Typological-GIS as a conceptual integration between GIS and BIM.
First results on case study of Aversa

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Highlights

This paper highlights the role of building typologies as a tool for conceptual integration between GIS and BIM. In fact, this integration is difficult as GIS is focused on the representation of real buildings whereas BIM is focused on their design process. A Typological GIS - T-GIS - permits to compare the design choices, operated with BIM support, with the different typological solutions that during the centuries established the character of a specific built environment.

Abstract

This paper aims to explain the first results of a research on the application of T-GIS (Typological GIS) in the building regeneration design. T-GIS is conceived as an instrument allowing the user for a deep knowledge of built environment and so it could become an effective support in the complex building design process, also because it is potentially integrable with BIM. In fact, it might be the tool for conceptual integration between GIS and BIM. This article shows the first results of a complex and articulated work that is still in progress: the build of aT-GIS on the case study of a town called Aversa, North of Naples.

Keywords

GIS, BIM, Buildings typologies

1. INTRODUCTION

The building regeneration as been defined as the process giving physical design directions to conservation, change and sustainable growth. This definition includes the concepts of maintenance, re-use, sustainable transformation, urban “ecology” and is closely related to economic evaluations. Then, building regeneration is a complex process that requires a deep knowledge of the architectural object. The knowledge is one of the most delicate moments of the whole process as the correctness of the next design steps mostly depends on it. According to Grecchi and Malighetti [1] “per “oggetto” si intendono non solo le caratteristiche fisiche dell’edificio, ma tutta la complessità di aspetti che di volta in volta devono essere indagati per far proprie le conoscenze che riguardano la nascita, la crescita e lo sviluppo dell’edificato e del suo contesto” (as knowledge of architectural object means not only the
knowledge of physical characteristics of the building, but all the complexity of issues that, time after time, should be investigated to adopt knowledge on birth, growth and development of buildings and its context). The built environment is the humus in which the architectural organism was born and developed, representing the starting point for its knowledge. The knowledge of the built environment is important because it allows the correct assessment of the social, environmental and economic implications of a regeneration project. Generally, this work is very complex because there are many variables influencing the decisions and design choices. In this way, GIS (Geographic Information System) may have a significant role in the regeneration design. Indeed, GIS is a very powerful support tool for in decision-making, involving the integration of spatially referenced data in a problem-solving environment. A GIS is usually used as a support for urban design and not for regeneration design at building scale; therefore traditional urban GIS contains referenced data about urban infrastructures (streets, sewers, schools, public buildings etc.) but it contains no information about buildings (maintenance state, technologies, typologies etc.). In literature, it is possible to find many papers explaining the role of building typologies in the urban regeneration process, mainly in the field of energy consumption reduction. A number of papers on the possible applications of BIM (Building Information Modelling) are also available, but only a few among them show the interaction between GIS and BIM at building scale, mainly on the role of GIS in the management of logistic issues related to building process. There is not a significant literature on the role of GIS in the building design process. The decision to develop a GIS finalized to support the design process of buildings came up by observing that the latter is highly conditioned by physic and cultural background of the built environment in which it is located. The major tool enabling the management of the background is the building typology. In fact, according to Muratori’s vision, the typological invariants are the summary of all the physical and immaterial characteristics that set the character of buildings and cities. Therefore, to manage correctly the regeneration process from urban to building scale, the knowledge of the typological invariants and their frame is needed. Traditionally, the investigation on typological aspects is limited to one building or, at most, to one neighbourhood. GIS offers the possibility to study typological aspects of each building without neglecting the typological complexity of a historically stratified city. Moreover, GIS can be integrated to BIM, so that the design process results to be simplified since BIM permits an interdisciplinary interaction, during the design process, between different professionalisms and, at the same time, GIS allows to compare the design
choices to the different existing typological solutions. This paper aims to show the first results of the integration of a traditional urban GIS with geo-referenced data of single buildings. The small town of Aversa, north of Naples, was chosen as a case study. Data processing is ongoing.

