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"Sensing" the "City Model" to improve effectiveness of digital resources

Keywords: smart city, city model, city sensing, knowledge management, semiotic taxonomy.

Abstract The current way of handling knowledge, based on ICT, has reached a high level of performance in using digital information and managing digital archives. Nevertheless, there are still a lot of unexpressed potentialities in the way of storing, retrieving and using knowledge also in combination with non-digital information. These potentialities are even more relevant in the field of urban and territorial data where there are still lots of innovative technologies that can be used when managing digital information related to the city and if combined with the big challenge represented by the new concept of "smart cities". This article illustrates one of these potentialities: the use of semiotic taxonomy concepts to increase the effectiveness of data that are related to a digital representation of the city we call *City Model*. The purpose of this article is to foster the joint activity of institutional offices with web users towards the goal of creating a new, structured, semantically interconnected, shared and open knowledge resource based on a substrate of information that represents the physical environment.

INTRODUCTION

Before the Internet era, before the arrival of book printing and the public press, the transmission and storage of knowledge was a very complicated and delicate matter. Only few people with specific cultural, handwriting and drawing skills had the capacity to do it. Which is why it was considered an art, hence featuring all the peculiarities of an artistic product. One of these peculiarities is related to interpretation. In the storage process, notions and data were transformed into information through a transcription procedure. This step of creating information from raw data was a crucial point in the ancient way of storing knowledge because it was an action calling upon the sensibility of the person in charge of it. It was a skill, a work of art that involved creativity for its nature. Therefore, the results of the transcription operations transforming raw data into knowledge features come from a creative process that the final product inevitably reflects. Most of the time this contamination is positive and enriches the work that has been done with new contents and meanings. Luckily enough, sometimes the process was so relevant and driven by free interpretation that the result was the creation of new knowledge.
In the field of art and architecture, the free interpretation of data was quite common during the Renaissance period.[1]

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1 A full essay on this topic has been written for the Getty Publications (The J. Paul Getty Trust). Condotta, M. Using Controlled Vocabularies for a Creative Interpretation of Architectural Digital Resources. In: *Getty Research Journal*, no 5, 2013. (Under publishing, 2013).

It is also thanks to this tendency to interpret architectural objects, ancient monuments and ruins during the study and transcription phase – and not during re-processing, as it is, for example, in Postmodern or Neo-eclectic architecture - that Italy and Europe have the Renaissance and Baroque architecture as it is now.

This process of creative interpretation of information was of course a peculiarity of that historical period, yet it has not been limited only to the Renaissance period. It may be seen as a consequence of the "technology" used to store data: any technique suggests or triggers a proper way of "creative contamination" of information.

IMPROVING ACCESS AND EFFECTIVENESS OF DIGITAL ARCHIVES

Current digital and computational technologies opened a new era in the way of accessing, using and reusing knowledge that is comparable with the positive consequences of the arrival of book printing in the 15th century. The digitalization of information and the creation of digital archives enable a rapid and wide dissemination of knowledge, increasing the number of people that can have access to data, improving the "findability" and enhancing the quality and the accuracy of the notion. In the domain of architecture and urban planning (among many others), this accuracy of the notions is quite relevant, and the social impact of an easy and open access to information by a large amount of people is fairly significant.

These achievements are not to be relinquished. On the contrary, they have to be improved by enriching them with new concepts and features. The reasoning that inspired this article is related to this goal. In our opinion, the current way of managing digital information ought to be enriched by integrating it with two of the characteristics that were typical of the renaissance way of recording and managing information. The first one, which emerges from the introductory example, is the *interpretation* of information, an action that in the manual way of recording data is carried out directly during the information writing procedure. The second one is the *collection* of information through an object, usually a codex,[2] that outperforms a folder, since it can be seen as a strive to put together information, notions, drawings and any other document that represent something existing in the reality and to interconnect all these pieces of information.

To sum up, if we were able to enrich the modern way of managing digital knowledge with these two features, this would be a great improvement. But how is it possible to do this?

