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REPRESENTING THE SOCIAL CHARACTER OF PLACES: ONTOLOGY MODELS OF THE URBAN ENVIRONMENT

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Chapter 1

Introduction

This thesis contributes to the definition of an ontology of the urban environment for supporting the development of place-based information systems. Place-based information, differently from space-based information, concerns people and their interaction with geographic space. Therefore, the ontology we propose describes human-made geographical objects and their social roles, the latter determined by people's behaviour in using those objects in their everyday life. In the following we present the background of the work (Section 1.1), and the methodology applied (Section 1.2). This chapter also describes the urgency of a more human-centric and *socially-aware* representation of the urban environment, which constitutes the ultimate motivation of the thesis (Section 1.3). Finally, the research questions are listed specifying the Chapter where they will be addressed (Section 1.4) and the structure of the thesis is illustrated (Section 1.5).

1.1 Background

This work is highly interdisciplinary. It ties together notions spanning computer science, in particular the field of ontology engineering, human geography, as well as sociology, employing the theory of social practice. It prioritizes the need to recognize, by the means of an ontology representation, the social character of urban places through modelling the architectural aspects of the city, its *form*, and the behaviour of city dwellers, the *experience*.

It is possible to specifically frame the thesis as intersecting two fields of study: the relatively new research area of Urban Informatics (Foth et al., 2011; Williams et al., 2009; Burrows and Beer, 2013) and the field of ontology engineering concerning the representation of place.

Urban Informatics crosses several disciplines, from urban geography to computer science and urban planning, in its aim of understanding and interpreting the city as *an ecology that consists of technological, social, and architectural layers* (Foth et al., 2011). Within the last decade, attention and interest towards the area of Urban Informatics have increased in parallel with some criticism raised against the smart city paradigm (Foth, 2017). The *Smart cities* approach has been accused, particularly by scholars in urban studies (Kitchin et al., 2017; Vanolo, 2014), of being excessively technology-driver rather than human-centric. On the contrary, the Urban Informatics area of research is generally interested in people, city and technology. It acknowledges the urgency of recognizing people's role in the production of a human-centric representation of the city. To refine the subject of Urban Informatics, Williams et al. (2009) proposes to focus on *situated urbanism*, which is the everyday life of city dwellers, to capture knowledge about the ways people experience the city. This thesis wishes to contribute to the field of Urban Informatics providing a core ontology, allowing a formal representation of urban places which includes people's social experiences in its definition.

The ontological analysis undertaken in this thesis concerns specifically the concepts which should be used in describing the mutual interaction between people and the built environment. In particular, we employ notions such as artefact, role and social practice to characterize the urban environment from a social perspective. These notions, particularly those of artefact and role, are widely discussed in the field of ontology engineering and we build upon the existing body of studies, contributing to the discipline with new insights from the specific characteristics of the urban domain.

1.2 Methodology

In the last decades, the wealth of available geographic data is more and more produced by the so-called *human-sensors* (Goodchild, 2007). This data provides bottom-up knowledge about the city, expressing the social complexity of the urban fabric from the point of view of people's experiences. They are generally analysed to describe the urban environment through data-driven modelling approach. However, according to Thakuriah et al. (2017) this approach is posing significant problems in deriving generalizable knowledge to be used by specialists in urban design, being too narrow on specific case studies.

Our methodological choice is therefore motivated by the growing need of generalized, documented and shareable knowledge providing the real-world semantics behind the urban social environment. In this thesis we propose (1) a Core Ontology; (2) a set of Design Patterns; (3) and an experiment using real data to collect behavioral patterns. Our proposals aimed at describing the social aspects of the urban environment to serve as a set of supporting semantic tools for representing and sharing knowledge about the city.

In more detail, our methodological approach consisted in:

- Introducing new entities to fill the gap in the representation of the social and dynamic character of urban contexts. More specifically, we address issues related to: (i) the human-made world of the urban fabric introducing the notion of urban artefacts; (ii) the dynamic and unplanned use it can be made of urban artefacts, modelling the roles and social roles urban artefacts may play; (iii) the relation between urban artefacts roles and people behaviour which has been represented by modeling urban artefact actual usages and social practices.
- Modelling problems arising from a socially biased conceptualization of the urban environment have been handled by designing reusable Ontology Design Patterns (ODP) (Gangemi and Presutti, 2009; de Almeida Falbo et al., 2013). They represent the key building blocks of the geo-social knowledge that we have identified.

- A Core Ontology - named *Urbis* - is the result of the ODPs composition. It offers a more comprehensive model of the core entities and their properties to represent the urban environment with an explicit social bias. As a core ontology it is grounded in top-level ontologies entities, and it will serve as a basis for the design of geographic domain ontologies.
- Finally, we conduct an experiment extracting data from a popular platform, TripAdvisor. The experiment aimed at: recognizing social practices from patterns of collective behaviour and organizing the data and analysis results following the proposed ontological model. It allows an evaluation of the extent to which our representation model, in comparison with existing ontologies, is able to capture the social and dynamic knowledge that can be obtained from crowdsourced geographic data.

1.3 Motivation

The increasing number of people participating in forms of crowdsourcing of geographic information in the last decade has driven some scholars to introduce the expression of *human sensors* (Goodchild, 2007). In our view, in order to fruitfully interpret data generated by humans via the mediation of geographic platforms, new models able to represent the way people commonly conceptualize places are needed. In particular, a very important practical concern of contemporary geographic information science is to make explicit, for the purpose of mutual understanding, people's assumptions about their everyday spatial experiences. Geographic technologies have the potential to play a significant role in supporting urban design and planning in contemporary cities(Resch et al., 2015; Guerrero et al., 2016; Crooks et al., 2015; Jarvis et al., 2016) in several domains: 1) the smart city paradigm grounds its operating in the growing availability of crowdsourced data; 2) public participation in urban design relies more and more on applications to collect geographic data directly from citizens; 3) the very concept of geography has been reconceptualised in terms of *neo-geography*, stressing the role of non-experts in the production of geographic knowledge. Developing new models able to represent and render computable the social knowledge about places is become pivotal, not only

to foster advances in technological systems, but also to promote a city management more attentive to citizens' needs and social differences. This topic is discussed in Chapter 2. Our work builds on these observations, and aims at proposing an ontology model to represent the specific social character of urban places.

1.4 Research questions

The research questions that this work aims at addressing can be summarised as follows:

RQ1 : What entities are required for an ontology to represent the social character of urban place?

We address this question in Chapter 4, where we provide a review of the existing ontologies of the urban environment. From the analysis of such related body of work we will specify the concepts required to describe urban place in light of the social contexts in which the built environment is grounded. We essentially identify the need to:

- represent the urban fabric which is constituted by human-made physical objects, intentionally designed to fulfill certain usages;
- model the dynamic and unpredictable nature of the interaction between people and the built environment;
- introduce a notion to specify the conventional and social character of this interaction;

Points listed above bring us to introduce the following entities: urban artefact, urban artefact's roles and social practice. Therefore, a set of subquestions becomes relevant:

subQ1: What is an urban artefact?

We address this question building upon the existing body of knowledge in formal ontology regarding the human-made world. Chapter 5 is a specific focus on the notion of *artefact* and its extension as *urban artefact*.

subQ2: How can urban artefact's roles be defined?

The multiple possible uses of urban artefacts greatly extend their planned uses. However, to avoid that a change in the urban artefact use may imply a change in its typological classification we introduce the notion of roles. Chapter 6 provides definitions of the different roles urban artefacts may play.

subQ3: How can people collective behaviour be modelled in terms of social practices?

Roles, specifically social roles, depend on contexts. In the case of an urban artefact's social role we refer to its social context as the social practices characterizing its collective uses. In Chapter 7 we propose ontology models of social practices.

RQ2: How to recognise social practices from crowdsourced geographic data? To what extent our proposed model is able to capture the social and dynamic knowledge extracted from this data?

We address this question in Chapter 8 through an experiment using a real dataset extracted from the Trip Advisor platform. We build upon the work undertaken in the previous chapters, integrating the results of the data analysis in the ontology model and evaluate the proposed approach by comparison with other ontologies.

1.5 Structure

The thesis is structured as follows:

Chapter 2 sets the background for the work undertaken in this thesis. It provides an overview of the growing role that crowdsourced geographic information is nowadays playing to support city management. In light of such role, the problem of representing and sharing the social knowledge emerging from these new data sources should not be considered a purely technological one, but also social. To clarify this point, in Chapter 2 we review how crowdsourced geographic information, particularly the one obtained from *human sensors*, relates with societal issues in terms of: 1)the *democratizing* potential of the

geographic web and 2) the opportunity to reach a variety of viewpoints and uses of the city. Providing a summary of the role of crowdsourced geographic information, Chapter 2 presents the urgency of new models to render explicit the multiplicity of people's perspectives and experiences of the urban environment.

Chapter 3 introduces topics concerning computational ontologies and Ontology Design Pattern that are more related with the thesis.

Chapter 4 presents: i) foundational characteristics of ontologies in the context of geographic information systems and ii) state of the art ontologies engineered to deal with human aspects of the geographic world. Theories developed in human geography and urban studies which explicitly aim at interpreting urban context in the way they are experienced by people are also discussed. Comparing ontological models with the conceptualization of urban places made by human geographers, a current lack of formalized concepts to represent the social and dynamic character of the urban environment has emerged. This has pushed us to introduce some basic entities to fill this gap that are briefly discussed at the end of the Chapter.

Chapter 5, 6 and 7 present the ontology-based modelling of entities used to describe the urban environment from a social perspective. The notion of urban artefacts is introduced in Chapter 5. Social roles theories applied in formal ontologies are reviewed and used to tackle the dynamic and social meanings associated with urban artefacts (Chapter 6). In particular, the context which urban artefact social roles depend on is related to conventional uses of the urban artefacts and it is framed within social practice theory. Chapter 7 presents the notion of social practice as discussed in philosophy and sociology with a specific focus on social practices involving the use of urban artefacts. Then, some modelling choices to formalize the notion of social practice in the ontology are presented.

In **Chapter 8** we analyse a sample of crowdsourced data extracted from the Trip Advisor platform to recognize social practices. Results are then mapped in the core ontology, composed by the Ontology Design Patterns developed in the thesis, following an Ontology Based Data Access approach. An evaluation has been done by comparing the proposed model with other existing ontologies.

Chapter 2

The social role of Geographic Information

2.1 Introduction

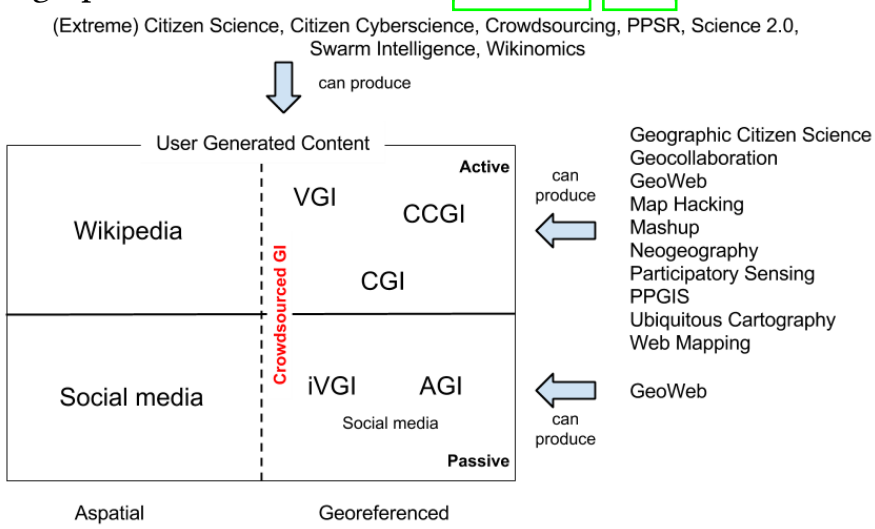
In this Chapter the social role of geographic information in informing urban planning and policies in contemporary cities will be critically discussed. The crowdsourcing of geographic data is nowadays a common practice and city governments and citizens are making large use of these new sources to inform decision-making strategies. As a consequence, the way this data is produced, organized and analysed is not only a technological issue but it strongly concerns the social impact that this data could have in influencing the way the city is managed. In particular, we refer to the opportunity, given by this data, to understand the social differences in the way people live and experience the city as a cornerstone for a more *socially* informed urban planning. To present the social impact of the geographic information crowdsourcing, we identified two dimensions of analysis: one is related to the *democratization* potential of crowsourcing activities and the other concerns the capacity to return a pluralistic view of the city. The analysis undertaken in this Chapter serves to frame the relevance of modelling the social knowledge about the city in light of the current impact that new geographic technologies, more and more integrated as providers of information for city management strategies, may have at a societal level.

2.2 Crowdsourced Geographic Information: new challenges

Everyday, people are involved into the crowdsourcing of geographic data as *human sensor*(Goodchild, 2007), through the use of social media (i.e. Foursquare, Twitter), producing their own maps (i.e. Ushahidi, Google My Maps) or contributing to collective maps (i.e. Open Street Map, Wikimapia). As a consequence, geographic data and information are classified differently depending on the way they are crowdsourced and the terminology employed has nowadays become extremely variegated (See et al., 2016) (see Figure 2.1). The growing number of keywords used to refer to Geographic Information (GI)

can be considered as a sign of the increased complexity brought about by technological advancements in the field.

Figure 2.1: Terminology found in the literature and the media. AGI: Ambient Geographic Information; CCGI: Citizen-contributed Geographic Information OR Collaboratively Contributed Geographic Information; CGI: Contributed Geographic Information; PPGIS: Public Participaton in Geographic Information Systems; PPSR: Public Participation in Scientific Research; iVGI: Involuntary VGI: Volunteered Geographic Information. From (See et al., 2016)



For a long time GI has been primarily mediated by experts, analysing and communicating official data provided by institutional agencies. Scholars in critical Geographic Information Systems (GIS), such as Crampton and Krygier (2006a), have problematized GIS science for being erroneously conceived as objective in the way it represents the reality and they have emphasized the crucial role of the way data is selected and organized. They claimed that the process of selecting and representing geographic knowledge is a mean for playing power, communicating a specific view of the world, in the case of traditional GIS the viewpoint is mediated by experts. This can ultimately influence people conceptualization of space and place, as well as their spatial decision making. As a consequence, critical thinkers in the field of geography and, more specifically, in cartography (Crampton and Krygier, 2006a) have

highlighted the need to semantically deconstruct maps, identifying whose point of view they are expressing (Harley, 1989) and unveiling how to lie with maps (Monmonier, 2014). A specific field of GIS studies born in the nineties, Public Participation in GIS (PPGIS), explicitly aims at recoding maps, in order to synthesize a bottom-up perspective of the reality, engaging people directly in the data collection to be more inclusive of non official voices (Sieber, 2006; Elwood and Ghose, 2011; Sheppard, 1995).

The emergence of *neo – geography* in the last decades has greatly amplified the process of involving common people in the mapping activities, resulting in the blurring of the distinctions between producer, communicator and consumer of GI (Goodchild, 2009); the term, indeed, emphasizes the birth of a *new* geography made by non-expert users, the *neogeographers*, collectively producing maps by web and mobile applications thanks to technological advances. Geographic data sources and content have become more heterogeneous since, on the one hand, there are more tools to collect data from a crowd of people and on the other hand, the crowd is intrinsically diverse, producing information obtained by the contribution of different social groups (Elwood, 2008). Framing this phenomenon in broad perspective has brought some scholars to stress its democratization potential (Warf and Sui, 2010a; Hudson-Smith et al., 2009; Felgenhauer, 2017) given by the extended access to produce and share GI.

As a matter of fact, technological advances have been exploited to ease and increase public participation and extensive data collection, especially in urban areas; however, the actual possibility of having a more democratic and pluralistic representation of the geo-social reality through these applications is not assured. On the contrary, the most developed idea of *smart city* is generally much more techno-centered than human-centered (Kitchin et al., 2017; Vanolo, 2014); the viewpoint it represents is generally objectified as a unique set of peoples desire and intentions, without recognizing the social and cultural differences which are present in cities.

Therefore, if on the one hand, geographic data that we can obtain from crowdsourcing might mirror much better than before the complex social nature of city dynamics; on the other hand, the complexity of the social reality seems not to be comprehensively framed with the tools and techniques which are currently adopted.

2.3 Is the crowdsourcing of Geographic Information democratizing our cities?

The term democratization associated with the concept of neogeography, according to Haklay (2013a), has been often enthusiastically used in a *weak* sense, about the potential to make more accessible the production and consumption of GI to all (Warf and Sui, 2010a) rather than about advancing the specific concept of democracy. A democratization process in a *stronger* sense concerns the possibility of concrete Public Participation, which requires, at least, some forms of empowerment [†], where empowerment, in the terms of participatory democracy, does not imply that people must have legal power to deliberate but it mainly refers to the right of, at least, influencing decision-making (Bobbio, 2006).

The distinction between democratization in *weak* and *strong* senses proposed by Haklay (2013a) brings us to recognize two main trends within the extensive debate of the last decades about the democratization potential (or limits) of neogeography: one is related to public participation in the decision-making process of urban planning, the other concerns the democratization of the geographic knowledge production process.

In both cases, technology plays an important role and can be seen as the potential channel to people empowerment (or disempowerment). The following subsections are a literature review of these two main trends, highlighting possibilities and limits of neogeography for Public Participation (PP) and Geographic Knowledge Production (GKP).

2.3.1 Neogeography and Public Participation in Urban Planning.

Debates about the challenges of involving the public in urban planning, using geographic tools, can be grounded in the literature of Public Participatory GIS (PPGIS), which is extensively reviewed and framed in Sieber (2006). As

[†] There is nothing more frustrating of participation without empowerment, (Bobbio, 2006)

Sieber (2006) concludes, “PPGIS provides a unique approach for **engaging the public in decision making** through its goal to incorporate local knowledge, integrate and contextualize complex spatial information, allow participants to dynamically interact with input, analyze alternatives, and empower individuals and groups". Following Sieber’s definition of PPGIS, in this subsection the engaging of people in the decision-making process will be adopted as the key criterion to consider neogeography as supporting a *strong* democratization process. This demarcates the distinction we want to make between the need of an official, top-down, recognition of the process that should result in (or at least influence) some form of decision-making - which is the case of Public Participation - and a form of bottom-up empowerment through the production of geographic knowledge, which will be discussed in the next subsection[†].

Ertiö (2015) classified types of digital applications used for decision-making in urban planning on the basis of theories of participation selecting three dimensions: *type of data collected*, *information flow* and *empowerment* with levels shown in table. She underlines that, at the moment, participatory apps involve citizens mostly in tasks of data collection, even though Turner Wilson and Graham (2013) maintains that, to be better intersected with the notion of neogeography, they should also include the *map creation, personal analysis, interactive feedback, collaboration, and reading and understanding of GI.*(Wilson and Graham, 2013). Furthermore, it is still not clear how citizens’ inputs are finally evaluated in the actual process of policy-making Ertiö (2015). A limit of these tools, indeed, seems to be independent from the technology used but mostly related with the *amount* of power that the government decides to share with the public. Participatory processes can be limited to treat “citizens as passive sensors, in a one-way direction, or as partners, contributing information in a two-way dialogue surrounding an issue and providing an opportunity for direct democracy, enabled by information technology" (Johnson and Sieber,

[†]Literature in PPGIS does not show such a clear demarcation between top-down engagement and spontaneous participation in the production of geographic knowledge. However, we found critical to distinguish between engagement strategies, which are set officially by a public administration, and collaboration of people who decide to work as a pressure/support group to show alternative ways to filter the geo-social reality. In particular, this distinction provides a frame to interpret different ways people can be empowered by producing geographic knowledge: the first is a top-down empowerment, the latter is bottom-up.

2013). However, besides the political dimension, as noted by Johnson and Sieber (2013), government acceptance of VGI also depends on the reliability of information, pushing the authors to suggest a more formalized collection process, focusing on data quality and identity verification.

Another way to look at the relation between neogeography and democracy is through the notion of Open Government (OG). OG is a concept which combines e-participation and open data availability (Hansson et al., 2015). Some of the tools used in OG are explicitly related to geographic knowledge and discussion about local issues, such as reporting local problems (i.e. Ushahidi, FixMyStreet) or debating and "liking" proposals using social networks (i.e. Facebook)[†]. In this perspective OG seems to take some features of the neogeographic approach. Hansson et al. (2015) organized a framework to review the literature related to OG, grounded in the three dimensions corresponding with the phases of the decision making process: understanding, deliberation, representation. The **understanding** phase concerns the collection of information from citizens through the use of technologies, as mentioned in Ertiö (2015), and, in the case of OG, it also stresses the *transparency* of government, associated to releasing data to the public. To this end, several Open Data Initiatives have been launched by governments in these years, gathering expert developers as well as non experts, in contests to produce apps aimed at solving certain urban problems. Neogeographers and developers, in this case, work together and they are involved not only in the data collection phase, but also in knowledge production, elaborating data to answer people needs. The **deliberation** phase results in a collective and informed decision-making, mediated by supportive tools, generally focused on structuring the discussions and voting to record a decision, i.e. LiquidFeedback (https://liquidfeedback.org/), or on negotiations between stakeholders, i.e. in urban design, Geodesignhub - a powerful tool that allows users to visualize up to eight layers of territorial information on a map, and adding geographical primitives enabling teams to discuss urban designs (Campagna et al., 2016). Finally, that of **representation** seems to be the most underestimated issue in the OG literature, which presents the public mostly as an homogeneous group of people without considering social differences (Hansson et al., 2015).

[†]For a more accurate review, see Hansson et al. (2015) and Desouza and Bhagwatwar (2012)

Both Ertiö (2015) and Hansson et al. (2015) have underlined the generally limited empowerment of public participation processes on actual decision-making. Similar argumentations brought authors like Kleinhans et al. (2015) to stress the potential of web based platforms for self-organization at the neighbourhood scale. Such platforms would give an additional potential role to neogeography in terms of democratization, as a support for horizontal interaction between citizens. In Italy, the possibility of using them to support self-organization in local communities finds a legal framework in the *Regulation on collaboration between citizens and public administration for the care and regeneration of urban common goods*. From 2014, when the first regulation was approved in Bologna, a growing number of municipalities have started integrating it in the government rules Ciaffi (2014). The Regulation, when implemented, allows citizens to autonomously take care of public spaces in agreement with the municipality, with which they conclude a *collaboration pact*. However, despite the potential of web-based tools for self-organization Kleinhans et al. (2015), the way technology has been supporting collaboration between citizens under this framework is still unexplored.

2.3.2 Breaking the ground of experts' Geographic Knowledge Production using the neogeography's toolbox

"Professional Geographers would - I think - take exception to the notion that Geography is primarily devoted to the production of geographic information, thinking of themselves as contributing to geographic knowledge by synthesizing and interpreting data and information obtained from a wide range of sources. In that sense the geographic data and information acquired through VGI may certainly contribute to the production of geographic knowledge. But [..] while there is plenty of acceptance of the role of neogeography in producing useful and reliable data and information, the idea of a neogeography producing geographic knowledge would cause plenty of anxiety."

This is how Andrew Turner, in an interview with Mark Graham and Matthew Wilson (Wilson and Graham, 2013), emphasizes the resistance of professional geographers towards the rise of the amateurs. Compare to the discussion about the relation between neogeography and democracy analysed in the

previous section, arguments about who is entitled to the production of geographic knowledge concerns a type of empowerment that does not come from the top (from public administrations), but it is inherent in the map making process. Creating maps is not a neutral activity but is a channel to make people see reality in a certain way, and this has definitively something to do with power. The way power is inscribed in maps, and has been supporting dominant political structures as well as counter-mapping activities, has been discussed in the critical cartography field of studies since the beginning of the nineteens(Wood and Fels, 1992; Crampton and Krygier, 2006b). Their arguments take, nowadays, new inputs in the light of technological advances. As stressed in Zook and Graham (2007b) "virtual Earth and digital representations of place are often characterised by a reflexive relationship with their physical counterparts: they are shaped by, and, in turn, shape the physical world".

The empowerment potential of the map making process has two direct consequences: on the one hand, it empowers big private firms, such as Google Maps, playing a pivotal role in the production, manipulation and organization of geographic knowledge in digital spaces (Zook and Graham, 2007a); on the other hand, the spread of user friendly toolboxes for making maps, from the data collection to the web map representation, provide people with the *power* to produce geographic knowledge by themselves presenting their specific view of the reality. In particular, we can summarize the following trend in geographic knowledge production using the neo-geographer's *toolbox*.

Digital counter-mapping activities. Counter-mapping is a term that has been coined by Nancy Peluso to describe a map-making activity by indigenous people in Indonesia. The need to counter the mainstream map making emerges when the voices of marginalized people are not taken into account in political discussions. Harris and Hazen [2005, 115] define it as "any effort that fundamentally questions the assumptions or biases of cartographic conventions, that challenges predominant power effects of mapping, or that engages in mapping in ways that upset power relations." Counter mapping practices make a large use of non-digital tools, however the possibility to collect and analyse data and to make maps through electronic applications has been explored (Dalton and Stallmann, 2018). A recent project of counter-mapping is the

Anti-Eviction mapping project set in LA (Maharawal and McElroy, 2018). The project (https://www.antievictionmap.com/) aims at highlighting problems related to gentrification, such as evictions, low housing affordability, high levels of surveillance and security. The activists make use of numerous methods, analog and digital, using a user-friendly software for web mapping, Cartodb (cartodb.com), after having analysed the data with traditional GIS techniques (with the support of GIS professionals). Ushahidi (ushaidi.com) is used for crowdsourcing information about evictions. In this project, we can safely claim that the digital meets the analog in order to empower invisible people affected by gentrification, and make visible their knowledge about the city dynamics.

Neogeoraphy in Citizen Science. Haklay (2013b) distinguishes six types of citizen sciences, highlighting to what extend it relates with neogeographer's production of VGI showing that the domain which better overlaps with it is that of environmental and ecological observations. Connors et al. (2012) stresses the potential of VGI in the context of environmental monitoring; the authors also reported that particularly in this field neogeography could be part of a "broader social trend that favours citizen involvement in decision making and policy implementation across multiple levels of government" (Berkes, 2009; Gouveia and Fonseca, 2008).

Crisis mapping. Zook et al. (2010) report on the case that mostly exposed the potential of neogeography to support disaster response management: the Haitian earthquake. Analysing some of the software that can be considered part of a neogeographer toolbox, such as CrisisCamp Haiti, OpenStreetMap, Ushahidi, and GeoCommons, the authors emphasizes the important role that these sources of information played to support the logistics in disaster response. At the same time, they recognize that the success of any response greatly depends on the ability to aggregate and evaluate data for planning via logistical back support. Liu and Palen (2010) give a review of the diverse and numerous types of systems used in disaster response which include the participation of non expert citizens showing the extent of context in which is applied, from natural disasters to war and population dynamics. Haworth and Bruce (2015)

record an increase in the trust that authorities have of crowdsourced data and, as a consequence, in the geographic knowledge which is produced.

The emancipatory potential of neogeography, regarding geographic knowledge production, rises from the opportunity to collect, organize and present data in a cartographic form which can be spread through the web. From an ontological point of view, we can talk about “a democratization of ’truth’ production, while ’truth’ is constructed as relative to specific group of users" Warf and Sui (2010b). However, motivations for volunteering or withholding will shape the dynamics of inclusion and exclusion in VGI development and influence data content (Elwood 2008b; Leszczynski 2012; Thatcher 2013; Stephens 2013). To this regard, transparency about who is the map producer and what are the motivations behind the map-making become crucial to deeply understand the social nature of the geographic knowledge that has been produced, and, therefore, to evaluate the *democratizing* potential in respect to who is being empowered. Furthermore, while the *democratization* in geographic knowledge production depends on the producers and their motivations, the state of “institutional" recognition of non expert geographic knowledge gives us a less *democratized* overview 2.2. Geographic knowledge which emerges from counter mapping activities enjoys a low level of formal recognition given that those activities are, in general, explicitly excluded from the political dominant discussions and not used as a support for policy making. At a middle level there are citizen science projects, which seem to be gradually recognized as legitimate sources of knowledge to support public administration, especially those focused on environmental sustainability (Connors et al., 2012). Finally, at the highest level of formal recognition there is the neogeography applied in disaster response management, which it is still problematic in terms of assessing data quality, but comparing with other fields of application is the most integrated in official workflows at several administrative levels, from the local to the international organizations, even within the UN.

