SCIRES it
SCIentific RESearch and Information Technology
Ricerca Scientifica e Tecnologie dell'Informazione
Vol 8, Issue 2 (2018), 121-133
e-ISSN 2239-4303, DOI 10.2423/i22394303v8n2p121

VISUAL AND INTERACTIVE TOOLS FOR A MULTIPLE CROSS-READING OF A DATABASE SOURCE

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Abstract

Interpreting the need to process complex data in contemporary research processes, the research group worked on developing a web-based tool that integrated the potential of the visual language of interactive infographics into the process of organizing documentary sources. After analysing the major tools currently used to search and catalogue data through online collaborative systems and the study of specific examples of data visualisation, the paper presents the project for an online platform that allows researchers to analyse and query data in order to create transversal readings and new narrations that make it possible to interpret the field of study in new and original ways.

Keywords

Visual interactive tool, data visualization, database interface

1. *Introduction. The context and the goals*

This paper focuses on the advancement and the potential for sharing the experience of using new digital technologies in the design research process.

Design is taken into consideration as a possible field of application because it is the research group's specific field of investigation[1], but the project described in this paper may also be applied for research in other fields in which the investigation, in reference to authors and their works, is characterized by special attention to aspects of time and semantics that are considered key elements.

In their work, researchers collect a large amount of information, case studies and references, which they share and which day after day leads to the accumulation of a large mass of data within which they must orient themselves (Dalla Mura, 2016; Manovich, 2009).

Today, various systems are available to support scientific research that requires new tools to understand the complexity of data, from the traditional interfaces for collecting databases to the more contemporary tools for data-visualisation that have introduced a more user-friendly approach to the visualisation of information (Hochman & Manovich, 2013; Manovich, 2013; Zannoni, 2018).

If in the past all a researcher needed do was to organize the results of his work on simple spreadsheets, or classify them in databases, this approach is no longer sustainable and the need to process data, correlated with the continuous increase in online information, available in the form of datasets from many government or independent sources, has led to the development of various software programmes to generate different types of visualization. These digital systems which were originally used in the field of statistics, were gradually oriented toward a wider range of users. Many public and private subjects helped facilitate the process by providing open access to data analysis tools such as Google Data Explorer[2] or Google Trends[3] to researchers, journalists and anyone wishing to explore data.

[1] The paper was conceived and written jointly by the three authors. However Michele Zannoni and Alessandra Bosco are responsible for the paragraphs *Introduction. The context and the goals* and *Conclusion. Future development of the project*; Alessandra Bosco for *The project. A tool for research on the data*; Michele Zannoni for *The prototype*; Elena La Maida for the Case studies. *Visualizing the relationships in research.*

[2] Google Public Data Explorer: https://www.google.com/publicdata

[3] Google Trends: https://trends.google.it/trends

The appearance of these advanced open online research platforms was gradually accompanied by the rise of new professional figures such as visual journalists and information designers, whose job is to build forms of representation that describe complex phenomena or specific situations and make them legible.

In the past, the prevalent personal cataloguing tools chosen by professionals and researchers were commercial software programmes such as Microsoft Access on the Windows operating system, or FileMaker for the Macintosh platform. But with the growth of network connectivity and the development of open source software such MySQL[4] based on a client-server architecture, the field of personal cataloguing gradually shifted to a web-based approach.

A popular library for the creation of web-based infographics is D3.js[5], a veritable Javascript framework for the construction of interactive visualisations (Fig. 1).

Fig. 1: The D3.js Javascript library (Source: The D3.js website, https://d3js.org)

Based on this project, a group of designers and developers created a RAWGraph[6] tool (Fig. 2) at the Density Design Laboratory of the Politecnico di Milano. The tool exploits the potential of this library making it easier to use and easy to customise (Mauri, Elli, Caviglia, Uboldi, & Azzi, 2017). Another tool dedicated to a wider public is Flourish[7], a subscription-based commercial platform that offers a quick and simple way to build complex data representations starting with normal spreadsheets that don't require writing code (Fig. 3).

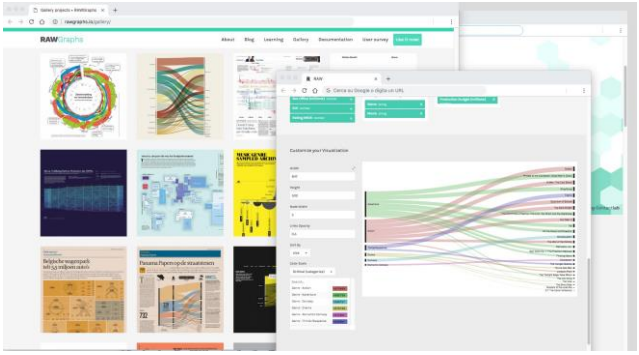

Fig. 2: The RAWGraph tool (Source: RAWGraph website, https://rawgraphs.io)

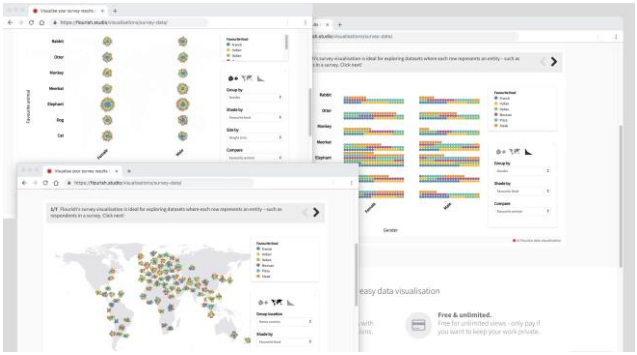

Fig. 3: The Flourish survey visualizations (Source: Flourish website, https://flourish.studio)

Many of the tools available to researchers and designers provide a process of data visualisation for the sole purpose of cataloguing. It configures and relegates the visualisation of information to the phases of communicating and reporting the research results. Thus scholars are deprived of the possibility of investigating and verifying data during the process of cataloguing documentary sources, whereas the critical evaluation of data during the archiving phase is a fundamental step in the research process, because it can help to complete the field of investigation by laying bare specific shortcomings in the cataloguing and suggesting possible new directions to explore.

