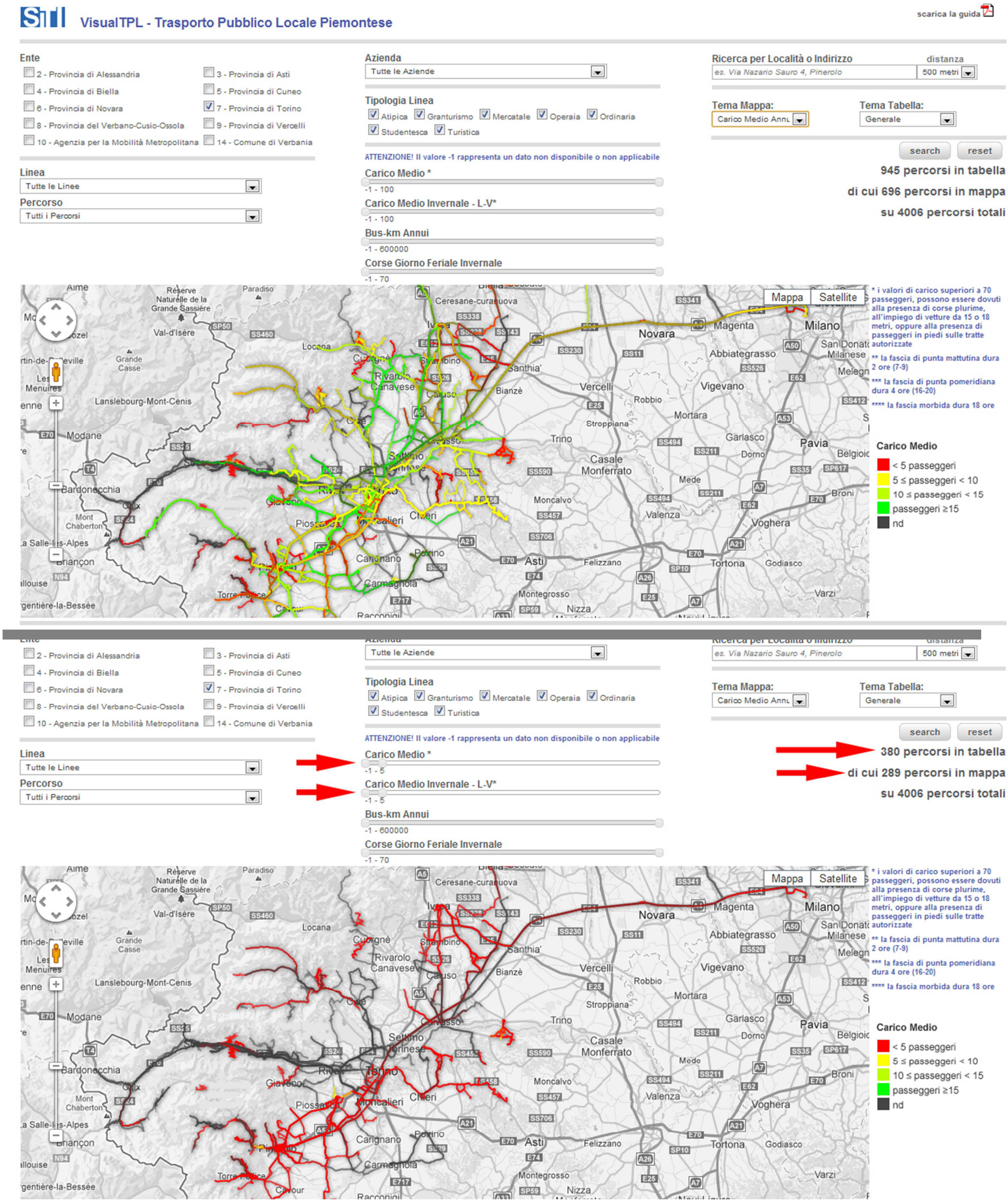

Fig. 2. Comparison among two different selection: (top) selection of all lines in the province of Turin; (bottom) highlighting data with given average ridership only. Note the change of the number of lines displayed.

For these reasons, the tool aims to support decision-making rather than provide precise solutions. In line with the overall study conducted by SiTI (2012), the Visual TPL focuses on aiding decision-makers on locating specific typical issues which have been conceived as the basis of the assessment of the bus network and are detailed in Isabello, Arnone & Rosa (2013). The Visual TPL tool provides a visual method to explore the indicators characterizing issues such as:

- Sections of interurban lines entering the urban area of Turin
- Overlapping among bus routes belonging to the same line
- Overlapping among bus routes belonging to different lines
- Underutilized services for factory workers
- Underutilized market lines
- Other services with limited ridership
- Inefficient routes

For instance, by using color intensity, the tool provides visual information on where overlapping among routes are located, while it also can show every single line which corresponds to specific indicator values.

The tool can be utilized to explore existing data on the current status of the public transport system of the Piedmont region. Moreover, it can be used to investigate and locate the intervention areas on the basis of specific purposes, allowing the experts to select the lines which require new planning, see Fig 2. More importantly, the tool is interactive, so that to each query of the users corresponds a prompt response.

4. Conclusions

The Visual TPL showed to be an innovative tool in the transport system evaluation and planning. Its high level of usability allows research to be applied in the planning practice, producing an instrument that can actually generate important information for increasing the efficiency and effectiveness of the regional transport system.

At the present, the tool is ready to be used by planning and contracting bodies to evaluate possible reorganization of transport facilities.

Some further improvements are considered important for the development of this type of tool. First of all, the tool requires the possibility for the user to save or download both the list of selected elements and their location on territory. Secondly, it has to integrate GIS tools which could provide a larger contribute to the analysis and visualization of data. Furthermore, the possibility for users of drawing and customising their personal maps is an option considered and is currently under evaluation. Finally, in a global context in which the Web 2.0 is providing new strong perspective of development, such as the VGI or social mapping, this kind of tool should be improved in reading dynamic databases so to constantly visualize updated data coming from the web.

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