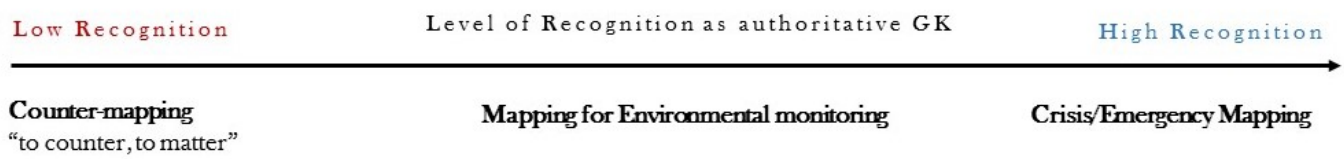


Figure 2.2: Level of recognition of Geographic Knowledge (GK) produced by non experts

2.4 Does Crowdsourced Geographic Information return a pluralistic view of the city?

In the previous section we reviewed the literature about ICT-based crowdsourced geographic information in the light of its democratization potential. While we cannot deny that there are still many limits to the accessibility of technology for us to argue about a "universalism" in the ability of producing geographic knowledge (and, even less, in the possibility to influence or participate in decision-making), on the other hand, it is almost two decades that a non expert user-base of geographic technology is growingly expanding. This implies that a large part of the society is now *empowered* to generate geographic knowledge: the private sector is exploiting the business opportunities of collecting huge amount of data, producing user-friendly tools, accessible geographic information and navigation services; governments are more and more engaged in promoting the idea of a *Smart City* as a pillar for urban governance. Citizens have become the centre of this phenomenon, the source of the so-called *collective intelligence* to be harnessed. Given the spread of crowdsourcing activities, both passive and active, we could claim that technological advancements are, in a sense, democratizing our cities, in that they are giving new tools to non expert. However, we have also highlighted that this does not automatically imply a leverage on the existing power structure of the society given that (1) some people are entirely excluded from the data collection phase (it is especially the case of who is already marginalized) thus becoming invisible to the process; (2) also in relation to those who are in-

cluded in the crowdsourcing activity their social differences are generally under represented. In particular, we believe that technology should provide new solutions to be more aware of the social differences characterizing city users who generate the data. In particular, in order to represent the city from the citizens perspectives, mapping tools and techniques need to be aimed at returning a pluralistic view on how the city can be lived. Knowledge about the urban environment is not unique, each of us experience urban places differently both at a cognitive and social level; while cognitive differences are mainly focused on individuals, social ones refers to specific social groups of people i.e. teenagers who generally prefer certain city spaces that would be likely different from elderly, or tourists who generally prefer to explore city centers, or parents mainly concerned at finding places for children.

Cities have been considered by human geographers as the overlapping of these *relational* spaces where many geographies intersect and the multiplicity of identities of places emerge (Massey, 2010). The advent of Information and Communication Technologies pushed some scholars to investigate the impact of ICT in the conceptualization of place and space. Stephen Graham (1998) reviewed the main trends at the time, which were a *tracendend* view, calling for the substitution of digital places over the physical; a *co – evolution* perspective, seeing the digital and the physical as produced together; and the *relational* approach claiming the emergence of complex combinations of new sets of spaces and times, which are always contingent and impossible to generalize. Mark Graham (2010), more recently, used the expression *palimpsest of place*, where the term palimpsest, originally used to refer to medieval writing blocks that could be reused while still retaining traces of earlier inscriptions, describes the possibility that technologies give to record the multitude of present and past discursive and physical layers that people use to interpret place.

In other words, the diverse identities of places seem to show up from the growing use of geographic technologies rather than to be replaced by the digital. Evidence of the variety of meanings which are attributed to the same places come from crowdsourced information, and these evidences are making the interpretation of geographic information much more complex. Studies on Wikipedia data have shown that some topics can be classified as controversial when users' contributions determine an *edit war* (Yasseri et al., 2014). The

data analysed in Yasseri et al. (2014), has shown that the 17% of controversial articles are about Geographical locations, Countries, Cities, Towns. Mooney and Corcoran (2012) analysed objects which have been edited 15 or more times in the Open Street Map database of UK and Ireland reporting that the number of edits do not depend on the increasing number of contributors, but it is just among the 11% of more active users than controversies emerge. *Edit wars*, within systems that promote the production of an *objective* knowledge such as Open Street Map or Wikipedia, are a problem to be addressed synthesizing the different viewpoints to result in high quality information. On the other hand, the phenomenon demonstrates that *unique* and *neutral* knowledge about concepts in general, and places in particular, is difficult to be reached and, likely, in some cases impossible. Also, as noted in Graham (2010), "dominant societal narratives necessarily play a large part in determining what is considered acceptable content". Framing the notion of place in a relational perspective, the problem of synthesizing multiple viewpoints in a single, objective knowledge gives way to the possibility to let the multiplicity of *knowledges* about places emerge.

Geographic data can be crowdsourced either actively or passively through *human* sensors. Both types of information can be analysed, resulting in what is commonly known as Urban Analytics. Broadly, "Urban Analytics" can be thought of as collections of indicators of the current state of a city, often made available via "Urban Dashboards" on the web (i.e. citydashboard.org/london/, www.dublindashboard.ie) (Kitchin et al., 2017). A variety of methods and techniques originating in complexity science (Guo et al., 2017), machine learning (Arribas-Bel et al., 2015), data mining (Crooks et al., 2015), ontological and statistical reasoning (Dashdorj et al., 2017) have been used in the last years to interpret city dynamics using crowdsourced data. However, "a critical understanding of data recognizes that data do not exist independently of the ideas, instruments, practices, contexts, knowledges and systems used to generate, process and analyse them, regardless of them often being presented in this manner" (Kitchin et al., 2017). Therefore it is important to note, as critical geographers have underlined, that as cartography is never neutral, technology is not as well. Data and information flow through several applications or sensors, and the design and functionalities of the applications themselves, as well as the way they are analysed, mediate the type of content which is collected and the

knowledge which is produced. The world presented from crowdsourced data analysis tends to be a merge of the multiple urban experiences of people in a common and unique knowledge. One important reason for this trend is the limited informational content of big data. As Kwan (2016) exemplifies “many variables needed for addressing specific questions, i.e. about human mobility (home and workplace location, travel route, travel mode, gender, income, and race) are often not available in popular big data sets".

As a consequence, even if the social and cultural groundings of a crowd of people is very diverse, crowdsourcing does not automatically return a more pluralistic representation of the cities. However, the potential to give voices to different social groups pushes us to reason about ways to make the differences in viewpoints clearly emerge, rather than hide them in a world seen from a single and universal perspective.

2.5 Social Space is a Social Product: the problem of representing socio-spatial Knowledge in a Digital Environment

The increasing amount of geographic data related to people daily life activities, opinions, networks pushes us to conceive crowdsourced GI as more and more mirroring the complexity of the social life in cities. As we have reviewed in this chapter, the potential given by these new sources of information has been recognize in literature in relation to the possibility to use GI technologies as a support for making our cities more democratic, while recognising their plural geographies. However, the path to realize this potential seems to be still very long; in particular, we believe that the greatest challenge is to embed and render explicit the complexity and dynamism of the real-world socio-geographic knowledge in the digital world. In the design of geographic information systems, the standard to formalize the geographic space is essentially based on geospatial geometries, i.e. geographic reference system, and considering place as an entity that have a “somewhat fixed, physical extension" (schema.org) or adding to it some thematic dimensions (https://inspire.ec.europa.eu/Themes/Data%20Specifications/2892) such

as land use, statistical units or geographical names. We believe that those standards are not enough to frame the social complexity emerging from crowd-sourced GI. A completely different perspective is the one of scholars in human geography, such as Lefebvre (1991), Massey (2010), Cresswell (2013), who have conceptualized the geographical space as a social product. In their view a place can be considered as the overlapping of the different geographies which are socially produced depending on how a space is *lived*.

Geo digital information has become an amplifier of the lived space, giving more opportunities to communicate it. However, it seems that there is still a huge gap between the digital and the social worlds of the everyday reality that impedes to exploit the potential of geographic technologies to understand geo social dynamics. Indeed, there is a lot of criticisms to unveil the limits of the digital geography, as reported in the work of (Graham, 2010): "Although myriad representations and interpretations of place are now easily accessible, it remains important to note that the virtual Earth remains highly shaped by dominant power structures, software algorithms and the cultural links between producers of information"; or regarding the smart city paradigm which have emphasizes the limits of concerning only the relation between space and technology without giving the main stage to the people (McFarlane and Söderström, 2017). Brenner and Schmid (2015) even stronger criticism underlines that "technoscientific urbanisms replicate, and indeed reinforce, the basic urban age understanding of cities as universally replicable, coherently bounded settlement units. The law-bound understanding of urbanization it embraces is used [..] to justify a universalizing, naturalistic research agenda, and as part of a broader technoscientific ideology that aims to depoliticize urban life and thus 'to assist the cause of sound management"', in other words, social differences among people and the bottom up practices, which add new meaning to urban spaces, are generally not taken into consideration in determining the urban agenda.

Nevertheless, we believe that technological advancements can address the challenge of being more focused on humans and try to channel the social meanings coming from the crowd, transforming crowdsourced data in the social knowledge they produce about spaces. Similarly, McFarlane and Söderström (2017) calls for moving from a technology driven to a knowledge driven

smart urbanism.

2.6 Conclusions

This chapter provides a critical review of the variety of geographic data crowdsourcing activities and it underlines its unexpressed potential in terms of returning the multiple identities of urban places. The enthusiasm for a *smarter* city is now facing much criticism primarily given by the techno-centric approach of traditional smart city paradigms. The thesis grounds its motivation in trying to enable technological systems in the understanding of the geographic knowledge as socially contextualized, being the result of a plurality of viewpoints. In particular, we believe that enabling the development of more *socially-aware* systems can be a powerful support for dealing with the *democratizing* potential of the neogeography and CGI in the management of our cities. We will provide ontology design patterns and a core ontology as the mean to organise the geosocial knowledge trying to render explicit the social contexts which determine the multiplicity and relational character of urban places.

Chapter 3

Ontologies

3.1 Introduction

In Chapter 2 we pointed out how the ubiquity and diffusion of new geospatial media is changing the nature of geographic information. These new data sources are able to mirror the social complexity of contemporary cities much more than the data provided by official agencies, posing significant theoretical challenges to traditional models in Geographic Information Science. In this thesis we propose Ontology Design Patterns, which can be composed in a core ontology, to formally and explicitly represent the social knowledge which emerge from these new data. In this Chapter, we discuss the topics of ontology and Ontology Design Patterns, which background the work that will be presented in the thesis.

3.2 Ontologies and Information Systems

Ontology, also referred to with the capital *O*, is the branch of philosophy concerning the $a - priori$ nature of reality (Guarino, 1995). In philosophical discourses, the study of Ontology deals with problems about the most general features and relations of the entities which do exist. In this thesis we approach the term ontology (with the lower o) as it is used in the computer science community.

(Computational) ontology was originally defined by Gruber as *an explicit specification of a conceptualization* Guber (1993). Broadly, an ontology aims at providing a shared understanding of the concepts and relationships that can exist for an agent or a community of agents. According to Guarino et al. (2009) the definitions of computational ontology can be summarized in the following three key aspects: i) they result from a conceptualization of the real world, ii) they are created by mean of an explicit (and formal) specification, and iii) they should be expression of shared knowledge. These terms are further clarified by Studer et al. (1998) as follows:

- *Explicit* refers to the definition of concepts and the relations used.
- *Formal* refers to the language of the ontology which is machine readable.

- *Shared* reflects the idea that an ontology captures knowledge accepted by a group.
- *Conceptualization* is the abstract model of some real world phenomenon.

According to Noy et al. (2001) computational ontologies should be developed to:

- share a common understanding of the structure of information among people; this would allow to make information scattered into many sources interoperable;
- enable the reuse of domain knowledge;
- making domain assumptions explicit; this is vital to clarify the specifications and underlying semantics of an information system to end users;
- analysing domain knowledge; ontology-driven analysis may be valuable for several applications supporting, i.e. measures of semantic similarity or semantic queries.

3.2.1 Types of Ontologies

Ontologies have been classified in different ways. Uschold and Gruninger (1996) classified ontologies depending upon their formality and complexity as a continuum as belonging to the following major categories:

- Highly Informal: Ontologies that are expressed loosely in natural language.
- Semi-Informal: Ontologies expressed in a restricted and structure form of natural language.
- Semi-Formal: Ontologies expressed in artificially formally defined language.
- Rigidly Formal: Those that are clearly defined terms with semantics, theorems and proofs.

The work presented in this thesis concerns formal ontologies, which have been further classified by Guarino (1998a) in relation to their level of dependence on a particular task or viewpoint. He distinguished:

- Top level ontologies describe very general concepts like space, time, matter, object, event, action, etc., which are independent of a particular problem or domain;
- Domain ontologies and task ontologies describe, respectively, the vocabulary related to a generic domain (like medicine, or automobiles) or a generic task or activity (like diagnosing or selling), by specializing the terms introduced in a top-level ontology;
- Application ontologies describe concepts that depend both on a particular domain and task, and often combine specializations of both the corresponding domain and task ontologies. These concepts often correspond to roles played by domain entities while performing a certain task, like replaceable unit or spare component.

Other ontology classification are reviewed in Oberle (2006) as related to: purpose, expressiveness and specificity. According to purpose we have **application ontologies** (or operational ontology in Guizzardi (2007)) which are artefacts encoded to guarantee desirable computational properties and which can be used during run time of a specific application, and **reference ontologies** which are conceptual models used for reaching a mutual understanding of a conceptualization. In relation to expressiveness Oberle (2006) distinguishes between **lightweight** and **heavyweight** ontologies: the former consisting of a minimal set of axioms, the latter extensively axiomatized to exclude terminological ambiguities. Finally, the specificity dimension results into three types of ontology: **Generic**, **Core**, **Domain**. The first and the third can be bridged with the Top level and Domain types provided in Guarino (1998a) while Core ontologies are situated in between and are generally characterized by the following features: i) to have few concepts which represent the core aspects of a domain, ii) extend concepts formalized in foundational ontologies, iii) can be easily extended with more detailed concepts concerning a specific domain. Ideally, core ontologies would serve the construction of a three layered ontology library where each class from an extracted domain top-level is

a subClassOf a class of the core ontology, and each top-level class of the core ontology is subClassOf a class in the foundational ontology (Gangemi et al., 2002).

In this thesis, we provide a core ontology which specializes concepts at a foundational level to serve as a reference for the development of human geo-ontologies. Furthermore, it has been modularized into the form of Ontology Design Patterns, whose definitions and classification will be treated in Section 3.3 of this Chapter.

3.2.2 Ontology Design Principles and Evaluation

Although reality may be shaped into form of an ontology in different ways, ontology design choices should be grounded into some basic principles. Guber (1993) has formulated some criteria for the design of formal ontologies as following:

- Clarity: an ontology should be able to effectively communicate its intended meaning to its users.
- Coherence: an ontology should support inferences that are consistent with its definitions.
- Extendibility: an ontology should be designed to anticipate the uses of shared vocabulary. One should be able to define new terms based on the existing definitions.
- Minimal encoding bias: the conceptualization should be as much as possible independent from the representation language.
- Minimal ontological commitment: an ontology should not restrict the domain being modeled, allowing the users the freedom to specialize and instantiate the ontology as required.

Taking inspiration from philosophical discussions, Guarino (1998b) proposes principles to design foundational ontologies. These are briefly summarized as follow:

- *Be clear about the domain*: the domain can be of particulars (i.e. things of different sorts), universals (conceptual properties or relation) or linguistic entities such as nouns, verbs or adjectives. He suggested to keep lexical items out of the domain;
- *Take identity seriously*: the identity criteria (IC) - which are sufficient and necessary conditions for equality - should play a crucial role in the ontological distinctions; problems encountered in some foundational ontologies are related to an "ISA relation" overloading (i.e. a person which is both a physical object and a living being); when IC are clearly stated this undesirable outcome can be overcome - given Lowe's principle - by avoiding ISA relations with sorts that carry different IC.
- *Isolate the minimal taxonomic structure*: the basic taxonomic structure should have types and categories at its core.
- *Identify roles explicitly*: roles are anti rigid and dependent properties and they need to be identify for avoiding to put essential and non essential properties on the same footing, i.e. in CYC an apple is both fruit and food, while food is only the role of the apple.

Starting from these principles the OntoClean methodology has been proposed by Guarino and Welty (2002) to evaluate the ontological decisions made. The framework includes some metaproperties and provides a set of constraints to be applied to organize the taxonomic structure.

The metaproperties are: i) **Essence and Rigidity**: a property if essential if an entity does not hold it *accidentally*, i.e. *being hard* is essential for hammers but not for sponges, which only accidentally may be hard; a special form of essential property is rigidity, a property is rigid when it is essential for all its instances, i.e. being a person; it may also be anti-rigid or semi-rigid, when respectively it is never essential, i.e. being a student, or it is essential only for some of its instances, i.e. being hard for hammer but not for sponges. ii) **Identity and Unity**: identity is determined by criteria which states the sufficient and necessary conditions for equality while unity refers to the problem of describing how parts of an entity are bounded, in other word what are the conditions to consider an object as a whole.

The constraints are: i) a rigid property cannot be subsumed by an anti rigid property; ii) a class inherit the identity criteria of its superclass, therefore, a class cannot be subsumed by classes which carry different identity criteria; iii) if a class has a unity criterion, its subclasses must also carry the same criterion.

These are very general and ground notions that are believed to hold in any reasonable representation of the world. Other methods of ontology evaluation can follow different approaches. In particular, some of the most common have been reviewed and classified by Hlomani and Stacey (2014) as:

- Gold standard based evaluation: this typically consists in a comparison with an existing ontology which can be considered to be well-constructed Brank et al. (2006), Dellschaft and Staab (2006). The problem of this method is that the gold standard should be also evaluated.
- Application or task-based evaluation: such evaluation measures the effectiveness of an ontology in the context of an application. This kind of evaluation is generally carried out through use-case scenarios and setting some criteria for evaluating the performance of the ontology.
- User-based evaluation: this approach consists in involving potential users in the evaluation process, through compiling questionnaires or observing their interaction with the ontology. It should be noted that this method does not assess the semantic validity of the ontology per se but it captures the subjective information about the ontology (Supekar, 2005).
- Data-driven evaluation: this typically involves comparing the ontology(ies) against existing data about the domain the ontology models. Often this methods applies to textual data, measuring how much the ontology covers the topics provided within corporaHlomani and Stacey (2013).

In this work we follow principles provided by Guarino (1998b) for defining concepts introduced and presented in Chapters 5, 6 and 7, while other approaches are applied for evaluation in the context of experimentation described in Chapter 8.

3.3 Ontology Design Patterns

Ontology engineering is an expensive task and promoting the reuse of ontologies is acknowledged to be a valuable approach Poveda Villalon et al. (2010); de Almeida Falbo et al. (2013). However, most ontologies, even if well-designed, are generally large and covering more knowledge that what might be needed Gangemi and Presutti (2009). Ontology Design Patterns have been introduced to overcome this problem, providing small and documented ontologies which can be seen as ontology's components or *building blocks* Gangemi and Presutti (2009); de Almeida Falbo et al. (2013). In this thesis we propose three ODPs to solve modeling problems which arise from the conceptualization of different facets of the urban domain.

de Almeida Falbo et al. (2013), inspired by the works on pattern language in Architecture and Software Engineering, tend to emphasize the role of composition among patterns in their contribution. A pattern language, indeed, is defined as a set of patterns and relationships among them that can be used to systematically solve coarse-grained problems. What the authors maintain is that the relationships that can exist between pattern help to strengthen and extend the power of an individual pattern beyond its specific focus. In line with their reasoning, our work proposed a composition of the three ODP to form a core ontology related to the urban domain which has an explicit bias on social aspects. This choice overcomes the striking current use of patterns in Ontology Engineering which have been generally applied as stand-alone entities (de Almeida Falbo et al., 2013).

3.3.1 ODPs classification

A common classification of Ontology Design Patterns is provided by Gangemi and Presutti (2009) and it is depicted in Figure 3.1.

At the topmost level we distinguish: *Structural ODP*, which serves logical constructs to solve problems related to expressivity; *Reasoning ODP*, oriented to obtain certain reasoning results; *Correspondence ODP*, aims at transforming conceptual models, a source ontology, or other kind of resources (i.e. thesaurus,

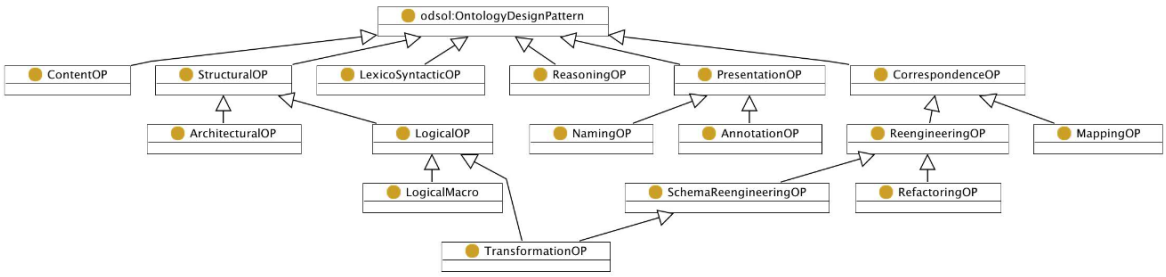


Figure 3.1: Types of Ontology Design Patterns Gangemi and Presutti (2009)

UML models) into a target ontology; *Presentation ODP*, refer to the usability and readability of ontologies from the users perspective; *Lexico-syntactic ODP* deals with linguistic structures or schemas of ordered types of words; finally, *Content ODP* is concerned with the encoding of the real world underlying semantics, therefore it deals with content problems; differently, from logical ODP it is dependent on a specific conceptualization.

This work provides the latter types of ODP designed to address modelling problems arising from a more human-centric - rather than space-centric - conceptualization of aspects of the urban environment.

3.3.2 ODPs documentation

Documentation of the ODP is crucial to facilitate their reuse. Karima et al. (2016) carried out a survey among 130 ODPs user of different expertise level to find out the best practices in ODP documentation from their users' viewpoint. According with their results, and following the structure of the NeOn ODP collector, the most important components for documenting an ODP are:

- Schema diagrams: representing classes and properties of the ODP
- Example of pattern instantiation: showing examples of ODP use in a scenario.

- Competency questions: which are typical queries that an expert might want to submit to a knowledge base of its target domain, for a certain task.
- Description of the ODP components.

In this thesis, the set of ODP that we designed are presented following this documentation requirements; plus they are encoded in OWL and can be found in the appendix.

3.4 Conclusions

In this Chapter we have presented the main topics regarding ontologies and ontology design patterns in the context of information systems. In the next Chapter we will specify the use of ontologies within Geographic Information Science and Systems.

Chapter 4

Ontologies and Geographic Information

4.1 Introduction

In this Chapter we outline the main topics and existing ontologies of the geographic domain. Reviewing the relevant literature in geographic ontologies highlights that the social character of urban spaces is almost totally neglected by state of the art ontologies. However, a social prospect on the geographic domain is needed to transform the wealth of geographic information collected through crowdsourcing - which has often a social nature - into knowledge. To fill this gap we looked at the wider literature of urban and social geography discussing the geographic domain from a socio-anthropological perspective. Finally, we derived *semantic facets* and their related categories which may support the development of an ontology of the urban environment for *socially-aware* information applications.

4.2 Foundational aspects

In the course of the 1990s, research in ontology powerfully crossed the boundaries of geographic information science and spatial theories. Barry and David (1998) summarized the reasons why we need an ontology of geographic kinds in the following points:

1. Understanding the ontology of geographic kinds can help us to understand how different groups of humans exchange, or fail to exchange, geographic information.
2. Understanding the ontology of geographic kinds can help us to understand certain characteristic types of distortions that are involved in our cognitive relations to geographic phenomena.
3. Geographic information systems need to manipulate representations of geographic entities, and ontological study of the corresponding entity types, especially those at the basic level, will provide default characteristics for such systems.

In the last decades a great effort has been put in producing ontological foundations for geographic information science. Aspects of the geographic world that have been widely discussed at a foundational level include the notions of boundaries, the relation between objects and events or processes, and the cognitive aspects of spatial contexts.

That of identifying the boundaries of geographic objects is a critical subject at least for two main reasons: 1) geographic objects can be connected and contiguous or scattered, therefore they require to integrate a topology with a mereologic theory of parts and whole Casati and Varzi (1999); 2) geographical objects, such as bays or forests, are part of the physical world, nonetheless they exist as in virtue of humans' demarcation. Concerning the first issue, a mereo-topological theory has been largely discussed and set the grounding for qualitative spatial reasoning (); this aspect will not be discussed in the present work since we do not focus on spatial relation, but mostly on human-space relations. The second aspect brings about the distinction between *bona fide* and *fiat* boundaries (Casati et al., 1998). These are respectively: i) dependent on the physical properties of an object; ii) dependent on humans' perception, decision or custom and may be social or not (Smith and Varzi, 2000). This distinction renders explicit the specificity and complexity of the geographic world, which is characterized by physical, cognitive and social phenomena. In this thesis, we mostly focus on the social dimension which, as it will be presented in the rest of the chapter, has been the least explored in literature so far.

Objects and events are dichotomized in almost all the ontologies at a foundational level. There is a general agreement indeed over the need to distinguish between endurant and perdurant (DOLCE, UFO) or continuants and occurrents (BFO). Objects are under the first category, since they are wholly present at any time they exist; events or processes fall within the latter, being only partially present at the time of their existence. However, the case of geographical objects carries some specific traits. In Galton and Mizoguchi (2009) and Grenon and Smith (2004) the pivotal role of processes to represent physical phenomena is discussed. The authors suggest the need of stronger integration in the conceptualization of objects and processes, suggesting that a mutual dependency between the two exists and, consequently, no object can exist without enacting

certain processes. This led to link the SNAP and SPAN ontologies, the first dealing with continuant entities, the latter with occurrent entities. The authors also maintain that at the levels of granularity with which specifically geographical ontologies are concerned, reality is essentially dynamic Grenon and Smith (2004). Geographic reality involves a continuous succession of physical and social processes, and these are in every case processes in or involving objects. Other foundational ontologies modularize the categories under this distinction. For example UFO is divided in UFO-A, an ontology of endurant, and UFO-B, an ontology of perdurant. Nevertheless, a third module (UFO-C), which represents social entities, makes use of both UFO-A and UFO-B categories Guizzardi et al. (2008). The need of defining the relation between objects and events is, therefore, rather recognized to represent both the geographical and the social worlds. Our work builds upon these observations, trying to link the endurant entities of the urban domain, to describe the built environment, with the much more dynamic nature of people's behaviour and their everyday life in cities. Dependent and anti-rigid entities, such as roles, are commonly used to describe the dynamic and changeable nature of reality, allowing to bridge endurant and perdurant entities through their own existence. Roles are categories very much discussed in foundational ontology and they generally emerge because of some event that makes an object play a role. In DOLCE roles have been recently distinguished between the participant and non-participant kind Masolo et al. (2011); the former emphasizes its being temporal, since it is dependent on the very occurring of an event, i.e. "passenger", the latter exists even when an event is not occurring, i.e. "teacher". Fonseca et al. (2000) used roles to integrate different geographic ontologies since roles allow him to represent the multiple, dynamic and context-dependent character of geographic objects.

Finally, the literature offers no shortage of debate around the cognitive aspects of the geographic world. This set of works concentrates not on space and spatial relations as objective entities of the world, but rather on human experience and perception of phenomena and relations in space (Mark and Frank, 1996). It implies that they stress the need of a focus change, from the space itself to the interaction between people and space. Their work has put the groundings to integrate cognitive aspects into formal models of the geographic space and they mark the emergence of the *Naive Geography* field of study. The latter

is a term coined by Egenhofer and Mark (1995) extending the idea of Naive physics to Geography; it essentially concerns the common-sense knowledge that people have about the surroundings. Identifying cognitive categories to define an ontology of geographic objects was one of the tasks these scholars undertook. An experiment they carried out is presented in Mark et al. (1999), during which ontologies have been elicited from common people; one of the results is that particularly in the case of (geographical) artifacts, functions and uses seem to be important for their conceptualization. Studies which approach the geographic domain from a cognitive perspective tend indeed to focus on activities which happen in space as the main channel for experiencing space. This very same result has been obtained in the context of an environmental psychology pilot study. Krämer (1995) presents an exploration of the cognitive classification of generic places. He pointed out that functions and activities performed in place are relevant classification criteria. Coherently with this idea, ontologies of places aimed at representing contexts from a human perspective have been often focused on activities. As Kuhn (2001) and Câmara et al. (2000) maintain, geographical space can be therefore considered as a system of entities and actions. In particular, recent advances in Geographic Information Science push towards the conceptualization of place, intended as a result of human experiences, besides space, which can be figured out as a geometrical abstraction of the geographical world.

From the literature analysis on the ontological foundations to represent the geographic world, what emerges rather clearly is that: i) the geographic domain has a multifaceted character, crossing the physical and the human aspects of reality; ii) the space-time relation characterizing natural and social phenomena play pivotal role in the context of geographic information.

4.3 Ontologies and Geographic Information Science

4.3.1 A Classification of Geographic Ontologies

Geographic ontologies have been recently classified by Tambassi (2018) as depicted in 4.1:

Figure 4.1: Geographic Ontology classification proposed by Tambassi (2018).

- Spatial Geo-ontologies (SGO) which are related to the computational processing of geographical data in GIS and GPS, and are generally aimed at analyzing (spatially) Earth's surface, locating (coordinates) and representing different geographic entities on maps, specifying the topological relations between these entities (disjunction, intersection, overlapping, inclusion, etc.) and the geometric aspects of geographical investigation (elements like points, areas, solids, taxonomies, concepts, implicit and explicit geometries and so on).
- Physical (or Natural) Geo-ontologies (PGO) are focused on those Earth aspects that are related to physical and natural phenomena (i.e. lithosphere, hydrosphere, atmosphere, pedosphere, biosphere, geomorphology, climatology and so forth).
- Human Geo-ontologies (HGO) deal with dynamics (for example, historical and temporal modifications) and artifacts produced by human activity. They are the most heterogeneous dealing with many aspects of geography such as political, administrative, social, urban, economical, population, cultural, archaeological, historical, tourism and so forth.

