Roma Crash Map: An Open Data Visualization Tool for the Municipalities of Rome

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Abstract. The open data availability, promoted by the open government approach, does not correspond to an effective and organized use of them with the detriment of both citizens and PAs. We assume that a data visualization tool could help the spread of information in an easy and accessible way, even for what concerns open data. In this paper we will focus on the map, as one of the most suitable tools for the interactive representation of spatial related data. So, we will present the Roma Crash Map platform, a web application that allows to visualize the road crashes open data related to the 19 Municipalities of the city of Rome. In details, we will report the considerations about the selection and design of the visualization tools, according to the purpose to familiarize the users with participating tools integrating maps or more complex geographical systems.

Keywords: Data Visualization, Information Visualization, Road Crashes.

1 Introduction

Nowadays the citizen life in cities and territories is increasingly based on the analysis of large set of data. Whether we consider the technological or the human or the institutional aspect of the *smart cities* [1], *data availability* is an enabling factor to achieve a better quality in the citizen life. In particular, the possibility to freely access to public data and information to use and republish them without any restriction is considered the key factor of a successful governance. The idea that public and available data could lead to *transparency*, *participation*, and *collaboration* among citizens and Public Administrations (hereafter PAs) is strongly sustained by the *open data* (and more generally by the *open government*) approach over an increasingly number of world countries, including Italy [2].

The problem is that the availability of open set of data online, even though consistent with the standardized and interoperable process for the production and the release

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of open data, is not sufficient to engage the citizen on the particular matter or information contained into the dataset.

As a result of this observation, we assume that from the raw data to a "usable" one there is an entire process to implement, which necessarily includes *data visualization* design. In fact, we also assume that the latter were a well-defined and experienced way to make data more user-friendly.

In this paper we will present Roma Crash Map (hereafter RCM), a web application for the visualization on a map of open data about road crashes occurred in Rome between 2012 and 2013 (June), in order to show a possible way to bring open data to citizens and PAs.

Moreover we will focus on the map as favorite visualization tool for the open data that require spatial distribution and for all citizens (not only experts) willing to be aware in order to participate in smart cities and territories issues. Regarding this, we observe that, despite of the great spread and talk about the open data and the geo-visualization tools, a deeper attention needs to be paid towards *usability* and *user experience*. In section II we will introduce the concepts of open government and open data, as wider framework from which the tool we designed originated. Then, in section III we will give an overview on the state of art about usability evaluation of geo-visualization tools. A detailed description of the RCM platform will be given in section IV, along with the reflections, in section V, about the constraints met and the choices occurred during the designing of the user interfaces. Findings and future work will be illustrated into the last section (Conclusions).

2 Open Government and Open Data

Open data is an extended concept crossing different fields and fostering the spread of knowledge [3]. In the government field, the term is connected with *transparency* and *accountability* [5]. This is the basis for a smarter government, where PAs collaborate with citizens, enterprises, and communities on a specific territory, in order to provide them with services and applications addressing public and private demands.

As a practical application of these principles derived from the *open government* doctrine, whose cornerstone is the Open Government Directive issued on December 2009, many institutions and governments have distributed online the open dataset they collected. In Italy the national catalogue of open data (dati.gov.it), stemmed from several government data stores, has been published on October the 18th, 2011 [2].

In details, a dataset is considered *open* when it is made available online in open and freely accessible formats, without copyright restrictions, patents or other forms of control that restrict its re-use, and redistributed by anyone. It is subject only, at most, to the requirement to *attribute* and *sharealike* [6-7]. In order to be consistent with the international standard for the open data, the information released should be: *complete*, *primary*, *timely*, *accessible*, *machine-readable*, *non-proprietary*, free from licenses restricting their use (*freely-usable*), *re-usable*, *discoverable*, and *permanent* [7-8]. In general they had to be published in an open platform independent format that can be retrieved, downloaded, indexed, and searched by commonly used web search applications [9].

There are different formats used for open data. In this regard, the W3C elaborated a cataloging model based on a scale of values from one to five stars, i.e. from raw data (unstructured and not reprocessable file) to linked open data (interoperable open format). Only formats from the third level can be considered “open” [10].

Anyway, the doctrine at the basis of the *open data* promotes the largest spread of data, even raw. As a consequence, with the increasing of the number of data shared, also *data visualization* tools and *info-graphics* had spread, due to their ability in communicating information in a clearer and more effective way.

