Browsing and correlation of territorial data in tangible maps - a Venice case study

Massimiliano Condotta, Till Nagel, Frank Heidmann

Università Iuav di Venezia, Tolentini S. Croce 191, Venezia, Italy
condotta@iuav.it
Interaction Design Lab, University of Applied Sciences Potsdam, Pappelallee 8-9, 14469 Potsdam, Germany
nagel@fh-potsdam.de; heidmann@fh-potsdam.de

Abstract: Information technology and new visualization methods are transforming approaching strategies for urban and territorial planning processes. In particular, these play an important role in transmitting, organizing and analyzing large quantities of notions related to territories. Due to the relevance of these new works, a continuous evolution and experimentation of methodologies, tools, and platforms is needed. The paper explains the concepts in this context, including developing processes, and the results of a research project aimed at conceiving and developing an experimental tabletop application to explore and investigate urban and territorial knowledge. To test the tool in a real scenario, our initial effort focused on current urban and territorial transformation processes in the City of Venice, Italy.
Keywords: urban planning, territorial information, knowledge organization system, tabletop display, geo visualization, tangible interaction, user interface.

1. Introduction

The objective of the research project described herein is to conceive and develop new methodologies to communicate urban and territorial data in visual and interactive ways, enabling experts (architects, urban planners, city managers, etc.) and non-experts (students, citizens, etc.) alike to participate in the discovery and analysis of physical and geographical data located in a shared information space. Supporting new ways of viewing, browsing and understanding the urban and territorial environment can lead to a more efficient evaluation of underlying data, thereby fostering knowledge generation and consequentially enriching the planning process. We aim to improve this understanding through dynamic, flexible and user-friendly methods to gather and evaluate spatial and cultural data connected with territories.

The following pages describe the experiences and outcomes of a research project carried out at the University IUAV of Venice and University of Applied Sciences of Potsdam. In this project we designed and developed a tabletop application for not only transmitting information through the visualization of data itself, but also fostering further and unexpected outcomes by allowing users to study inherent conceptual relations of collection contents. The rich flux of information flow, composed of data about projects and conceptual relations between them, is also enriched with geographic locations. Thus, the system visually combines analysis of data features about urban and territorial structures into a single information space. Our research results are a new way of reading and interpreting the urban text of a city and/or of the territory, with the aim to move exploration activities towards more creative processes by extending and tracking a nearly infinite number of possible navigation routes, consequently increasing the quantity and relevance of discovered notions.

2. Theoretical and conceptual background, motivations and objectives of the tool

The motivation of the project is based on two ideas and assumptions.

First, solving complex problems related to territories is not simply the sum of each participant's knowledge, but the result of a process of knowledge exchange and construction embedded in social interaction. This *social creativity* (Arias et. al. 2000) can be used to improve the decision making processes and related planning choices. Nevertheless, this knowledge exchange should be stimulated by the involvement of various *stakeholders communities* in new knowledge processes including people and citizens interested in the processes of their territory and enhancing their knowledge of it. To enable this involvement, it is essential to improve access to data for stakeholders to advance their territorial knowledge. Some experiments performed in this field by city administrations confirm this tendency. In Venice, several exhibitions, meetings, and specific web sites[1] directed to citizens, and dedicated to illustrating urban transformations of various cities has been held over the past 10 years. In the cities of Bologna and Torino exist structures called *Urban*

[1] For example, the "Carta delle Trasformazioni Urbane" database, which has been used in our project case study (http://194.243.104.176/ctu/home/default.asp)

Centers[2]*:* essentially public communication centers as places of mutual information exchange and confrontation about urban transformations.

Second, when multiple levels of notions and concepts are overlaid into a single information space, urban design processes can be increased and supported (cf. Ishii et. al. 2002), and decision-making about new ways of approaching complex design problems related to territories may be improved.