The thesis focuses on the last type of geographic ontologies which overlap with the spatial and physical domains but whose objective is specifically to represent the human aspects of the geographical world. Foundational studies on geographic entities presented in the previous paragraph were born when

Geographic Information Systems (GIS) were used by experts manipulating official data. Now that geographic technologies have become more user friendly and crowdsourced GI is considered a potentially crucial source of knowledge about cities, HGOs are playing an increasingly important role to support and address the challenges of this transition.

In this chapter we review the state of the art of those HGOs that are specifically related with the built environment and human activities. The reasons why we focus on the urban domain and not on the geographic domain in general (including the natural world) are the following: i) cities are the most evident result of human transformation of the environment, they are entirely created and lived by people, and HGO cannot avoid to be primarily concerned with these areas; ii) we are interested in ontologies that can be used to organise crowdsourced GI (see Chapter 2), and the information collected through crowdsourcing is mostly concentrated in urban areas; iii) human activities provide knowledge about the way people live and interact with the geographic world, this would allow a change of perspective, from the geographic objects to the people; urban areas are the most dense of population and human activities, therefore, - even if some concepts that we will present might apply to human interaction with both natural and artefactual entities - we do not focus on ontologies of non-artefactual objects.

4.3.2 Geo-Ontologies of the Built Environment

The built environment can be differently encoded within the various upper level ontologies:

- SUMO has the class *StationaryArtifact* defined as “an Artifact that has a fixed spatial location. Most instances of this Class are architectural works, e.g. the Eiffel Tower, dams, office towers, single-family houses, etc.".
- UMBEL includes elements of the built environment under the class of Facilities, a subclass of Artifact, defined as “physical places or buildings constructed by humans, such as schools, public institutions, markets, museums, amusement parks, worship places, stations, airports, ports,

carstops, lines, railroads, roads, waterways, tunnels, bridges, parks, sport facilities, monuments. All can be geospatially located. Facilities also include animal pens and enclosures and general human “activity" areas (golf course, archeology sites, etc.). Importantly Facilities include infrastructure systems such as roadways and physical networks. Facilities also include the component parts that go into making them (such as foundations, doors, windows, roofs, etc.) Facilities can also include natural structures that have been converted or used for human activities, such as occupied caves or agricultural facilities. Finally, facilities also include workplaces. Workplaces are areas of human activities, ranging from single person workstations to large aggregations of people (but which are not formal political entities)"

- GFO does not explicitly refer to elements of the built environment but they can be ascribed under the category of *Material persistants* “which are particular universals whose instances are material structures; they are related to those entities that are sometimes called continuants or objects, as apples, cars or houses. Material persistants represent the phenomenon of persistance through time of a material object." As for Material Structures they occupy a certain space-region.
- Both in UFO and DOLCE the elements of the built environment can be classified, like other objects, as endurant; nevertheless, a further specification is the class of artifacts which is present in DOLCE and defined as a physical object unified by some plan or project.

In the first decade of the 2000s, the interest in developing domain ontologies to model the built environment has grown. An European network was set up - Towntology project [†] - joining research efforts of several universities to deal with information about cities through the use of ontology models. In Berdier and Roussey (2007) the Towntology project is presented showing some case studies on urban renewal and mobility. They mostly worked on a lightweight ontology, providing terms relative to the domain but without further specifying their properties. Such an ontology has been applied to urban planning in support of communication among stakeholders as described in Métral et al. (2007)

[†] The Towntology project was a Cost Action ended in 2009 which promoted the development and use of ontologies in the domain of Urban Civil Engineering

and Kaza and Hopkins (2007). A geographic ontology involving a representation of elements of the built environment has been encoded by organizing tags used in OpenStreetMap (OSM) project (www.openstreetmap.org), which is a platform to crowdsource geographic information. The aim of OpenStreetMap is basically to create open source base maps updated by a crowd of users rather that from institutional agencies. OSMonto (Codescu et al., 2011) is an ontology which structures tags used when adding geographic features into a basic taxonomy. The result is an organized collection of the OSM tags which would facilitates users in the tagging activity. It provides a typological classification of objects composing the built environment i.e. Amenity specialized in, among others, school, restaurant, theater. The Ordnance Survey building and place ontology, that was in use until 2009, also offers such a typological classification but with a more sophisticated conceptualization of place as a topographic object having a purpose; since it refers to activities taking place somewhere, this ontology is mentioned also in the next section. More recently, Berta et al. (2016) have proposed the Urban Morphology Ontology (UMO) to evaluate alternative design scenarios based on possible changes in the urban morphology. It is composed of few top-level geometrical concepts such as Surfaces, Volumes and Lines, middle-level concepts related to the urban objects' functions and top-most types (Dwelling, Public Open Spaces) and their subclasses are more specialized types of the objects, i.e. Semi-detached house, Garden.

Besides domain ontologies, we believe that some aspects of currently used conceptual models applied to the urban domain are relevant to be mentioned. CityGML (www.citygml.org/about) is an open standard data model proposed by the Open Geospatial Consortium. It essentially represents the geometry, attributes and kinds of different 3D city objects. CityGML has also been mapped into the ontology developed by Falquet et al. (2009). In CityGML elements of the built environment are *CityObjects*. The most extended representation of city objects is in the class *GenericCityObjectType*, which extends the *CityObject* class, with features not explicitly covered by CityGML and they are: a class of the object (i.e. public building, garden, bridge), the function (i.e. dwelling, office building) and the usage in the case the actual usage differs from the intended function. The conceptualization of city objects behind this choice seem to ground them not only in a mere classification of city objects' types

or in the description of their functions, but it demonstrates the need to take into consideration the actual usage that people make of city objects. CityGML has been also integrated with the conceptual models proposed in the Infrastructure for spatial information in Europe (INSPIRE) directive. INSPIRE is an other pivotal standard for managing spatial data of the natural and urban environment; it is an European initiative, providing directives for the spatial data modelling, to reach interoperability of spatial data infrastructures across the partner countries. In the guidelines for modelling data on *Buildings* some of the properties that can be found in CityGML are implemented. In particular, even within the INSPIRE directive we found the *buildingNature* and *currentUse*, which would be the function and the usage of a cityObject in CityGML.

Other kinds of ontologies of the built environment are focused on the specifications of architectural structures' elements. Such ontologies are generally created to support architects in their planning practice (Hois et al., 2009).

Form these ontologies and conceptual models we can report that: at a foundational level city objects are generally conceptualized as artefacts; domain ontologies mostly focus on defining a taxonomy of types of the built environment's elements; standards to develop spatial data infrastructures suggest to take into consideration both the function and the actual uses of built environment's artefacts. At the same time, there are still some underestimated aspects to a comprehensive representation of the built environment: i) since elements of the built environment are artefacts, they are designed and created by someone. As a consequence, the way they are designed should be explicitly considered as the realization of the designer's intentionality; ii) the property of having functions should not be modeled as essential properties of objects of the built environment; such a choice would rule out cases when the actual uses do not comply with its function, i.e. a Stadium used for a concert, or a school as a polling station, this would significantly limit the possibility of representing real world situations.

4.3.3 Geo-Ontologies of Place and Human Activities

In geographic information science the relevance of introducing cognitive ontology based on human activities into geographic models is widely recognised

(Câmara et al., 2000; Kuhn, 2001, 2005; Montello, 2009). The argument in favour of this introduction has been the need to contextualize geographic knowledge in relation to human experiences Kuhn (2001) and *affordances* of geospatial elements (Sen, 2008; Scheider et al., 2009; Kuhn, 2003; Scheider and Janowicz, 2014). Moreover, notions of situated activity and affordance to represent the geographic domain has been matched with the design of place-based rather than space-based ontological models (Jordan et al., 1998). The difference between place and space is very well known in human geography but a formalized and machine-understandable notion of place is still missed. This is a major limit of geographic information science and GIS nowadays, which have been criticised for not being able to deal with a *platial*, besides spatial, perspective (Goodchild, 2015). Couclelis (1992) finely summarized this difference in a single phrase: “the notions of space and place can be considered as the opposite extremes of a continuum which goes from the ideal geometrical abstraction of space to the experiential world of place". As mentioned above, it is since about three decades that the GIScience community - stimulated by a recognition that digital representations of geographic information are necessarily particular models of the reality represented, not the reality itself - has been interested in giving main stage to human experiences to represent the geographic world (Montello, 2009). An extensive research program was carried out in the nineties by Mark et al. on the “naive" geography - it is already discussed in section 4.2 - opening way to a new field of study focused on the commonsense geographic knowledge. Agarwal (2004) experiments demonstrated that an intuitive and commonsense notion of place is very much context-dependent, and it is surrounded by vagueness and ambiguity (Bennett and Agarwal, 2007). Bennett and Agarwal (2007) identified some semantic categories of place from a linguistic perspective; these categories may have: non-spatial essential properties (i.e. town, country), a purely spatial character (i.e. region, point) and a meta-level function when they are used to characterize the semantic nature of more specific place (i.e. location, situation or place itself, one can say “Overlooking the river is a nice location" of “London is a place"). Vagueness seems to characterize also the very spatial boundaries of places, namely cognitive regions (Montello et al., 2014) (i.e. downtown, Northern California). Cognitive regions are delimited by fiat boundaries as for administrative spatial regions; while the former are generally vague, the

latter are exacts but may change on time.

When conceptualizing places specifically at the urban level, the role of human actions significantly enters the domain of discourse. Alazzawi et al. (2012) proposes to associate service types - used to encompass both the notions of economic and other human activities - with place types. They created the ontology by mining the web to extract pattern of place-type associated with actions. Their approach reached good results both from an user-based evaluation and in comparison with a domain ontology. In ElGindy and Abdelmoty (2014) a similar work has been done, retrieving folksonomies to populate a place ontology which relates place types with activity types. A more sophisticated and comprehensive ontological model of activities and affordances in relation to place is proposed by (Scheider and Janowicz, 2014). They maintain that place should be treated as a logical reification of involvements in potential activities (conceptualized as affordances), existing independently from the actual performing on that activity. Their objective is to provide a place referent system where the place referent, rather than being coordinates as in the spatial referent system, is the performance of the action relative to the potential activity associated with that place (to be in a place would become to perform the related action).

Some of these discussions can be found in existing ontologies and semantic resources. Top-level ontologies, hitherto, define place (when specified) as: any area with a space which may be agentive (*geopolitical entity*) or non agentive (UMBEL); a non-agentive physical or non-physical object, non-physical place is defined as a social or cognitive construction (DOLCE); it has also been specified that place, differently than space, does not need to have a spatial dimension (DUL - DOLCE + DnS) [†]. Cognitive theories have strongly influenced the development of the GUM-Space ontology aimed at representing the semantics of spatial language expressions (Bateman et al., 2010). An archived domain ontology of Buildings and Places was provided by the Ordnance Survey until 2009; it is composed by 678 classes of buildings, which are defined as fixed permanent roofed structures and places, conceived as “where something happens". The scope of this ontology was to cover the identification of such buildings and places with respect to the main activities that occur in them. A

[†]For a review of place ontologies see also Ballatore (2016)

popular resource to structure data on the Internet is *schema.org*; one of the attribute that has relatively recently added is the *potentialAction* “indicates a potential Action, which describes an idealized action in which this thing would play an ’object’ role".

4.4 The Urban Environment: Humanistic Approaches

So far we have reviewed the state of the art ontologies concerning both the built environment and the role of human activities to conceptualize place. In this section, we assess them against pillars of theories of the human and urban geography literature.

4.4.1 Designer’s Intentionality

As we have seen in Section 4.3.2 there is a significant agreement in foundational ontologies to define elements of the built environment as artefacts. However, the role played by the designer while providing specifications to build the object is not discussed. On the contrary, theories which look at the built environment through sociological and anthropological lenses, stress the socio-cultural role of architectural and urban design. Brenner et al. (2011) states that it is crucial to distinguish between the inanimate character of material objects and the intentionality of humans. In particular, architecture is not neutral but it is the result of the designer’s intentionality which is, in turn, influenced by social and cultural values; this statement can be scaled from the design of single pieces of urban furniture (i.e. hostile architecture (de Fine Licht, 2017)) or buildings (architectural styles, i.e. brutalism (Mould, 2017)) to large-scale development or revitalization strategies as shown in (Swyngedouw et al., 2003) who identify significant similarities in large-scale urban development projects across several cities in the world. Therefore, it results rather relevant to be able of distinguishing between the designer’s culturally and socially situated perspective - which in a top-down fashion attributes specific values and uses to the artefact he/she designs - and the people who live urban spaces in such

a way that can validate or subvert the uses associated with the typology of a design.

To address this duality Aldo Rossi (Rossi, 1984) introduces the notion of urban artefact, which have both an architectural typology and typicalities. Architectural typologies are characterised by the uses that the urban artefact's author intends to attribute to it, i.e. the Stadium typology is designed to be a place for playing football; typicalities concern the conventional use that people make of them. The latter has been conceptualize in terms of social practices associated with the use of an urban artefact by authors such as McFarlane (2011); Brenner and Schmid (2015); Soja (1989), i.e. a Stadium as place for doing concerts. Both typologies and typicalities characterize an urban artefact, a typology provides information about the artefact's usage which may remain only a planned usage - driving his/her design choices - and not necessarily realized in actual usages; on the contrary, typicalities emerge from the concrete uses people make of them in their everyday lives.

4.4.2 The Notion of Place: Multiplicity and Relationality

In human geography the notion of place has been longly discussed. The seeds of place theories have been covered during the second half of the seventies. In 1974 Henri Lefevbre intervention, *The production of space* (Lefebvre, 1991), proposed a comprehensive theory of (social) space. It unifies three interacting spheres — the mental, social, and physical — into a conceptualization of what space is. He distinguished between the *conceived* space - ordered and articulated by urban planners -, the *perceived* space - which is the space of everyday practices - and the *representational* space - lived at a mental level (Pierce and Martin, 2015). While Lefvebre referred to social space, rather than place, his theory radically reversed previous conceptualizations in geographical thinking which conceived space as a mere container of spatial phenomena. (Social) space, after Lefevbre, becomes dialectically produced by its constant interaction with the people and society. His theory has been echoed by Soja (1989), as well as by many post-structuralist geographers Murdoch (2005), and re-elaborated under the notion of relational place by scholars such as Massey (1994) and Cresswell (2013). These authors, respectively, stressed

the role of situated social practices as a driver to the production of (social) space (Soja, 1989) and the need to embrace a multiplicity of social and cultural meanings in defining places (Massey, 2005; Cresswell, 2013). Contemporary of Lefevbre, two very influential authors have contributed to the definition of place in human geography, Yi-Fu Tuan Tuan (1979) and Edward Relph Relph (1976). The first frames the notion of place at an experiential level, which ranges sensations (smell, taste, touch), visual perceptions and conception - intended as an "indirect mode of symbolization" Tuan (1979). Relph (1976) introduced the idea of *placelessness* as a consequence of places standardization and uniformity, pushing towards a detachment of places from their cultural and social settings Relph (1976). From these theories the multiplicity of uses and meanings seem to be essential to identify a place as such. Furthermore, this multiplicity derives from a constant interaction between people, with their intrinsic social and cultural diversity, and urban artefacts. Such a notion of place takes a clear relational stance since it entails people spatial behaviors into the very definition of what a place is.

4.4.3 Social Practices

The concept of social practice has already been mentioned above. Broadly speaking, when the term comes to geography it refers to the everyday activities and ways of doing that take place somewhere, and that aggregate people into groups which share common habits. The function of social practices in the characterization of urban areas is synthesized by Brenner and Schmid (2015):

"Urban space is defined by the people who use, appropriate and transform it through their daily routines and practices, which frequently involve struggles regarding the very form and content of the urban itself, at once as a site and stake of social experience. The qualities of urban space, across diverse locations, are thus also embedded within and reproduced through everyday experiences, which in turn crystallize longer term processes of socialization that are materialized within built environments and territorial arrangements."

Social practices and the everyday experiences of people are proxies to understand place meanings from a social perspective. Differences and hierarchies in societies are reproduced through the material arrangements of the built

environment Gieryn (2000). The impact it has on shaping people behaviour is recognizable by looking at social practices, which can be seen as conventional and recurrent behavioural patterns. Differently from affordances, which undoubtedly play a crucial role in the process, social practices add a social dimension to the cognitive one; it means that answering the question “what can I do there?" is not only a matter of what I perceive possible to be done, but also of what the societal structure tells me is acceptable. Note that the acceptability of social practices is not the result of a vertical relation between institutions and people, it spreads horizontally through social influence within social collectives, carriers of the practice. Social practice theories have been often applied to frame geography research lately.

4.5 Constructing an Ontology for Socially-aware Geographic Applications

While cognitive aspects have been discussed in geographic information science, from the state of art review, it turned out that the social facet of the urban environment has been mostly neglected in geographic ontologies or handled by introducing the category of geopolitical (or conventional [†]) entity. On the contrary, human and social geographers, have extensively explored the notion of place and the dynamics underneath the urban fabric through their social dimension. We believe that an ontological clarification - resulting in a computational ontology - of the concepts required to represent the urban domain from a social perspective might bridge the two approaches, and support the developing of more *socially-aware* applications to frame data and information provided by a crowd of people.

To this reason we propose an ontology of the urban domain with an explicit social bias, which scales the reasoning from physical objects and individuals' perceptions to urban artefact's design and social practices. Analysis of literature on ontologies and geographic information has been assessed against social theories coming from the humanities about place and the urban environment. We identify two main intersecting semantic facets of the urban domain to

[†] see Couclelis (2010)

deal with social aspects of places: on the one hand, an **artefactual facet** - the built environment composed by urban artefacts - on the other, a **behavioural facet** - the people living the city. These two semantic facets intersect into relational concepts such as roles. Roles played by urban artefacts emerge in the context of human actions and social practices. This provides the groundings to conceptualize the ***Geographic Object of Discourse*** (Couclelis, 2010) that we want to model in the ontology. In a modern interpretation, objects of discourse can have four distinct level of meanings: the *formal* dimension, what kind of object something is; the *constitutive*, what the object is made of and how its parts are connected; the *agentive* dimension, the roles of objects as agent in a process; the *telic* dimension, the purpose of things. The formal, constitutive and telic dimensions concern the artefactual facet of the urban environment, since we refer to objects that are created by human agents and its very constitution is encoded in their design as well as its purposes; regarding roles that elements of the built environment have, we maintain they should be more clearly conceptualized as a result of the different ways people live the city; our argument indeed - in line with humanistic literature on places and urban contexts - is that from a human-centric perspective, social aspects of places emerge from peoples' experiences and play a crucial role to the construction of geographic knowledge. To have a simple demonstration of this - besides the body of study presented in Section 4.4 - we can compare two kinds of description of the same place: Camden Market (London). The Wikipedia page on Camden Market starts by defining it as "number of adjoining large retail markets in Camden Town" (formal and constitutive dimensions), it follows that the market operates to sell different types of products (telic dimension): "among products sold on the stalls are crafts, clothing, bric-a-brac, and fast food". From a more bottom-up perspective we may take as example the memories posted by Guardian's readers about the same place [†]. In these brief texts no one mentioned the formal, constitutive and only few the telic dimensions of Camden Market, on the contrary, to say what the place meant to them, they extensively refer to their experiences and the role the place had in those experiences: "Camden Lock was where we met friends and made new ones",

[†]The integral version is available at the following link: https://www.theguardian.com/cities/2016/dec/07/londons-subcultures-readers-memories-stories-camden-market-redevelopment

“Camden became my nexus. I would head down there on Sunday nights to be part of a safe place"; furthermore, that particular place is remembered as being the “mecca" for the subcultures of that time and, one criterion to point out how the place changed is that it has been increasingly populated by “tourists" (“Sadly, slowly, things began to change. The number of tourists multiplied, and the corporate places and tourist shops began to move in"). These brief extracts exemplifies that non essential properties (roles) of Camden Market (as its being a meeting place) are the ones that mostly matter from the people viewpoints; moreover, these roles generally conflate the social insofar they refer to specific social groups inhabiting them.

4.6 Conclusions

For Schuurman (2006) taking into consideration the dynamic and complex meanings which spatial objects embed calls for the recognition that a multiple dimensionality needs to be incorporated and operationalized in GIS science thinking. Goodchild and Li (2011) underlines that place can be ranked among other spatial concepts (i.e. location, distance, spatial heterogeneity) dealing with physical phenomena distributed in space and time, or - as social scientists do - it can be conceived as a relational and dependent entity which emerges from contexts of interaction between people and their environment. Acknowledging the relationality characterizing the urban environment from a social perspective within an ontological framework can be a preliminary step to tackle the dynamic and social nature of the human-places relation Ballatore (2016). The practical implication of this stands in the possibility to deal with the social nature of crowdsourced information and to provide systems able to characterize the urban environment without neglecting existing social differences in the way cities are lived.

The next Chapters will present and analyse the concepts introduced here.

Chapter 5

From Artefacts to Urban Artefacts.

5.1 Introduction

The central concern of this Chapter is to introduce and define concepts which enable an ontology representation of the urban fabric. Such an ontology has to be constituted by entities conceptualizing the artefactual rather than natural world objects. The urban fabric, indeed, is composed by human-made physical objects, namely urban artefacts. In this Chapter we will build upon the general conceptualization of artefact to specialize it in the concept of urban artefact, providing a proposal for an ontology design pattern to model urban artefacts.

5.2 The ontological analysis of Artefacts

The ontological analysis of artefacts has been the object of a rich discussion in the fields of philosophical and formal ontologies. Even though there is a general agreement in considering artefacts as results of one ore more agents' creation - as Zalta and Hilpinen (2004) puts it "an object is an artefact if and only if it has an author" - their ontological status is still debated. The *hard* problem (Houkes and Meijers, 2006) of artefacts stands in their "dual nature", that is in their being at the same time amounts of matter and functional objects. This has brought some scholars to question their very existence, mirroring the more general problem of the existence of physical objects. A common example of this problem is the case of a statue made out of a lump of clay: the lump of clay and the statue must be distinguishable entities, amount of matter and physical object respectively; but this brings to the conclusion that two different entities co-exist in the same region of space. Some philosophers, to avoid this closure, rejected the existence of physical objects as individual entities (Franssen et al., 2013), claiming that artefacts too do not have any ontological status. Among those who accept the existence of physical objects a similar discussion takes place about artefacts' identity. In particular, examples of physical objects are animals, persons, rivers; in these cases it is possible to identify some unity principles that allow to conceptualize objects as a whole, as dictated by the laws of nature (Franssen et al., 2013) or, as proposed in (Galton and Mizoguchi, 2009), in their mutual dependence with processes and events.

On the contrary, the nature of artefacts has complicated the debate in that they are essentially human-made and therefore do not hold any natural explanation that characterizes their existence, as is the case with natural objects. “David Wiggins emphasized this by defining “artefact" as an object that has some unity with respect to its composing matter, but lacks a clear principle of unity or organisation dictated by the laws of nature" (Franssen et al., 2013). As a consequence, a crucial issue regarding the metaphysics of artefacts, which have crossed the field of formal ontologies, concerns the recognition or not of an existential dependence of artefacts from the mind and intentions of humans.

Regarding the way studies in formal ontologies tackle the conceptualization of artefact, we will mostly refer to the work by Borgo and Vieu (2009), which has been expanded to account for *technical artefacts* in Borgo et al. (2009, 2014); Kassel (2010), and by Guarino (2014). The works by Borgo and Vieu (2009) and Guarino (2014) are presented to show two perspectives on the formalization of artefacts which mainly differ in the role attributed to intentionality in their constitution. In Borgo and Vieu (2009) artefacts are modelled as the result of an intentional selection of their creators. In their view, an intentional selection is a mental event that *creates* an artefact, in such a way that if an agent takes a pebble to use it as a paperweight, an artefact is created as soon as it has been selected. In their formulation artefacts have the following characteristics:

- “the essence of any artefact lies in the creator’s intention"; furthermore, the agent’s intention, underlying the creation of an artefact, is to obtain an entity suitable for a particular purpose and not directly aimed at physically modifying some pre-existing entity;
- an artefact is created by a mental event which produces distinguishable and stratified co-located entities; therefore the pebble, which has been intentionally selected by an agent to be used as a paperweight, is at the same time an amount of matter, a physical object and an artefact;
- artefacts have qualities that can be defined as *capacity* and *attributed capacity*. The former is associated with the physical object’s quality, while the latter is the quality resulting from the intentional selection.

Using the same example, the capacity of the paperweight is to have the pebble's weight, while its attributed capacity is to hold paper down;

- artefacts can be repaired preserving the same identity by virtue of the intentional aspects of the attributed capacity.

In Borgo et al. (2014), the notion of artefact has been extended to account for technical artefacts providing three definitions:

1. Ontological artefact. A technical artefact *a* is a physical object which an agent (or group of agents) creates by two, possibly concurrent, intentional acts: the selection of a material entity (as the only constituent of *a*) and the attribution to *a* of a technical quality.

2. Engineering artefact. A technical artefact *a* is a physical object *a* created by an intentionally performed production process. The process is intentionally performed by one or more agents with the goal of producing the object *a* which is expected to realize an intended behaviour in some given generic technical situation, and the object *a* can realize to some extent that intended behaviour and/or has a property which supports that behaviour.

3. Technological artefact. A technical artefact *a* is a physical object which is, firstly, created by the carrying out by an agent (or group of agents) of a make plan for a physical object with a physical description id, and for which, secondly, a use plan exists.

Guarino (2014) criticised the emphasis on intentional selection and introduced the category of artefactual object, comprising objects which are the realisation of a specific design. Doing so he claimed that not all artefactual objects are also artefacts resulting from an intentional selection, i.e. there are pens that do not work, so they are not intentionally selected, but they still must be considered as artefactual objects, even if not artefacts. Also, he introduces the concept of artefactual role which depends on the actual use of an object, that can also be played by non-artefact, i.e. natural objects. Therefore, to Guarino (2014) artefactual objects are entities whose essence lies not in their mere capacity to fulfill a certain function, but rather in the way an attributed capacity is obtained as a result of a rational design process encoded in design

specifications. The property of *being an artefact* in Guarino (2014) does not satisfy the conditions for an object to be considered a genuine ontological category. On the contrary, it seems to be an anti-rigid property, in the sense that it is accidental for all its instances and not just for some of them. Therefore, he claims that a distinction between the artefactual type and its artefactual role is needed, and it is only the latter which includes the objects that are accidentally used as artefacts. In the case of the pebble example, it only plays an artefactual role but it is not an artefact in itself, while an artefactual object instantiates an artefactual type only if it has been properly designed to be used in a certain way (resulting from an intentional design action of the author/s). Following the example, this will be an object properly designed to fulfil the function of a paperweight. Comparing the concept of artefactual object in Guarino (2014) to the more specific notion of *technological artefact* provided in Borgo et al. (2014), the two perspectives tend to approach a common view. In particular, they overlap insofar a technological artefact needs to be provided with a make plan and a use plan, and the essence of an artefactual object lies in its design features encoded in design specifications. At the same time, excluding intentional selection as the criterion for creating an artefact, has pushed towards the recognition of the artefactual roles that every kind of object may play, to model a situation where a non-artefactual object is used as an artefact (i.e. a pebble).

5.3 From Artefacts to Urban Artefacts

The urban fabric is composed of artefactural objects; to specify and frame artefacts within the urban domain we introduce the notion of urban artefact. The term urban artefact firstly appeared in Aldo Rossi's 1966 book "The architecture of the city". In his theory, he found the notion of urban artefact as pivotal to express that the elements of the built environment are essentially compliant with an architectural typology, but their realised uses go far beyond those planned by its designer. His contribution stands in explicitly contrasting the idea of an urban artefact as merely resulting from the intentional act of its designer, with its being a *collective urban fact*, in the sense that it is used and experienced to fulfill several cultural and social purposes. Taking

inspiration from Rossi's work we conceptualize urban artefacts both in terms of their fix character - an architectural typology - and their dynamic nature - their multiple roles. To ground urban artefacts in the broader literature about artefacts we can start asserting that urban artefacts normally originate from an act of rational design and intentional construction, according with the notion of technological artefact introduced in Borgo et al. (2014). In its constitution an urban artefact, indeed, is the result of one or more designers who plan and organize the composition of several elements as compliant to certain architectural typology. This is the case, for example, of "residential block", "office block", "hospital", "school". All these are examples of architectural typologies that make explicit the general aggregation rules of several physical objects, and guide the realization of an urban artefact. These aggregation rules are encoded in detail within the urban design specifications, therefore, they can also be considered as artefactual objects in line with Guarino (2014). Furthermore, we stress that the essence of an urban artefact does not lie in its capacity to fulfill a function (nor on its being intentionally selected) but it has to result from a rational design encoded in some design specifications; however, since an urban artefact, as every other technical artefact, is realized to be used in some ways, it makes sense to assume that it is associated with certain planned uses.