3 Related Work

The academic literature offers many studies about the transformation of data and geo-data in a usable form. First of all, in [11], the authors argue that the simple operation of releasing open data does not entail the immediate understanding of data by users. In particular, the bigger the dataset is, the more likely the user is unable to extract useful information. This difficulty can be overcome thank to efficient visualization tools [12], which need to be studied through usability methods [13].

According to [14], “*data visualization is the graphical presentation of data that can help reveal important traits and relationship*”. In [15], the author identifies five steps in order to make visual communication more effective and efficient: 1 - definition of the problem; 2 - choice of relevant data; 3 - adoption of a visual matrix for the treatment of data; 4 - conversion of data into graphical visualization; 5 - interpretation and decision. This method is similar to the EDA (Exploratory Data Analysis) approach [16], where the visual representation is used to encourage statisticians to better explore data, and possibly formulate hypotheses. In order to obtain from a dataset the requested information that he/she needs, user should be able to zoom and filter the data [17].

The map is one of the better tools through which represent patterns and relationships in data, especially when integrated with other representation methods to provide different perspectives of data in multiple linked views [13]. In most cases, digital maps are the representation of data contained within a GIS, a system of storage, manipulation, analysis and management of geo-referenced data. Since GIS are complex systems [32], in the academic literature the usability studies focused on the evaluation of the operational tools rather than on the maps [18]. For these tools, a specific evaluation methodology is needed [13]. One of the aims of these studies is to facilitate the interaction, also on the part of users without expertise in using GIS [33].

Moving beyond the geographical aspect, the maps are considered as tools of knowledge construction [19]. In fact, especially web-based online mapping allows users to explore, analyze and visualize spatial dataset to better understand patterns. Moreover the maps display many different data and information (spatial, social, political, etc.) in a very intelligible way [20] and are useful in supporting problem’s exploration and decision making, mainly if united to other graphical presentations [21] or multiple criteria decisions models (MCDM) [14].

In this context, GIS and other web-based mapping software can also foster the citizen's engagement and collaboration [20-22-23]. With regard to this, we mention: participatory geographic information system (PGIS) [24], public participation geographic information system (PPGIS) [25-26], volunteered geographic information system (VGIS) [27], and other open map tools generally based on open source software and web 2.0 tools [28-29]. Besides being valuable communication means used to actively involve citizens, they can be used also as instruments for monitoring the quality of public service in all its stages of implementation [30-31].

Mobility data offers several challenges in data analysis and visualization. Their attributes are not only spatial [34], but also temporal [35]. In [12], a description of the most used techniques for spatio-temporal data visualization is provided. Anyway, the map is the most appropriate interface to represent mobility data [34], since they can provide users clear and accessible information, deliver services more efficiently, and support decisions. Transportation, parking places, and traffic are a few examples of fields of application that take benefit from mobility data visualization [20].

4 Roma Crash Map

Roma Crash Map platform is a web application that allows to visualize the data about road crashes occurred in the Municipalities of Rome between the 1st January 2012 and 18th June 2013. Data is provided by the Local Police Roma Capitale and released by the Municipality of Rome at the dedicated web site (http://dati.comune.Roma.it). It is distinguished into three different datasets on the basis of the period to which they relate. Through the interaction with the map of the city of Rome divided into 19 Municipalities and a set of filters, the user can browse and compare available data about road crashes. We consider as possible interested users the following categories: PAs, which can quickly "visualize" the extent of the road safety problem and decide to use the data in other monitoring and decision-making tools; citizens interested in retrieving and comparing information about road crashes for different reasons, e.g. dangerousness of the area where he/she lives; journalists seeking for data useful for their reports; businesses, which might be interested in such data within the preparation of their marketing strategies. To create different map and graphs, the user combines some default type of data extracted from the dataset:

1. *Time slot of the occurred crash*. The time slots have been divided into periods of four hours (all the time slots; 00.00-02.59; 03.00-05.59; 06.00-08.59; 09.00-11.59; 12.00-14.59; 15.00-17.59; 18.00-20.59; 21.00-23.59).
2. *Year* (all years; 2012; 2013).
3. *Period of the year* (all the time; the first quarter; the second quarter; the third quarter; the fourth quarter).
4. *Weather* (all conditions; clear; fog; cloudy; rain; high wind; hail; snow; grazing sun).
5. *Lighting* (all lights; daytime hours; enough; insufficient; not present).