The IUAV Research Unit and doctorate program in "New Technologies and Information for the city, the Territory and the Environment" (NT&ITA, "Nuove Tecnolgie e Informazione per la Città, il Territorio e l'Ambiente) have been working for several years on these questions, developing possible strategies and solutions have been applied and tested in different research projects and can be grouped in two different domain areas: one referring to the use of semiotic-based taxonomies to index digital archives with the aim of making them more effective, the other being related to the use of ICT to create digital models of reality with the aim of increasing the perception and the understanding of reality itself.

2 For Codex we refer to the "old" codex (Latin *caudex* for "trunk of a tree" or *block of wood*, *book*; plural *codices*) is a book in the format used for modern books, with multiple quires or gatherings (sheets of paper or vellum in multiples of two which are folded and stitched through) typically bound together and given a cover.

CREATIVE INTERPRETATION OF DIGITAL INFORMATION WITH SEMIOTIC-BASED TAXONOMIES.

The idea of using semiotic studies to interpret architectural objects and art production came out several years ago at the School of Venice at the University Iuav of Venice.

It is based on the assumption that the production of an architect or of an artist as a result of their work (a building, a sculpture, a painting, etc.) can be considered a process aiming at the creation of a message. This process that can be compared with the way a written text conveys a meaning through words.[3 4] Therefore, it is possible to read the composition, to interpret and to classify it according to conceptual categories that express the original meaning of the object or a new message outcome of a personal interpretation. The approach used to define the categories involved in the design processes stems from the semiotic models of A.J. Greimas from the school of Paris and his French, Swiss, and Italian students during the early 1970s. A whole dissertation would be too long and complex for this article. However, it is important to understand that 'these categories dismantle the *generative path* of the project, thus rendering the principal aspects and actions of such *path* "classifiable" and traceable'.[5]

A practical application of these concepts that goes in the direction of creative interpretation of data has been developed by the MACE[6] project (Figure 1) and its Italian spin-off[7] that developed a *Semiotic Based Faceted Taxonomy.*[8]

MACE is aimed at improving architectural education by integrating and connecting vast amounts of content from diverse repositories and existing architectural design communities. Through the creation of innovative e-learning tools, MACE provides the community with services such as finding, acquiring, using and discussing contents that were previously available to small groups. Based on an infrastructure of federated learning repositories, MACE provides unique, integrated-access facilities for high quality contents and it is relevant in architectural education by providing unique access to architectural pedagogical material. The correlation between various types of content, usage, social and contextual metadata enables to develop multiple perspectives and navigation paths that effectively lead to a number of unexpected experiences.

In order to get these results we have developed a Knowledge Organisation System, based on the above-mentioned semiotic model, which aims at offering the possibility to cater for different requirements of the various trends and approaches. For example an architect or a creative designer needs an approach based on personal and intuitive data and the keys may be about formal ideas, metaphors or intuitions selected as a starting point of the design language. A designer following the suggestion of transparency could search through the system for design cases featuring a *transparent perceptive quality* to use it as a model to develop his own project.