Design choices, indeed, are crucial in determining the uses of an artefact, and sometimes they also exclude some uses. Examples like these are generally known under the term of *defensive* or *hostile* architecture, emphasising the social impact that design choices can have as exclusive for certain social categories, i.e. anti-homeless design showed in Figure 5.3. This brought some scholars to explore the possibility that artefacts may embed values (Van de Poel and Kroes, 2014). Van de Poel and Kroes (2014) propose to rebut the neutrality thesis about technical artefacts in light of several examples; among them they also mention the rather debated case of an urban artefact committed by Robert Moses in the thirties. The case is discussed in Winner (1980), the artefact in question is an overpass which, as shown in Figure 5.2, was extraordinary low to prevent public transport to reach the beaches. Moses was accused to have intentionally designed the overpass to only allow cars to pass through, deliberately making it impossible for African-Americans, who predominantly did not own cars and travelled by bus, to visit the beaches. Van de Poel and

Figure 5.1: Examples of hostile architecture.

Kroes (2014) believes that "it makes sense to say that the overpass embodies the disvalue of racism". The same is valid with positive values, i.e. green buildings embody the value of pursuing environmental sustainability. In Van de Poel and Kroes (2014) elaboration there are three possible values associated with an artefact: *intended* when related to the intentionality of a designer, *embodied* inferred by realised values, and *realised* when the value is realised in user practices. On one hand Van de Poel and Kroes (2014) proposal enriches our characterization of urban artefacts mainly in two respects: 1) it criticises the neutrality of artefacts' design in terms of values, whereas assuming the neutrality of urban artefacts' design the very real cases mentioned before would not have been properly modelled; 2) it stresses that values are not necessarily realised in practice by introducing their specialization as *realised* values or, viceversa, realised values are not necessarily intended. On the other hand, whether the values are embodied or not in the urban artefact concerns a much broader debate about the case for extending agency to physical objects. Our position is to retain the stance of a first wave of scholars pointing out that artefacts have agency only in a secondary sense, while all agree that agency remains primarily with the human designers and users (Mitcham, 2014). This will impact our modelling choices, as we will discuss also in the next chapter, insofar we introduce roles as played by artefacts representing their *secondary* agency; the agency of urban artefact is secondary since it is dependent on its relation with living beings [†].

[†] This restriction can be relaxed while talking about the agency of physical objects in i.e. Internet

Figure 5.2: Palmer Avenue Bridge, Bronx River Parkway, 1927

At the same time, values should be distinguished from normative constraints related to the deontic domain, which are also particularly relevant to the characterization of urban artefacts. Regulations, indeed, are also associated with the design of urban artefacts, i.e. a park where it is illegal to step on the grass.

5.4 Defining Urban Artefacts

We conceive an urban artefact as a component of the urban fabric, formed by physical objects and/or amounts of matter, shaped and organized in order to satisfy some design specifications. Design specifications provide details for the realization of an urban artefact and are related to specific architectural typology, i.e. architectural layouts for school, hospital, airport. Such specifications may deal with different kinds of information, including:

- Design constraints concerning the physical structure of the urban artefact and its physical qualities;
- Planned use scenarios in terms of modes of deployment, i.e., how an urban artefact is supposed to be used or exploited; this is influenced by the purpose of the architectural typology which prototypes the specifications.
- Normative constraints concerning forbidden uses or explicit use rights allowed to specific classes of users. For instance, a park may include a playground where children may play, or where only children may play, and a green area where to keep off the grass.
- Values generated by the urban designer intent, which are incommensurable values and they may be positive (i.e. sustainability) or negative (i.e. exclusion).

of Things paradigm; however, to the purpose of this thesis we would clarify our distance to some scholars, mostly in philosophy, sociology and urban geography proposing an *agential realism* that claim the existence of artefacts only in virtue of its relation with the social, see Leonardi (2013); while to us an artefact keeps its identity even if it is not used at all in virtue of its design specifications.

We shall assume that a design specification characterizes an urban artefact depending on an architectural typology, which is a prototypical design of architectural and urban interest, and has a specific purpose expressed in terms of planned uses. Once an artefact has a design prototyping a certain architectural typology it also instantiates the urban artefact type - whose planned uses are the same provided by its architectural typology - and it remains so for all its lifespan, i.e., until some disruptive change occurs, such as the destruction of the physical object that composes the artefact, or the modification of one of its core designed characteristics. In both cases, the original artefact ceases to exist while a new one with different design specifications may appear (i.e. the conversion of an old hospital in a residential building, of a church in a pub). As a consequence, urban artefacts need to be identified by an ID; it should be possible, indeed, to have co-located urban artefacts constituted by the very same physical object, whose identity - at least under DOLCE definition of physical objects - is given by the location. Note also that planned uses of an urban artefact concern changes in the specific urban design that characterize it: when the urban artefact is modified in its core features it does not enable anymore the planned uses. To model changes in the actual and temporary uses of an urban artefact we will employ roles theory as it will be presented in more detail in Chapter 7. Of course, design specifications can be described at different levels of detail: in general each specification is associated to an urban type, which may be further specialized in several variations. In principle, once a design is completely specified, it may be realized by multiple physical objects (say, multiple buildings with the same design), but often urban artefacts are realized just once. According to DOLCE, design specifications are descriptions, which are a kind of abstract entities, while urban artefacts are physical objects, and more exactly non-agentive physical objects (NAPO), at least in the typical case. In turn, physical objects are a subclass of endurants (entities that persist in time by keeping all their parts present at each time), and are distinguished from amounts of matter (M) since their identity depends on a specific structure, and not just on the parts they are composed of. Like physical objects, all urban artefacts have a spatial location, which is a geo-referenced quality, since its quality space is associated with a geographic coordinate system (GCS). However, if we aim to model finer changes in the evolution of the city, and in particular changes caused by social practices, this view needs to be

enriched with a more flexible classification, where an object of urban interest can change its status depending on the context. An urban artefact, which is often a system of both artefacts and natural objects (buildings, benches and trees), can be observed at different levels of granularity: sometimes the square is the focus, in other cases the focus is the neighbourhood of which the square is just a component. In the latter case, the benches or the trees in the square may not be considered as elements of the larger urban artefact just because, at a coarser granularity, the square may be considered as atomic. In particular, the unity principle of an urban artefact stands in its design, which can be related to different geospatial scales.

5.5 An Ontology Design Pattern of Urban Artefacts

In this section we explore the possibility of an ontology pattern to represent urban artefacts based on the discussion presented above. The pattern mainly concerns the definition of two entities: Urban Artefact and Urban Design Specification, while artefactual roles and the context which they depend on will be detailed in the next Chapters.

5.5.1 Competency Questions

Competency questions of this pattern are the following:

- Which is the design specification of an urban artefact?
- What is the architectural typology prototyped in the design specification of an urban artefact and what are its planned uses?
- Who created the urban design specification of an urban artefact?
- What are the values and the legal regulations associated with an urban artefact?

5.5.2 Classes and Properties Description

The ontology pattern reuses some of DOLCE Lite Plus 3.9 entities such as:

Rational-agent: “Either a rational physical object (e.g. a person capable of meta-representations), or a social object acted by a rational physical object (e.g. an organization)." A rational-physical-object is encoded as having the ability to internally represent meta-descriptions (descriptions that have other descriptions playing roles used by them). Other theories of rational agency assume desires and intentions for these objects, but in principle any agent can have desires and intentions: the very difference seems to be the ability to choose among different desires or intentions by going ’meta-level’."

Physical Quality: “A quality inherent in a physical endurant."

Spatial Location Q: “A physical quality, q-located in (whose value is given within) ordinary spaces (geographical coordinates, cosmological positions, anatomical axes, etc.)."

and it introduces the following new entities:

Urban Artefact: “A system of material artefacts which has a spatial location or spatio-temporal location quality whose components are unified by urban design specifications."

Architectural typology: ‘A prototypical architectural layout that provides information about the necessary elements an urban artefact must have to enable certain planned usages. Urban artefact planned usages i.e. dwelling, working, teaching etc. are the purpose of an architectural typology i.e. office block, residential estate, educational establishment etc."

Urban Design Specification: “A detailed description of the urban artefact created by a rational agent which can be a professional designer, an architecture firm, or a non professional group of people (or a person) whose intention is to realize an urban artefact, i.e. an informal settlement. It needs to prototype an architectural typology which refers to some intended uses of the urban artefact. Furthermore, an urban design specification may have some Intended Values and refer to Urban Regulations."

Urban Regulation: “A description containing norms which regulate either the physical characteristic of an urban artefact and its possible and/or forbidden use."

Urban Artefact Planned Usage: “Planned usages express the purpose of an architectural typology, i.e. dwelling for the Residential house typology, and influence the design of an urban artefact which has to enable those usages."

Urban Design Intended Value: “Social and ethical incommensurable values, positive, i.e. environmental sustainability, regeneration, social inclusion, or negative, i.e. defensive, hostile, that motivated the design practice; they are not considered intrinsic values of an object, even if the topic is debated, but they are attributed to the object by mean of its design."

Spatiotemporal Location Q: “A physical quality, q-located in (whose value is given within) ordinary spaces (geographical coordinates, cosmological positions, anatomical axes, etc.) and time."

5.5.3 Diagram Presentation

Figure 5.3 depicts in the form of a diagram the Urban Artefact ODP we propose.

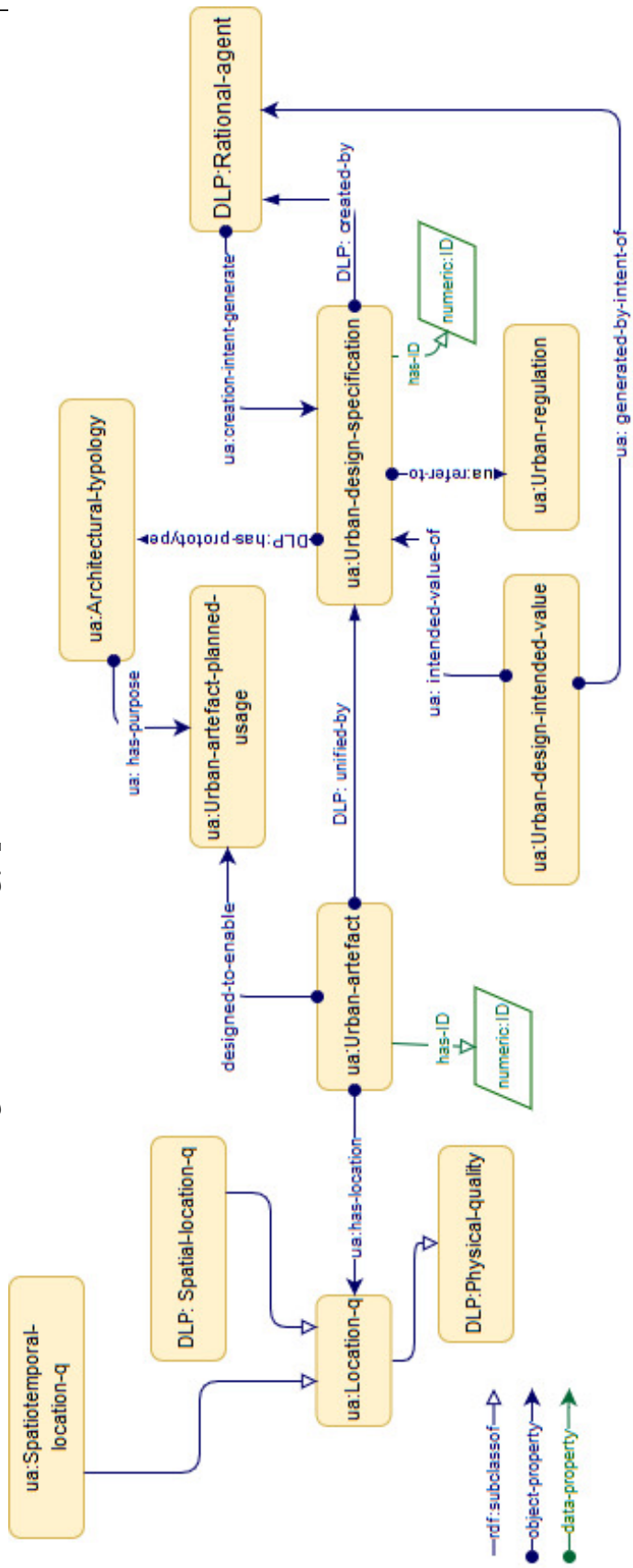
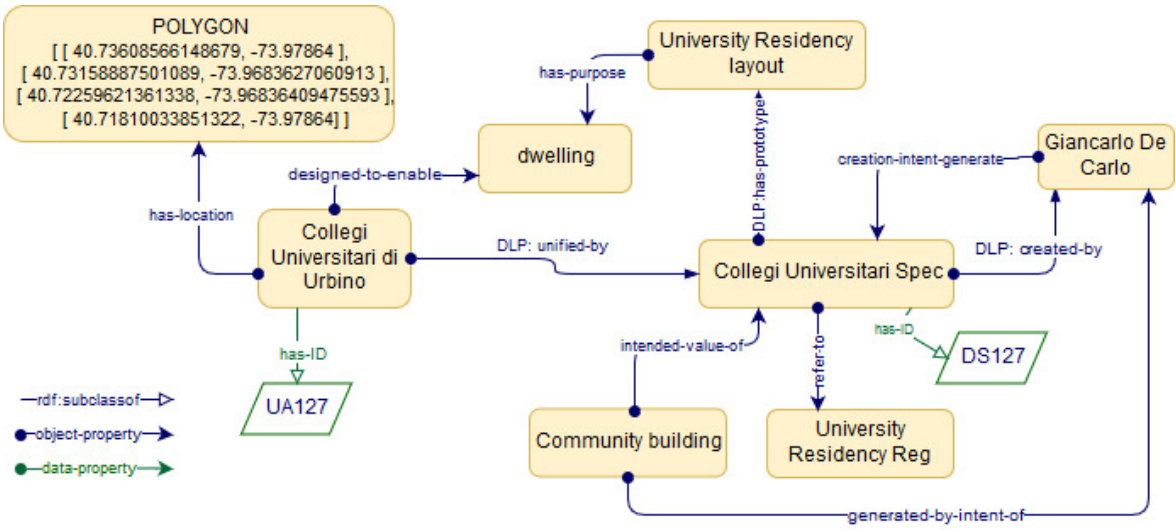


Figure 5.3: Ontology pattern of urban artefact.

Figure 5.4: Sample use of the Urban Artefact Ontology Design Pattern. A model of the “Collegi Universitari di Urbino" by Giancarlo De Carlo.



5.5.4 Sample ODP Usage

Through this ontology pattern is possible to model elements of the urban fabric. Figure 5.4 graphically reports a possible use of the ODP. *Collegi Universitari di Urbino* is an University Residency designed by Giancarlo De Carlo, a famous Italian architect. The structure enables its planned use, that of dwelling, which is the general purpose of University residencies. The latter is the architectural typology which prototypes - provides the general characteristics - the design specifications created by the architect. In encoding specifications of the residency design Giancarlo De Carlo has focused on providing spaces for collective activities. The attention given to these spaces is not accidental but the result of designer intention to embed the value of community building in its design.

5.6 Conclusions

We believe that introducing the notion of urban artefact can boost the broader discussion about artefacts with new insights related to a particular class of artefacts. At the same time, while different kinds of artefacts have already been objects of research, namely technical (Kassel, 2010), digital (Kallinikos et al., 2013) cognitive (Heersmink, 2016), the specific nature of urban artefact remains still an understudied area. Our work opens the way for further discussions. Moreover, urban artefacts are the basic elements of the urban fabric but their formalization in existing related work ontologies for describing places has been underestimated, leaving the task to approach seeking a technical perspective, generally pursued with application ontology, to architectural buildings. So far, our modelling choices reflect a rather traditional way to conceptualize objects of the urban fabric, focusing mostly on the build environment rather than on the interaction of the people with the built environment. To pave the way for modelling and characterizing possible unplanned uses of an urban artefact, i.e. a school used for a theatrical performance, through the notion of roles that will be presented in the next chapter. We believe that it is in the use relation between people and the physical structures that a conceptualization of the urban environment may emerge more clearly in its social dimension.

Chapter 6

Urban Artefacts Roles

6.1 Introduction

In this Chapter we extend the work presented in Chapter 4 specifying the roles urban artefacts may play. The aim of this Chapter is to render explicit the semantics behind the interaction between people and urban artefacts. From the ontological analysis of urban artefacts, indeed, emerged the necessity to distinguish between the planned uses of a urban artefact - deriving from the purpose of a certain architectural typology -, and the actual uses that people make of that urban artefact. Roles theory provides the grounding to model a dynamic classification of urban artefacts depending on the way they are used by people. In the first part of the Chapter, definitions and classifications of roles are described with a specific focus on social roles. Then, the notion of urban artefact roles is introduced in two declinations: as a participation role and as a social role. Finally, urban artefacts roles are specialized to distinguish between two possible situations: when the actual use is compliant with the use planned by design, a role of functional place emerges, and when the actual use is not compliant with the use planned by design, a role of social place emerges.

6.2 Roles and Social roles

Roles in ontology engineering have served the modelling of very different situations and even if there are still many open issues in the definition of roles, some general agreed characteristics, following Mizoguchi et al. (2007), can be summarized as:

1. Roles are anti-rigid: a role can be played or not by a role-player without influencing its existence i.e. John can stop playing the role of student but he does not cease to exist as a person;
2. Roles are dynamic: they can be played by more than one role-player simultaneously, and a role-player can play more than one role;

3. Roles depend on extrinsic (relational) properties, or on contexts, therefore they necessarily need some external concepts to define them (roles are externally founded);

While the characteristics of being anti-rigid and dynamic of roles seem to be broadly accepted[†], their dependence on contexts produces various elaboration of different types of roles. In particular, there is no agreement among scholars on the very definition of context: contexts have been i) generally considered as related with role by a *role-of* relation (Loebe, 2005); ii) explicitly codified as descriptions (Masolo et al., 2004) (i.e. the social role of Italian prime minister is defined by a description which is the Italian Constitution); iii) defined as either objects (i.e. the role of *school-teacher* depends on the object *school*), or occurrent - process or event - (i.e. the role of *speaker* is dependent on the act of speaking (Mizoguchi et al., 2015)); iv) a pattern of relationships that allows the dependence on external properties (i.e. being a student is defined on the basis of being enrolled in, being a person, and being a university (Masolo et al., 2005)).

From these different conceptualizations about the nature of the external dependence of roles derive various classifications of role types, such as the one proposed by (Loebe, 2005). The authors distinguish between: 1) *relational roles* where the role is seen as a special and contingent quality of its player, externally dependent on a context which is the relation between the two - i.e. John is medically treated by Sue, therefore John is playing the role of being a patient (John-qua-patient) and Sue is playing the role of being the doctor (John-qua-doctor) in virtue of the relation *medical treatment* between John and Sue; 2) *processual roles*, corresponding to the way a single participant behaves in some process, in this case the relation with the context can be considered as a *part-of* relation of the role-player in the process - i.e. John is moving a pen, both John and the pen are role-players in terms of John as mover and the pen as moved in the context of the process of moving - other examples of processual roles may include heart-body, car-engine; 3) *social roles* which, differently from the others that are considered as qualities of their players, are defined as social objects depending on a social context, which is

[†] There is a proposal of considering roles as rigid universal in (Wieringa et al., 1995) which is critically discussed in Guizzardi (2005).

not further specified. As a consequence, only social roles bear the possibility of different entity individuals playing the same social role individual - i.e. the Italian prime minister is an individual of social role that can be played by either Silvio Berlusconi or Matteo Renzi.

Another classification can be found in Mizoguchi et al. (2015), who distinguishes between object and occurrent roles, depending on an object context and event or process context respectively - i.e. front-wheel is the object-role played by a wheel in the context of a bicycle, while murderer is the occurent-role played by a person depending on the murdering context. In Masolo et al. (2011) the role kinds are classified as participation-roles or non-participation-roles. The former stresses the participation of an entity in an event to play a role, i.e. passenger. This kind of role is temporally dependent on the event. The latter is founded in a relation that does not involve the participation in an event - i.e. citizen, student, teacher: these roles exist on the basis of an event, i.e. having a passport, being enrolled, working in a school, but it is not necessarily the case that the role is being played at the time of the event. The most typical non-participation role is the social role. Social roles are discussed in Masolo et al. (2004) as reified anti-rigid, dynamic and founded properties of entities.

Having briefly summarized the conceptualization of roles that are broadly discussed in the field of ontology engineering, we now introduce artefacts role and our proposal about how urban artefact roles can be characterized.

6.3 Artefact Roles and Urban Artefact Roles

In Mizoguchi et al. (2012) an artefact role is introduced as subclass of occurrent-role and externally-founded role. In the authors' view the role played by an artefact is dependent on an occurrent, either an event or a process. Similarly, in Guarino (2014), artefactual roles are played depending on the use that is made of a physical object, which does not need to be an artefact - i.e. a branch of a tree can be used for sitting, playing a chair-role. As a consequence, the artefact role of being a sitting chair should be considered as dependent not on the design of the artefact-chair, enabling the planned use of sitting which

is the purpose of a chair, but on the sitting event. Such an artefact role can be classified as an occurrent-role Mizoguchi et al. (2012) or as a participation-role Masolo et al. (2011) but it may not be enough to represent the ways artefact roles, and consequently urban artefact roles, can be conceptualized. In particular, we propose to keep the distinction between participation and social roles also when they are specialised into urban artefact roles. Note that our conceptualization of participation roles resembles the *processual roles* described in Guizzardi et al. (2016).

Broadly, urban artefact role concerns a kind physical objects' usage which is related with an architectural typology, i.e. dwelling place, dining place, educational place etc. The need of introducing roles lies in the multiplicity of uses and relational character which can be ascribed to places in general and, therefore, to urban artefacts. As discussed in the previous Chapter, all urban artefacts should enable at least a kind of usage, in particular the one (or many) related to the architectural typology which prototypes their design specifications. However, the actual usage of an urban artefact goes much beyond the ones planned by design. Modelling urban artefact roles allows to overcome limits of a rigid typological classification of urban artefacts in virtue of a more dynamic and action-driven conceptualization of the urban fabric. For example, we can compare the following two properties an urban artefact may have: being an *Enrolling Place* and being a *University*. According to Aldo Rossi's idea of typology, urban artefacts are designed to follow certain typological architectural layouts; in line with this view, the being an *University* should have to do mainly with the urban artefact design specifications working as unity criteria to consider that physical object as a whole prototyped by a university layout - which enable the performing of some planned usages. Being an *Enrolling Place* at a first sight could be considered an essential - hold by all its instances - and rigid - valid for all its existence - property of the *University*, however, it would rule out cases when, for example, a university is temporarily suspending its activities such as the one of enrolling. To harmonize our ontological model with the dynamic and social character of the urban environment we favor the view in which being an *Enrolling Place* is a role - therefore an anti-rigid and non essential property - of urban artefacts; it may also be the case that an urban artefact designed to be a *University* must be temporally closed for renovation and the enrolling activity of the very

same university is managed into unused public offices. At the same time, we assume that the kind of knowledge which mostly matters for people is not the “typological" one but that which emerge from the actual usage of urban artefacts.

Given these premises we can now consider the two following cases when an university might be playing an enrolling place[†]: 1) *university x* is participating in an *enrolling* event; 2) *university x* is not participating in an *enrolling* event but it generally does. Both the cases are representative of real world situations where an urban artefact plays a role but they should be differently conceptualized. In particular, we argue that they refer respectively to different kinds of role:

1. in the case one *university x* is instantiating an occurrent-dependent or participation role;
2. in the case two *university x* is instantiating a social role, which is a non-participation role;

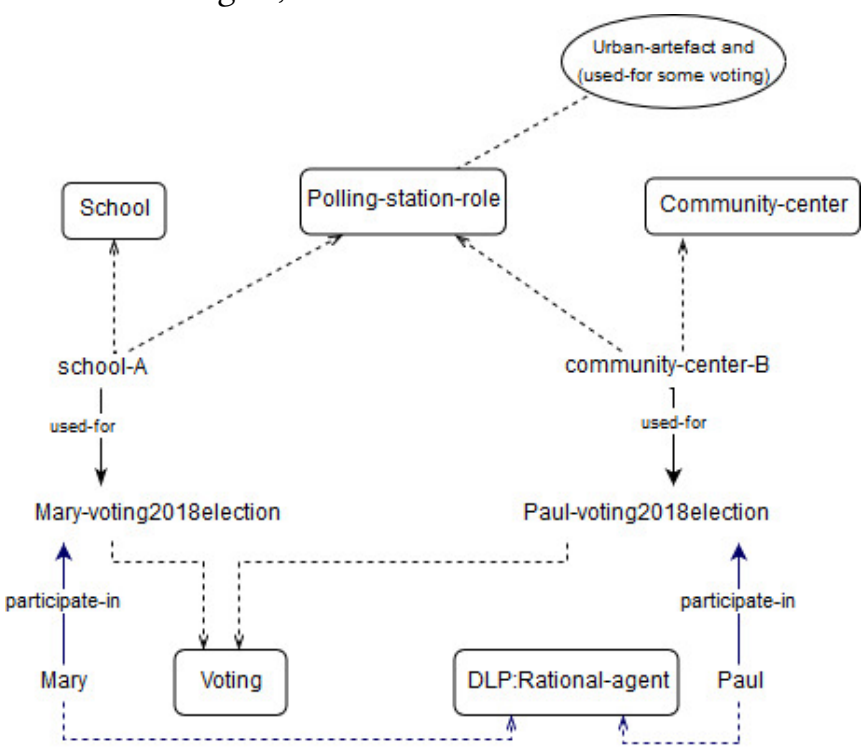
In the next sections we will detail these cases providing further examples.

6.3.1 Urban Artefact Roles as Participation Roles

Participation roles in the case of urban artefacts are particularly useful to describe the many possible cases of temporary uses of different types of urban artefacts. This kind of role is dependent on the occurring of a participation relation with a perdurant in which the urban artefact - to instantiate the role - has to be involved. We assume that a temporary use of an urban artefact (i.e. a school used as hospital during a war or as polling station during elections) does not affect its type insofar its design specifications have not been critically changed.

[†]Note that the playing relation between an object and the role is conceived as an instantiation relation dependent on a contextual condition.

Figure 6.1: Urban artefact role as participation role. The role is instantiated when the urban artefact is involved in a *used-for* relation. Classes are in rectangles; restriction in ovals.

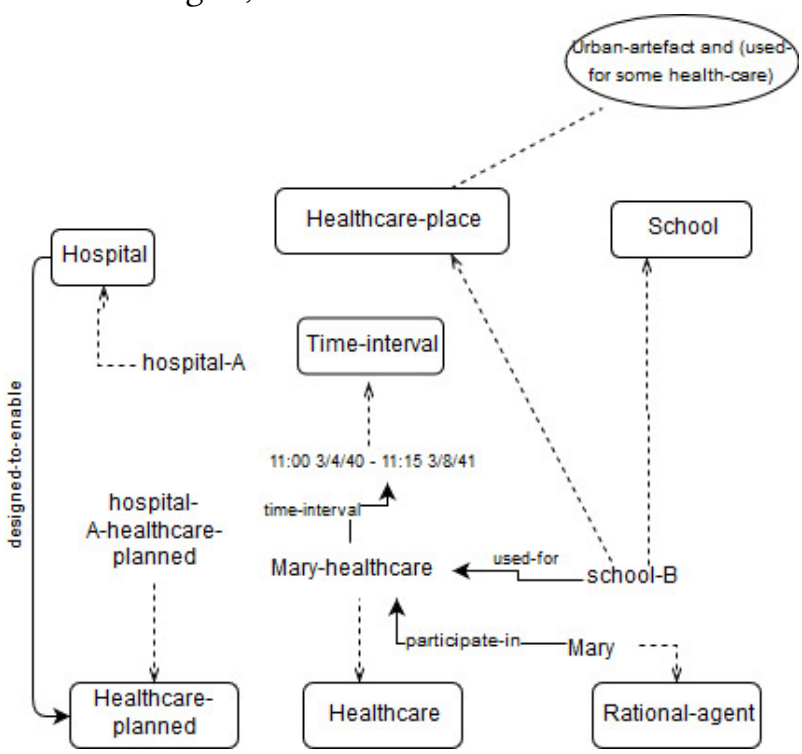


Scenario 1

During election days citizens are called to express their vote and they can generally do it in very different places. Notably, the setting for enabling people to vote does not have complex requirements and it may happen either in schools, community centers or others. As a consequence, we can assume that when a school is used as a polling station this would not change its core design and it is not the case that a new urban artefact replaces that school. Moreover, being a polling station is by definition dependent on a specific event, that of the elections.

Figure 6.1 depicts the situation of a school and a community center used as polling station. The polling station role is constrained as dependent on a *voting* event which involves an urban artefact.

Figure 6.2: Urban artefact role as participation role. The role is instantiated when the urban artefact is involved in a *used-for* relation. Classes are in rectangles, restriction in ovals.