2. STATE OF THE ART

In the end of XX Century the use of GIS spread, first in urban planning and later in urban design [2]. In that time, the research was oriented towards the creation of digital 3-D models of cities, frequently realized by using CAD software and only rarely based on GIS. For example, the UCLA group [3] used a GIS in a 3-D modelling environment. In the first decade of XXI Century, the potentialities of GIS determined its increasing usage as a support tool in decision making for urban design and the possibility of using GIS as support also for conservation of built heritage started to be investigated. In this phase, the efforts were addressed to the study of the interaction between natural and built environment, in particular the relationship between natural hazard and structural safety. Among the First contributions to this research line, there is the study by Lazzari et al. [4], who worked on the building heritage of Rabatana, a medieval village in Basilicata, characterized by a valuable vernacular constructive culture, and the work of Fuentes [5], who proposed the use of GIS as a support to carry out a respectful conversion of traditional European farms. This latter Author stated that the knowledge is the base of every correct regeneration building design and that the complexity of built environment needs the support of GIS to have a respectful, collaborative and shared conversion to new use of vernacular buildings. This approach may be called “typological” (T-GIS). While for heritage, a typological approach is used and the GIS is intended as a support to architectural project, in cities the search is mainly addressed to energy consumption reduction. However, also in this second case, studies show the role of GIS as a support for the connection between different work scales, since it is impossible to design a sustainable building out of a sustainable built environment [6]. In this view, papers of many other authors are noteworthy [7, 8, 9, 10]. A recent work [11] shows the role and relationship between building typologies and urban space, demonstrating how the GIS can be considered as the simplest and most efficient tool to manage the complexity of built environment and to interpret the modifications produced by regeneration design at urban and architectural scale. In the past two decades a “collaborative GIS” has been developed, intended as collaborative design at urban and architectural scale.
A real-time C-GIS system provides a multi-user, real-time collaborative work environment [12]. In addition, BIM, the prince tool of buildings design process, permits an interdisciplinary interaction among different professionals during the design process [13] but it lacks of georeferentiation. Recently, some researchers experienced methods to automatically transform the geometric and semantic information from a BIM (Building Information Modelling) model to a geo-referenced one [14]. In fact, methods allowing GIS and BIM to communicate together are still being searched, as explained by Liu et al. [15], because such a tool is potentially applicable in many building fields such as cadastre, asset management, heritage management, site selection and layout plane, urban environment analysis, safety and more. However, the integration between BIM and GIS presents some difficulties since the two systems “interpret 3D modelling from two different perspectives: GIS focus on real world modelling, while BIM is more focused on design process”. Therefore, the same information is treated differently by BIM and GIS [16].

GIS normally has a geographical approach to the knowledge of building shape and components, while, BIM interprets the buildings from an architectural and constructive perspective, focusing on the details, building components and project information [17]. The integration attempts are focused on the informatics and semantic integration of data but a true conceptual integration is still missing [15]. The conceptual integration takes into account the different roles held by GIS and BIM in the building design process. BIM manages the project of one building (or a group of buildings) which will be part of the city, comparing his identity to the one of the city, and maybe in opposition to it. GIS should provide data to understand better the identity of city, its character. In fact, the design process of buildings is highly conditioned by physic and cultural background of the existing built environment. It is therefore possible that with BIM, the various professionals are properly connected and, at the same time, with GIS, it is possible to guarantee a building project consistent with the city in which it is placed, respecting its character and improving the quality of life of its citizens. To obtain this result, the knowledge of the elements characterizing the city is needed. The character represents “how” things are in place so, to understand the specific character of one city, it is necessary to know how the constructive elements are assembled together in that specific context. In fact, the constructive elements that architects can use are relatively few but, with those, it is possible to create infinite different buildings, giving many different characters to the city. The actual danger is to build up the city as a jumble of buildings that do not speak the same language: many monads without any unifying character, as in suburbia of contemporary