3 Hjelmslev, L. (1943). Omkring Sprongteoriens Grundlaeggelse. Copenhagen.

4 Greimas, A. J., Courtes, J . (1979). Sémiotique. Dictionnaire raisonné de la théorie du langage. (Paris)

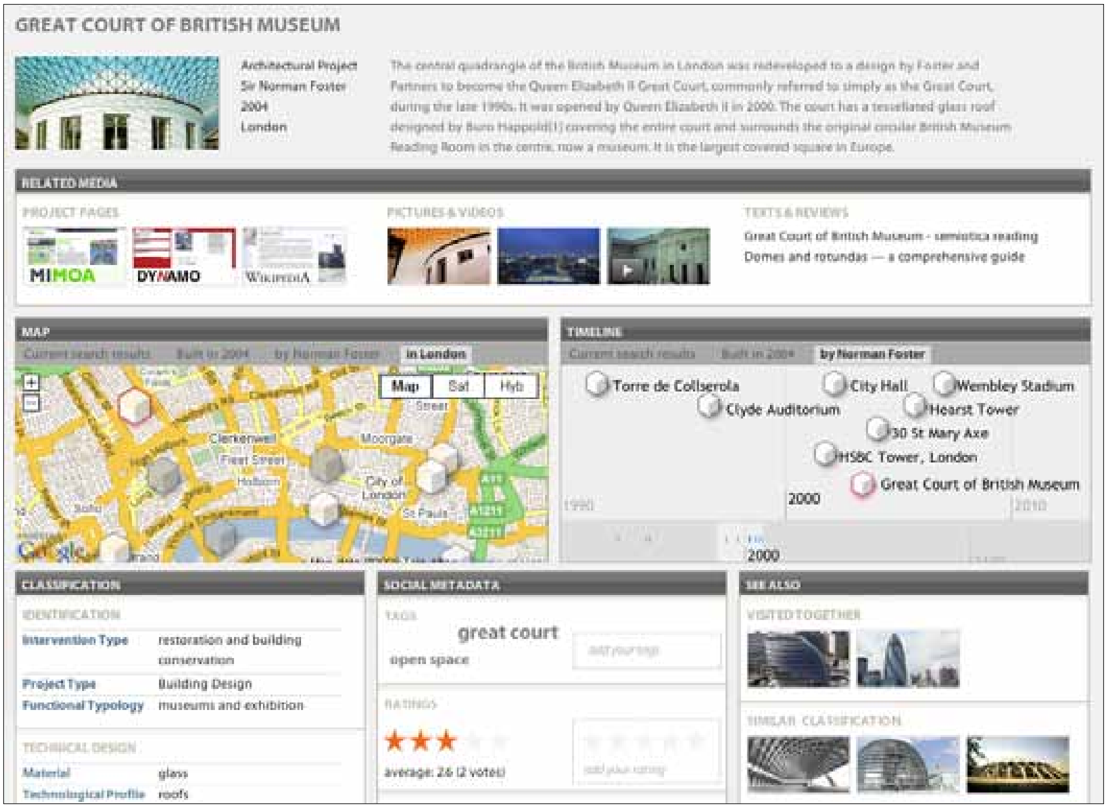
5 Spigai, V., Condotta, M., Dalla Vecchia, E. (2008). E-learning in didactic workshops. The virtual atelier system T-Labs: storage, conceptual metatagging and sharing of the architectural design knowledge. In *Proceedings of the CIB W102 3rd International Conference. Information and Knowledge Management – Helping the Practitioner in Planning and Building.* Stuttgard.

6 www.mace-project.eu. The Italian version at: http://portal.mace-project.it.

7 The project has been co-financed by the Italian Ministry of Education's inside the National Research program Prin 2008.

8 Spigai, V., Condotta, M., Dalla Vecchia, E., Nagel, T. (2008). Semiotic based faceted classification to support browsing architectural contents in MACE. In: *Proceedings of the Joint CIB Conference: W102 Information and Knowledge Management in Building, W096 Architectural Management.* (Helsinki).

Figure 1 Example of a page of the MACE portal. In this image a detailed view of a learning object as displayed in MACE (in this case, the content is the Great Court of the British Museum). Related media, locations in proximity (shown on map), contents belonging to same period (shown on timeline), the classification terms according to the Semiotic Taxonomy, social metadata, and related contents are shown on this page.



This knowledge organization system relies on a semiotic-based taxonomy composed of a hierarchical classification of terms in a controlled vocabulary. Through this taxonomy that features categories related to both *objective data* (e.g. Materials, Structural Profile) and *personal and intuitive data* (e.g. Perceptive Qualities, Project Cue), it is possible to classify and find all the LOs (Learning Objects) according to the principle described in the previous paragraphs (Figure 2). Moreover, to assure that the taxonomy is matching the real necessity of users, it is supported by a free tagging system that create a folksonomy. This folksonomy is periodically checked and a selection of terms becomes part of the official taxonomy.