Scenario 2

A similar scenario is that of an emergency hospital which has been temporarily, i.e. during a war, set in an existing urban artefact. Let's hypotesize that the urban artefact in object instantiates a school type and it is used to provide health care - a kind of usage which is planned to be enabled by an hospital - so that it is only accidentally playing that role. It may also be the case that an hospital designed to enable the healthcare activities is not located in a safe area and it is not used at all; as a result the urban artefact which instantiates the healthcare place class is the school. This case is depicted in Figure 6.2.

In both these scenarios the role is dependent on the occurence of an event. The temporal interval defining when the role is played has been object of further discussions. Mizoguchi et al. (2015) have classified what they call occurrent-

role, on the basis of the specific time-frame when the role-instantiation is defined. Particularly, the authors distinguish among i)process-dependent role, when the role is played only during a process, i.e. singer; ii) event-dependent role, when the role is played in instantaneous event, i.e. murderer; iii) prospective derived role, when related to future playing, i.e. candidate; iv) retrospective derived role, when related to events in the past, i.e. witness. These distinctions could be also applied to urban artefacts, i.e. being an Olympics-candidate-stadium is an example of (iii), being a restructured house is an example of (iv), while examples of process and event dependent roles are the most common, such as a square as a place for a concert, or a terrace playing the role of observation point.

6.3.2 Urban Artefact Role as Social Role

So far, we have modelled urban artefact roles by: i) allowing that different urban artefact types can play the same role and, ii) considering the role playing as a contingent quality which the entity acquires in virtue of a temporally dependent participation relation. We can now discuss the possibility of having urban artefact social roles; this kind of role is played independently from the occurring of a particular event, in the sense that it emerges from one or more events - a person enrolled in a university and enabled to sit exams is a student, the sign of a working contract makes a person playing the i.e. teacher role - but it is instantiated not only during the occurring of the event. This happens in the urban environment when particular urban artefacts become socially recognized to be used in certain ways as a consequence of collective experiences. These uses may also not directly reflect the design choices of the urban artefact, actually they can also not be compliant with the uses planned in their design specification. At the same time, they are especially relevant to people because they mirror ways in which the city is actually lived. For example, the role of being a meeting place could be played by a square or a shopping mall almost independently from their design specification [†]. Social

[†]Note that when we refer to unexpected or unplanned uses it is relative to the design specifications insofar they provide explicit information about the planned uses. However, it is always assumed the fact that uses enabled by the urban artefact design are much more than the one explicitly provided. In this thesis we do not explore in detail this aspect - which

roles played by urban artefact may change depending on their specific *social characterization*. Social roles, in the urban context, can be use to express not only the **relationality** characterizing the use of urban spaces - this is done by modeling participation roles - but also its social **multiplicity** in terms of the meanings people attribute to them. Distinct social collectives recognize different uses of urban spaces based on their own perspective, i.e. a meeting place recognized as such by the teenagers is not the same place for other social collective such as the elderly, a shop is the place for buying from the customer perspective but a working place for the employee. In these cases, the reason why the role emerges is intrinsically social and concerns the local knowledge about place uses, resulting from certain social conventions that we define in term of social practices.

Social role is broadly considered as dependent on a social context, and it has been classified as a non-participation role (Masolo et al., 2011), since its being played does not depend on the contingent involvement of the player in a participation relation. The social context has been intended as a generic social object (Mizoguchi et al., 2007) or, more specifically, as a description (Masolo et al., 2004). In the case of urban artefacts we refer to their social roles as the way they can be conventionally used. We assume that when an urban artefact is recurrently used in a certain way by a collective of people, it becomes identifiable as playing that social role independently from its contingent participation in a use relation.

Scenario

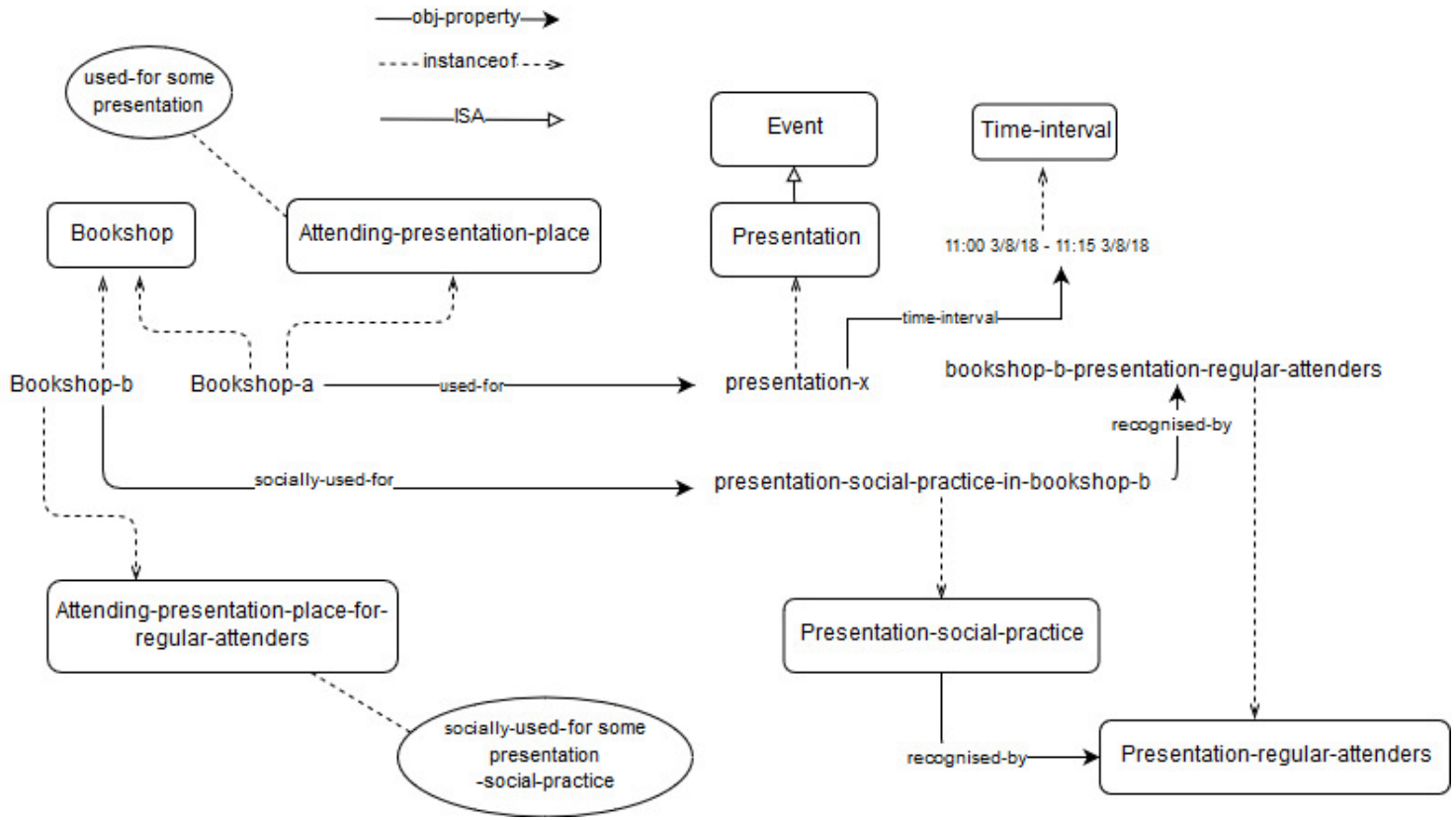
Let's take as example two different bookshops, bookshop *a* and bookshop *b*; we can hypothesize that in bookshop *a* a cultural event has been hosted, involving few days of presentations so, differently from bookshop *b*, bookshop *a* is now playing the role of being a place where to attend presentations. In particular, it is instantiating a participation role as described in the previous section. We can now imagine that, given the success of the event in bookshop *a*, the owner of bookshop *b* decides to organize weekly presentations

is generally discussed in terms of cognitive affordances - we just assume the existence of cognitive affordances to focus more on actual behavior and its social character.

in his bookshop. The information about the weekly presentations hosted in bookshop *b* will spread particularly among people interested in attending them, to the point that if someone will ask which is a place for attending cultural presentations bookshop *b* will be surely mentioned. Is the role of being the place for attending cultural presentations played by bookshop *a* the same kind of role played by the bookshop *b*? We believe it is not. In a certain sense, it is the recurrence of presentations organized in bookshop *b* which has produced a social knowledge about that place, which is independent on the concrete progress of a presentation event. Bookshop *b*, indeed, has become identifiable as being a place for attending presentations; the nature of such a role goes beyond depending on either the designed features of the bookshop or its participating in a relation of attending presentation between the bookshop users and the bookshop itself. Our proposal, indeed, is to consider the role played by the bookshop *b* as a social role, which is generally conceived as a non-participation role. This role emerged from a social practice which is recognized by a specific social collective of people which are able to consider that bookshop as a place for attending presentations. This social characterization could give us further insights about the meaning of that role in terms of people collective experiences.

The two cases are depicted in 6.3. Bookshop *a* follows the same modelling pattern of 6.1 since the role played by the entity bookshop is dependent on the attending presentation relation. In the case of bookshop *b* the role of being the place for attending presentations holds different dependences than in the case of bookshop *a*. Indeed, if taking a definition of social role as non-participation role, it does not involve the participation of the player in an event. For example, “one sense of ‘student’ or ‘teacher’ does not focus on a specific studying or teaching event, but rather on the relation ‘being enrolled’ (in an university) or ‘holding a teaching contract’ (with a school)". Social roles are mostly exemplified in literature as recognizable on the basis of patterns of relationships Masolo et al. (2005) or encoded descriptions Masolo et al. (2004), which can be i.e. the Italian Constitution, a teaching work contract stating the rights and duties which a teacher holds. However, cases like bookshop *b* do not completely fit with the existing interpretation of social roles. Broadly, even if the very notion of social proposed in Masolo et al. (2004) refers also to conventions, it is not further specified how a conventional

Figure 6.3: Urban artefact role as participation and social role. Bookshop a is playing a participation role; while bookshop b is playing a social role depending on the social practice of attending presentations in bookshop b.



situation pertaining behaviours recognized as ordinary but not specifically codified, such as attending a presentation in bookshop *b*, can be modelled in terms of description. Work going in that direction is described in Mika and Gangemi (2001) and Mika and Gangemi (2004) who propose a pattern to model social relationships, i.e. friendship. In particular, they introduce a description of social context: a course of events entity which is essentially a sequence of events and a modality target for a functional role, where “"Modality for” is the functional counterpart of the “participation" relation from DOLCE ground ontology. In analogy with endurants participating in perdurants, functions have a way of participating to courses according to a mental plan, a social habit, a legal norm, etc." Regarding our bookshop example we can preliminary think of attending presentation in bookshop *b* as a sequence of participating events involving bookshop *b*, whose way to participate is considered a social habit (this particular use involving the bookshop is expressed by the *socially-used-for* property in Figure 6.3). Moreover, the recurrent social use of the bookshop is recognized by the people performing the practice, its regular attenders. In the next Chapter, we will further discuss and elaborate on the notion of habit in terms of social practice following theorists in sociology such as Giddens (1986); Schatzki (1996); Reckwitz (2002) in order to stress the specific social and collective character of such people behaviour.

6.4 Ontology Design Patterns of Urban Artefact Roles

6.4.1 Competency Questions

As in the previous Chapter we propose a preliminary ontology design pattern to represent urban artefacts roles. The competency questions are:

- What kind of role an urban artefact is playing?
- Which is the social practice that determines the social role of an urban artefact?

- Which is the event that determines the participation role of an urban artefact?

6.4.2 Classes and Properties Description

Some of the classes have been imported from Dolce Lite Plus (DLP) 2.9:

- **Event**: An occurrence-type is stative or eventive according to whether it holds of the mereological sum of two of its instances, i.e. if it is cumulative or not. A sitting occurrence is stative since the sum of two sittings is still a sitting occurrence.In general, events differ from situations because they are not assumed to have a description from which they depend. They can be sequenced by some course, but they do not require a description as a unifying criterion.
- **Collective** : A collection with only agents as members.
- **Rational-agent**: "Either a rational physical object (e.g. a person capable of meta-representations), or a social object acted by a rational physical object (e.g. an organization)." A rational-physical-object is encoded as having the ability to internally represent meta-descriptions (descriptions that have other descriptions playing roles used by them). Other theories of rational agency assume desires and intentions for these objects, but in principle any agent can have desires and intentions: the very difference seems to be the ability to choose among different desires or intentions by going 'meta-level'."

others have been introduced:

- **Urban Artefact Actual Usage**: An event which involves an urban artefact and a rational agent;
- **Urban Artefact Planned Usage**: Planned usages express the purpose of an architectural typology, i.e. dwelling for the Residential house typology, and influence the design of an urban artefact which has to enable those usages;

- **Urban Artefact Participation Role**: A participation role played by an urban artefact when participating in some urban artefact actual usage;
- **Urban Artefact Social Role**: A social role played by an urban artefact when it is socially used for some social practice;
- **Social Collective**: A collective of agents unified by a common social role or status, i.e. teacher, student, rich, poor or by a social practice, i.e. vegetarians. The latter type is emergent and cannot be identified a-priory but only after recognizing a specific social practice as the collection of agents performing the practice.

an the property introduced are:

- *used-for*: it is a use relation having as domain Urban-artefact and range Urban-artefact-usage.
- *socially-used-for*: it is a use relation having as domain Urban-artefact and range Social-practice.

6.4.3 Diagrams Presentation

Figure 6.4: Ontology design pattern of the urban artefact participation role. Restriction in the ellipses.

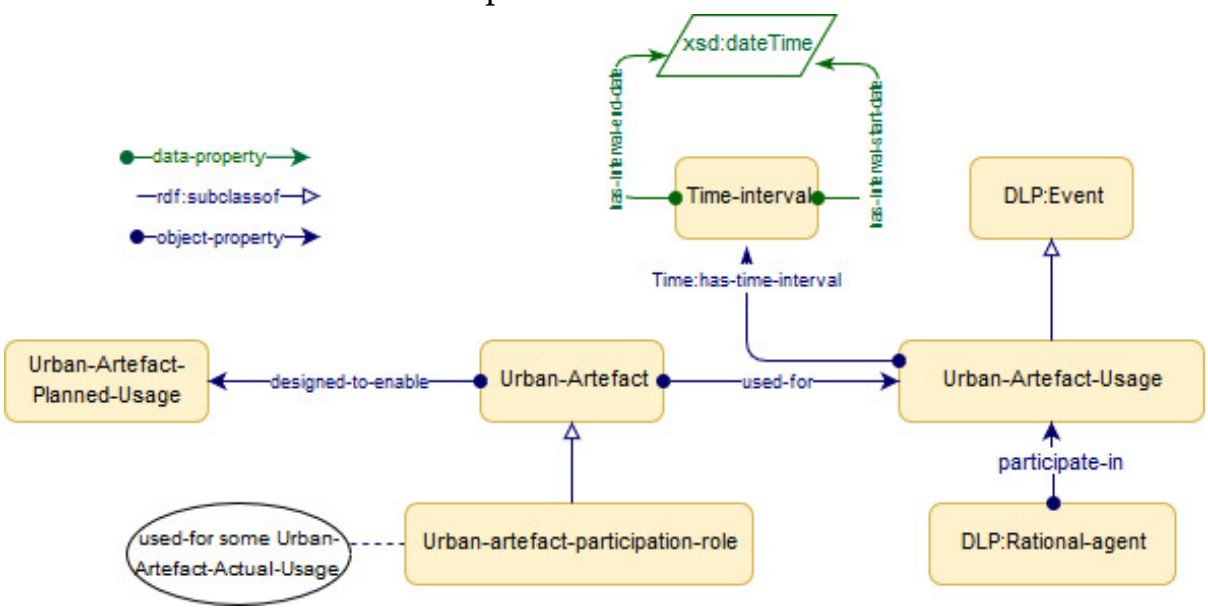
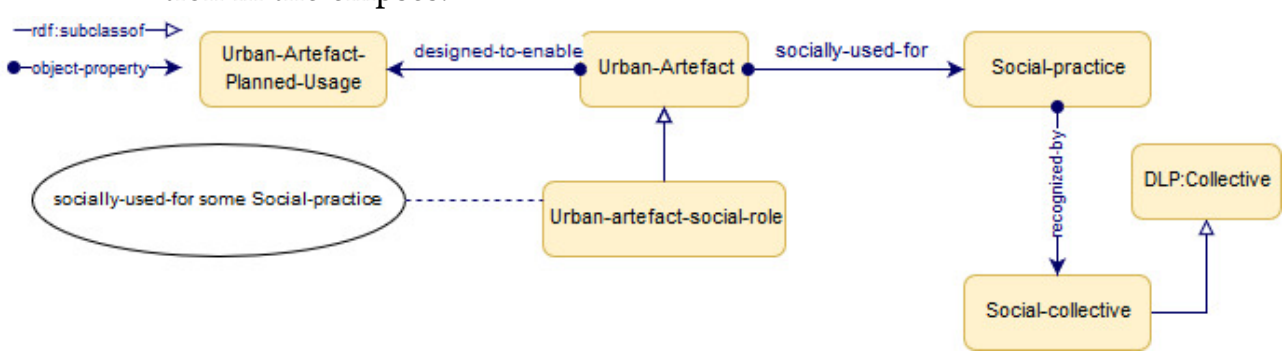


Figure 6.5: Ontology design pattern of the urban artefact social role. Restriction in the ellipses.



6.4.4 Sample ODP Usage

Usages of these patterns have been presented in Subsection 6.3.1, see Figures 6.1 6.2 as scenarios for the *Urban-artefact-participation role* and in Subsection 6.3.2 Figure 6.3 as a scenario for *Urban-artefact-social-role*

6.5 Conclusions

In this Chapter the kinds of urban artefact roles and their specialization in terms of functional place have been discussed, grounding our arguments in the broader discussion in ontology engineering about roles. Introducing roles will serve the modelling of the very common mismatch between the planned and unplanned uses of urban artefacts. Over time, disciplines such as urban planning and design as well as urban geography have been concerned with the systematic study of the mutual interaction of people with the built environment. Roles theory applied to ontology can provide a standardised tool for modelling the dynamic nature of this interaction. In particular, we focus on its social character exploring the notion of social practice, considered as the proxy for the emergence of urban artefact social role. The next chapter proposes an in depth analysis of social practice theories, some modelling alternatives of a real case example and an Ontology Design Pattern.

Chapter 7

Urban Artefact roles through the prism of Social Practice theory

7.1 Introduction

In Chapter 5 and Chapter 6 we presented the main building blocks for an ontology representation of the urban environment in its dynamic and social character. In this chapter we discuss a key concept for expressing the social use of an urban artefact: that of *social practice*. Theories of social practice have been elaborated in the field of sociology to provide a theoretical framework of collective behaviour and social influence. We assume that the way we collectively conceptualize the sense of an urban place relies on the way it has been physically shaped by its design, but also on the habitual use we make of it. Moreover, habits are considered as intrinsically social, insofar different social and cultural collectives of people tend to internalize ways to behave that are common to all members of the collective (Giddens, 1986; Bourdieu and Nice, 1977). Looking at this phenomenon spatially implies that different collectives of people may hold different spatial behaviours, using urban artefacts to various purposes. The thesis aims at rendering explicit this ordinary knowledge about places embedded in the social life of cities. In this Chapter social practice theories and alternative modelling choices of the notion of social practice will be discussed and applied in a real-case scenario.

7.2 From Individual Cognition to Collective Sociality

Social Practice theory (SPT), or, more accurately, theories, are discussed in social science since the seventies by authors such as Bourdieu and Nice (1977), Giddens (1986) and Butler (2015), in philosophy by Tuomela (2002) and Schatzki (1996). The main objective of these authors is to open the way towards a conceptualization of social reality as lying on the middle ground of a continuum spanning from a purely individualistic view, to the idea of a social totality. Their assumption is that individual behaviour is the result of internalized social structures which vary among different social collectives of people. As a consequence, individual agency should also be considered as part of the wider we-attitude Tuomela (2002) which is carried by the social collective of

“practictioners" Reckwitz (2002). Social practice theories have increasingly influenced the study of the city to explain how and why particular forms of human activity have been adopted, made popular, persisted and disappeared, adding a new heuristic to understand how places are socially characterized. Several rather recent researches in geography have applied the lens of social practice theories to investigate the pro-environmental behaviours (Hitchings and Day, 2011; Hargreaves, 2012; Shove, 2010), migration (Maller and Strengers, 2013), health (Maller, 2015), and mobility (Watson, 2012; Shove et al., 2012), demonstrating that a focus on social practice provides the opportunity to appreciate the social and cultural reasons (as distinguished from individual reasons) which influence people’s behaviour.

Compared to cognitive approaches in the study of the interaction between people and space, that have been rather influential in the elaboration of recent ontologies of place (see Chapter 4), social practice theorists stress the prevalence of the sociality, over perceptions, in driving people behaviour. Studies focused on environmental cognition often ground their elaboration in Gibson’s notion of affordance. Essentially affordance theory results in the rejection of a dicotomy between the objective/physical and the subjective/mental worlds, conceiving the perceived environment as the *meaningful* environment in virtue of the different ways individuals afford objects Heft (2015). Using Gibson’s words “what we perceive is not quality but affordance" (Gibson, 1979). Broadly, modelling affordance provides tools for representing what actions or behaviours are possible in a particular situation, under what conditions, and for whom. An evolution of Gibson’s approach has been Baker’s elaboration on *behaviour settings* (Barker, 1981). His research suggests that, since the environment is structured and ordered, there exist identifiable settings which influence behaviour in a predictable way. Despite the undeniable value of affordance theory to support a more contextual and cognitively grounded understanding of the geographic environment, as presented in the studies of Scheider and Janowicz (2014); Kuhn (2003, 2005); Scheider et al. (2009), this theory lacks explicit references to the ways geo-spatial behaviour is influenced by peoples’ cultural and social characterization. For example, a restaurant affords certain activities depending on context, a formal or informal dinner for example, but the specific way people interact, even in the same context of a formal dinner and in the same restaurant, may change if the performers

of that activities are Italian or Japanese or, in some cultures, it may change if they are rich or poor. Those social features are related to the carriers of what we consider as a social practice, influencing the way to participate in certain activities in a context. Therefore, what people afford is dependent not only on context and location, but also on the social and cultural belonging of the people themselves.

Social practice theories are primarily concerned with reconstructing the way webs of agents coordinate themselves with their milieus (Schatzki, 1996). As Reckwitz (2002) has underlined *a specific social practice contains specific forms of knowledge* shared by the carriers of the practice. Schatzki (Schatzki, 1996) defines different types of settings of action as media of sociality when the lives of participants in a practice hang together by virtue of taking place within the same or different locations. He distinguished socialities in this medium between those embracing single settings (namely *commonality*) and those encompassing multiple ones (namely *orchestration*). In both cases, coordinated and non coordinated sets of actions are considered as constituting a social practice, and settings can either be organized in a specific layout of objects or not (therefore, social practices in Schatzki (1996) are different than Barker's behavioural settings since they do not emerge only from a specific setting).

An approach based on affordances pushes towards the search of the physical characteristics of objects which, in certain contexts, may support specific behaviour; on the contrary, our approach is focused on people's social behaviour in order to conceptualize the use people make of urban places regardless of their physical features.

7.3 An Open Ended Interpretation of Social Practices

Social practices are generally conceived as socially mediated behaviour, however the relevance of the *social* in determining and influencing behavioural choices can be treated in different ways.

A preliminary clarification should indeed be related to the term social, in its qualifying varying degrees of sociality. A first possible way to interpret the term social is to consider it the simplest and concrete interaction between people, whereby actions performed by an agent are somehow influenced by the presence of one or more other agents. However it is generally accepted that, in order to manage the concrete interactions between each other, agents need to represent and internalize the multiplicity of non-physical entities that every society produces. Masolo et al. (2004) and Bottazzi et al. (2006) stress the distinction between the social, intended as conventional behaviour, and the social intended as related to the institutional organization of societies. We can further specify the latter as an idea of social which is formally encoded by some institution or official rule, and the former in terms of something which has become a conventionally accepted standard. A social practice is the concretely performed behaviour which embodies either declination of "the social", institutional and conventional. Looking at the social through the lens of social practices is essentially a way to reverse the problem of representing social reality, from focusing on the non-physical entities produced by society, to the recognition of behavioural patterns which can be recognized as ordinary, patterns which tacitly refer to those entities.

The specific value of studies based on the analysis of social practices is that they are grounded in actual behaviour providing empirical evidence of how a certain social context can be characterized, and focusing on the tacit knowledge that underpins human behaviour. However, up to now there is no unique understanding of how to precisely define and classify social practices: despite several attempts at defining them within a general framework, for example in Shove et al. (2012) or Schatzki (1996), the debate is still ongoing on how to bound the notion. However, some characteristics of social practices which seem to be commonly accepted can be listed, following McMillan (2018), as: 1) The domain of social practices is the realm of activities, which can be of different types, but must be connected by a shared knowledge, i.e. selling and buying are two different action types, but they may be intended as the same social practice type of trading; 2) Social Practices can be determined by the site where they are performed, since many practices are carried in routine locales, in those cases the locales are part of the identification of the practice itself; in other words, if people routinely perform certain activities in a specific

site or site type it makes that activities identifiable as social practices. For example, meeting friends in a shopping mall is a social practice which has recently emerged, it is directly related with a specific site type - the shopping mall. We should consequently say that meeting friends in a square is not the same social practice than meeting friends in a shopping mall 3) Agents of a social practice are tied together by mean of the practice itself, and they cannot be identified a-priori, but as a result of their participation in the practice.

In order to use the concept of social practice to socially characterize places, a further specification is needed. In particular, we refer to the notion proposed in Tuomela (2002) considering the core sense of a social practice as a repeatedly performed collective social action (CSA), because of a certain shared we-attitude, where the we-attitude must be a primary reason for the repeated activity: one without which the agents would not take part in it. Therefore, the carriers of a social practice can be associated with a we-attitude which is not only joint intentionality, but also resulting from an unintentional way of recurrently participate in an action with the same attitude of others. As a consequence, we refer to the carrier of a practice as a social collective, using the definition of collective proposed in Bottazzi et al. (2006), who considers collectives to be something more than collections - since they are composed by agents - but something less than social groups, because, for example, they can exist even in absence of joint or shared intentions among agents, which are requirements for the entities treated by the classical literature on collective intentionality as social group.

7.3.1 The Dual Nature of Social Practices

From an ontological perspective, modelling social practices is a particularly challenging task, given their dual nature as actions performed by individuals and as the specific way of participating in the action performed by a social collective of people. Indeed, the social practice of meeting friends in shopping malls can be seen both at the individual level, i.e. the action of Mary meeting her friends in the shopping mall, and at the collective level, i.e. the social practice of meeting friends in shopping malls associated with a social collective of practice carriers. This duality, which more generally concerns the modelling

of collective social action, is problematised in philosophical terms as the ontological appropriateness of defining a collective social action as a primitive action or not. Ludwig (2014) states that there is no collective social action which does not involve multiple individual actions, as a consequence he proposes to consider collective social actions as a mereological sum. Regarding social practices, such a conceptualization may produce an excessively strong ontological commitment, given that individuals of action are not necessarily part of a social practice, while individuals of action are necessarily part of their mereological sum. For example the social practice of vegetarianism can be more or less practiced, but it still maintains its identity as a social practice, therefore the practice of vegetarianism and the sum of all the actions of not eating meat must have different properties and must be kept distinct. If we can assume the latter as true, then the social practice is not a mereological sum of all the action performed by the practictioners. Guizzardi et al. (2015) tackles the issue of collective entity to define powertype, suggesting to characterize it as proposed in Fine's variable embodiment argumentation: as an entity with two facets, one which is timeless and determines its identity, another which is its manifestation at a certain time. This allows us to talk about i.e. biological species which are temporarily endangered, or which can qualitatively change while remaining numerically the same. This argument may be the best way to define social practices too. Furthermore, the problem of modelling the dual character of social practices has also a very practical concern: the possibility to refer to social practices as concrete entities with their own properties which differ from the properties of individual actions. For example, if we consider the following phrases: i) Paul is running this morning, ii) Paul has the hobby of running in the morning; the first one refers to an action performed by Paul which may be considered consequent of his individual choice to run; the second has a more complex semantics since it refers to the social practice of running as a hobby which is recognized by all the hobbyists. The individual running of Paul then would not be recognizable as a social practice if not in virtue of his participating in the action as hobbyists, while it would be a different social practice had he gone running as a professional athlete. We can assume, indeed, that the social collective of *practictioners* recognizes only the social practice and not the individual action of running of Paul, therefore we should consider recognition by a social collective as an essential property of a

social practice class, and not also of an action class. While the latter happens in a specific time interval and space location, the former can be conceptualize as an endurant which is recognized by social collectives independently from its being actually performed. However, a relation between the two - an individual action and social practice - exists insofar a social practice can be conceived as a variable embodiment whose manifestations are collectives of particular actions. In the Chapter we propose an ontological model to represent this dual nature which has been further extended applying the notion of *powertype* and its use to characterize the urban artefact social roles.