alla riduzione dei consumi energetici. Anche in questi casi tuttavia gli studi dimostrano il ruolo del GIS come supporto di collegamento tra le diverse scale; non è, infatti, possibile pensare di costruire un edificio sostenibile, a prescindere da un ambiente costruito sostenibile [6]. In tal senso vi sono numerosi lavori che ne evidenziano come il GIS sia lo strumento più semplice e efficiente per gestire la complexità dell'ambiente costruito. Inoltre, su una base di ricerca, la riduzione dei consumi energetici e la riduzione dei consumi energetici. Anche in questi casi tuttavia gli studi dimostrano il ruolo del GIS come supporto di collegamento tra le diverse scale; non è, infatti, possibile pensare di costruire un edificio sostenibile, a prescindere da un ambiente costruito sostenibile [6]. In tal senso vi sono numerosi lavori che ne evidenziano come il GIS sia lo strumento più semplice e efficiente per gestire la complexità dell'ambiente costruito. Inoltre, su una base di ricerca, la riduzione dei consumi energetici e la riduzione dei consumi energetici. Anche in questi casi tuttavia gli studi dimostrano il ruolo del GIS come supporto di collegamento tra le diverse scale; non è, infatti, possibile pensare di costruire un edificio sostenibile, a prescindere da un ambiente costruito sostenibile [6]. In tal senso vi sono numerosi lavori che ne evidenziano come il GIS sia lo strumento più semplice e efficiente per gestire la complexità dell'ambiente costruito. Inoltre, su una base di ricerca, la riduzione dei consumi energetici e la riduzione dei consumi energetici. Anche in questi casi tuttavia gli studi dimostrano il ruolo del GIS come supporto di collegamento tra le diverse scale; non è, infatti, possibile pensare di costruire un edificio sostenibile, a prescindere da un ambiente costruito sostenibile [6]. In tal senso vi sono numerosi lavori che ne evidenziano come il GIS sia lo strumento più semplice e efficiente per gestire la complexità dell'ambiente costruito. Inoltre, su una base di ricerca, la riduzione dei consumi energetici e la riduzione dei consumi energetici. Anche in questi casi tuttavia gli studi dimostrano il ruolo del GIS come supporto di collegamento tra le diverse scale; non è, infatti, possibile pensare di costruire un edificio sostenibile, a prescindere da un ambiente costruito sostenibile [6]. In tal senso vi sono numerosi lavori che ne evidenziano come il GIS sia lo strumento più semplice e efficiente per gestire la complexità dell'ambiente costruito. Inoltre, su una base di ricerca, la riduzione dei consumi energetici e la riduzione dei consumi energetici. Anche in questi casi tuttavia gli studi dimostrano il ruolo del GIS come supporto di collegamento tra le diverse scale; non è, infatti, possibile pensare di costruire un edificio sostenibile, a prescindere da un ambiente costruito sostenibile [6]. In tal senso vi sono numerosi lavori che ne evidenziano come il GIS sia lo strumento più semplice e efficiente per gestire la complexità dell'ambiente costruito. Inoltre, su una base di ricerca, la riduzione dei consumi energetici e la riduzione dei consumi energetici. Anche in questi casi tuttavia gli studi dimostrano il ruolo del GIS come supporto di collegamento tra le diverse scale; non è, infatti, possibile pensare di costruire un edificio sostenibile, a prescindere da un ambiente costruito sostenibile [6]. In tal senso vi sono numerosi lavori che ne evidenziano come il GIS sia lo strumento più semplice e efficiente per gestire la complexità dell'ambiente costruito. Inoltre, su una base di ricerca, la riduzione dei consumi energetici e la riduzione dei consumi energetici. Anche in questi casi tuttavia gli studi dimostrano il ruolo del GIS come supporto di collegamento tra le diverse scale; non è, infatti, possibile pensare di costruire un edificio sostenibile, a prescindere da un ambiente costruito sostenibile [6]. In tal senso vi sono numerosi lavori che ne evidenziano come il GIS sia lo strumento più semplice e efficiente per gestire la complexità dell'ambiente costruito. Inoltre, su una base di ricerca, la riduzione dei consumi energetici e la riduzione dei consumi energetici. Anche in questi casi tuttavia gli studi dimostrano il ruolo del GIS come supporto di collegamento tra le diverse scale; non è, infatti, possibile pensare di costruire un edificio sostenibile, a prescindere da un ambiente costruito sostenibile [6]. In tal senso vi sono numerosi lavori che ne evidenziano come il GIS sia lo strumento più semplice e efficiente per gestire la complexità dell'ambiente costruito. Inoltre, su una base di ricerca, la riduzione dei consumi energetici e la riduzione dei consumi energetici. Anche in questi caso...
cities. Conversely, traditional cities are formed, by many individualities, even very different from each other, but unified together by a unique cultural matrix. To understand better this matrix, it is important to know the character of the city, according to Muratori’s opinion, identifying the typological invariants is the simplest way to identify the character of a city because the typological invariants just explain it [19].