Figure 2 The categories featured in the MACE taxonomy, grouped in five facets

Identification	Intervention type, Project type, Functional typology, Form typology
Context	Location, Geographic context, Urban context
Technical design	Materials, Construction form, Building element, Technological profile, Structure profile, Systems and equipment, Technical performance, Maintenance and conservation
Constructing	Construction management, Construction phase, Construction activity, Machinery and equipment
Theories and concepts	Styles, periods and trends, Theoretical concepts
Conceptual design	Project cues, Project actions, Form characteristics, Perceptive qualities, Relation with the context

Several experimentations to test the system and the related theories have been carried out in different university courses and several universities have been involved in the evaluation with significant student groups. The results have proved that using the MACE system and its features (like the semiotic-based taxonomy) significantly increases the student's performance.[9] Moreover, this performance has been evident in design courses that are marked by problem solving procedures and that are highly influenced by the creative interpretation of notions and information.
This example is focused on a specific scope but we believe that this approach can be applied to many other domains, applications and also to many other kinds of information that are related with the urban environment.

CITY MODEL AND CITY SENSING IN THE ICT

Nowadays, the actual amount of sensors and measuring systems of physical and environmental phenomena allows us to talk easily about *City Sensing*[10] as a widespread and pervasive approach to understanding the dynamics of the contemporary city. However, we must ask ourselves how useful a huge amount of data on some specific aspects of the city can be if we can't relate them to its shape and its topology, and if we can't virtually "try to change" its physical conformation before doing it in reality, with irreparable consequences. Nowadays, several technologies have been set up, so enabling us to do this. In fact, we can now digitally create various shapes of cities; sharing scenarios with thousands of people and finding those which best suit our vision. Bruce Sterling's work deals with the fascinating topic of 'Shaping Things' explaining how the shape that we can give to objects may influence and may be influenced by the way we interact with them; he wrote: 'sometimes I really want an object, the thing qua thing, the literal entity itself, physically there at hand. At many other times, many crucial times of serious decision, I'm much better served with a representation of that object'.[11]
Sterling's argument continues, within the same book, showing how sharing a detailed digital model of an object enables to stimulate creativity and interactivity of thousands of people who can fully explore the model and get to the definition of evolutionary hypotheses on the object in a cooperative manner. If we think about the long and laborious process that led ancient architects and artists to encode the result of their study with the explicit goal of storing knowledge, making it available to other scientists and researchers hence ensuring the hoarding of knowledge and the progress of science, nowadays we do have to consider the potentiality that the cooperative sharing of high-

9 Wolpers, M., Memmel, M., Giretti, A. (2009). Metadata in architecture education - First evaluation results of the MACE system. In: *Proceedings of the EC-TEL 2009 Fourth European Conference on technology Enhanced Learning*. (Nice).

10 Borga, G. (2011). City Sensing. Ph.D. thesis, Iuav University of Venice. Venezia.

11 Sterling, B. (2005). *Shaping Things*.. Cambridge, Massachusetts.

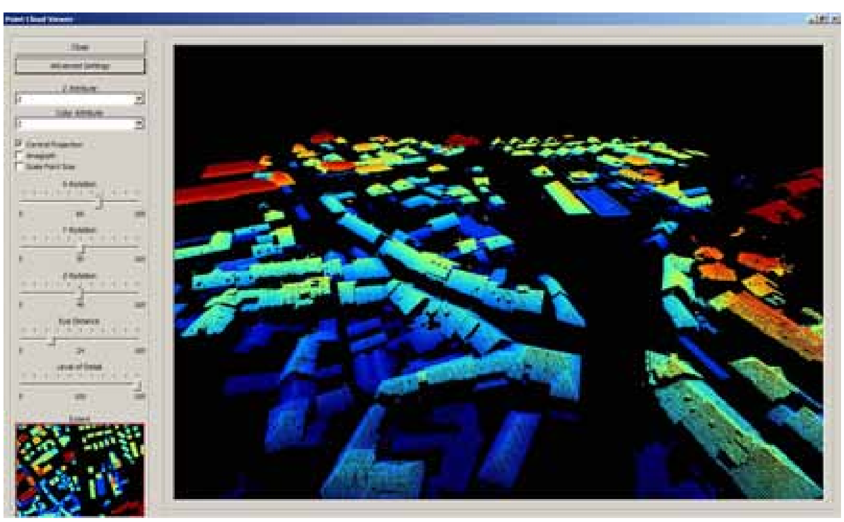
definition digital and interactive models of the city can have in the social networks and sensors era. *City Model* and *City Sensing* are two different approaches to the city knowledge. The first is based on the intensive data retrieving phases: high-density information with low temporal resolution. The second is based on heterogeneous integrated datasets that are continuously updated in time by both technological systems (sensors measure) and measurement campaigns, surveys, management and content-enriching processes that provide information on specific parts of the city.