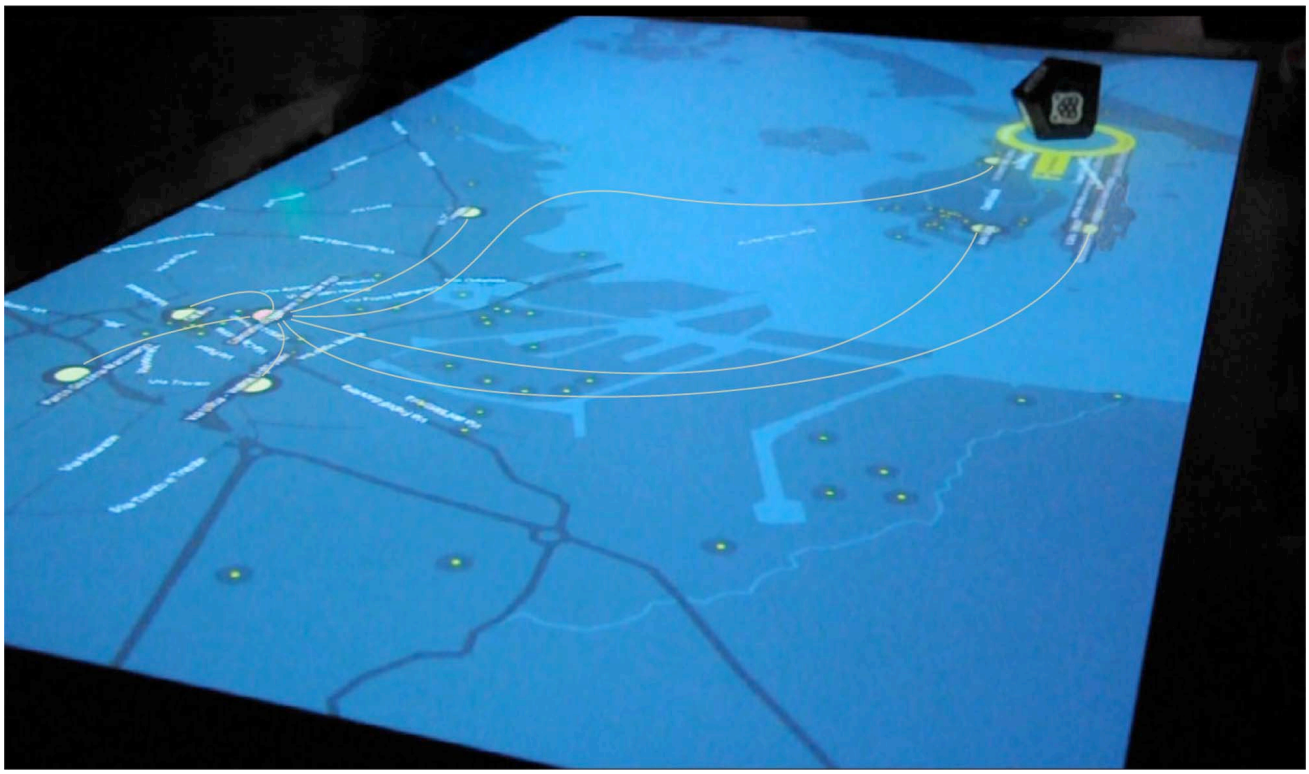

Fig. 1 The tabletop application showing projects and relationships between them in the Venetian region.

2.1 State of the art in knowledge exchange and information spaces systems

There have been several studies over the last several years utilizing tabletop interfaces to represent information, and allow novel ways of tangible data interaction. Among them, the most relevant to our work are: the "Envisionment and Discovery Collaboratory (EDC)" research project (carried out at the Colorado University) that studied the impact of socio-technical environments in support of learning, participation, collaboration and design (Arias et. al. 2000); and the "Augmented Urban Planning Workbench" project that using the "Luminous Table" experimented with and evaluated new combinations of physical and digital media for a more holistic design approach (Ishii et. al. 2002). Their outcomes and conclusions suggest that: (1) this kind of approach shifts the emphasis away from computer screens as the focal point, by creating an integrated environment in which stakeholders can incrementally create shared understanding through collaborative design; (2) a successful design tool can stimulate creativity as well as help solving problems by combining the benefits of multi-layered representation with possibilities for tangible interaction, thus providing a platform for meaningful collaboration and territorial support.

Furthermore in recent years – reinforcing our position about the essential involvement of stakeholder communities – *neogeography* gets higher exposure through easy-to-use interactive maps. It can "help shape context, and convey understanding through knowledge of place" (Turner 2006), while analyzing how users "tend to create their own maps, on their own terms, by combining elements of an existing toolset" (cf. Satyaprakash 2008) experts understand interactions stakeholder communities have with their territory.

