Subjectivity and Objectivity in Urban Knowledge Representation

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Abstract: The question of subjectivity and objectivity of information is an important open issue in the knowledge engineering research community. In the context of space representation, they have been traditionally considered competing themes in the study of places, particularly in urban ones. This is highlighted by the distance, in terms of cultural training and operational approach, between the professionals of the city: urban planners and urban anthropologists. The growth in modeling capabilities allows a quantitative study of a city but information about the meanings of space elements are often not taken into account. Starting from this basic assumption, our paper aim is to give a novel point of view to integrate subjectivity and objectivity in an operational model. Space Syntax, as a theory and a methodology, is used as a tool to study the objectivity of the urban space. Ontologies, as an approach and a method to formally represent knowledge, is used to provide Space Syntax with the subjectivity of the same spaces.

1 INTRODUCTION

In the era of big data, the use of formal models and techniques is a necessary task to represent and manage large amount of information. In the context of spatial information this is a hard issue due to the continuum nature of this kind of data. Our interest is focused on cities, as complex entities. In fact, they seem to challenge descriptions, so that they can hardly be defined and treated in disciplinarily terms. Planners and urban designers have always tried to use simplified concepts and notions, thus emphasizing hierarchies, regular geometries and the separation of parts from wholes. In this broad framework, one approach that is increasingly engaging scholars and practitioners rethinks the way we can look at the city and its problems and potential; another approach that starts from space and urban life at the same time, hence grasping the two dimensions of a place: cognitive and geographic. The city is considered as an uniform fact. For this purpose we need to imagine cities as complex system consisting of many variables that interact with each other, assuming the space as a primary element in such dynamics rather than the mere and inactive background of social and economic phenomena. Configurational approach provides a concise and effective overview on how a city *operates*, but it is unable to render a formal representation of the meaning of urban elements In the recent years, several approaches have been proposed to represent knowledge. Some of them, based on ontologies, aim at deleting, or at least smoothing conceptual or terminological mess and actually provide a common view of the same information. The ontological aspects of information are intrinsically independent from information representation, so that information itself may be isolated, recovered, organized and integrated with respect to its contents (Rinaldi, 2008). The traditional approaches to configurational analysis are based on the idea that it is how things are put together that matters (Hillier, B., 1996). From this point of view, the semantic of built environment is completely neglected.

In this paper we introduce a new informative layer based on a formal description of the elements spread throughout the city. We propose a conceptual position, and its capability to be used in an operationalized

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model in order to integrate space syntax and space semantic.

2 THEORY AND TOOL TO CITY INVESTIGATION

Configurational analysis was pioneered as a general attempt to relate urban physical dynamics and social process. Its genesis was in the 1960's urban revolution, as a way to dominate the contradiction between the impressive architectures that were flourishing and the un-urban nature of their spaces. Among different theoretical specifications and operative techniques, the most important configurational approach is known as Space Syntax. As a theory and methodology, it is widely applied and appreciated for its capability of extracting cognitive data and information out of the spatial layout of urban settlements.