The growing complexity of information also underscores the need, in parallel, to work synergistically between groups of people in a collaborative on-line process. In this regard, following the release of Google Suite, a collaborative online tool for editing documents alternative to the Microsoft Office software package, the realization that writing and editing could be a participated process led to the diffusion of collaborative functions on the clouds offered by various software companies.

[4] MySQL is an open source relational database management system. https://www.mysql.com
[5] D3.js Javascript library: https://d3js.org
[6] RAWGraph: https://rawgraphs.io
[7] Flourish: https://flourish.studio

An interesting commercial product worthy of note is AirTable[8]. Based on two principles – "Spreadsheet, meet database" and "Organize anything, with anyone, from anywhere" – it is configured as a collaborative tool to generate data in common.

Adopting a geographical approach MapStory, "The atlas of change that everyone can edit"[9] offers an open solution that can develop historic and contemporary narratives to describe the changes in territories using maps and dynamic infographics (Fig. 4).

Interpreting the needs defined in the analysis above and the specific requirements that emerged during our research process, and having demonstrated the absence of tools that could help to graphically visualise the data being catalogued in the fields of design, architecture and the arts, we developed a prototype of a tool conceived to read the sources on multiple levels.

2. *The project. A tool for research on the data*

The development of our analysis tool began in February 2017 as part of the research programme "Enhancement of the cultural heritage in exhibition and museum contexts through the use of new technologies" at the University of the Republic of San Marino.

An early version of this work and a prototype of the tool were presented at the 2CO Conference in Tenerife in 2017.

We analysed a contemporary design context that is not yet completely historicized.

At that time, we collected data from books, articles in magazines, catalogues of exhibitions and online blogs, interviews and designers' website.

In the early phases of the research process, we understood that we would have to create our own tools to sustain the collecting process. We realized that the software we used did not allow us to analyse the contents and the connections between them; in many cases, the system was helpful in retrieving the information as needed, but was not a useful tool for understanding and creating knowledge.

In the past, we used conceptual maps hung on the walls of our workplaces and other kinds of visual tools, but now, as we rely on digital systems to organise the sources, these practices are no longer available to us. It is not a problem of big data because every record we collect on the database, which delucidates a specific phenomenon, hides the information behind fewer data, increasing the complexity and causing a loss of the bigger picture.

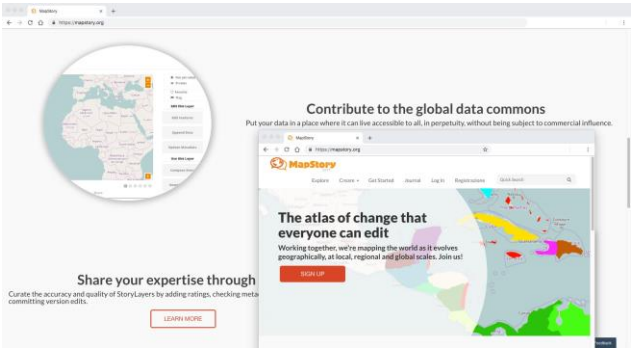

Fig. 4: The homepage of MapStory, the atlas of change that everyone can edit. (Source: MapStory website, https://mapstory.org)

Therefore, interpreting the common need to orient ourselves within a complex data system and to read its contents easily and immediately – based on our direct experience, the literature and existing case studies – we designed a new tool for managing and visualizing data. The idea was to create a specific tool for different levels of users that could be integrated into the cataloguing system.

In summary, the project develops a web-based tool that is easily accessible from any device with a browser and can interface with a set of tools. It will allow scientists to work together collaboratively and make it possible to integrate the traditional instruments of cataloguing and data visualization, designated henceforth to support the exploration and research.

3. *Case studies. Visualizing the relationships in research*

During the analysis that led to the development of the design for the database's reader interface, a series of case studies were examined to address the many different themes involved in visualizing the complex relationships between authors, catalogued projects, and the underlying technology.

Three types of examples were examined to bring the node-network relationships to light. It was a framework that allows the creation of a narrative representation in order to explain, filter and highlight the relationships.

[8] AirTable: https://airtable.com
[9] MapStory: https://mapstory.org

We choose in this text to report the more representative cases and so we limited the selection to four from each typology of data visualization.

The first typology of examples refers to the identification of the network of designers who work on interaction projects.

In the year 2009, Jens Weber and Andreas Wolter designed The ImpulsBauhaus[10] to reveal the social network of the Bauhaus art movement through an interactive table installation - designed for the exhibition celebrating the 90th anniversary and developed through the use of fiducial markers (Fig. 5). Their placement highlights the most significant information and the related insights between authors and researchers. The social networks have been systematically structured and entered into an online research database visualized on an interactive digital tabletop (Weber & Wolter, 2015).

source software[12] that makes it possible to visualise data by means of dynamic interactive graphics that illustrate the networks of relationships between the protagonists, filtered on the basis of their profession, scientific field and place of operation (Fig. 6).