7.4 Formalizing Social Practice

Our primary objective here is to model social practice as the way performed activities are situated in time and space and organized in a skilled and knowledgable fashion by collectives of human agents (Giddens, 1986). What we need to capture is the relation between usages performed by individual agents - perdurants -, and social practices recognized by social collectives of agents - endurants. . Following our previous model of urban artefact roles, we have:

$$SocialCollective(y) \rightarrow Collective(y); \tag{7.1}$$

$$RecognizedBy(x, y) \rightarrow SocialPractice(y) \wedge SocialCollective(x); \tag{7.2}$$

$$UsedFor(x, y) \rightarrow UrbanArtefact(x) \wedge UrbanArtefactUsage(y); \tag{7.3}$$

$$SociallyUsedFor(x, y) \rightarrow UrbanArtefact(x) \wedge SocialPractice(y); \tag{7.4}$$

$$UrbanArtefactSocialRole(x) \rightarrow UrbanArtefact(x) \wedge sociallyUsedFor(x, y); \tag{7.5}$$

To relate the human agent who uses the urban artefact to a social collective that recognizes a social practice, we introduce the *member-of* relation. In the context of social practice modelling this relation acquires a specific meaning since we are dealing with social collectives whose members share a similar *performing-mode* in the way they act. According to Tuomela (2002) the carriers of a social practice have additional reasons to perform it which are shared collectively. This might be clarified by comparing the same action, i.e. *running*,

performed by two different social collectives, i.e. *hobbyists* and *athletes*, which tend to converge to the social practices they recognize, *hobbyists* have knowledge on how to run at the amateur level while *athletes* follow more advanced running techniques. Let's now consider actions, performed by members of different social collectives, and that involve the use of an urban artefact; the intrinsically social way in which that uses are performed is somehow able to transfer new social meanings to urban artefacts themselves: running routes generally used by hobbyists have a different social role from the running routes mostly used by athletes, the former might be characterized by better landscapes while the latter by proper terrain, we actually do not know but identifying urban artefact social roles as dependent on social practices may help discovering new insights about social preferences and dynamics in cities.

To capture the relation between *UrbanArtefactUsage* and *SocialPractice*, given the agent's membership, we introduce the following rules:

$$ClassifiedBy(x, y) \leftarrow UrbanArtefactUsage(x) \wedge SocialPractice(y) \wedge RationalAgent(ag) \wedge SocialCollective(c) \wedge memberOf(ag, c) \wedge participateIn(ag, x) \wedge recognizedBy(y, c) \wedge UrbanArtefactUsage(x) \tag{7.6}$$

$$SociallyUsedFor(x, y) \leftarrow UrbanArtefactUsage(z) \wedge SocialPractice(y) \wedge classifiedBy(z, y) \wedge UrbanArtefact(x) \wedge used - for(x, z) \tag{7.7}$$

To illustrate the approach in the next Section a running example is presented[†].

[†]It has been encoded in OWL and SWRL and can be found here: https://gitlab.com/misplaced/Thesis-UrbisCore/blob/master/Examples/PiazzaDelMercato.owl

7.4.1 Piazza del Mercato, Napoli - A running example

Piazza del Mercato is a square in Naples which represents an interesting as well as rather complex example of the way social practices determine the social roles marked by urban artefacts. Several urban regeneration plans of Piazza del Mercato have been discussed in the last decade and the process is far from being over. Since it is not possible to illustrate here all the aspects related to this area, we focus on two situations that exemplify how to use the models presented before to represent this real case scenario. Note that each situation presents different processes which in turn provide multiple perspectives of Piazza del Mercato.

First situation

Piazza del Mercato in Naples (pdm) is an urban artefact classified by the urban type square and constituted by a number of non-agentive physical objects such as fountains and lampposts, and with specific physical qualities, e.g., location, size and delimitations, and normative constraints like the no-parking restriction over the whole area.

$$UrbanArtefact(PdM); \tag{7.8}$$

Although parking was not allowed, pdm has been used as a parking area until 2006, when fences and a CCTV system were installed. This is an example of an urban artefact that was not designed to be a parking area, but a typicality of its use is related to the social practice of parking. As long as the social practice existed, pdm was classified by the local social community as a parking place. This social practice conceptualizes a recurrent activity of parking that was performed in pdm. The activity was recognized specifically by users that participate in that use of pdm. Also, in pdm's design specifications it was (and currently is) required not to use the area for parking. Therefore, being a parking place was a non-functional role of pdm, being in contrast with the normative constraints of its design specifications.

To represent the case we add the classes of: **ParkingPlace** which is a subclass of *Urban-artefact-social-role*, whose instances are urban artefacts *socially-used-for* some **ParkingSocialPractice**; **ParkingSocialPractice** subclass of *SocialPractice* and *recognized-by* some *ParkingUsers*; **Parking** subclass of *UrbanArtefactUsage*; **ParkingUsers** subclass of *SocialCollective*. Therefore, given the following conditions:

$$RationalAgent(Mary); \tag{7.9}$$
$$ParticipateIn(Mary, MaryPdMparking); \tag{7.10}$$
$$UrbanArtefactUsage(MaryPdMparking); \tag{7.11}$$
$$SocialCollective(PdMparkingUsers); \tag{7.12}$$
$$MemberOf(Mary, PdMparkingUsers); \tag{7.13}$$
$$SocialPractice(PdMparkingSP); \tag{7.14}$$
$$RecognizedBy(PdMparkingSP, PdMparkingUsers); \tag{7.15}$$
$$ClassifiedBy(PdMparking, pdmParking) \tag{7.16}$$
$$UsedFor(PdM, MaryPdMparking) \tag{7.17}$$

We can infer that *pdm*, when the *parking in pdm* was classified as a social practice, was a *parkingPlace*:

$$ParkingPlace(PdM) \tag{7.18}$$

7.4.2 Second situation

After 2006 the parking practice was eliminated and new social practices emerged. As we can see in Figure 7.1, pdm became a place where Muslims meet to pray and young people play football. These are unexpected uses of the square that are not specifically ascribed to its type nor identifiable through design specifications. However, the knowledge Muslims or young people have about pdm is related to their experiences of pdm. Let us say that Muslims meet in pdm to pray generally on Friday mornings and youngsters play football on Sundays. Only from the activities that members of the two social collectives

Figure 7.1: Muslims praying in Piazza del Mercato, Napoli

(recurrently) perform we can identify the two social roles played by pdm: being a praying place and being a football playing place. So we add the following classes:

- **MuslimsPrayingPlace**: a subclass of *UrbanArtefactSocialRole* whose instances are urban artefacts socially used for Muslims praying.
- **PlayingFootballPlace**: a subclass of *UrbanArtefactSocialRole* whose instances are urban artefacts socially used for playing football.
- **MuslimsPrayingSocialPractice**: a subclass of *SocialPractice* recognized by the *Muslim* social collective.
- **PlayingFootballSocialPractice**: a subclass of *SocialPractice* recognized by the *footballPlayer* social collective.
- **MuslimsPraying**: a subclass of *UrbanArtefactUsage*.
- **PlayingFootball**: a subclass of *UrbanArtefactUsage*.

$$RationalAgent(Raha); \tag{7.19}$$
$$MemberOf(Raha, MuslimsPrayingInPdM); \tag{7.20}$$
$$MuslimsPrayingSocialPractice(PdMprayingSP); \tag{7.21}$$
$$MuslimsPraying(RahaPraying); \tag{7.22}$$
$$SocialCollective(MuslimsPrayingInPdM); \tag{7.23}$$
$$RecognizedBy(PdMPrayingSP, MuslimsPrayingInPdM); \tag{7.24}$$
$$ClassifiedBy(RahaPraying, PdMprayingSP); \tag{7.25}$$
$$UsedFor(PdM, RahaPraying); \tag{7.26}$$
$$RationalAgent(John); \tag{7.27}$$
$$PlyingFootballSocialPractice(pdmPlayingFootballSP); \tag{7.28}$$
$$PlayingFootball(JohnPlayingFootball); \tag{7.29}$$
$$SocialCollective(youngPeoplePlayingFootballInPdM); \tag{7.30}$$
$$MemberOf(John, youngPeoplePlayingFootballInPdM) \tag{7.31}$$
$$RecognizedBy(pdmPlayingFootball, youngPeoplePlayingFootballInPdM); \tag{7.32}$$
$$ClassifiedBy(JohnPlayingFootball, pdmPlayingFootballSP); \tag{7.33}$$
$$UsedFor(PdM, JohnPlayingFootball) \tag{7.34}$$

Therefore, we can obtain that:

$$MuslimsPrayingPlace(PdM) \tag{7.35}$$
$$FoodballPlayingPlace(PdM) \tag{7.36}$$

An excerpt of the various situations described above are graphically depicted in 7.2.

7.4.3 Final remarks

The example of PdM has been used to exemplify possible implementations of the notion of social practice to represent the multiple roles an urban artefact

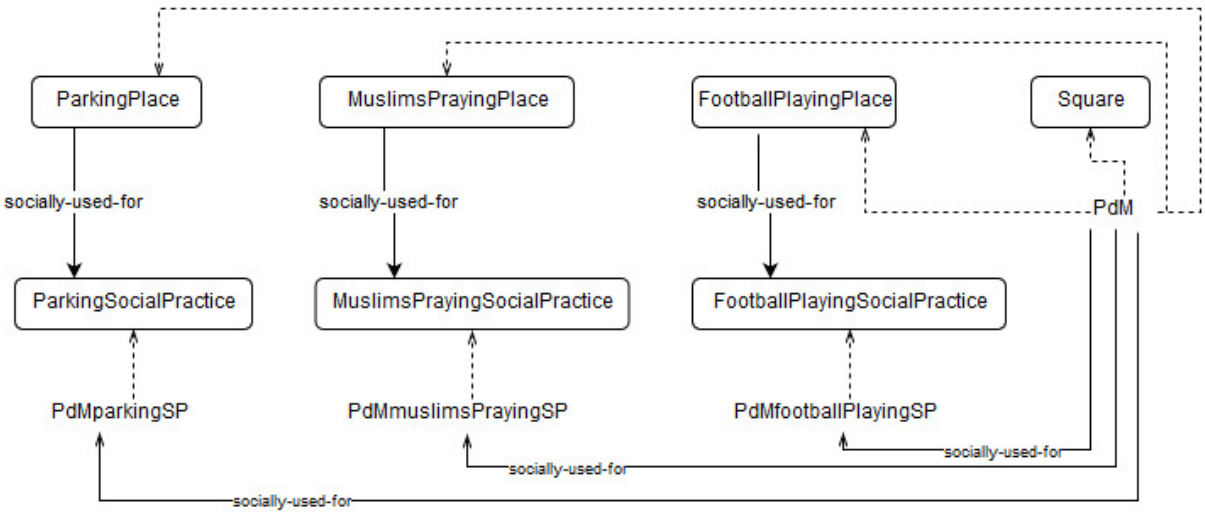


Figure 7.2: The figure shows some of the classes (in rectangles) and instances to represent the situations characterizing Piazza del Mercato (PdM). It can be seen that the urban artefact PdM instantiates different social roles; this is expression of the multiple social collectives' points of view which experience PdM through different social practices

may play depending on how different social collectives experience it. In particular from the situations described we are able to:

- identify which social collective is recognizing a social practice;
- relate a social practice with the urban artefact usage;
- defining the social roles of an urban artefact depending on the experiences of different social collectives;

7.5 Social practice as powertype

So far, we have introduces a *classifiedBy* relation between the urban artefact usage and social practice but in doing so we have to assume that the urban artefact usage class collects both usages that are classifiedBy social practices

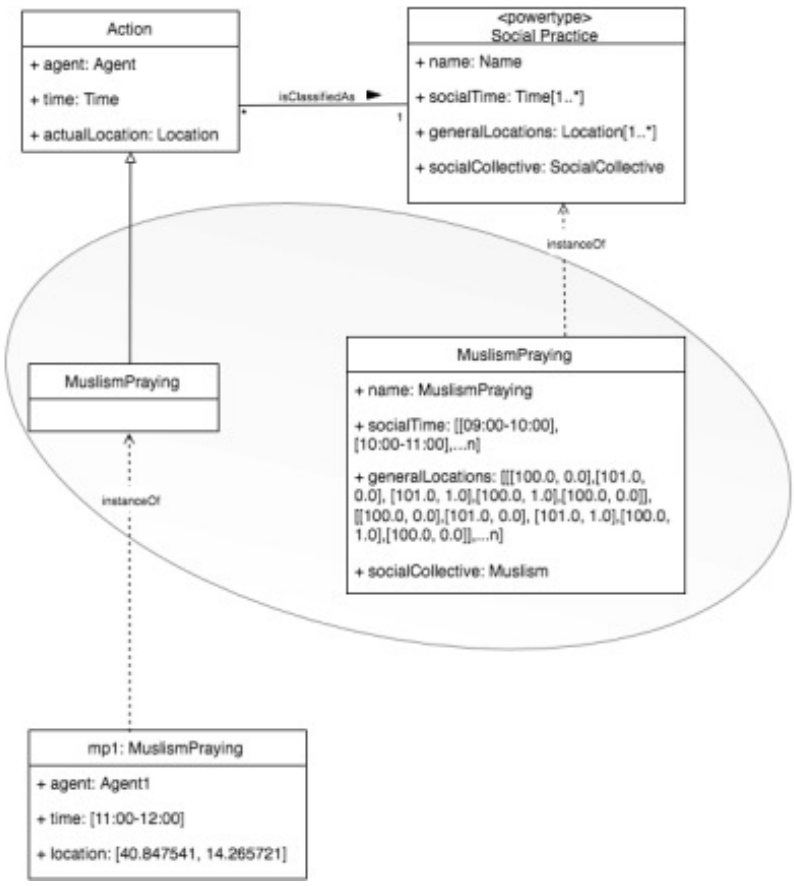


Figure 7.3: A powertype pattern for modeling Social Practice

and not. This implies that the *running* of John, who is an athlete, and the *running* of Mary, who is an hobbyist, are the same type of urban artefact usage classified by two different social practices. A more accurate representation would consider the two activities as different types and, each of them can be classified by different social practices. Indeed, we can also have Paul *running* for the first time, whose action should be classified by no social practice of *running*; therefore, it instantiates a class of *Running* but none of its subtypes which are classified by a social practice. It results that we have the *athletesRunning* which is an instance of social practice, since it expresses the *performing mode* of *running* characterizing the *athletes*, and a subclass of *Running*, collecting all the individuals of *Running* whose participants are member of the *athletes* social collective. This produces a model where entities should be linked at multiple levels, changing the traditional semantics of

instantiation established only between classes and individuals. The notion of Powertype has been introduced by Odell (1994) to handle such kind of multi-level modelling approach. A powertype is a type whose instances are subtype of another type. Powertype and subtype are thus related indirectly through the entities that are instances of the former and, at the same time, subtypes of the latterOdell (1994). A common example of the use of powertypes is the classification of biological species (Henderson-Sellers and Gonzalez-Perez, 2005; Atkinson and Kühne, 2001; Guizzardi et al., 2015). It is generally recognized the problem of treating species as concrete entities existing in time and space in order to explain their biological evolution or changes in their typical habitat (Guizzardi et al., 2015). For example, an elephant is an individual of the elephant-species class, but we may also refer to the elephant as a biological species which is endangered; in the latter case, we need to have biological species as a concrete entity, discernible from the individual elephant. Likewise, we refer to social practices as entities with their own properties. In particular, social practices can be spatially or temporally characterized and they refer to a social collective whose members are the carriers of a practice. On the contrary, non collective actions have different properties such as a single agent, which might be or not be member of a collective, a specific temporal and spatial location related to the individual activity. Figure 7.3 exemplifies Piazza del Mercato scenario in UML notation, as in Henderson-Sellers and Gonzalez-Perez (2005). Note how the entity *muslimsPraying* in the light grey ellipse is both an instance (object in OO) and a class. Foundations for introducing powertypes in ontology representation have been recently discussed in Carvalho et al. (2016); Guizzardi et al. (2015).

Guizzardi et al. (2015) tackles the issue of what kind of collective entity a powertype is, suggesting to characterize it as proposed in Fine's variable embodiment argumentation: as an entity with two facets, one which is timeless and determines its identity, another which is its manifestation at a certain time. This allows us to talk about i.e. biological species which are temporarily endangered, or which can qualitatively change while remaining numerically the same. This argument has implications also for our understanding of social practices. However, while in the case of biological species, individual animals can be easily collected in a species type, in our case under what conditions an urban artefact usage individual instantiates an urban artefact usage type is

more critical, and it has to do with what the essential properties of a social practice are. As mentioned before, in its essence a social practice concerns a way of doing and saying which is recurrent among a collective of people; it can be recognized at different levels of granularity (i.e. vegetarianism can be considered the same practice all over the world, or specialized in its local differences: in India it may involve eating a certain set of food which differs from the Italian one); it may be dependent on specific temporal patterns (i.e. drinking the 5pm tea) and/or spatial location (i.e. going for a walk in shopping malls). In any case it must be routine behaviour at the collective rather than individual level: if every day Paul gets up and switches on the radio it is his routine but not a social practice, while if Paul drinks a tea at 5pm in the UK, and several other actions of drinking tea at 5pm in the UK are performed by other people, then it is a collectively recognized routine, therefore a social practice. As a consequence every social practice has to be recognized by a social collective so that each participant in an urban artefact usage, which is classified as a social practice, has to be member of the specific social collective which recognizes the social practice. It is important to note that we assume that members of a social collective share the same *we-attitude*, which brings them to perform an action - or urban artefact usage in the case the action involve urban artefacts - and a similar *performing mode*. In particular, urban artefact usages can be subtyped, depending on the social practice they refer to, when there is some collective reason which influence the individual behaviour. There can be many reasons for drinking a tea at 5:00 PM but in the UK this is clearly recognized as a conventional way of drinking tea: is the action of Paul who is accidentally drinking a tea at 5:00 the same type of action of Mary, who recognizes the drinking tea at 5:00 as a social practice, and she is drinking the tea at 5:00? We believe that the very nature of these two actions are different since the latter is influenced by Mary's acknowledgment of the social practice existence. Assuming this reasoning valid we have to consider the property of *being classified by a social practice* as a necessary condition to instantiate an urban artefact usage type. Instances of such a type are all classified by the same social practice instance, in other word, instances of an urban artefact usage type are all *manifestation of* the same social practice. Here, we have actions (urban artefact usages) which relates with endurants (social practices); a similar situation has been tackled in Guizzardi et al. (2016)

and exemplified by discussing the relation between a *Task assignment*, which is an endurant, and the *Work Day* events throughout its active life is manifested. As a result we introduced a cross level relation, *has-manifestation*, between the urban artefact usage subclasses and the social practice instances whose it is manifestation of. In this way we can, on the one hand, verify that all the individuals instantiating that type are also classified by the social practice and, on the other hand, distinguishing between those actions that are classified by social practice and those that are not.

7.6 An Ontology Design Pattern of Social practice

7.6.1 Competency Questions

The following is a proposal pattern for the ontology design of social practices using the multi-level approach through the notion of *Powertype*. The competency questions are:

- Which social collective recognize a social practice?
- Which urban artefacts are socially used for a social practice?
- What are the social uses of an urban artefact?
- Which urban artefact usage type characterizes a social practice?
- What are the usages of an urban artefact?

7.6.2 Classes and Properties Description

- **Urban Artefact Actual Usage**: An activity which involve an agentive and a non agentive physical object.
- **Social Collective** A collective of agents unified by a common social role or status, i.e. teacher, student, rich, poor or by a social practice, i.e. vegetarians. The latter type is emergent and cannot be identified a-priory

but only after recognizing a specific social practice as the collection of agents performing the practice.

- **Social Practice**: A collective social action representing a *way of doing* or *performing mode* shared within members of a social collective. A social practice manifests itself in a pattern of collectively performed - coordinated or nor - activities carried out by members of the social collective, who recognize the social practice as a standardized behaviour, spontaneously emerged, or regulated by institutions or formal organizations.

We have introduced a cross level property which links subclasses of Urban Artefact Usage to instances of Social Practice:

- *has-manifestation*: this property links instances of social practice with the respective urban artefact usage subclass, implying that all the instances of that class are classified by that instance of social practice.

7.6.3 Diagram Presentation

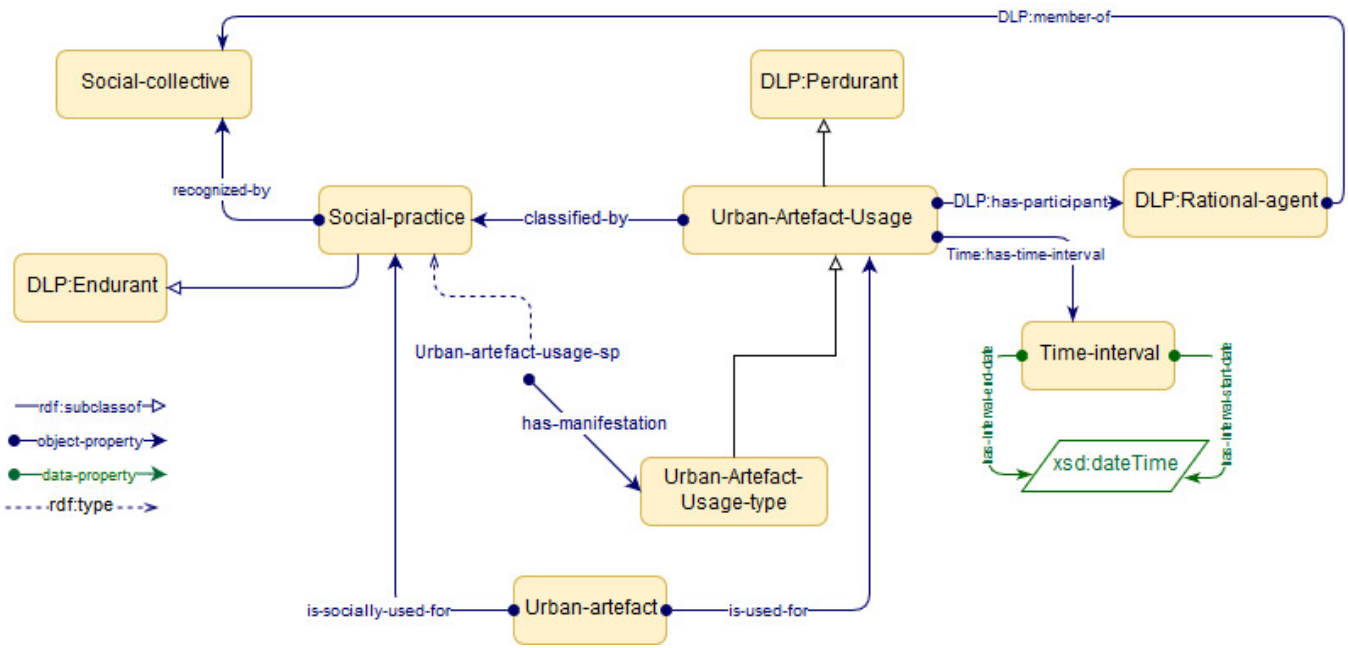


Figure 7.4: A social practice pattern

7.6.4 Sample ODP Usage

The case of Piazza del Mercato, Naples, has been discussed in Subsection 7.4.1 in the form of a running example which is mostly focused on Piazza del Mercato emergent social roles. Here the situation where Raha is praying in Piazza del Mercato is modeled through the use of the social practice ODP which includes also a cross level relation.

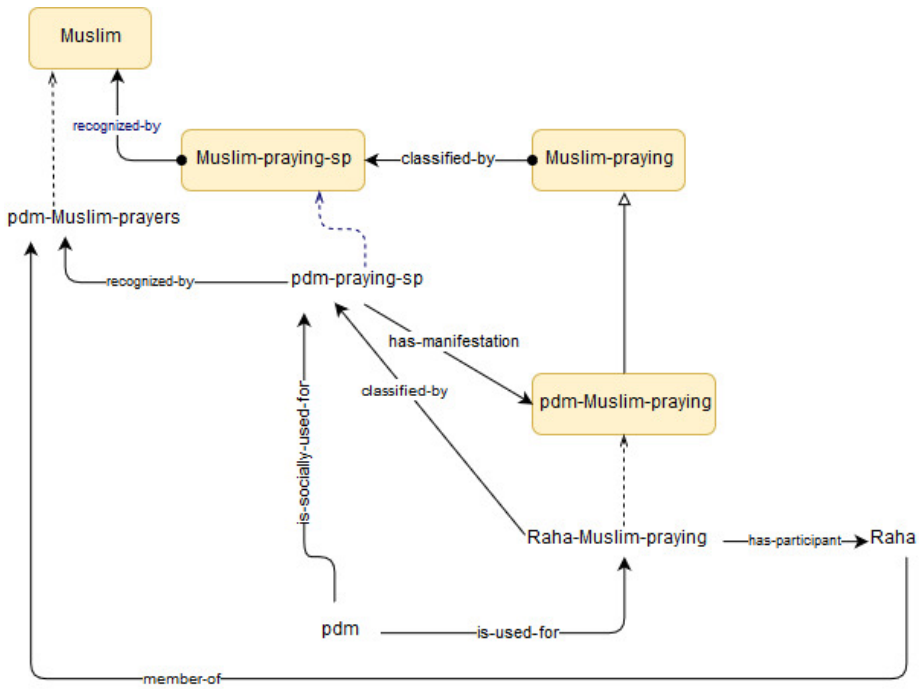


Figure 7.5: A sample usage of the social practice pattern

7.7 Conclusions

Modeling social practices is a preliminary task to recognize the social character of urban places. The main advantage of taking social practice seriously in the ontology representation of the urban domain is to provide a tool to model knowledge about the social roles of urban artefacts in the everyday life of people. Cultural and social aspects may strongly influence the people habitual interaction with urban artefacts, resulting in the multiple and sometimes also unexpected ways the city is used. Also, when some uses become recognizable as common among a collective of people, so when a social practice emerges and is localized in some urban artefact, the very conceptualization of urban places is affected. The work we undertake in this Chapter aims at modeling social practices, which can be considered as the context generating the existence of urban artefacts' social roles.

Chapter 8

An ontology of the urban domain: a data-driven experiment

8.1 Introduction

In the previous Chapters the Ontology Design Patterns (ODPs) of urban artefact, urban artefact roles and social practice were presented. By composing those patterns we obtain a core ontology aimed at representing the urban domain. It encodes the three required building blocks which resulted from the literature review presented in Chapter 4. In this Chapter we present the core ontology model, *Urbis* core ontology, composed by the ODPs, and we show how it can be applied to guide the analysis of crowdsourced georeferenced real data. To carry out the experimentation we extracted a data sample from the Trip Advisor platform. The ontology is therefore integrated as a semantic support within a knowledge discovery process. It has been used with two main purposes: 1) to address the selection of data which are relevant to the *socio-spatial* urban domain; 2) to semantically enrich the data analysis results by integrating them into the ontology model. Finally, we evaluate the integration results by comparing *Urbis* with other ontologies.