Space Syntax indicates an objective way to investigate and define the relationships between the physical structure of man-made environments and social structures or phenomena (Hillier, B. and Hanson, J., 1984). Space syntax theorises that certain configurational measures of centrality in graphs express a potential to embody or transmit social ideas, and then pushes this potential to spatial structures, by geographically linking the graph to the space. Many years of research have highlighted that centrality is related to several aspects in human interaction (Freeman, 1978). There are three main distinct intuitive conceptions of point centrality, and many measures for each of them. The simplest and perhaps the most intuitively conception is that centrality is function of the degree of a point on the net, that is the number of connections a node has to other nodes. It is generally known as *Degree Centrality*. Another simple idea is that the independence of a point is determined by its closeness to all other points in the graph: the *Closeness Centrality*. Another view of point centrality is based upon the frequency with which a point falls between pairs of other points on the topological geodesic paths connecting them, in the idea that it has a potential to control their communication: the *Betweenness Centrality*. Space Syntax is mainly pivoted on closeness centrality, in terms of *Integration Index*. It shows the cognitive complexity of reaching a street, and is often argued to predict the pedestrian use of a street: the easier it is to reach a street, the more popular it should be. Very interesting and distinctive is also the way Space Syntax performs the network making process. It is based upon the reduction of the city to the set of maximum size convex spaces in which the urban public space is divisible. On this map, known as the *convex map*, the minimal set of lines crossing the convex spaces that oversee them all is drawn, getting the *axial map*. It is an inversion of the urban graph: axial lines represent the nodes of the graph, while their intersections are the edges. On this net centrality measures could be performed. To associate their meaning to the real urban space, it is therefore necessary to take the opposite road. This method is known as dual or indirect approach. Several different operational techniques have been so far developed, all sharing the base assumption that it is the urban space, according to the way it results from the arrangement and alignment of blocks and buildings, what primarily involves the precondition for its use, thus strongly influencing the whole inner geography of the settlement. On this basis, such approach allows drawing out of the grid configuration specific parameters, which were proved suitable for reproducing a wide range of urban aspects. Besides its effectiveness as a knowledge extraction tool, this capability also makes configurational analysis suitable for supporting town planning, in that it allows simulating and predicting the effects of any planned transformation of the physical consistency of the grid. Since it appears confronting the traditional territorial modelling, based on a strictly interactional approach, it is no wonder that the introduction of a configurational point of view was received as somehow heretical and likely to raise discords and criticisms, which have nourished strong debate and lengthy discussions.

Far from increasing such debate, the explanatory limits and the practical utility of such a successful (and widely misinterpreted) approach appear worth highlighting. To this aim, we will try to define it by subtracting; namely what it's not. We daresay that Space Syntax is not a whole theory of the city in itself. Such a theory, in fact, should be able to grasp the essence of city as a whole, thus encompassing any functional and aesthetic aspect, so as to account for forms and reasons of urban genesis and development; what space syntax, actually a "theory of society and space" (Hillier and Netto, 2001), cannot really achieve. Moreover, Space Syntax does require some specific theoretical position on city's status to be explained and properly used: the expression of a set of social relations forming part of a wider phenomenon or structure. This assumption *de facto* creates the extent of Space Syntax boundary, re-defining the concept of space, the way it is inserted in the process of urban transformation and the way the latter is accounted: through a *non-discursive* approach. Nevertheless, space syntax is not even a mathematical theory of the urban space. It uses mathematic (and its graph theory elements) to explore the physical space

due to the admission that we are “extremely good at using relational systems [...], but rather bad at knowing how to talk about them” (Hillier, B. and Hanson, J., 1984). Much more properly than a theory in itself, space syntax can so be regarded as a theoretical approach and a robust operational technique based on the assumption that the grid of urban paths is the active mechanism where social relations occur, suitable for investigating and supporting the understanding of the *social logic* of the city as a cultural product.

On such basis, several different operational techniques have been so far introduced, so as to shape the configurational approach as a widely ramified tree. In order to contribute to the development of this approach, three directions are actually feasible. The first is to concur in increasing the height of the tree, refining the operational tools and making them more powerful and friendly. The second is to widen the crown of the tree so as to eneble it cover and loom up more and more territorial issues and increase its diffusion. The third is to try strengthening its roots by working on conceptual issues, aiming at clarifying and then expanding the epistemological and operative boundary of the discipline. This latter purpose will be discussed, in the conviction that the future sustainability of the approach could benefit from the overcoming of the logic of *wonderful isolation* that has gone characterizing space syntax, mainly due to the fuzziness of its foundations.

The main aim of this paper is to explore the possibility of integrating space syntax with tools capable of returning the semantic aspects of urban space; with the idea that a heuristic model, as space syntax is, would greatly benefit from the direct access to the semantic information asset of the same space it does syntactically analyze. The access to the semantic information layer is, however, complex in itself in that it needs to seize them by means a generalization process of the locally acquired knowledge (through the individual spatial experience). Our idea is based on two essential cornerstones: the role of local communities in shaping, and then meaning ascribing, the urban space, and the representation objectivity such meanings must be provided with. The first one is a conceptual issue ascribable to the scope of townscape. As a fundamental concept in our proposition, it will be discussed in the following paragraph. The second one concerns the way we intend to acquire any semantic information. This will be done to turn the concept of ontology.