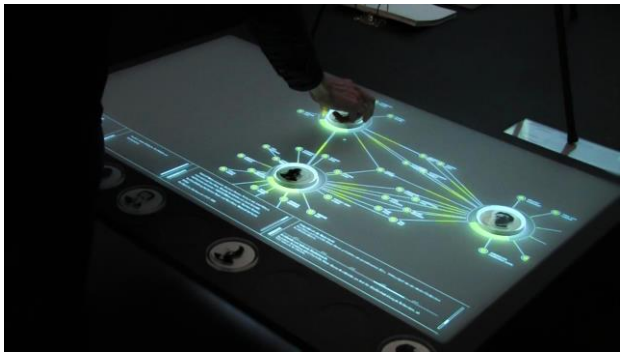

Fig. 5: The user moves the fiducial markers on the digital interactive table to visualize the people's networks (Source: ImpulsBauhaus in 3 minutes, https://vimeo.com/5333614)

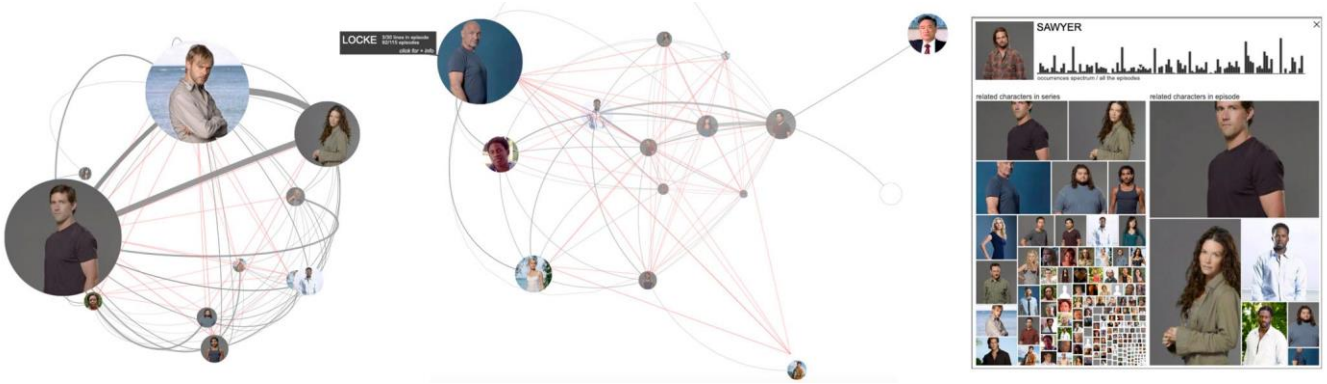

Fig. 7: The interactive visualization Lostalgic, project by Santiago Ortiz (Source: Lostalgic website, http://intuitionanalytics.com/other/lostalgic/)

In 2007, the interdisciplinary research center Aspi – the Historic Archives of Italian Psychology – developed the web portal titled Archivio storico della psicologia italiana. Le scienze della mente on-line[11] (Bollini, De Santis, Radice, & Zocchi, 2017) to process and utilize archive inventories. Conceived as a working tool for scientific research, it was updated in 2015 using an open-

Santiago Ortiz is an interactive visualization developer. He creates and develops highly innovative and interactive projects for the web. In 2012 he designed Lostalgic[13] to read and enjoy ABC's television series LOST in a different way. It shows the complete scripts, 115 episodes in 7 seasons, and visualizes information about the relationships between the characters using multiple types of visualization (Fig. 7).

[10] The ImpulsBauhaus Project: http://mediaarchitecture.de/projekte/impuls_bauhaus-interaktiver-tisch-interactive-table/

[11] Archivio storico della psicologia italiana. Le scienze della mente on-line: https://www.aspi.unimib.it/protagonisti-relazioni

[12] The open source software is Collective Access, conceived for managing the cultural heritage and museum collections. https://www.collectiveaccess.org

[13] The Lostalgic project: http://intuitionanalytics.com/other/lostalgic/

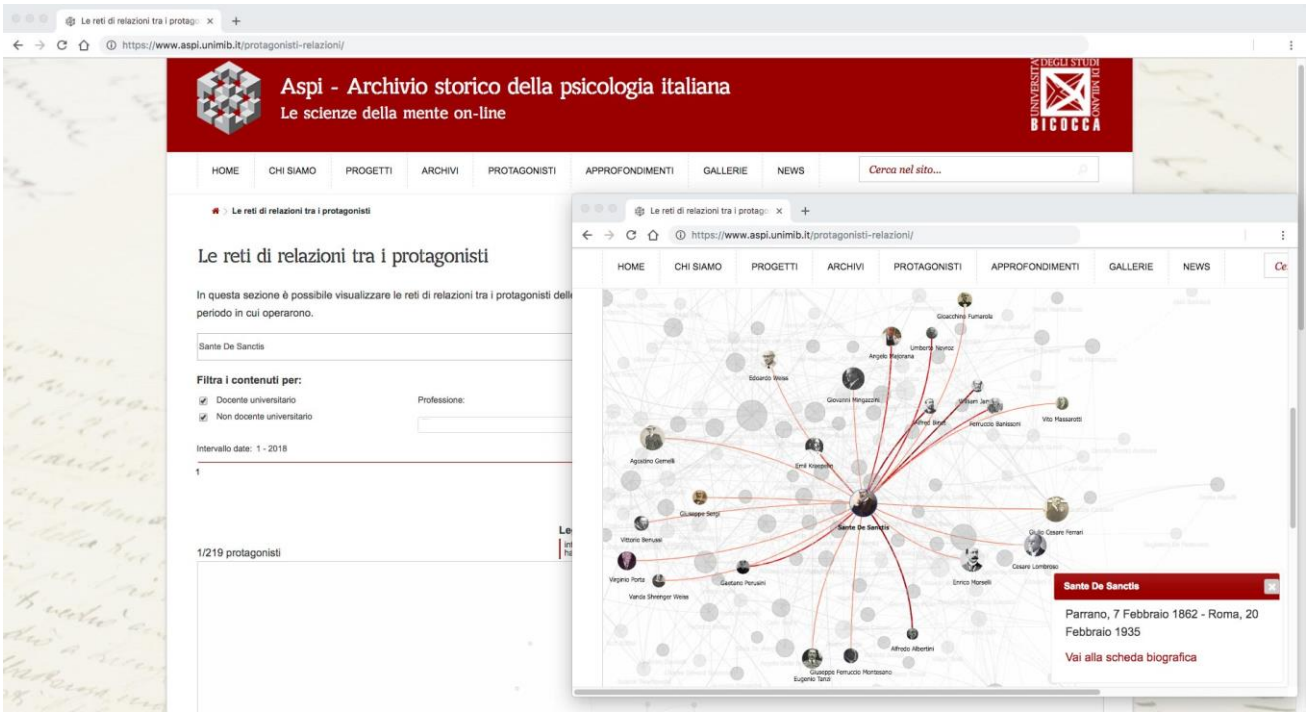

Fig. 6: The interactive web platform of the Historic Archive of Italian Psychology (Source: Archivio storico della psicologia italiana, https://www.aspi.unimib.it/protagonisti-relazioni/)