A knowledge model embodying the *City Sensing* approach is based on layers of information with heterogeneous spatial and temporal resolution, whereas the *City Model* concept is based on homogeneous data covering the entire area that is considered; which is why it becomes natural to think about their integration to produce the most complete information framework of a city.

According to these purposes, the research group in “New Technologies and Information for the City, the Territory and the Environment” at the University Iuav of Venice and its spin-off Unisky[12] began to develop a pilot project in the area of the city of Feltre (a town within the Belluno province) called “City Sensing Feltre” and based on the integration of institutional databases, aerial surveys, satellite images and data streams from a multi-sensor smart boxes network. As an evolution of “City Sensing Feltre”, the research group also initiated an additional project on the same city called “Energy Web Feltre” based on the integrated *Sensing City - City Model* approach. The project aims at developing a high resolution model of the city obtained by centimeter-resolution aerial photography, LiDAR[13] measurements (see Figure 3), laser scanner ground shots (in Figure 4) and infrared photos that could be useful in developing actions and policies about energy efficiency in urban areas.

These activities are part of a broader and vast ongoing research that aims at integrating the two kinds of data typical of the *City Model* and of the *City Sensing*.

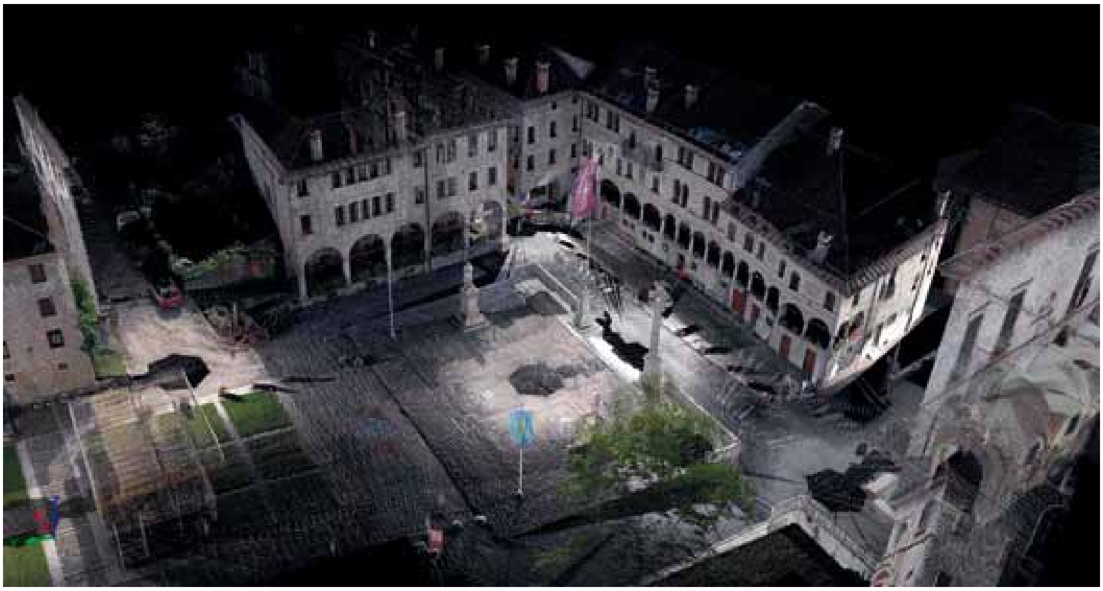
Figure 3 Model of a part of the city of Feltre (Belluno) derived from LiDAR data.