By default the web application shows the number of road crashes occurred on the basis of all the possible variables (all the time slots; all years; all the time; all weather conditions; all lights) in all the 19 Municipalities of Rome. The user can set the parameters of his/her research by selecting some filters corresponding to the variables above mentioned (Fig. 1). Another type of query is to compare two Municipalities on the basis of these variables. In addition to the said filters, the user has to select the name of the two Municipalities to compare. Through the reset function, the web application set the filters on the initial state.

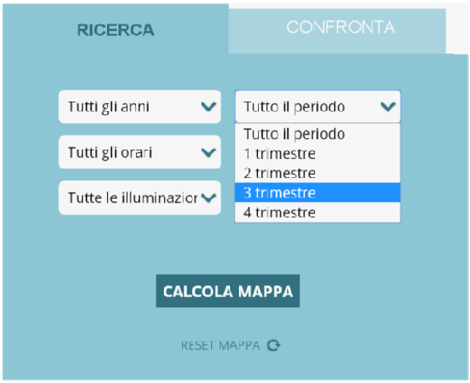

Fig. 1. Users can set the parameters of his/her research by selecting some filters

The results of the query are visualized on various tools, in respect of the benefits provided by each one in the information communication: interactive map (Fig. 2), graphs (Fig. 3) and tables (Fig. 4).

The user can select a specified Municipality by clicking the corresponding area on the map. The graphs and the table change, as a consequence, showing only the data about the selected Municipality.

The map provided in RCM (Fig. 2) is a thematic map obtained through a web mapping application, here OpenStreetMap. It represents the different Municipalities' areas on the basis of the numbers of crashes occurred according to the variation of different statistical variables. In details, the colors of the different areas vary proportionally according to the quantitative value of the data. Three different *hues* (Table 1) are used as a progression indicating the result of the comparison between the number of crashes occurred in the different geographic areas (Municipalities) in respect of three defined quantitative values (maximum, medium, and minimum number of crushes occurred). On the other hand, the *opacity progression*, from a dark to a light shade of the same hue, indicates the extent of the number of crashes occurred within a single zone in comparison to the maximum and minimum value in the dataset (according to the statistical variables set) (Fig. 5).

Below the map, four graphs, one for each type of information, visualize the comparison among the 19 Municipalities on the basis of the variation in the number of road crashes, deaths, injuries, and unharmed occurred in the specified conditions.

The graph chosen to visualize the results is the *polar area* chart, which gives an easy view of the value of each Municipality in respect to the others. Each Municipality occupies a portion of the chart characterized by a specific color (Fig. 3).

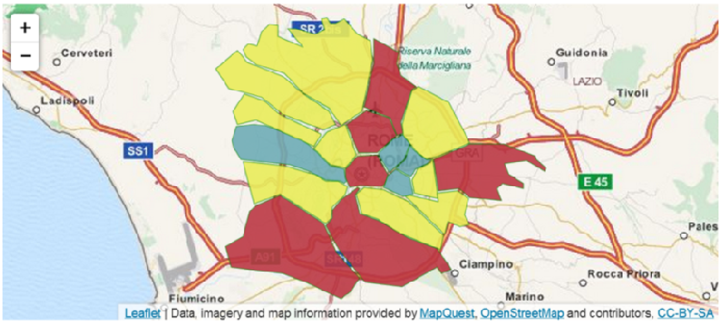

Fig. 2. Users can visualize on the map the results of the query

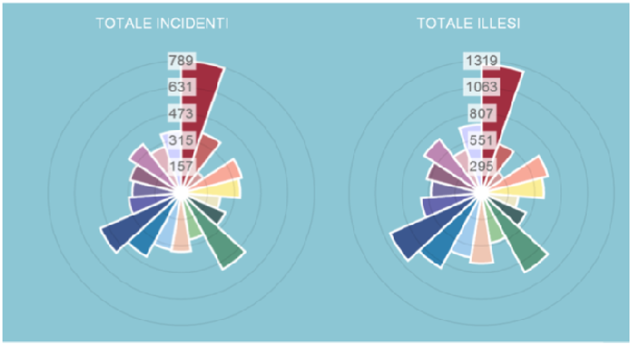

Fig. 3. Users can visualize on the graphs the results of the query. In particular, the above illustrated graphs represent for each Municipality the number of road crashes and of unharmed.

Another type of visualization is the table, which allows the user to better examine the numerical data value. The user can click the header of each column to sort (from the higher to the lower value) the list of Municipalities by number of the Municipality, road crashes, deaths, injuries, and unharmed. The table is hidden by default and can be shown or hidden by selecting the button, respectively, plus or minus.