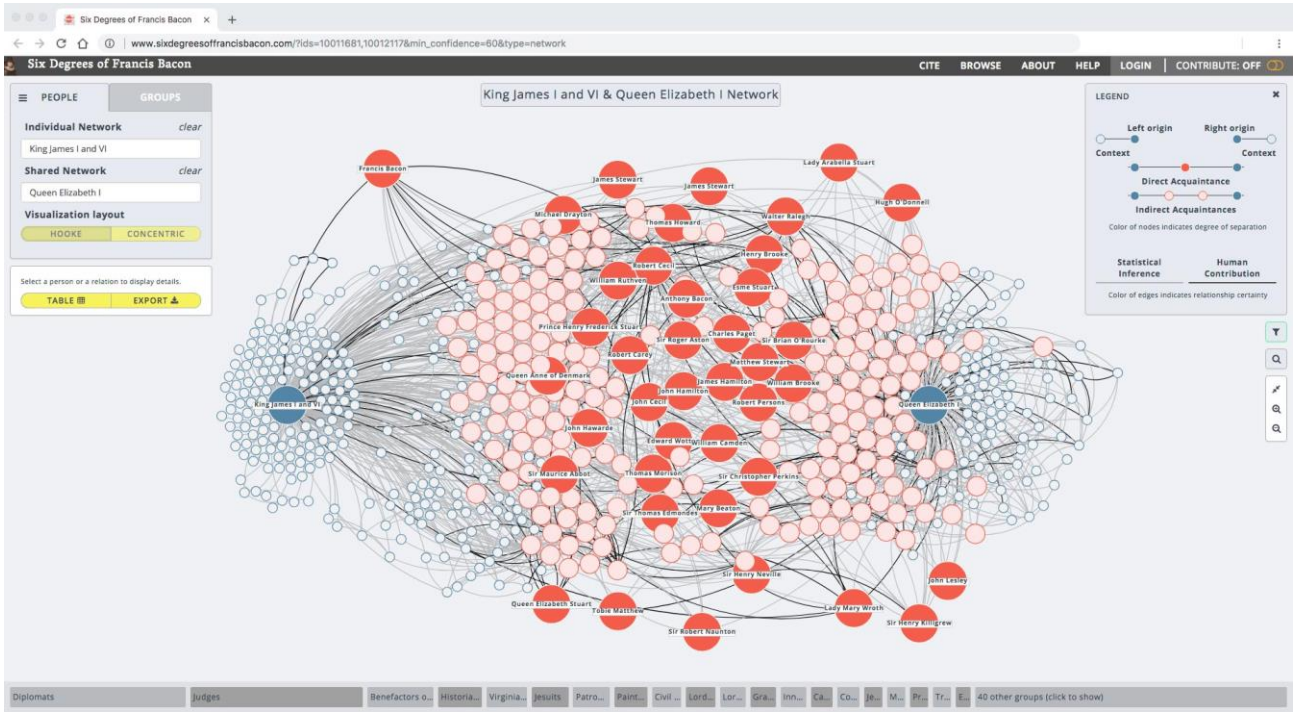

Fig. 8: The interactive tool which visualizes the relations between people (Source: Six Degrees of Francis Bacon, http://www.sixdegreesoffrancisbacon.com)

In Six Degrees of Francis Bacon[14] designed in 2017 by John Ladd, David Newbury and the Density Design Lab at the Politecnico di Milano[15] the relationships between the people connected to Francis Bacon are represented through a structure of connections that can be configured in various modes of representation. The reading can be selected and filtered through the varying degrees of relationships between the individual people (Fig. 8).

The second typology of examples refers to the possibility of interrogating the project reference database according to the parameters initially defined by the project and its structure.

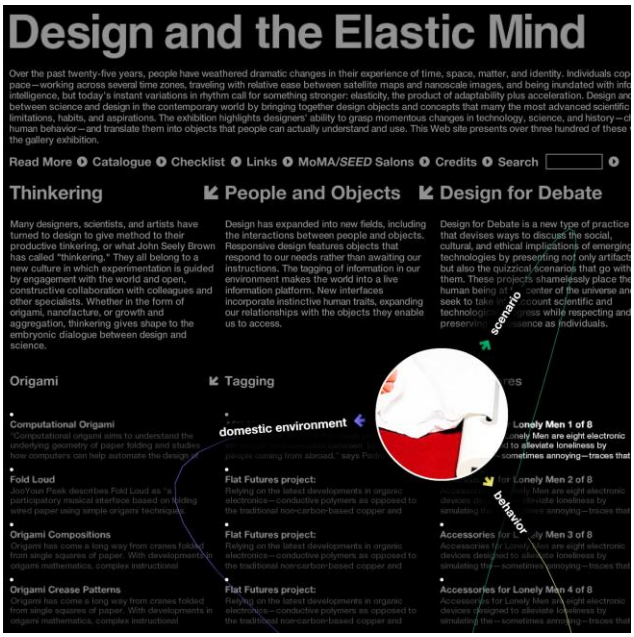

Fig. 9: Design and the Elastic Mind exhibition website, presented by The Museum of Modern Art (Source: Design and the Elastic Mind website, https://www.moma.org/interactives/exhibitions/2008/elasticmind/)

The Design and the Elastic Mind[16] exhibition was presented at The Museum of Modern Art (MOMA) in 2008. The exhibition explored the relationship between science and design through a collection of objects, projects, and concepts by artists, designers, scientists, and engineers in the contemporary world. The exhibition was accompanied by a website project by THA 1Ldt. (Fig. 9), which allows users to browse the exhibition projects using an interactive dynamic interface that tested new ways of tagging (Antonelli, 2016). The projects are systemized by name; every element is associated with a number of tags that connect the projects to one other.