12 www.unisky.it

13 LiDAR (Light Detection And Ranging) is an optical remote-sensing technology that can measure the distance or other properties of a target by illuminating it, often using pulses from a laser. Its applications include: geomatics, archaeology, geology, geomorphology, seismology, forestry and remote sensing.

Figure 4 Example of City Model. This is an image derived from a 3D Model of Piazza Vittorio Emanuele, Feltre (Belluno).



SEMANTIC CITY MODEL / CITY SENSING

As Sterling pointed out, the online availability of a detailed and structured three-dimensional digital model of an object allows people to make many interpretations and characterizations of the object thanks to the various points of view and the technical and cultural distinctive features of the users. However, the large amount of additional information produced by the web community interaction is unlikely to bring significant advantages in knowledge settling without a specific system-add-on to combine “*Sensing*” in terms of “meaning” and “*Sensing*” in terms of “data-retrieving”. This logical “*Sensing-Sensing* combination” allows the full exploration of relations and links between all the features of an object described through the digital model (see Figure 5).

The semantic tagging currently appears to be one of the more efficient data-mining techniques due to the higher quality in the additional knowledge extracted correlating different datasets considering the same tagging work-unit. The “MACE” project is fundamentally based on these techniques, its main goal being to make the richness of relations between art and architectural contents or projects more evident and to support researchers in finding the most effective references for their activities. In “MACE”, users can add tags to different objects using a multiple taxonomic structure that can reflect interpretive approaches of different professionals and scientists; the taxonomy structure provides sets of tags, which can be related with digital documents and images of monuments or projects available in the MACE web database.

Both the *City Model/Sensing* and the MACE approaches can be effectively integrated aiming at producing an innovative system with new potential in information retrieving and sharing, alongside with knowledge management. The present limitation of knowledge management systems - even those as advanced as the MACE project, for example – is due to the database information type on which the user develops his interpretive process, because the MACE database only contains the media (text documents, images, videos, etc..). This limitation can now be easily overcome by integrating high-definition digital models with interactive tools and multimedia in a web-oriented application that greatly enhances object observation chances. Like the ancient “codex” used in the Renaissance to hand down knowledge and practices acquired through experience, it is now possible to explore cities in a virtual way (where the *City Model* works as the codex in which collet all the *sensing* data), to develop projects and formulate scenarios in a cooperative manner in which each new user adds information to all the knowledge already settled by a multitude of other users. Unlike what happened in ancient times, the study and interpretation of a monument is possible even though a direct contact with it is not available: it can be done using its digital model through an application in which all the knowledge inferred by a single user immediately becomes an asset for the global community.

Figure 5 Example of *City Model* integrated with the thermo camera "*sensing*" data. Piazza Vittorio Emanuele, Feltre (Belluno).

CONCLUSIONS

The examples illustrated and the exemplifications described so far have proved that we have the right technology to solve both sides of the problem that was raised in the introductory paragraph. We can improve digital archives related to architecture and urban environments with more features and, in particular, with the possibility to interpret information to increase their effectiveness around an object to allow a better interdisciplinary connection between contents.

It is therefore the right time to develop a new global digital "codex" for the modern city and its environmental, historical, cultural and social resources. It needs to be written according to Web 2.0 and the *creative taxonomy* philosophy upon the richest, most detailed and updated substrate of information ever seen. As we have explained, the components of this system are already available and so are all the procedures to get plenty of data. We need to launch a new step towards the integration of the actual application now operating in stand-alone mode with the World Wide Web potentialities. The idea is to foster the joint activity of institutional offices and authorities with web users towards the common goal of creating a new, strongly structured, semantically interconnected, shared and open-knowledge resource.

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