As an additional reminder of the variables set for the query that is currently visualized, a legend with icons and tags is present below the map. In fact, despite the change of the filters' options, the results are not shown on the map until the user does not press the *calculate map* button. So a sort of visual reminder is needed.

Research and *Compare* are the main function of RCM that allow the query of the dataset, anyway there is also a function to download the data in the CSV format.

The user can interact with the map by scaling, zooming, panning, and shifting it, or selecting the colored area of Municipalities.

Municipio	Incidenti	Illesi	Feriti	Morti
Municipio I-Centro Storico	788	1281	536	2
Municipio II-Parioli	379	543	187	0
Municipio III-Nomentana-San Lorenzo	157	295	86	1
Municipio IV-Monte Sacro	370	696	190	3
Municipio V-Tiburtina	349	639	227	2
Municipio VI-Prenestino	234	394	163	3
Municipio VII-Centocelle	286	507	172	2
Municipio VIII-delle Torri	516	909	370	4
Municipio IX-San Giovanni	281	527	166	2
Municipio X-Cinecittà	350	720	234	0
Municipio XI-Appia Antica	343	670	198	3
Municipio XII-EUR	430	861	245	2
Municipio XIII-Ostia	524	1003	336	2
Municipio XV-Arvalia	312	625	197	0
Municipio XVI-Monteverde	289	527	135	2
Municipio XVII-Prati	312	585	153	0
Municipio XVIII-Aurelia	369	699	211	2
Municipio XIX-Monte Mario	293	481	156	0
Municipio XX-Cassia Flaminia	369	702	202	4
Totale #	6951	12664	4164	34

Fig. 4. Users can visualize on the table the results of the query, representing for each Municipality the number of road crashes, deaths, injuries, and unharmed

Table 1. Color legend of map

Color Code	Color	Type of Value
#bb3743	red	higher value
#e9ed5a	yellow	medium value
#6eacb6	blue	lower value

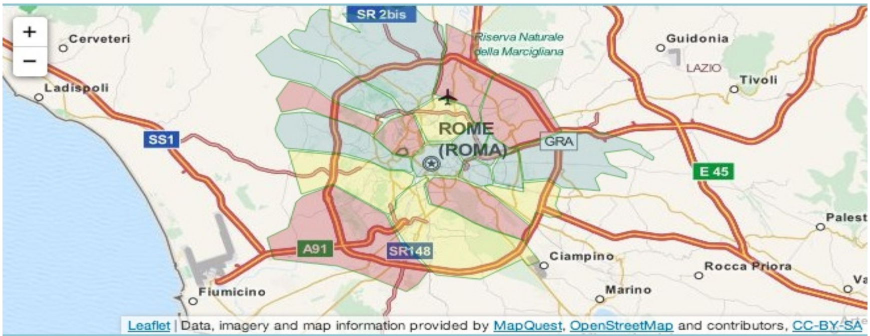

Fig. 5. Hue progression and opacity progression

The tools included within the platform make available for the user the following operation: locate, categorize, cluster, rank, compare (Table 2). These correspond to some of the basic visualizations operators that users might perform in a visual environment indicated by [13].

Table 2. Basic visualization operators and related RCM's tools

Visualization operator	Operational visualization task	Tools available
Locate	Indicate data items of a certain range of value	Graphs and table
Categorize	Define all the regions on the display, and draw boundaries. Indicate spatial positioning of elements of interest and spatial proximity among the different elements	Map divided into different colored areas corresponding to the 19 Municipalities of Rome
Cluster	Find differences in the data on the display	Filters, different colored map's areas, graphs, and table
Rank	Indicate the best and worst cases in the display for an attribute	Table with four type of information that can be sorted by clicking on the header of the relative column
Compare	Compare values at different spatial locations and the order of importance of objects (data items) accordingly	Compare filters, different colored map's areas, and graphs

5 Considerations about the Design of Roma Crash Map

Road safety is a sensitive issue, affecting both citizens and PAs. Consequently the need for information in respect of this issue is always high. We deem that, through RCM, the presentation of the information as derived from the dataset can be equally interesting and affordable both to professional actors and to inexpert users.

The larger part of the academic literature about the use of road crashes open data concerns the study of the determining causes of the crashes, along with possible solutions, and the use of related road crashes maps, often integrated with the GIS [36]. We found many examples of map disseminating open data about road crashes, especially in UK: CrashMap.co.uk, UK Casuality Map, Crash: Death on Britain's roads, Chicago Crash Browser, RoadSkillMap. In Italy two maps of road crashes were developed on the basis of data released by ISTAT (National Institute of Statistics), but no one focuses on the single Municipalities of Rome.