In 2012 Justin Matejka, George Fitzmaurice and Tovi Grossman from Autodesk Research, designed an interactive visualization titled Citeology: Visualizing Paper Genealogy[17] to look at the relationships between research publications. The system analyses a dataset of 11,699 citations from 3,502 papers published at the ACM CHI and ACM UIST conferences between 1982 and 2010. Selecting a paper generates a visualization represented by curved lines (Fig. 10), that display the genealogy of the citations connecting each paper to the papers that it references and to those that will reference it in the future (Matejka, Grossman, & Fitzmaurice, 2012).

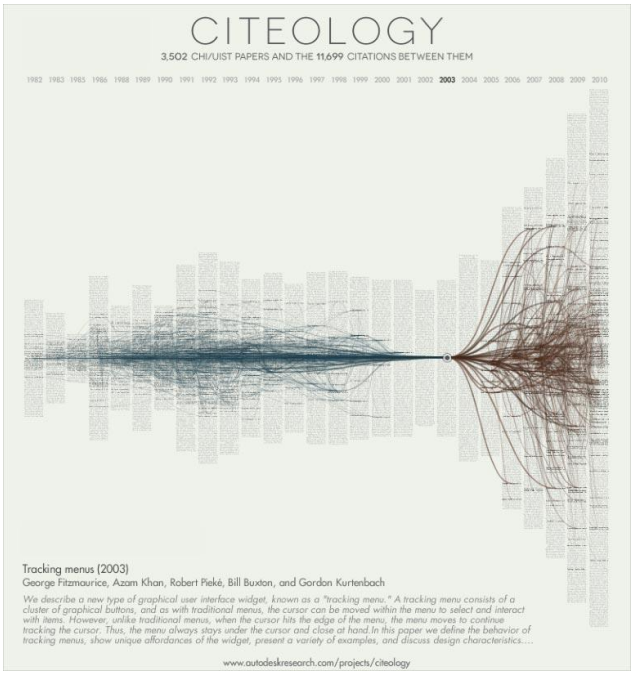

Fig. 10: The interactive visualization Citeology: Visualizing Paper Genealogy, project by J. Matejka, G. Fitzmaurice and T. Grossman (Source: The Autodesk Research website, https://www.autodeskresearch.com/publications/citeology)

In 2011, The Senseable City Lab of MIT developed a project with General Electric regarding human

[14] Six Degrees of Francis Bacon: http://www.sixdegreesoffrancisbacon.com

[15] Paolo Ciuccarelli, Tommaso Elli, Michele Mauri, Michele Invernizzi

[16] Design and the Elastic Mind: https://www.moma.org/interactives/exhibitions/2008/elasticmind/

[17] Citeology: Visualizing Paper Genealogy: https://www.autodeskresearch.com/publications/citeology

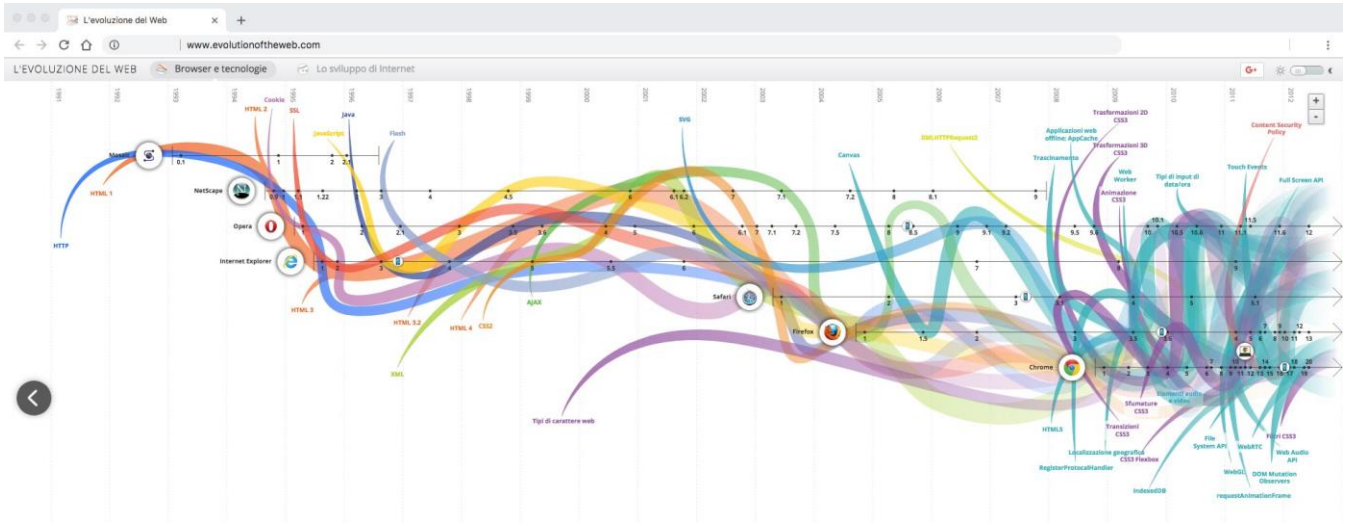

Fig. 12: The interactive infographic about the evolution of the web (Source: The evolution of web website, http://www.evolutionoftheweb.com/)

health in the United States. The Health InfoScape[18] project analyses data from over 7.2 million patient records in GE'S database and visualizes the relationships between various conditions and their effects with an interactive disease network.