[2] In Torino the "Urban Center Metropolitano" (http://www.urbancenter.to.it); in Bologna the "Urban Center Bologna" (http://www.urbancenterbologna.it)

2.2 Purposes

In this context we presume consolidated representation models of territories are turning towards integrated systems of georeferenced information converging with contributions from social networks by layering different notions into a single information space. Due to the ever-increasing demand of territorial and urban knowledge of stakeholder communities and urban planners, we consider a continuous acquisition of new concepts, ideas, methodologies and technologies to be desirable and necessary. With the tabletop application developed for the *Tangible Maps Venice* case study, we aspire to contribute beneficial visualizations and innovative user interfaces to this up and coming research and public interaction area by studying and evaluating new methods of communicating spatial and cultural information.

2.3 The characteristics of the tool: analysis requirements

As emerged from the previous paragraphs, alternative tools need to be characterized by features to fulfill their purpose. Therefore, based on studies of existing tools and our previous experience in knowledge management systems in architectural and territorial domains (Nagel et. al. 2009, Stefaner et. al. 2007, Condotta 2008) we developed a list of specific characteristics which can be organized and reorganized around the followings points:

- A friendly and direct access to data must be a key point of the interface. Users need to interact directly with relevant information to control the several parameters involved without being hindered by difficult devices. Moreover, interaction elements need to be intuitive and familiar.
- Navigation of the information space needs to be as free as possible, flexible and evolving according to the users' needs. A subtle, but permanent guidance giving visual feedback needs to be in place to prevent users from getting lost in environments they openly can explore.
- To enhance knowledge exchange processes by overlaying concepts, relational networks between notions has to be explicated and explained in simple and visual ways users can intuitively grasp to increase both their understanding of notions, and general exploration activities. In turn, this enhances "*analytical strategies for information seeking* based on planning, query terms [such as through dynamic filters], and iterative adaptations of queries based on evaluation of intermediate results" (Rice Ronald 2001). Moreover if logical connections between contents are visually displayed, intermediate results are themselves self-explanatory giving an overview of possible end results. This helps information finding and access based on *browsing strategies,* an activity typical of architects that utilize processes of scanning and glancing in which pre-attentive perception serves to identify objects or message of interest (Arthur et. al. 1992).
- Finally, an important aim is to create a social system, not as personal and introverted as stand-alone desktop computers, instead opening shared information spaces for collaboration and discussion, which can increase *social creativity* processes.

2.4 Conceptual base of the tool: the city and environment as an urban or territorial text

To create new interface design strategies according to the points above, and to allow semantic operability among contents (Stefaner et. al. 2007), we need to rely on a suitable *Knowledge Organization System* (KOS) (cf. Hodge 2000). In our project, a subset selected by domain expert of the MACE Application Profile[3] has been used as base to create the database schema of the Tangible maps tool. Since it is based on the conceptual idea that the anthropized territory can be considered as a text - a sort of architectural or natural speech expressing his meanings through perceptible signs (Spigai et. al. 2008, Condotta 2008) - using this KOS is possible to support the notions exploration activity according to the methodologies previously described. Use of the MACE AP as a foundation is important for several reasons. First, the AP is based on several existing and shared thesauri. Second, since we can draw from various sections of the MACE AP, we can cover a variety of domains related to architecture, urban and territorial environment.

2.5 The Venice case study

To illustrate and describe the work done so far, we introduce and explain the tool developed with a concrete knowledge base. The project utilizes the dataset "Carta delle Trasformazioni Urbane", a web based platform developed by the City of Venice to catalog new urban processes (new building complex, infrastructures, environmental actions, etc. hereafter called

[3] The MACE AP defines a common metadata structure to describe architectural contents, and is an extension of the LOM standard based on faceted taxonomy It has been developed in the MACE research project. The EU project "Metadata for Architectural Content in Europe" (MACE) consists of a Web information system that organizes and connects major architectural archives with architectural and urban planning data. (http://portal.mace-project.eu/)

"projects") involved in the transformation of the urban and natural environment of their city. This scenario has been used during the development phase (as documented in Fig. 2) to test the tabletop application, and to conceive new design strategies.