8.2 *Urbis*, a Core Ontology

The ODP presented in the previous Chapters can now be combined to provide a core ontology of the urban domain. It has been designed to deal with the social facet of urban places, translating it in a machine-understandable format. In Chapter 4 we presented the past and present discussions regarding the complexity of the socio-spatial domain within urban contexts. Scholars working in the field of human geography and urban studies have clearly pointed out that the urban environment is a complex and still largely unpredictable interacting system of humans and human-made objects. Existing ontologies of place and of the built environment mostly fail in dealing with the dynamic of social phenomena which is pivotal to represent such complexity (see Chapter 4). From the extensive and markedly interdisciplinary literature review presented in Chapter 4, we identified three key building blocks to describe the urban environment which should allow to take a more human-centered and social perspective: 1) the built environment; 2) people's social behaviour; 3) the relational concepts that link these two facets. The built environment is composed

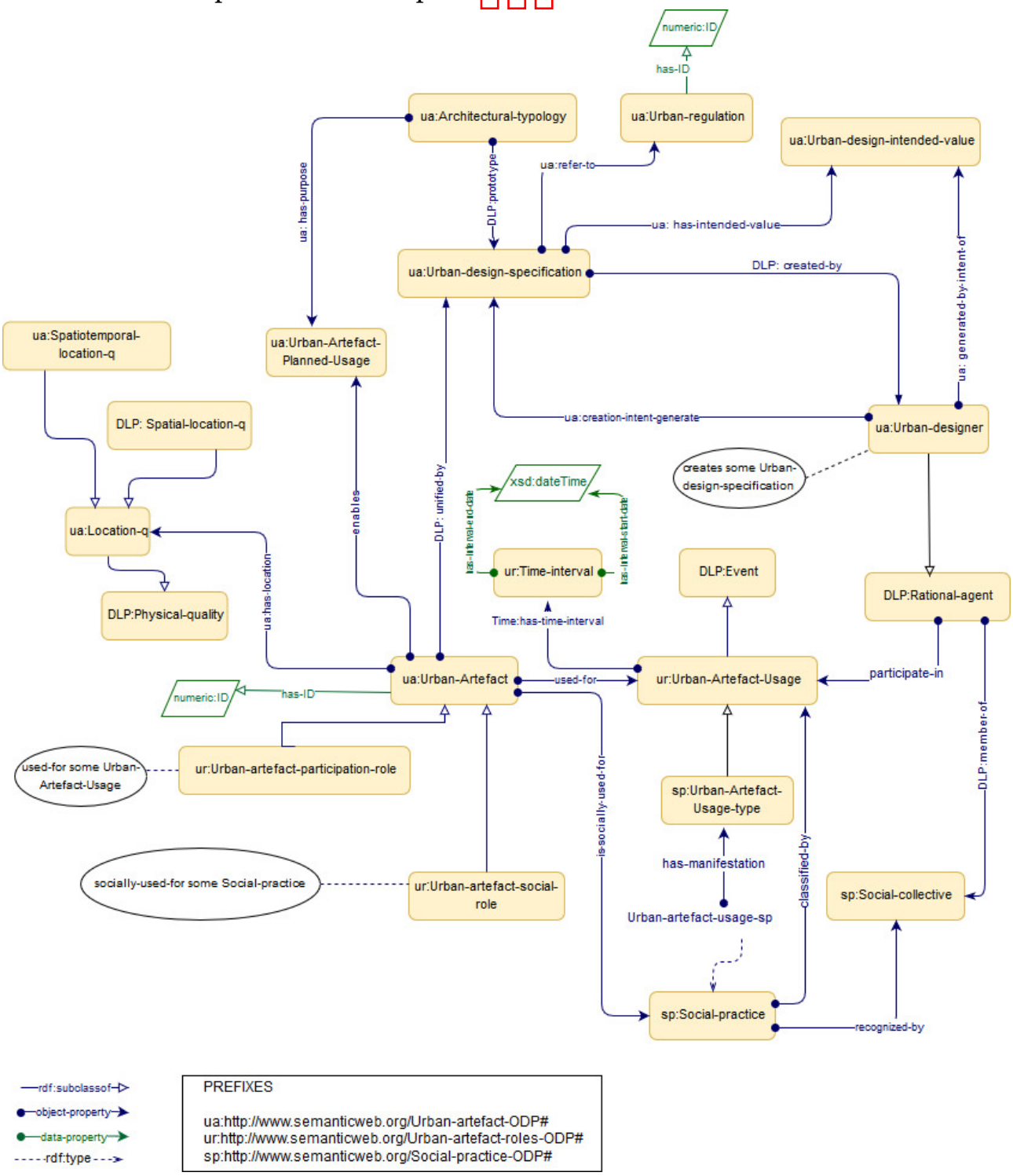
of artefactual objects whose very notion is subject of extensive debates in both philosophical and computational ontology at a foundational level. An extract of these discussions is presented in Chapter 5 as a baseline knowledge needed to create the Urban Artefact ODP. On the other hand, there are people living the city whose behaviour strongly influence the social meanings attributed to urban artefacts in terms of the way they are socially used (i.e. a square as a meeting point place for teenagers). This latent knowledge about places is made explicit through the recognition of behavioural patterns performed by specific social collectives of people. The notion of Social Practice is introduced and modelled (see section 6) to conceptualize these patterns both as a classification of different types of actions, and as a definition of a generalizable behaviour which follows a shared *performing mode* of the agents. Finally, we bridge these two facets of the urban environment, the physical - built and planned following certain technical principles - and the social - emerging from people's collective behavior. In doing this, we attribute the anti-rigid property of *role-playing* to urban artefacts in order to model the dynamic and multiple uses people can make of urban artefacts as well as the possible mismatch between the planned and the actual use of places. The typology of urban artefact roles that we introduced is presented in Chapter 7. Figure 8.1 depicts the core ontology which results from the combination of the ODPs. It represents the urban domain with an explicit social bias. The final aim is to deal with social information about places that can be extracted from crowdsourced geographic data. In the following sections we present an experiment using the ontology to transform georeferenced crowdsourced data into socio-spatial knowledge base.

8.3 The Experiment

The experiment we present aims at demonstrating how the ontology can support the transformation of georeferenced data into socio-spatial knowledge base. It would provide insights from data in a formally structured format to be interoperable and interpretable by urban domain experts.

In the so-called information age, the use of data mining techniques in the process of knowledge discovery is becoming significantly relevant to the everyday

Figure 8.1: *Urbis*, a core ontology of the urban domain based on the building blocks presented in Chapters 5, 6, 7



life of people. According to Dou et al. (2015) the purposes of an ontology-driven approach to data mining have been summarized in the following three points:

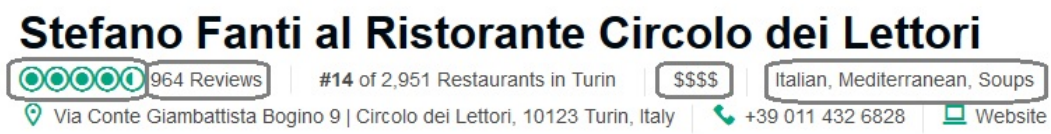
- To bridge the semantic gap between the data, applications, data mining algorithms, and data mining results.
- To provide data mining algorithms with a priori knowledge which either guides the mining process or reduces/constrains the search space.
- To provide a formal way for representing all the steps of the data mining flow, from data preprocessing to mining results.

Our work mainly focus on the last two. We provide prior knowledge in the form of the ontology which encode and make machine-understandable the social character of places given by people behavioural patterns. It guides the data mining process towards the exploration of these patterns, concerning ways the city is *socially used* by a targeted population, i.e. teenagers, tourists, elderly, homlessness. The issue at stake is to manage the social knowledge about places - which results from people everyday practices and experiences - coming from the wealth of crowdsourced information. Analysing data to extract knowledge about people behaviour and their social differences is not a new research area. McKenzie and Janowicz McKenzie and Janowicz (2015) mined the geosocial behavior from FourSquare's check-ins to improve the reverse geocoding of locations. Call Detailed Records have been used to human behaviors recognition tasks or land use classification respectively in Dashdorj et al. (2017) and Pei et al. (2014). Social inequality and segregation have been discovered by Shelton et al. Shelton et al. (2015) using georeferenced social media data, and comparing the daily activity spaces of two different social groups - west end and east end residents in Louisville. These studies have produced many valuable results, proposing innovative methods and techniques; however, they remain framed into stand-alone case studies which cannot be grounded into a domain knowledge and be managed as knowledge bases.
An ontology-driven approach may overcome such a limitation through a semantic enrichment of the mining results Roy et al. (2015).

8.3.1 Datasets Description

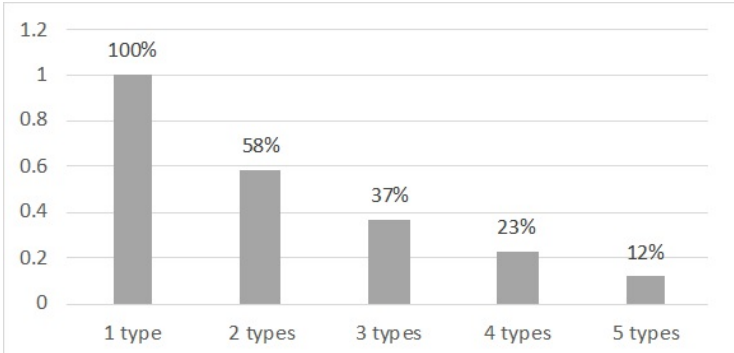
The information extraction of the Trip Advisor platform have produced two datasets about Turin's restaurants and their reviews. The first dataset is the scraping of the page result from the search: *restaurant in Turin*. It produced 2116 observations, of which 1886 are within the Turin's city boundaries. The addresses of all restaurants have been geocoded and mapped. Also, each restaurant in Trip Advisor is associated with information about the cuisine type, ratings and average cost. Figure 8.2 shows a typical restaurant page in Trip Advisor highlighting the fields which have been extracted.

Figure 8.2: A typical restaurant page. Fields extracted are underlined in light gray.



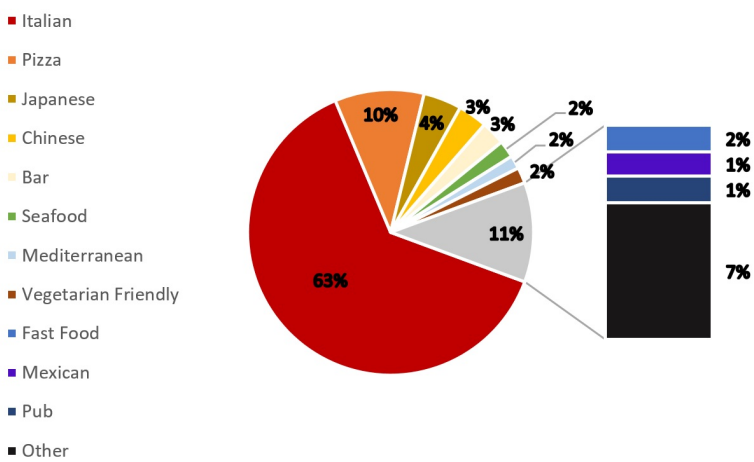
Each restaurant's cuisine type field corresponds to both different cuisine type i.e. Italian, Chinese, Japanese and business type i.e. Bar, Pub, Fast Food. More than one type can be added in the cuisine type field, i.e. a restaurant in the dataset has up to 23 types. However, it can be seen in Figure 8.3 that all the restaurants have at least one tag while only the 12% has up to 5 annotations. Our analysis is based on the first type added.

Figure 8.3: Percentage of restaurant's with up to 5 types.



We count 51 unique value of types and the pie chart in Figure 8.4 shows the percentage of restaurants by cuisine and location types. Italian restaurants are the great majority covering the 63% of the restaurants population, followed by the 10% Pizza's places, which is an other Italian typical food. At lower values Chinese and Japanese cuisines are the most common among non Italian restaurants.

Figure 8.4: Percentage of restaurant's cuisines and business types.



The other dataset is an extraction of each restaurant page scraping the individual reviews made in four different languages, Italian, English, French and Spanish. We count 238.394 reviews from 2007 and 2016, of which the 95% is written in Italian while only the 5% is in the other languages.

Each review has a date, a title and an extract of the review is shown, it is associated with users ids, user name and the city where he/she comes from.

Figure 8.5: A typical review. Fields extracted are underlined in light gray.

A typical review is shown in Figure 8.5

Not all the user profiles have their origin set. We assume that all the reviews made in languages other than Italian have been added by foreign tourists. In order to distinguish among Italian tourists and Turin's residents we subset the original dataset to have only users with the origin set and we have added a new field with values 0 and 1 for users whose origin is Turin or not (details on the distribution of total review by group are presented in section 7.6.1). To count users we used as identifier the userID, userName and userOrigin but still some of them cannot be recognized as individual users. This problem raises from the integration between Facebook login and Trip Advisor login; in some cases, indeed, to identify users we only know that the user is "A member of Trip Advisor on Facebook". These users cannot be clearly distinguished among each other, therefore they are not counted as users but the number of reviews they have posted is specified in the Table 7.1 part B.

8.3.2 Statistics Summary

The use of Trip Advisor, as for many other web platform, is significantly increased in the last decade. This trend emerges clearly from our data sample regarding the city of Turin. The data collected covers nine years from 2007 to 2016. The Table in the appendix summarizes how the reviewing activity has spread among a growing number of people, and has produced an increasing number of reviews, covering more and more restaurants throughout the city. What follows is a report of the main figures we found.

Part (A) of the table shows changes in number of users posting reviews on the platform. *Usr* lists numbers of users that have posted reviews each year;*New usr* the numbers of users who started using the platform each year, therefore all the users IDs that were not present in previous years, are counted. We count a total of 107627 users which have reviewed at least one restaurant in Turin in the time series analysed. In 2008 less than 100 users were posting reviews; in 2016, instead, we count 45022 users which evaluated a restaurant in Turin, of which 33699 are new users, meaning that they have made their first review of a Turin's restaurant in 2016. The high number

of new users gives us the idea of a phenomenon which is likely to keep increasing. However, the highest relative variation of new users registered ((*newUsers*2011-*newUsers*2010)/*newUsers*2010), equals to 610 % increase, is seen between 2010 and 2011. Regarding the distribution of reviews posted by each user, the average of reviews per user does not vary significantly on time, maintaining its value at about 1.7 reviews. The global maximum of reviews posted by a single user, 80 reviews in a year, is reached in 2015 but we do not see any particular trend of an increased or decreased users attitude in posting reviews; broadly, both the mean and the median, which equals 1 every year, demonstrate that the majority of users post a low number of reviews while very few contribute more. However, we see in 7.6.2 that the willingness to post change among different social collectives.

Part (B) shows changes in number of reviews by year. The number of reviews have increased significantly in the years considered, reaching 82.807 reviews posted in 2016. As expected, given the trend seen for users, the highest increase in reviews number is between 2010 and 2011.

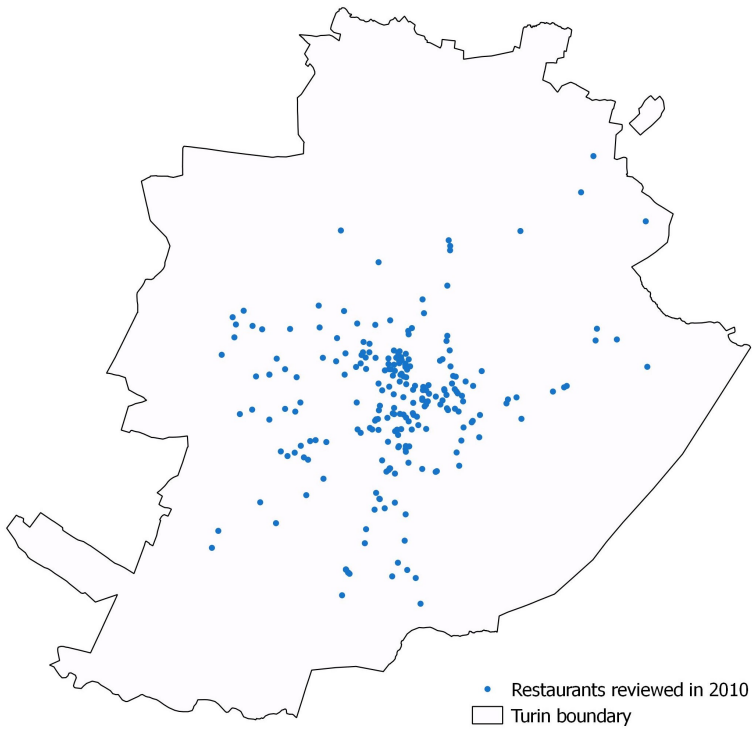
Figure 8.6 shows Turin's restaurants with at least one review in 2010, 2013 and 2016. The first restaurants reviewed were mostly concentrated in the city center, while in the following years the reviewing activity expanded to restaurants in more peripheral areas.

8.3.3 Methods applied to *mine* Social Practices.

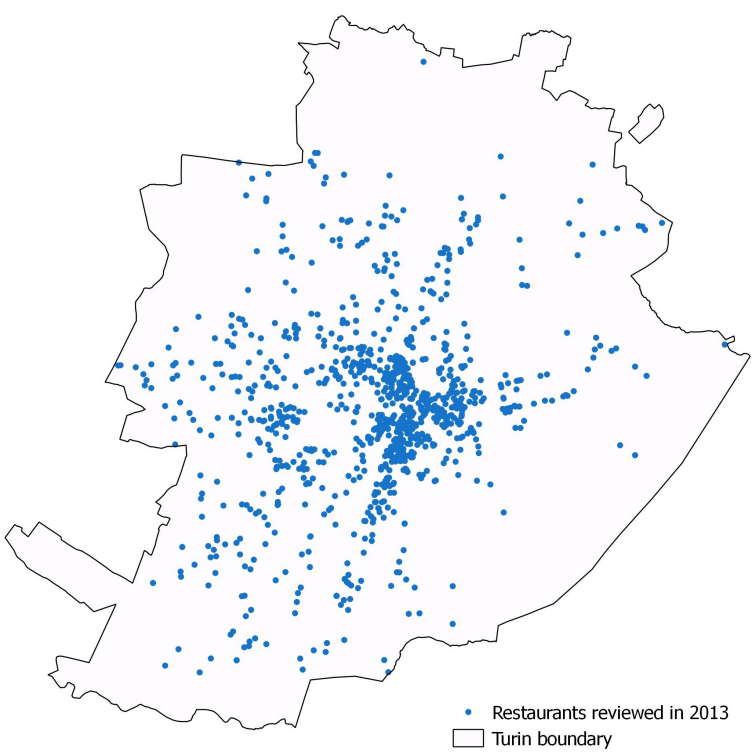
Having reported the general trends of the Trip Advisor platform we now focus on the methods used to recognize social practices performed by different social collectives. In particular, we maintain that the activity of reviewing restaurants can be considered a proxy for two different social practices: that of using Trip Advisor itself and, assuming that users have actually visited the places they review, the practice of eating out in Turin. In light of the latter, we try to identify different social collectives in the data and compare their shared attitude when deciding where to dine out in the city.

In order to recognize social practices we applied two opposite approaches: one starts from our prior knowledge about users social differences and look

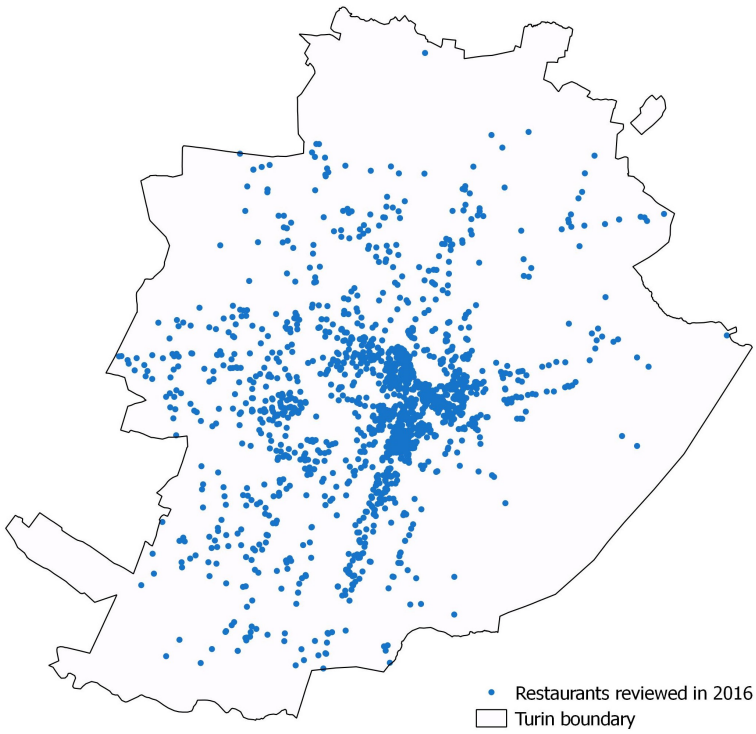
Figure 8.6: Maps of restaurants (points) with at least one review in 2010, 2013 and 2016



(a)



(b)



(c)

at statistically significant spatial pattern in their behaviour; the other aims at detecting emergent social collectives from the perspective of naive geography, therefore using the neighborhood as basic spatial unit since it reflects more the common sense knowledge of a city Meegan and Mitchell (2001).

From Social Collectives to Social Practices.

What we evaluate to recognize social practice from social collectives is the spatial concentration of reviews posted by users which we classified given our a priori knowledge of their origin - Italian tourists, Turin locals, foreign tourists.

To measure the statistical significance of the reviews' spatial concentration we analysed the data on a grid of 971 hexagons of 33,000 squared meters [†].

[†]We used hexagonal cells in line with recent works (Shelton et al., 2014; Poorthuis and Zook, 2014; Rzeszewski, 2018) which favor them to rectangular grids for essentially two reasons:

The hexagon's area has been chosen to approximate the average area of the 92 census tracts of Turin - which approximate the average population density - and to better cover all the city extent. Three distributions of reviews per restaurant are obtained by isolating those posted by members of each social collectives. Then they are aggregated per cells by taking the sum of reviews posted to each restaurant spatially located within the cell itself. To detect social practices from the behavior of each social collective we combined two methods

- we visualize and select the most popular areas, measured by the proportion of reviews posted for each cell and computing the classes by natural break; the latter allow to minimize the variance within the class maximize the variance between classes.
- we verify where the number of restaurants does not explain the area's popularity; this imply that other reasons, besides the mere restaurants presence, drive people behaviour there.

The combination of the two methods return the areas that are the most popular among each social collective, independently from the restaurants' presence.

From Social Practices to Social Collectives.

We also analyse behavioral patterns depending on users neighborhoods' preference structures. We used the 23 Turin's neighborhood to characterize people spatial behaviour since neighborhoods are known to reflect the naive knowledge about the city Egenhofer and Mark (1995). Neighborhoods have been defined as a "key living space [..] which symbolizes aspects of the identity of those living there to themselves and to outsiders" Meegan and Mitchell (2001). Given the strong symbolic meanings people associate with neighborhoods, we hypothesized that neighborhoods' preferences would have been informative of the social influence embedded in peoples' choices. The ultimate aim of this analysis is to detect clusters of users which can be considered as "carrier of a social practice", while the social practice is given from the recognition

hexagons can be more easily varied in size to address the Modifiable Areal Unit Problem and they share six instead of four neighborhoods which is an advantage for statistical analysis.

of a shared preference in deciding where to dine out. Therefore, while the previous approach employs spatial data mining techniques, in this case we apply non spatial methods on reviews classified by their being located in different neighborhoods. We applied K-Means algorithm on the data, a commonly used, simple but generally rather efficient, clustering method. Essentially, the clustering intends to partition n objects into k clusters in which each object belongs to the cluster with the nearest mean. This method produces exactly k different clusters of greatest possible distinction. The problem of this method is that the best number of clusters k, leading to the greatest dissimilarity between clusters, must be decided a priori. Since the objective of K-Means clustering is to minimize total intra-cluster variance, or the squared error function, we can evaluate which number of clusters minimizes the squared error running it n times and look at the total within clusters sum of squares. Then we run the K-means algorithm to produce k clusters on an m x n matrix where m is the number of users and n is the number of Turin's neighborhoods. Each a_{mn} corresponds to the number of reviews the m user has posted in restaurants located in the n neighborhood.

8.4 Data mining Results

8.4.1 Charting Social Collectives' Behaviour

To classify users into different social collectives we started by using their origin as key criterion. The reviews from which we can extract the users' origin are 169.355. On that we distinguished among: **Turin locals**, **Italian tourists** and **Foreign tourists**.

Table 8.1: Social collectives on Trip Advisor.

Social Collective	Number of users	Avg. reviews per user
Italian Tourists	45404	2.04
Foreign Tourists	10200	1.02
Turin Locals	28000	3.0

Table 7.2 shows their presence in our data sample. Although the highest number of reviews is posted by tourists (Italian plus foreign), Turin locals are more active in producing contents, each of them post 3.7 reviews on average. This is rather expected given that locals have more opportunities to visit Turin's restaurant.

Table 8.2: Descriptive statistics of variables for the hexagons grid.

Variables	Total	St. Dev.	Mean
Italian Tourists reviews	74128	76.34	132.69
Foreign Tourists reviews	10442	32.61	10.75
Turin Locals reviews	84758	127.68	87.31
Total reviews	169355	278.08	174.41
Restaurants	1982	1.9	2.04

To evaluate and compare social collectives' geographies we created an hexagonal grid and aggregated the reviews posted in restaurants within each cell. Table 8.2 shows the total, standard deviation and mean of the relevant variables we analysed. Our objective is to isolate areas that are the most relevant from the perspective of each social collective and classify the reviews posted by them when they can be a sign of certain social influence. Therefore, we look at the areas which are popular among each social collective; however, we also need to distinguish between areas that are popular simply because they exhibit a significant density of restaurants, so people have just more chances to go there, from areas where people go for specific reasons - they may be the quality or popularity of a restaurant or the characteristics of the area. To do this, we combine a popularity value - which is given by the proportion of reviews posted in the area - with the level of independence reviews have from the restaurants presence - which is given by testing the hypothesis that the number of reviews is explained by the number of restaurants. Therefore, we select the areas where members of each social collective are specifically interested in, independently from the restaurants presence, and that interest is shared among the group, since also the popularity must be the highest.

Maps 8.7 display how reviews posted by each social collective are distributed throughout the study area. This gives us an overall idea of which are the most

popular areas from the perspective of each social collectives.

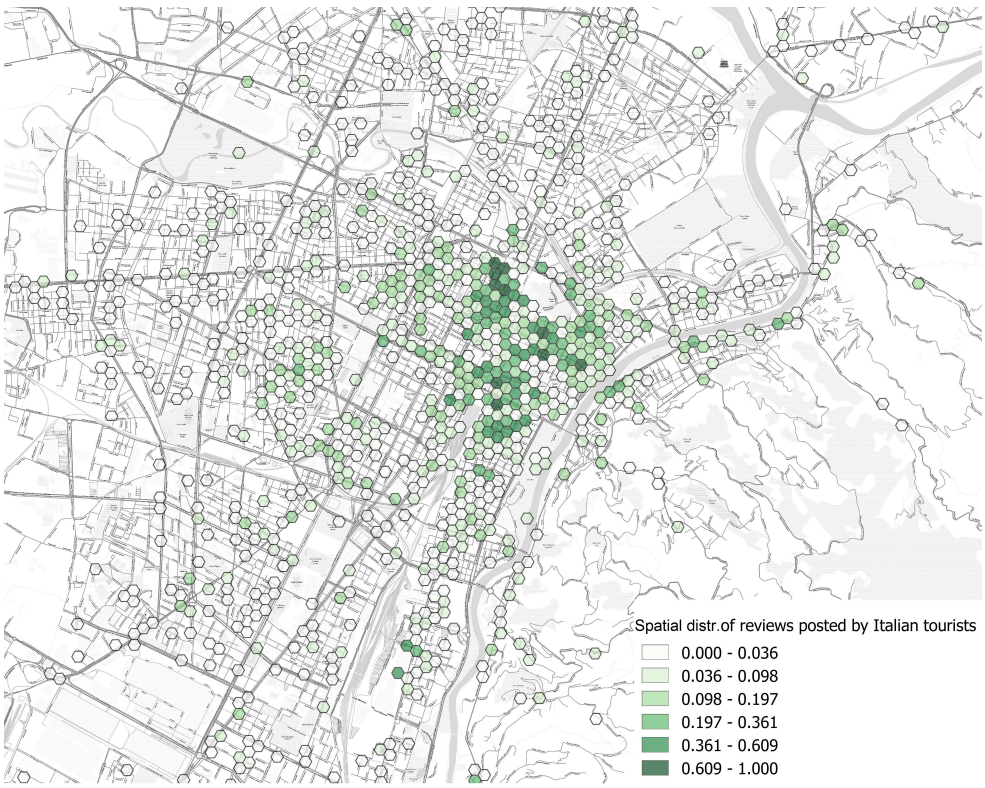
Then, we tested a very simple regression model to verify how much the number of restaurants is explicative of the areas popularity - which is measured by the number of reviews posted. Table 8.3 shows the results of the regression analysis we performed having the number of restaurant (NRt) as independent variable and the number of reviews ($NRv_{collective}$) as dependent variable. The variables have been normalized dividing by the maximum and obtaining intervals which go from 0 to 1. The R squared is the highest in the case of NRv_{tot} and $NRv_{ItalianTourists}$ - corresponding to the total and Italian tourists distributions - showing that for both the overall and the Italian tourists distributions the number of restaurants is explicative of the areas' popularity. The similarity between the total and the Italian tourists results is rather expected given that the most part of reviews are made by Italian tourists. This is not particularly interesting in our perspective since the dining out and reviewing restaurants activity in a certain area may just be due to the high density of restaurants - there are more chances to go there. In the other cases the model instead does not explain so well - in particular for foreign tourists - the variability of the observed data (R squared low), and looking at the outliers and residuals we found more interesting results. In particular, the way reviews are spatialized in the cases of foreign tourists and Turin locals are more likely to be influenced by other factors besides the number of restaurants. Residuals of the latter two distributions have been mapped and compared with the areas' popularity to detect where the most unusual high numbers of reviews are located.

Table 8.3: Summary of the hypothesis testing for the model $NRv_{collective}$ - NRt

Model	Est. par.	St. Error	p value	R squared
$Nrv_{ItalianTourists}$ - NRt	0.82	0.02	<2.2e-16	0.59
$Nrv_{foreignTourists}$ - NRt	0.25	0.01	<2.2e-16	0.3396
Nrv_{locals} - NRt	0.78	0.02	<2e-16	0.51
Nrv_{total} - NRt	0.82	0.02	<2e-16	0.59

Therefore, to identify social practices from the behavior of the different social collectives we combine the regression analysis with the popular areas. Map

Figure 8.7: Maps displaying the popular areas for the three social collectives. Spatial distributions have been normalized dividing by the maximum.