The diagrams, which rely on colour aids to make the information immediately and clearly legible, can visualize the category of disease or related symptomatology and also allow for a new reading of the information to understand how certain apparently unrelated health conditions can actually be related to one another.

In 2009 a research group at The New York Times journal published the infographic How Different Groups Spend Their Day[19]. It is an interactive data visualization that shows how different groups in America spend their day and time (Fig. 11). The data comes from the American Time Use Survey database and tracks the sleeping, eating, and leisure activities of different groups of people over a 24-hour period. The interactive visualization allows users to explore the use of time by gender, race, age, education, and employment (Kirk, 2010).

The third typology of examples includes time as a priority dimension. The diagrams which make the information easy to access and to read, display the succession of elements in chronological order.

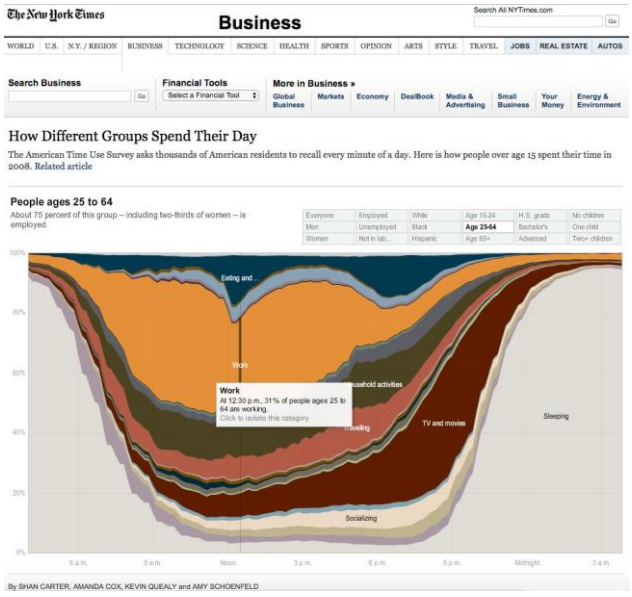

Fig. 11: The infographic "How Different Groups Spend Their Day". (Source: The New York Times Journal website https://archive.nytimes.com/www.nytimes.com/interactive/2009/07/31/business/20080801-metrics-graphic.html)

The Google Chrome Team presented an updated interactive component illustrating the evolution of web technology. The evolution of the web[20] is based on a static infographic designed by Mgmt in 2010 which shows the technology

[18] Health InfoScape: http://senseable.mit.edu/healthinfoscape/

[19] The New York Times: https://archive.nytimes.com/www.nytimes.com/interactive/2009/07/31/business/20080801-metrics-graphic.html

[20] The evolution of the web: http://www.evolutionoftheweb.com/

implemented in Internet browsers from 1991 to 2012. Each coloured band represents the evolution of the web and the interaction between coding and web technologies that have characterized the development of the system since the rise of the Internet (Fig. 12). In 2012, the Hyperakt and Vizzuality groups used HTML5 to develop a new responsive interface for the project. Available in six languages, it makes the visualization a valuable reference tool for the web community.

The Ebb and Flow of Movies: Box Office Receipts 1986 – 2008[21] published in 2008 by The New York Times is an infographic designed by Matthew Bloch, Lee Byron, Shan Carter and Amanda Cox illustrating movie grosses from 1986 to 2008 (Havre, Hetzler & Nowell, 1999). It visualizes the box office revenue, underlining the success and endurance of each film and its longevity in theatres. The interactive version of the visualization allows the user to query individual films by name on mouse over or by using the search box (Kirk, 2010).

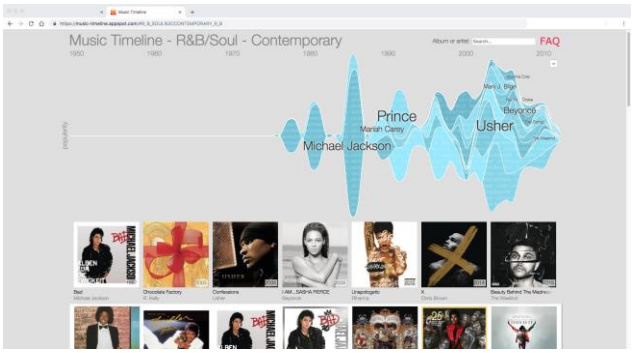

Fig. 13: An example of the visualization of the contemporary R & B soul music genre on the timeline (Source: The Music Timeline website, https://music-timeline.appspot.com)

The Music Timeline[22], designed by the Big Picture and Music Intelligence research groups at Google in 2014, shows the music genres timeline. Based on the music library of Google Play Music users, the Timeline is updated weekly and shows how different musical genres grow or shrink in popularity through the years from a starting point in 1950 (Fig. 13). Clicking on the stripes lets users zoom in on more specific information about artists and albums, showing which albums are still present in music libraries, finding key artists in each genre, exploring their biographies, their career and listening to their songs on Google Play Music (Cichowlas & Lam, 2014).

Gap Minder[23] is a web-service that displays development statistics on timelines for all different countries. Designed by Hans and Ola Rosling in 2005, it uses a Cartesian graph to display the variations of various statistic values relative to quality-of-life parameters. The timeline animation is defined by the authors themselves as an "animated bubble chart" that integrates the functions of tracing and visualizing changes in relation to time and individual countries (Fig. 14)[24].