The image represents a part of a workflow designed during the developing phase of the prototype. It simulates an exploration activity among the notions based on the semantic operability between contents. E.g. in step 9, the user decide to explore projects related to "edificio redienziale D" by the keyword "context relation, dialogue"; the system (step 10) gives some results; the user (step 11) chose to explore information and pictures of one of these results, in this case "Ca' Foscari" project.

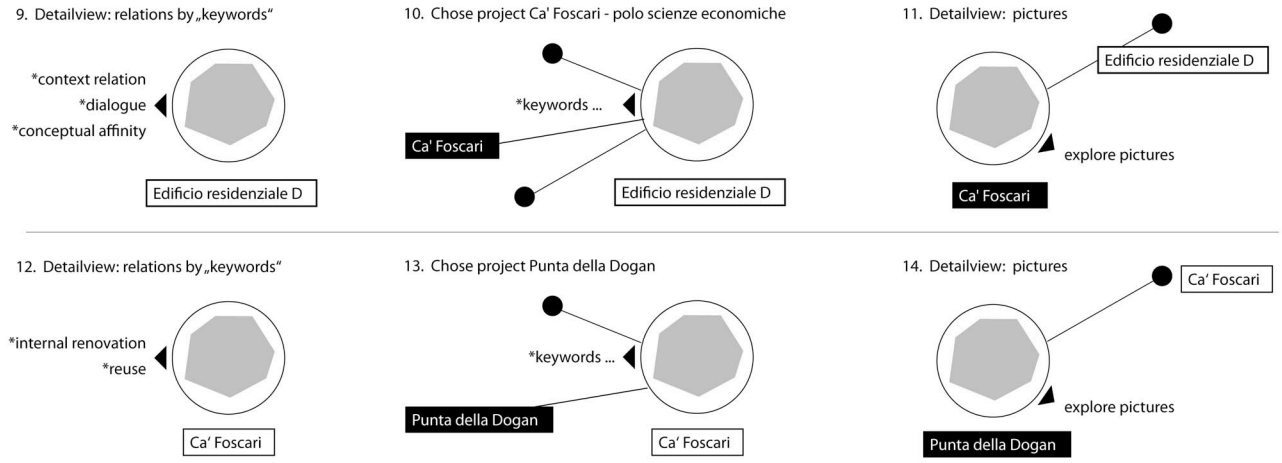

Fig. 2 Part of a workflow of exploration activities designed in the development phase.

3. The Tangible Maps Venice prototype

Based upon the tool requirements in the pilot case, we designed and implemented a working prototype by creating interactive visualizations using a multi-touch and object-tracking tabletop. We selected the architectural and urban projects of Venice from the previous mentioned relational database. The projects data, already classified with geo-location and other standard metadata, have been manually organized and enriched with terms from the MACE taxonomy.

Fig. 3 The interactive table during a development working session.

Fig. 4 Map overview with all study projects displayed in the tabletop.

The prototype consists of: (1) an interactive tabletop device and application, whose surface displays the map, but also media, texts, and metadata related to architectural contents; (2) an interactive polyhedral object to filter and select (see Fig. 5) relevant information. The table dimensions are 2.2 m x 1.7 m with a height of 1.0 m. Multiple users can use the table simultaneously, allowing easy access for standing users (see Fig. 3). The polyhedral object can be placed into the

table's graphical surface and used to filter and select various metadata by tilting it to one of its sides. Each active side of the polyhedron includes a *fiducial marker* printed on the surface. The marker reflects infrared light recognized by a high definition camera inside the table, allowing the system to identify the polyhedral side, as well as the object's position and orientation. This tracking procedure was developed with the reacTIVision framework (Kaltenbrunner e Bencina 2007).

Cartographic information shown within the map comes from OpenStreetMap[4], and Cloudmade[5] provides the image tiles. This allowed us to embed interactive maps fast and effortlessly without the technical setup of a complete map server stack. While the main reason was to customize the map according to interface design necessities, one further advantage is users contributing and updating underlying spatial data. This crowd-source approach encourages stakeholder communities to participate in solving territorial problems.

In the beginning, the map of the whole territory is displayed with various projects shown with recognizable markers at their locations (see Fig. 4). Users now can zoom and pan the map by touching and moving the screen surface with their fingers to adapt map segment to their needs. Tapping a marker (i.e. touching it with a finger) selects the respective project and shows related background information and media files (see Fig. 7, 8).