From an analysis of these maps, we found analogies and differences with RCM. In the former case, the use of different colors representing the crashes' numbers or seriousness, and the presence of filters (e.g. type of person involved, age, and seriousness) to set map and graphs.

In the second instance, the presence of a static map, the use of graphical elements to differentiate the type of information, the presence of a textual overview, and the representation of the exact location of crashes occurred.

In working with the data of the public datasets we faced different criticalities that influence the final aspect of the data visualization tool. Among the main problems observed there is the type of data contained into the released dataset. In fact, the datasets used in RCM were not a well-organized, consistent, and formatting error free set and were subjected to vary as a consequence of administrative changes[1]. Moreover they referred to three different time periods and had a different number of occurrences. So, before the development of the tool, it was necessary to operate on the data in order to make them usable within a single database created ad hoc.

We chose to use in the first place the variables that gave a panoramic of the road crashes in the city of Rome. Since the precise information on the location (address) of the single crashes was lacking, we chose to not focus on the information regarding the single event, such as the type of person involved in the accident with year of birth, gender, type of injury recorded, etc. This allows a simplification of the tool and the delivery of more consistent information to the users.

So, we tried to give the full set of data through the clearest and simplest user interface. The tools are shown on the basis of a hierarchical scale centered on the level of inference of the information at a first glance. In fact, the map and the graphs are immediately intelligible, while all the “numbers” included in the table (hidden by default) need a more careful reading. We maintained the assumption that using visual communication means is more useful and effective in getting involved the user, than showing at first “numbers”. Moreover in showing too many elements at the first time risks to create confusion and disorientation in the user.

Lastly, in choosing the colors for the progressions, we considered the work of [37], but we adapted it to the need to simultaneously view two measurements about the numbers of road crashes occurred, i.e. the one related to the variation from one geographical area to another, and the other related to the extent of the phenomenon within a single zone. In addition, it was necessary to show the geographic information under the colored areas. So we mixed the full spectral progression, from which we select the two hues at the extremis (red and blue) and one at the medium (yellow), and the opacity progression, interpreted as a single-hue progressions, where the chosen color fade from a dark shade (the higher value in the dataset) to a very light or white shade (the lower value in the dataset) of relatively the same hue. In general, in choosing the colors to use we considered their visibility and their ease of identification, even at the lowest level of opacity. Moreover, in the selection of the three different hues we individuated a progression which was easy to distinguish and perceive even by a part of visual impaired users, although consistent as possible with the most common progressions used in cartography or *choropleth maps*. The colors were also used according to their cultural significance, as the red and yellow are warm colors generally indicating

[1] Via the Regional Law n. 25 of 6 March 1992, the XIV Municipality merged with the City of Fiumicino, causing an inconsistency of the Municipalities numeration. Moreover with the Capitoline Assembly Resolution no. 11/2013 the number of Municipalities has been reduced from 19 to 15. Anyway for the released dataset was still effective the division into 19 Municipalities.

an alarm or danger more or less intense, while the blue is a cool color conveying feelings of calm and relaxation. Another possible solution being considered for the visualization of the two measurements on a single map was the superposition of a texture to the colored area. However, because of the features of the web mapping tool used, it has not been possible to adopt this option [36].

6 Conclusions and Future Work

In designing the RCM we identified some features that can improve user experience when interacting with an open data visualization tool:

1. Use of updated and standardized datasets
2. Use of multiple methods of data visualization (map, graphs, tables, etc.)
3. Use of thematic maps as facilitators of "visual thinking" about spatially related data
4. Dynamicity and interactivity of data visualization tools
5. Hierarchical organization of the data visualization tools
6. Consistency of information
7. Use of visual reminders

Anyway, to verify if RCM effectively makes immediately usable the data and fosters the spread of the information contained into the open datasets, in future work we intend to evaluate the system through usability tests with the different categories of final users. In the intentions, RCM is an elemental tool to construct knowledge, allowing exploration at a basic level and fostering the adoption of more complex tools, e.g. integrating GIS. RCM offers some function to compare and filter data, which make clear to the user the content of the dataset. In fact RCM can be an example of how to show open data in a familiar way to the citizen, since maps can be used at different levels of the open government process, bringing different levels of benefits for citizens. In this regard, in the future, not only we will evaluate the tool, but we also will consider how it can be combined with monitoring ad decision making tools. In this context we will also study the utility and the mode of presentation of open data in mobility.

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