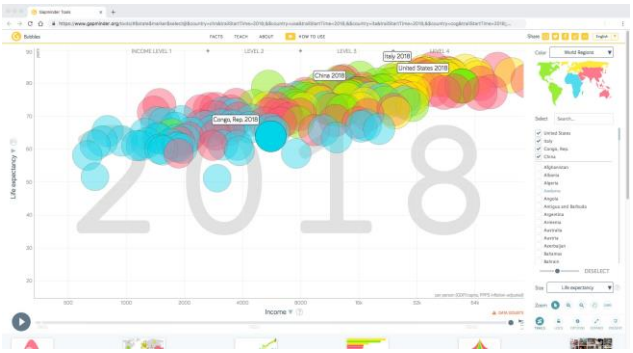

Fig. 14: An example of the animated bubble graph tool of the web-service Gap Minder (Source: Gap Minder website, https://www.gapminder.org/tools/)

4. *The prototype*

If the data visualization can instantly present the stratification of the collected information, the truthfulness of the visualizations always depends on the possibility of having a critical mass of data and on its being homogeneous.

During the experiments on the visualization of the cases catalogued in the database, we realized

[21] The New York Times: http://archive.nytimes.com/www.nytimes.com/interactive/2008/02/23/movies/20080223_REVENUE_GRAPHIC.html
[22] The Music Timeline: https://research.google.com/bigpicture/music/
[23] Gap Minder: https://www.gapminder.org/tools/
[24] More case studies on the visualizing the relationships, tag and time-based representation: Albrecht, K. (2017) *Trump connections*, http://trump.kimalbrecht.com/network/; Fathom, *athenahealth*, 2016, http://athenahealthvisualization.com/; Albrecht, K. (2017) Cultural Interflow, 2016-2017, http://interflow.kimalbrecht.com/migration.html; MIT Senseable City Lab (2011) *Spring Spree,* http://senseable.mit.edu/bbva; Yau, N. (2016) *Why People Visit the Emergency Room*, https://flowingdata.com/2016/02/09/why-people-visit-the-emergency-room.

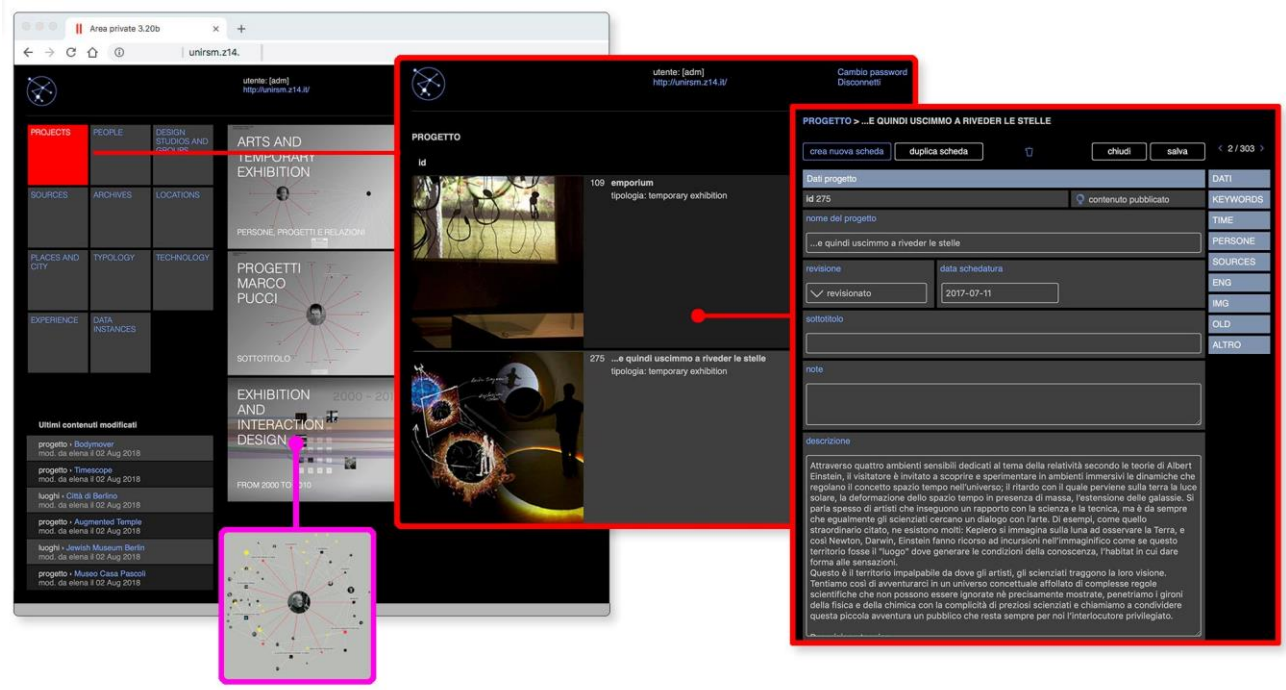

Fig. 15: The data visualization tool. The dashboard of the user interface.

that the information about each project was frequently not homogeneous and in many cases that the data was not coherent. The data visualization then, could help us to read the multilevel structure of the information collected during the research work, and to highlight the missing data that we would need to introduce in order to complete a coherent dataset.

Although the information collected in the database of the projects was at an early stage, we realised that the level of complexity involved was such that we could experiment with the prototype of a tool to read this complexity. It was sufficient to try to investigate and understand how this tool could change the way in which we obtain information from the data.

Our idea was to try to help researchers set up cross-readings of simple or complex archive materials using graphic patterns, diagrams, maps and interpretative relational models with the purpose of creating a personal interpretation for reading the project data.

We are working on the online platform, designing an interface for implementing and consulting the cataloguing system and connecting it to a strong data visualisation tool. The core of the system is developed in PHP on a Linux Server with Apache and MySQL server and can be used with a simple Internet browser. The data visualization is realized in P5.js with an experimental Javascript library for the data connection coding by Daniele Tabellini. At present, the software is stable. We are using an alpha version and many functions of the system are developed. All the parts of the user interface for collecting data in the database are ready to use. The tools for analysis are currently under development, but the researchers could use them to understand how the data is grouped and selected.