3 THE ROLE OF SUBJECTIVITY IN TOWNSCAPE GENERATION

In this section we stress the notion of urban landscape known as perceived space. We highlight the role of community in urban making and the necessity of describing this cultural process by means of a set of measures on city-networks (Space Syntax). “Landscape means an area, as perceived by people, [...]”(Europe, 2000): the European Landscape Convention defines landscape stressing the basic role of community perception of the surrounding environment. Moreover, many recent studies try to define the quality of landscape paying specific attention to the role it plays in the whole well-being of people, as related with physiological and cognitive elements (Velarde et al., 2007).

When we consider urban landscape, the question of perception becomes highly complex due to the several involved components, which arouse different perceptive reactions. Following the Bourassa’s schema (1990), the types of response to external perception can be summarized into three categories: instinctive, emotional and intellectual. This issue suggests that when it comes to investigating on the concept of perception, different types of reaction arise in the community related to aesthetics, emotional components and cultural factors. Humans tend to prefer landscapes whose characteristics are easily interpretable. The visual preferences are the result of emotional perception given by the ease of retrieving information about the surrounding environment.

From this prospective, the costruction of a formal knowledge structure to represent landscape elements is a mandatory task. In the process of landscape understanding, we can identify two main tasks at a cognitive level: assigning meanings to landscape elements (making sense) to *predict* (no surprise) what might happen (Kaplan, 1995); feeling attracted and involved (involvement) to feel a sense of challenge. The community has a crucial role in the way we relate to landscape. People try to give a meaning to every element to easily structure the knowledge of what is visually perceived. At the same time, people feel a great sense of attraction due to the complexity derived from the variety and heterogeneity of the elements that are part of the territory. Referring to the theory of Ulrich (1984), the visual preferences follow a parabolic trend: they increase as the number of elements, but until the complexity does not reach too high values.

Moreover, when people go into the space, they have a 3-dimensional perception of it: the capability to give a meaning is provided by the readableness while the feeling of being attracted shall be gen-

erated by the *mystery*. A scene could be accounted as readable if it has a homogeneous allocation of elements that could be mapped (landmarks) as interpreted. In which case, the scene can be interiorised and explored. The mystery is driven both by the exploratory sense (novelty) and by what we sense might be seen. We can so argue that visual perception has a key-role in this process. As already pointed out, the community perception of the urban environment stems not only from reading (more or less easily) the elements it is composed of, but induces a mechanism of affective interpretation. The affective perception descends from processes of education, socialization and acculturation, which deeply influence human behavior. Perception is screened by personal experience, age, culture, and so on, leading to non-unique answers on the same visual stimuli. The affective perception combines to bring about the sense of belonging to a territory. Landscape is relished if it is composed of coherent and effective elements (Coeterier, 1996): the being of a singularity (e.g. a historic building) is not enough to make a landscape charming, its harmony within the neighbourhood is the key.

The knowledge everyone gathers in life furthermore influences the relationship between human and environment, and the landscape perception in itself. The landscape components assume a local sense due to their relation to the human educational process. Landscape has become an essential tool to the characterization of community members due to its cultural leading. The human perception of the anthropic environment (signally the urban one) arises as a relation of a large set of different reading and interpretation forms strictly tied to the hosting community and the cultural changes in time. The mutation in urban environment could be seen as a key-process into the identity affirmation of social groups. A city, as an anthropic landscape, has elements in itself contributing to support the social and cultural cohesion of the community that made them.

4 A CONCEPTUAL APPROACH TO CITY REPRESENTATION

Once it is acknowledged that the process of understanding the space is a priority and a prerequisite for the determination of actions for its management, we need to identify the homogeneous territorial contexts that contain highly related and characterizing factors. Therefore, the process of knowledge acquisition about a territory starts from the recognition of its elements and from their interpretation depending on their context.

Starting form these considerations, we must try to resolve conceptual misunderstandings and semantic ambiguities and also generate a precise and accurate description of our knowledge. In this context, the definition of a common and shared ”language” is the first step in a knowledge formalization about the urban space. From our point of view, ontologies are an efficient and effective tool to address this issue. In the last years ontologies have been studied in the context of spatial knowledge and they have been used in different domains to represent spatial properties, data interoperability or relations among different data sources (Bateman and Farrar, 2004; Janowicz et al., 2013). In the authors' opinion, any landscape has a cultural meaning since it represents the main product of a community in time. We use ontologies to represent this kind of knowledge shared in a community and to give a formalization of all the elements spread throughout the city.