3. METHODOLOGY

The research was structured in different phases. In the first phase, the study area was selected. The study area is a town characterized by a noticeable stratification during different historical ages, with different typological and technological solutions. After that, one single age was chosen as a reference. This because the typological invariants depend on the physical environment (the city) but also on the cultural environment (the historical period).

In the second phase a preliminary study, aimed to the collection of geographical, historical and socio-economic data on the study area, was conducted. The materials, closely linked to local natural resources, technologies and typologies used in the area during the reference age were also included in the study. These specific data have been acquired through literature and archive documents.

The third phase involved the creation of an inventory of buildings constructed in the reference age. This catalogue was created by filling in some recognition
sheets, integrating literature data and aerophotogrammetric surveys. A different identification code (ID) was assigned to each building. This phase is long and complex, but essential for documentary data validation.

The fourth step concerned the typological classification: each existing building type was identified and the typological classes of constructive elements were selected. Finally, relational database tables were designed, based on the data acquired during field surveys, and dictionaries of the database were also processed to describe the form of all the data that were input in the database, taking into account the possible values of all the variables. A basic characteristic, common to all the tables, is a box recording the ID codes, in order to establish a primary connection between the various tables and the spatial data. Once these five phases will be over, the database will be complete and it will be possible to launch the analysis phase. Analysis will allow extrapolating the typological aspects of built environment to read the character of the city and draw the urban code. The latter is the actual instrument for a buildings design environmentally respectful and it is the real interconnection element between the different scales of urban regeneration design.

4. RESULTS

At the moment, the work is in between second and fourth steps and data are still being processed. In fact this three steps need to be carried out at the same time. During the last 18 months, accordingly to the methodology, the research group developed the work as follows. Aversa has been selected as study area because of its small dimensions and historical richness. The city is characterized by a stratification of different historical periods with different typological and technological solutions. The biggest urban development has been registered during the XX Century that was then chosen as reference age (Fig. 1).

It was then conducted a preliminary study aimed to collecting geographical, historic and socio-economic data on the study area. The base map used was an aerophotogrammetry, in .dxf vector format and in 1:5000 scale, obtained from the Aversa City Hall. In the present case study, the spatial data are presented as lines (road network) and as polygon entities (building blocks). Spatial data (attributes) also coexist and are usually characteristics of spatial data, defining the type. Data about the materials used in the area during the 1900’s were acquired by literature searching and archive documents. The third phase involved the creation of an inventory of buildings built during the XX Century (Fig. 2). During the fourth step, each existing building type was identified and the typological classes of constructive elements were selected. So far,
about 1500 buildings have been identified. Relational database tables will be designed based on the data acquired during field surveys, and dictionaries of the database will be created describing the shape of all the data that will put in the database, taking into account the possible values of all the variables. The work is not complete yet and the addition of referenced information at architectural scale is still in progress.

5. CONCLUSIONS

The results obtained so far are encouraging because they demonstrate that the construction of a T-GIS is feasible and it might be an important tool for building regeneration projects. The proposed work is still in progress because, as explained in the previous sections, the construction of T-GIS, that includes georeferenced typological information on the built environment at different scales (from urban to details) is complex and time consuming.

Figure 2. Example of detection tab.
Nevertheless, the groundwork has been laid and the research is at moment focused on the identification of the topological data - related to the mutual relationships between objects at different scales - that will allow analysis aimed at buildings regeneration and connecting BIM and GIS. A future development may concerns the creation of data acquisition automats between GIS and BIM.

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7. REFERENCES