The main exploration activity is performed with the polyhedral object, a physical artifact that allows *haptic direct manipulation* (Hornecker 2006). In the design of the object we opted for a shape signifying interaction possibilities by selecting different facets, while being an interesting physical artifact to invite architects and urban planners to touch and utilize it.

Fig. 5 The polyhedral object with the taxonomy categories to select (projects names, keywords, functional typology, designer, date).

Fig. 6 Selection of a specific characteristic of the project, here the designer.

Use of the object is twofold: First and foremost to select criteria to filter and display specific projects. The object consists of a base area and five surfaces in different shape sizes, which act as a data filter. The different sizes describe the amount of data in every single facet (Fig. 5). If users want to activate a filter, they tilt the object towards that area. The flattened edges make tilting easy. Users can select a conceptual category and then choose a single entry from all the terms in that facet, displayed in a radial visualization surrounding the object (Fig. 6). After a user's selection, matching projects are highlighted on the map. The map section automatically adapts appropriately, so highlighted projects always fit the whole table surface.

The second use of the object is to browse background information on a selected project. The design of that menu is similar to the filter menu. Users can choose one of three categories of information by moving the object towards one of the sides of the ring. By rotating the object inside the ring users can explore projects in detail; scrolling through description text (Fig. 8), and explanatory pictures (Fig. 7), or activating the project's conceptual network with other projects (Fig. 1).

The possibility of showing project's mutual relations in direct and visual ways (see Fig. 1) is a key point of the interface. The relations are based on shared metadata, e.g. same architect, similar construction date, or shared conceptual classifications according to previous mentioned KOS to allow exploration of corresponding projects. If this modality is selected (according to the desired characteristic chosen by the user) all projects connected to the current project appear on the map, and can be selected to start a new browsing and discovery process. All current selections may be cleared and other users can start their journey through the information flux.

[4] OpenStreetMap, http://www.openstreetmap.org/
[5] CloudMade, http://www.cloudmade.com/

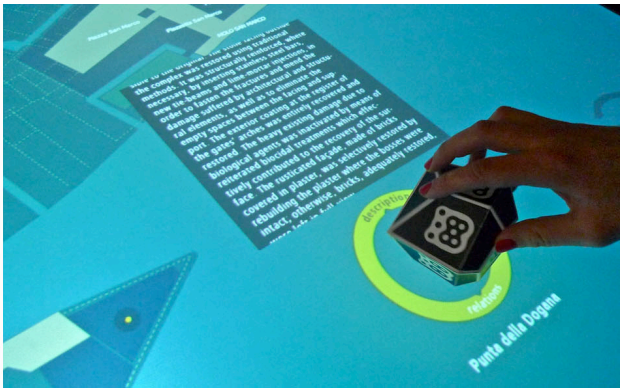

Fig. 7 Viewing of pictures and images related to the selected project.

Fig. 8 Viewing of text information related to the selected project

4. Conclusions & Outlook

In our opinion, the described system can be considered as an interesting and promising prototype tool in the sector of urban information, organization and seeking. Fulfilling the starting requirements allowed us to test new methodologies to access interact with urban and territorial data. The most promising characteristics are:

- Immediateness of non-mediated access to information thanks to "natural" representation of concepts;
- Highlighting and emphasis of interconnections between data, objects and concepts based on a structured database of semantic metadata;
- Personalized notion browsing, following paths based on previous associations of ideas;
- Simultaneous multi-user interactivity.

We conducted a formative user study to gather first feedback from users working with the prototype. The six participants ranked themselves technically savvy, and had first experiences with multi-touch devices. While the map and the display of the projects were interpreted correctly, all participants did not immediately understand the polyhedral object. Three users misapprehended the selection mechanism, and tried to tap the appearing items with their finger. For browsing through the alphabetical list, two users rotated the object in the opposite direction. After these initial errors all participants learnt the working interactions. Overall, the participants described the prototype as "playful", "inspiring", and liked the explorative approach, but criticized it as not self-explanatory, enough. In the continuation of the research, we will incorporate the given feedback and refine the interaction design aiming to improve the usability. Furthermore, the application will be tested with different sets of data to validate our conceptual background assumptions.

In summary, the prototype can be considered a non-conventional system for exploring urban and territorial knowledge that can trigger positive effects to improve the decision-making processes and related planning actions.

5. Acknowledgement

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