The interface is structured with a main dashboard (Fig. 15) organized into three areas: one dedicated to the implementation of the database, one dedicated to the tools for the data analysis, and the third, the header, dedicated to user management and system preferences.

The functions for data collection are organized similarly to the tables of the database in order to make the relational structure of the information visible.

The primary charts of the projects, people and professional firms, are supported by the principal categories into which the projects have been classified, such as typology, the technology used in the projects and the experience of the visitors in the exhibition space.

Within each one, the user will find a definition of the glossaries used and shared during the cataloguing process. In each area, the researcher will find the links to the archives and the sources consulted on a daily basis within the specific scientific research study. The range of functions in this area is completed by another tool that makes it possible to create data instances that may be studied by means of data visualization and could be published online in magazines, blogs or websites. The area dedicated to the tools for data analysis include several data instances which are currently the focus of research studies.

It is the authorial part of the system that allows users to create an interpretation of the information. The aim of this activity is to support the research with design solutions that activate 'storytelling actions', create visual representations of the data and generate processes of analysis. This is the most interesting challenge in the user interface design for research. The cataloguing system interface offers three types of data cross-reading; any data collected in the database in fact could be organized in instances and analysed with different data visualization tools.

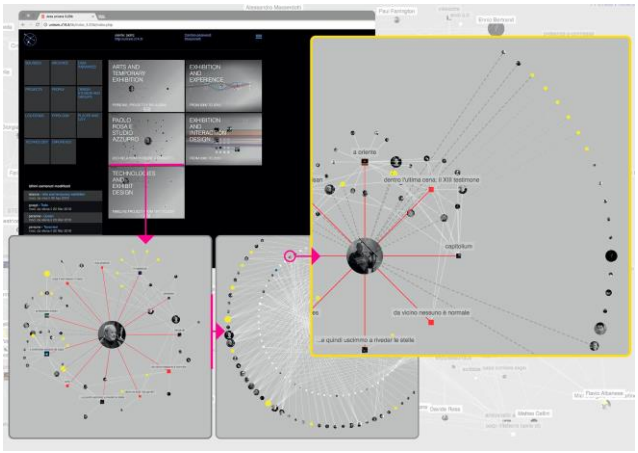

Fig. 16: The data visualization tool. The relationship between people and projects.

The first typology makes it possible to understand the connection between the people (Fig. 16), the second is an inspector that serves to understand the relation between the semantic and technological tags of the projects (Fig. 17) and the third is a time-based infographic (Fig. 18).

In the first case, visualizing the nodes and relationships between designers means being able to connect different generations of designers, to identify the pioneers and define the members of studios or collective groups and their followers, making it possible to explore the evolution of design in this area.

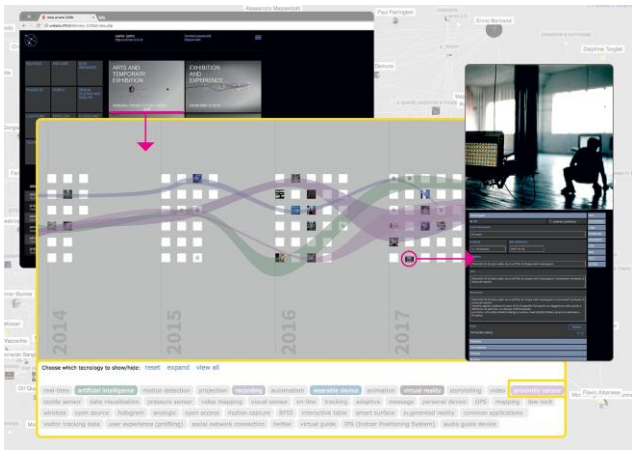

Fig. 17: The data visualization tool. The timeline and data information.

In the second, through the use of keywords, parameters and filters, the visual tool reveals the semantic attributes and their relrelevance in specific data instances, and displays them in visual maps.

The last interactive representation distributes complex information along a linear timeline, supporting both the chronological sequence of the projects and the course of a specific attribute of the projects.

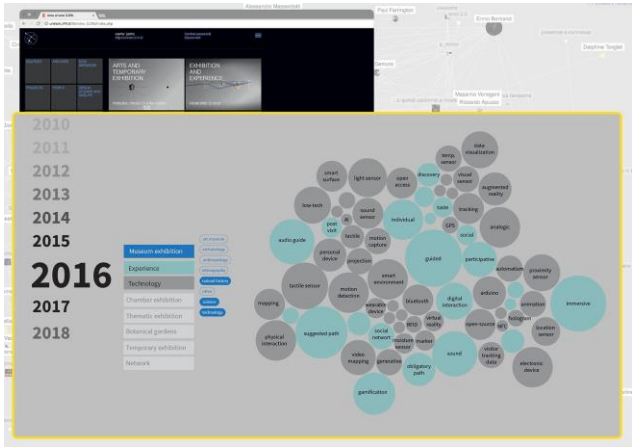

Fig. 18: The data visualization tool. Diagram of semantic relations and glossary of terms.

5. Conclusion. Future development of the project

The design of this visual tool prototype combines different kinds of data visualization as part of the research process. The tools help the people involved in the activity of cataloguing to expand their critical view with the aim of verifying and enhancing the contents of the research. Characterized by an interface based on an interactive system for data visualization, which can be configured as required, the system makes it possible to build narratives based on the data with an innovative approach that can be used by everyone involved.

The challenge for the future will be to collaborate with other colleagues to expand the database and share the most important narratives to open new directions for research in exhibit design. The future implementation of the system could be related to the use of machine learning to analyse connections, sources, and non-textual resources.

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