Our approach starts from the *modeling view* of knowledge acquisition (Clancey, 1993), where the modeling activity must establish a correspondence between a knowledge base and two separate subsystems: the agent's behavior (i.e., the problem-solving expertise) and its own environment (the problem domain). This vision is in contrast with the *transfer view*, wherein a knowledge base is a repository of knowledge extracted from one expert's mind. Using the modeling view approach, knowledge is much more related to the classical notion of truth as correspondence to the real world, and it is less dependent on the particular way an intelligent agent pursues its goals. Although knowledge representation is a basic step in the whole process of knowledge engineering, a part of the AI research community seems to have been much more interested in the nature of reasoning than in the nature of “real world” representation. The dichotomy between reasoning and representation is comparable with the philosophical distinction between epistemology and ontology, and this distinction is important to better understand our aim and approach. Epistemology can be defined as “the field of philosophy which deals with the nature and sources of knowledge” (Nutter, 1998). The usual logicistic interpretation is that knowledge consists of propositions whose formal structure is the source of new knowledge. The inferential aspect seems to be essential to epistemology: the study of the “nature” of knowledge is limited to its superficial meaning (i.e., the form), since it is mainly motivated by the study of the inference process. Ontology, on the other hand, can be seen as the study of the organization and the nature of the world independent of the form of our knowledge about it.

A formal definition of ontology as highlighted in (Gruber, 1993) is *"a formal and explicit specification of a shared conceptualization"*; *conceptualization* refers to an abstract model of a specific reality in which the component concepts are identified; *explicit* means that the type of the used concepts and the constraints on them are well defined; *formal* refers to the ontology propriety of being "machine-readable"; *shared* refers to the fact that an ontology captures the consensual knowledge, accepted by a group of persons. We also consider other definitions of ontology (Neches et al., 1991). This definition indicates the way to proceed in order to construct an ontology: i) identification of the basic terms and their relations; ii) agreeing on the rules to arrange them; iii) definition of terms and relations between concepts. From this perspective, an ontology includes not only the terms that are explicitly defined in it, but also those one that can be derived using defined rules and properties. Thus an ontology can be seen as a set of "terms" and "relations" among them, denoting the concepts that are used in a specific domain.

In the context of spatial information, we should stress that urban reading and interpretation lead to three basic questions. The first question refers to the territorial context: the discussion of city has an ontological nature and refers to several signifiers. The second question has a semiotic nature: the discussion of city is based on the representation of a territorial context (the real world) that consists of signs. The last and surely most theoretical question is epistemological and refers to meanings (concepts). From a strictly operational view, these three questions reflect many procedures. All general territorial sciences start with the generation of a model of reality to evaluate the meaning given to things, then conclude with an intervention in the reality itself. Signs, meanings, and signifiers are the triad upon which the representation sciences are based, and these ideas are tightly connected with each other. A sign produces models of intervention; targets and values followed by a planner affect and boost the building of meanings; meanings determine the criteria and modalities of intervention, which will affect reality and will change it; changing the reality changes the meanings; different meanings imply different signs, which produce new representations of reality. Thus, to interpret or define a landscape is to translate and simplify the complexity of space into decoded signs, meanings, and signifiers. Giving a meaning to an object (signifier) is not an easy action. The meanings include two concepts suggested in (Eco, 1968): a denotative element and a connotative element. To denote an object means to infer the function (meaning) of said object (signifier); we have an immediate communication because the denotative meaning does not lead to ideologies or meta-discussions. In contrast, the meaning has a connotative function when it expresses an ideology in a potentially implicit or hidden way. It is the meanings that refers to symbols, values, cultural products, and intangible culture. Finally, we can assess the idea that through forms it is possible to recognize the story of objects, the things that remain from past societies. Any object of a city, once recognized, gains the status of a sign, and so the need to be interpreted. This interpretation should not be limited only to recognizing single elements (through decomposing praxis), but instead should refer to the context to which the signs belong (relationship with the whole) or the ways in which they have meaning and functionality.

Moreover, we are are interested also in the formalization of the concept of relevance information. We can divide relevance into two main classes (Harter, 1992; Swanson, 1986) called *objective* (system-based) and *subjective* (human (user)-based) relevance, respectively. Objective relevance can be viewed as a topicality measure, i.e. a direct match of the topic of the retrieved document and the one defined by the query. Several studies on human relevance show that many other criteria are involved in the evaluation of relevance (Barry, 1998; Park, 1993; Vakkari and Hakala, 2000). In particular subjective relevance refers to the intellectual interpretations carried out by users and it is related to the concepts of *aboutness* and *appropriateness* of retrieved information. In addition, according to (Saracevic, 1996), five types of relevance exist: an *algorithmic relevance* between the query and the set of retrieved information objects; a *topicality-like type*, associated with the concept of aboutness; *cognitive relevance*, related to the user information need; *situational relevance*, depending on the task interpretation; and *motivational* and *affective relevance*, which is goal-oriented. The different aspects of relevance can help in the definition of a whole characterization of urban environment.

All these considerations can be summarized using a formalization of objective knowledge expressed by spatial syntax and a subjective knowledge represented with ontologies. The ontology concepts arise from the knowledge shared in a community. Considering the configurational indexes as previously described, and leaning them to a specific geographic location (i.e. a location on the network), the same will take on a local significance. In such a case, the term "local" means "in relation to a specific context". Otherwise, in configurational analysis, the same term "local" refers to a method of index calculation. Specifically, it means to reduce the analysis radius to a limited number of

topological steps or to a predetermined metric neighborhood, in order to explore the city at different scale levels (Hillier, 2009). On this assumption, considering the existence of a local urban element, formally described by an ontological model (e.g. (Cataldo and Rinaldi, 2010)), we can define the Configurational Ontology as:

$$CO = O(C^d, C^c, C^b) \quad (1)$$

Where O is the ontology as represented in our model, and C^x are the following network point centrality measures (Freeman, 1978):

$$C^d = \sum_{i=1}^{n} a(p_i, p_k); \qquad C^c = \frac{n-1}{\sum_{i=1}^{n} d(p_i, p_k)}; \qquad C^b = \sum_{i=1}^{n} \sum_{j>i}^{n} \left(\frac{g_{ij}(p_k)}{g_{ij}}\right)$$

where:

$$a(p_i, p_k) = \begin{cases} 1, & \text{if } p_i \text{ and} p_k \text{ are connected by a line} \\ 0, & \text{otherwise} \end{cases}$$

$d(p_i, p_k)$ = the number of edges in the geodesic linkingp_i and p_k

g_{ij} = the number of geodesics linking p_i andp_k

$g_{ij}(p_k)$ = the number of geodesics linking p_i andp_k that contain p_k

The above configurational indexes $C^x$are the topological attributes of the novel Configurational Ontology.

Unlike the others, our approach uses a combination of centrality measures quantitatively influenced by the meaning of urban elements, understood as "events" on the city network. In our ontology of the city, in fact, each of the above events has a numerical attribute directly related to the people flows which generates its own. This allow us to make the urban elements an endogenous part of the city model.

5 CONCLUSION

The proposed paper has investigated some issues related to the understanding of urban space following an ontology-based approach. This process, like all those based on cognitive mechanisms, is strongly affected by the local nature of knowledge: the subjectivity. Studies conducted in cognitive field return a complex fuzzy frame related to the difficulty of dealing with the issue of subjectivity in a quantitative way. On the other hand, studies dealing with the space in a purely quantitative way, proposing to derive the subjectivity through the post-processing of numerical data, are promising, but present several shortfall in some previous highlighted points. In our vision a possible solution is based on the concept of ontology used to give a formal and common structure to express the semantic complexity of the space. We consider both objective aspects of urban space using an algorithmic approach and subjective issues related to the perception of communities which change the city, recurring to the formalism of ontology. We give an integrated representation of urban elements both from a conceptual and topological point of view using ontologies and a configurational analysis tool (i.e. Space Syntax). Combining these information we propose a preliminary formal description of knowledge about a city by means of a Configurational Ontology.

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