(a) Normalized spatial distribution of reviews posted by Italian tourists

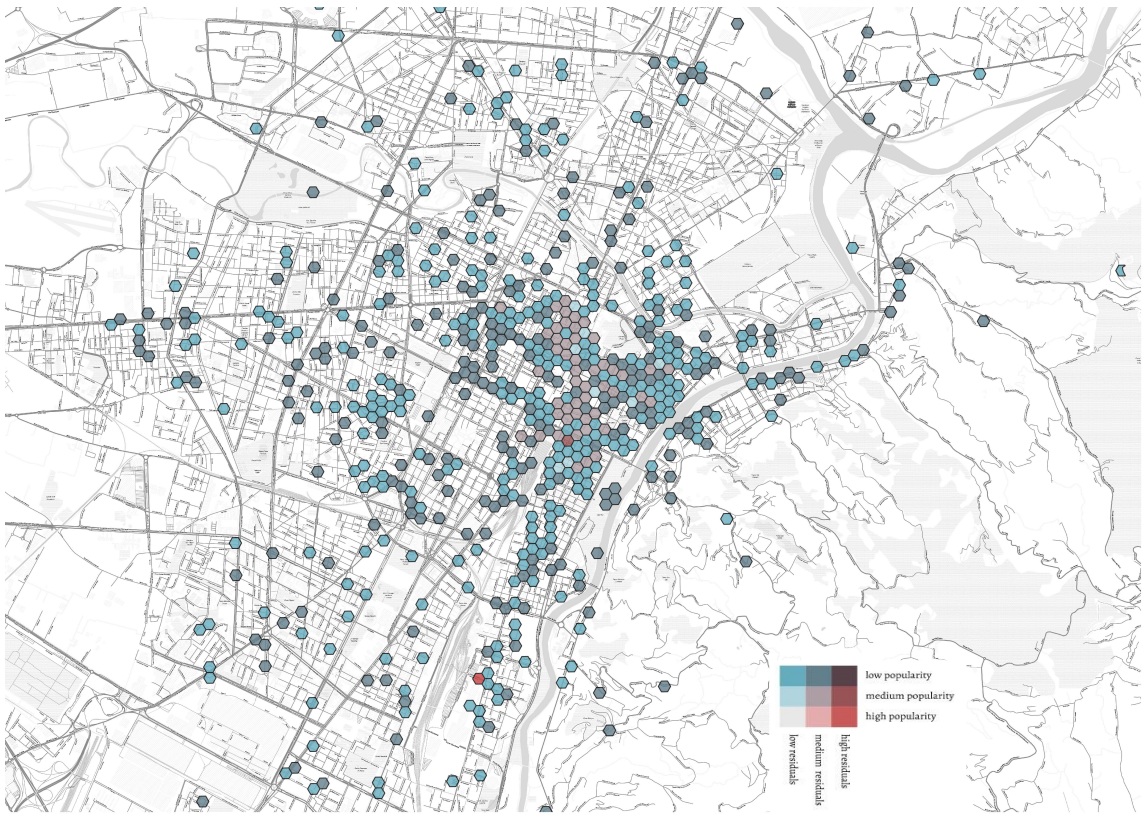
(b) Normalized spatial distribution of reviews posted by foreign tourists

(c) Normalized spatial distribution of reviews posted by Turin locals

in Figure 8.8 (b) exhibits the combined values. In the case of foreign tourists we have an hexagon cell which significantly diverges from the rest of the distribution both in terms of popularity and with respect to the expected value provided by the model. Looking at the restaurants in that area we find out that it corresponds to a rather famous multinational chain of Italian food, Eataly. As a consequence, the activity of “dining out" at the Eataly’s restaurant might be interpreted as a social practice which is characteristic of foreign tourists behaviour. Applying the same method to the Turin local distribution we selected all the areas that show high-high values - level of popularity and standardized residuals (see Figure 8.8 (a)).

This analysis serves us to detect which reviews can be tagged as a social practice performed by a specific group. Restaurants located in those areas which display atypical reviews concentration - the most popular independently from the number of restaurants - are selected; reviews posted by members of each collectives linked to the selected restaurants have been tagged as social

Figure 8.8: Maps displaying the comparison between popularity and model's residuals.



(a) Foreign tourists' reviews comparison.

(b) Turin locals reviews comparison.

practice adding a *review type ID*.

8.4.2 Detecting emergent Social Collectives

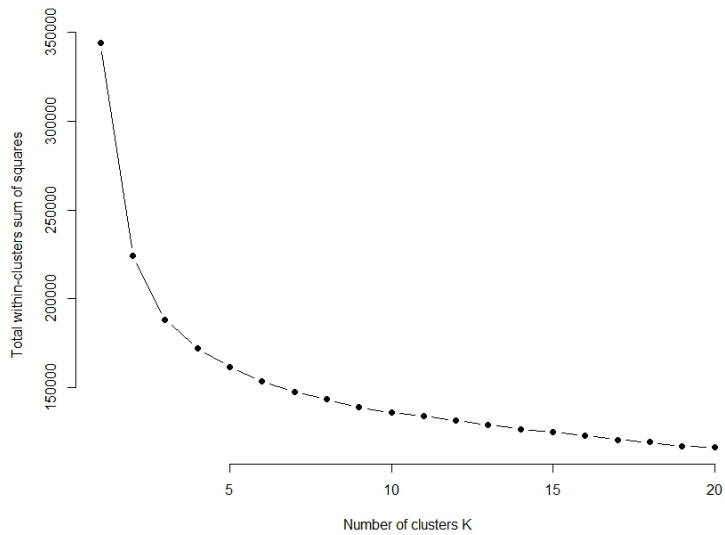
So far, we have shown collective behavioural patterns which take place in specific areas and restaurants resulted from our prior knowledge of the users' origin (if they are locals or tourists). We also tried to infer new knowledge by detecting social collectives which emerge from the clustering of people behaviours, considering their preference towards dining out in certain neighborhoods rather than others [†].

To do this we generate a matrix m x n, where m is the number of users and n is the number of restaurants' neighborhoods. Each a_{mn} corresponds to the number of reviews the m's user has posted in restaurants located in the n's neighborhood.

We applied the K-means algorithm on the data, a commonly used, simple but generally rather efficient, clustering method. This method produces exactly k different clusters of greatest possible distinction. The problem is that the best number of clusters k, leading to the greatest dissimilarity between clusters, must be decided a priori. Since the objective of K-Means clustering is to minimize total intra-cluster variance, or the squared error function, we evaluate which number of clusters minimizes the squared error by running the algorithm n times and looking at the total within clusters sum of squares by plotting the results (see Figure 8.9).

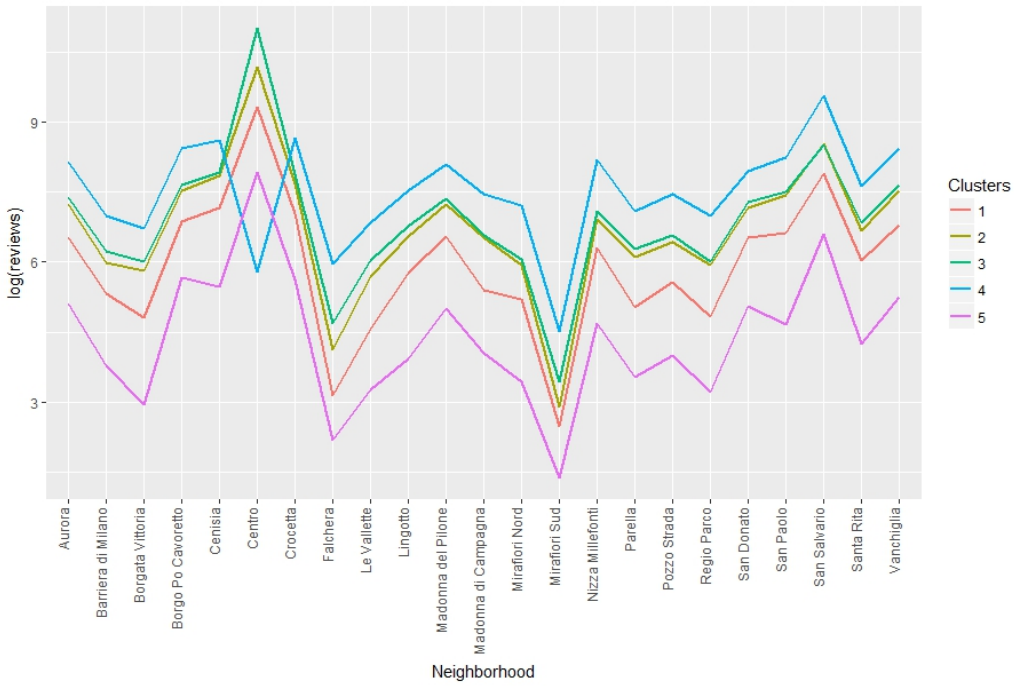
[†] To an explanation of the use of neighborhoods as basic spatial unit see par 8.3.3.

Figure 8.9: Squared errors in K clusters.



Results of the clustering phase are shown in Figure 8.10. Users groups display very similar behaviour regarding the favourite neighborhood - the global maximum corresponds to the city centre in clusters 1, 2, 3 and 5. While the strong preference of *dining out* in the city centre is rather expected, the distribution of reviews made by users belonging to cluster 4 changes significantly. The latter, comparing to other clusters, has a very low number of reviews in the city centre and a global maximum corresponding to the San Salvario neighborhood. Therfore, the cluster analysis highlights the presence of a group of users who consistently visit San Salvario, but very seldom dine out in other areas of the city. No other neighbourhood, including the most visited part of the city, the City Centre, shows such a pattern: a large number of users who, essentially, don't go anywhere else. In our view, this circumstance is particularly significant. As a consequence of this result, we decided to consider those users as members of an emergent social collective, which we called **San Salvario Users**.

Figure 8.10: The neighborhoods preference structure of five clusters of users.



Even in this case, the final aim of the analysis is to tag a subset of reviews as a specific type, which that are expression of the “we-attitude" collectives of users might have. Here, looking at users preferences we found out the existence of an other social collective, besides those given as input knowledge. Therefore, we can now tag the reviews posted by members of the detected social collective to classify them in terms of the social practice they recognize, that of *dining out in San Salvario*.

8.5 Ontology Population using Ontop: Classifying Restaurants by their Social Roles

Data has been analysed to detect collective behaviours performed by social groups. The classification and clustering of users brought us to distinguish among the *dining out* behavioural pattern of different social collectives - Italian Tourists, Foreign Tourists, Turin Locals and San Salvario Users - and, to tag

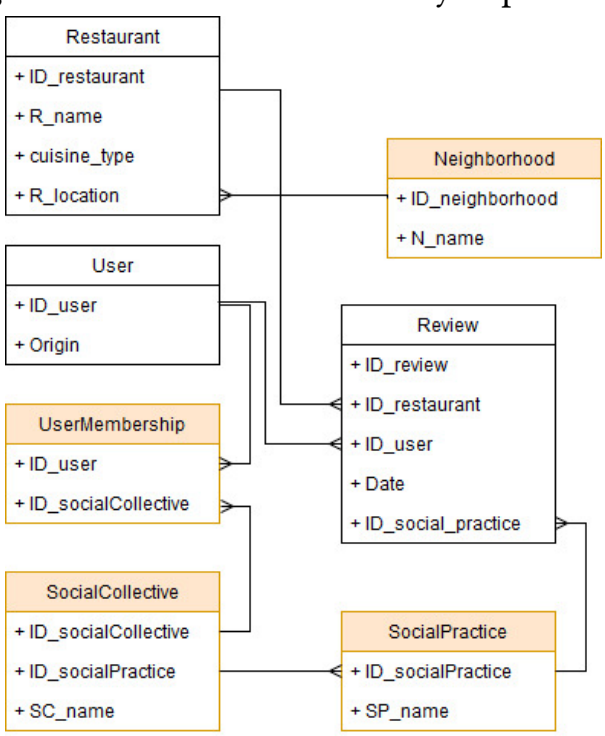
reviews as types, which are the actual manifestation of different social practices. This can ultimately led to the identification of urban artefacts social roles by mapping the data mining results with the domain ontology presented in Section 8.2. Moreover, the analysis performed so far was specifically aimed at covering the behavioural module of the ontology, namely the **Social Practice ODP**. Behavioral patterns associated with each social collective can be considered: on the one hand, types of the “dining" action; on the other hand, they can be conceptualized as social practices. The difference among these two facets of collective behaviour - as discussed in Chapter 6 - is that in the first case each action is related with an individual agent (a *Rational-agent*) and it exists in a specific space and time interval; on the contrary, a social practice of dining is an endurant, therefore it is wholly present independently from the time snapshot considered [†], but moreover it is recognized by a specific collective of people who carry out the practice. The practical consequence of this duality stands in the different kind of role played by an urban artefact (see Chapter 7). The fact that an urban artefact is being used by a person at a certain time implies that it is playing a **participation role**. While the fact of being socially used - when a relation between a social practice and an urban artefact exists - implies the emergence of a **social role** played by an urban artefact. Differently from a participation role, a social role is played even if it is not involved in a participation relation that links an endurant with a perdurant, i.e. Mary is a teacher even when she is not at school Masolo et al. (2011). For this experiment we focus on urban artefact social roles only, because the dataset analysed does not provide any meaningful information about time; reviews posted on the Trip Advisor platform do not correspond with the actual time of the performed dining activity. Other sources of data - such as the table reservation - could provide more insightful knowledge on participants roles which can be discuss in future works.

The database structure is depicted in Figure 8.11 using the UML notation. UML classes are represented in two colors to distinguish between those which were the input data and those resulted from the data mining step. By the mapping we virtually populate the ontology : on the one hand, to ground the results of

[†]Note that also social practices have a life cycle, they emerge and disappear on time; however, social practices have a timescale much longer than actions. Further exploration of how can be defined and represented a *social* timescale will be object of future work.

a single case study into a standardized and machine-understandable format which can be semantically queried; on the other hand, to derive restaurants social roles depending on the recognized social practices.

Figure 8.11: An UML representation of the TripAdvisor database. Classes in orange resulted from the data analysis phase.

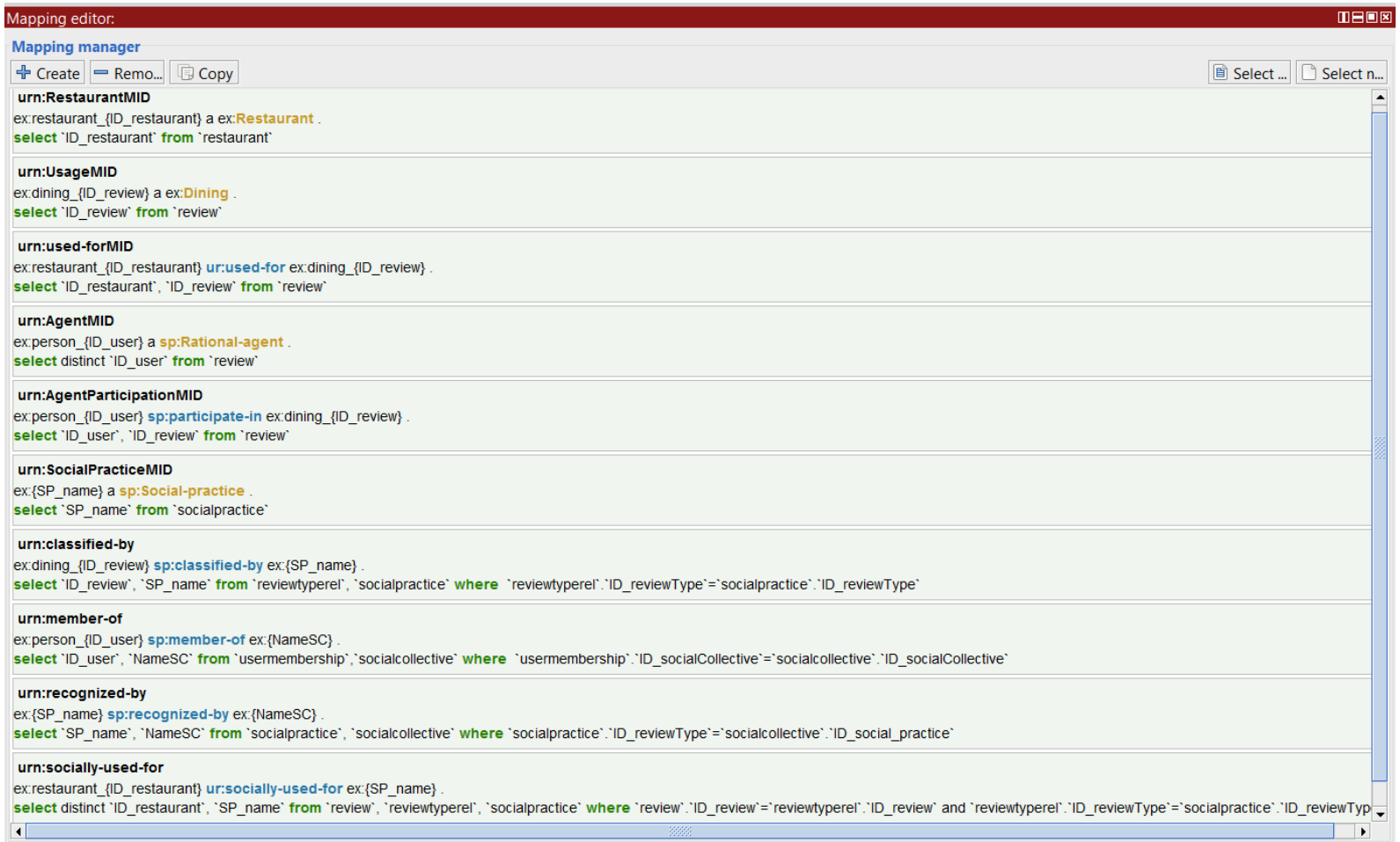


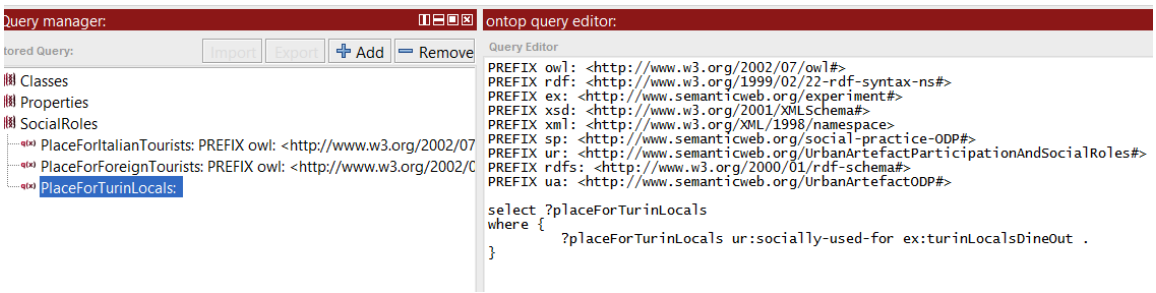
To manage the mapping we have used Ontop, a platform and Protègè Plug-in (Calvanese et al., 2017; Bagosi et al., 2014). It is an open-source Ontology Based Data Access (OBDA) system that allows for querying relational data sources through a conceptual representation of the domain of interest, provided in terms of an ontology, to which the data sources are mapped. The virtual approach to OBDA of Ontop avoids the need to materialize triples to perform queries over the ontology in SPARQL language. To do the mapping a connection between the database and the software has been established; data are retrieved through SQL queries to populate the ontology classes with virtual instances. While virtualizing ontology's individuals is a great advantage to support data integration and facilitate the use of ontology to semantically

enrich dynamic and changeable datasets, Ontop does not support either axioms present in expressive ontology nor rules. A solution to this problem is to simulate ontologies axioms and rules with mappings and queries. In this experiment SPARQL queries and SQL mappings have been used to recognize restaurants social roles.

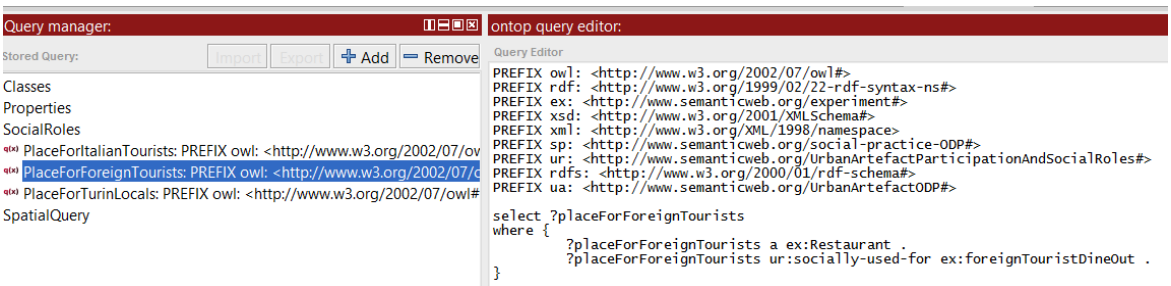
The specificity of the Trip Advisor platform allows us to assume that Trip Advisors' restaurants are unified by urban design specifications which all prototype the architectural typology of restaurant, and, as a consequence, they are all planned to enable the food consumption. Given these assumptions a Restaurant class has been added to the ontology and defined as enabling the food consumption planned usage; however, while all individual restaurants enable the dining usage, they do not instantiate all the same role. To classify restaurants depending on their social uses, and to ground the data into a standardized semantic format we mapped the database with the ontology classes as shown in Figure 8.12. Semantic queries can be now performed over the data; also they can be store and used to simulate axioms present in the ontology. To make urban artefact social roles emerge, we set as much queries as the social practices recognized into the dataset are. On the basis of our ontology model, an urban artefact instantiates an urban artefact social role when it is being socially used for a social practice. As a result of the mining phase, we have reviews data records tagged as distinct social practices when associated to a pattern of collective behaviour - the dining in san salvario - or to an a priori known social collective - foreign and Italian tourists or Turin locals dining. We can now retrieve the data as individuals collected in the social practice class and search for all the places that are socially used for each of of the social practice. Figure 8.5 shows three exemplary queries through which we can ask for individuals playing a social role since they are socially used for a social practice. Query *a* retrieves all the places that are socially used for dining out by Turin locals, but we can also verify if they are all restaurants, query *b*, or exploit the ontology taxonomy to search for all the urban artefacts playing that role, *c*.

Figure 8.12: A screenshot of the Protègè interface using Ontop for the mapping between the ontology and the database classes and properties.

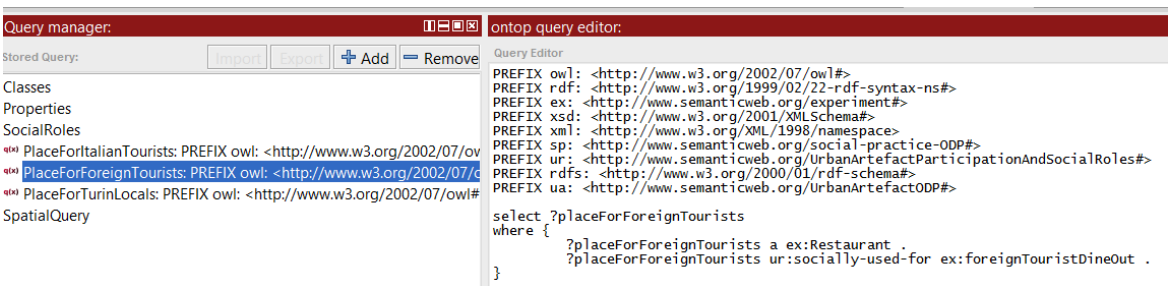




(a) This query retrieves all the things that are socially used for dining out by Turin locals



(b) This query retrieves all the restaurants that are socially used for dining out by foreign tourists



(c) This query retrieves all the urban artefacts that are socially used for dining out by Italian tourists

Given that we have a single case study and data source, that of Trip Advisor, listing only restaurants the experiment does not aim at evaluating the results obtained from the data themselves but the proposed approach. In recent years, many researches have focused on recognizing socio-spatial behaviour providing crucial insights on urban artefacts social uses, but they have never been integrated through a standardized format in order to built a *social* knowledge base on cities. Data organized into the *Urbis* ontology might serve that purpose insofar new data sources can provide information on other social practices; a recognized social practice can be about the very same dining of i.e. foreign

tourists but it may be manifested through the use of urban artefacts other than restaurants, i.e. parks or squares. The main advantage of our approach, indeed, stands in focusing not only on a typological classification of urban artefacts (restaurant, square, park) but in its giving main stage to the anti rigid and dynamic properties that urban artefacts may have, namely their social roles.

8.6 Evaluation

A possible approach to ontology evaluation is to compare it with other ontologies considered as “gold standard" (Alazzawi et al., 2012; Brank et al., 2006; Dellschaft and Staab, 2006). Existing core ontologies related with the geographic domain are proposed by the Open Geospatial Consortium in the form of micro theories (Ingo Simonis, Stephane Fellah, 2014); however, they are mostly concerned in dealing with geo-spatial aspects such as geometries, spatial relations and attributes while *Urbis* specifically applies to the socio spatial knowledge. As a consequence we do not believe it might be a valid approach to our case. An other option, generally referred as data-driven evaluation(Hlomani and Stacey, 2013), is to evaluate to what extent data can be mapped in the ontology comparing with others. Therefore, we opted to use extracts of two other ontologies for comparison: the Ordnance Survey Building and Place (OSBP) ontology and the DBpedia Ontology (DBO), and evaluate to what extent the data sample we used could have been mapped into other ontologies and how similar is the semantics behind ontologies’ classes. These were chosen as they exhibit different representations of geographic entities: the first grounded in expert knowledge, the second aimed at structuring information crowdsourced though various wikimedia projects. This way we can compare to *Urbis* with both top-down (OSBP) and bottom-up (DBO) approaches to describe the urban domain.

Figure 8.13: A comparison of the *Urbis* ontology with the Ordnance Survey Building and Place (OSBP) and the DBpedia (DBO) Ontologies. Red arrows highlight the presence of similar concepts.

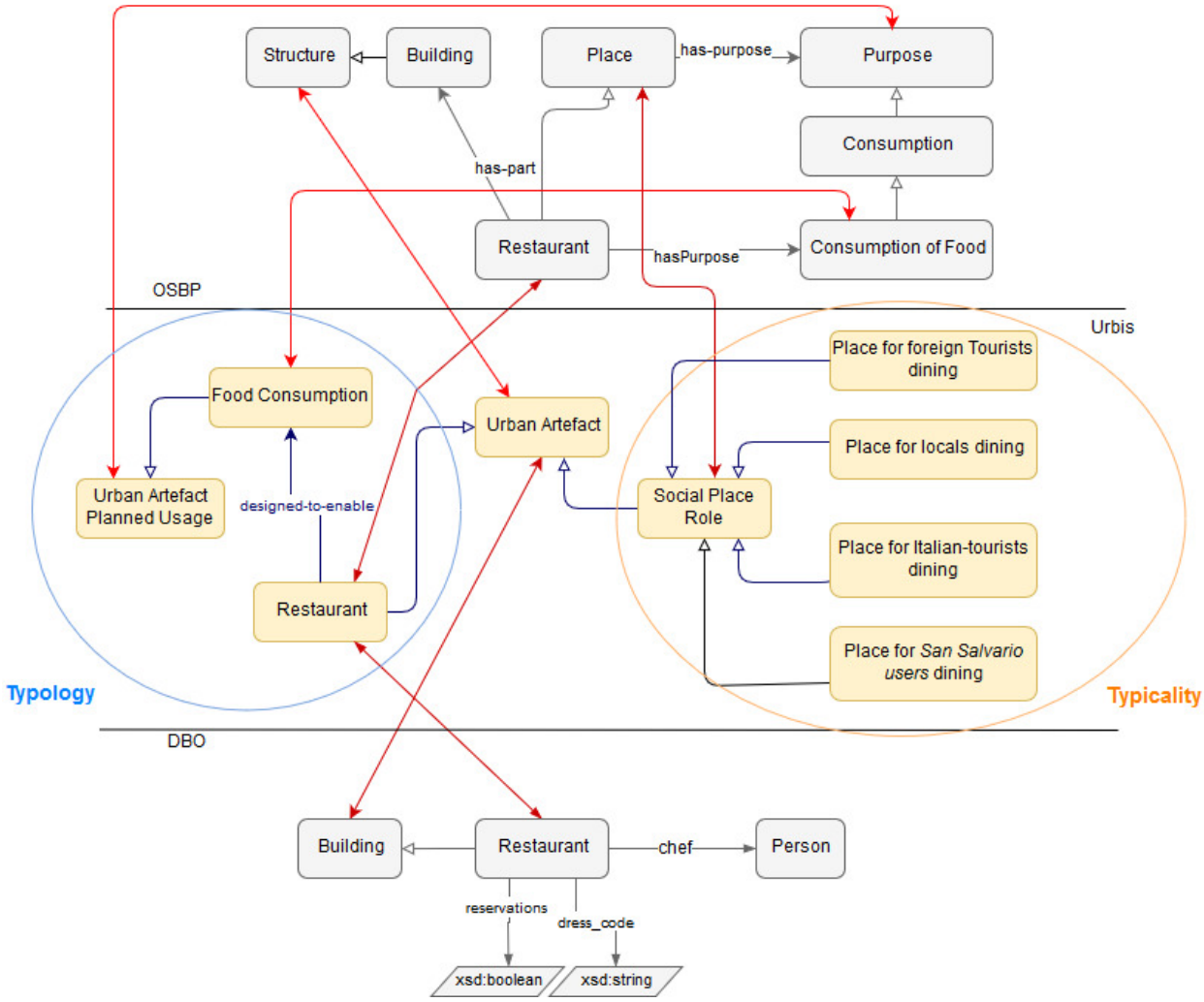


Figure 8.13 shows excerpts of the three ontologies and their similar concepts. Comparing *Urbis* with *OSBP* highlights that:

- Restaurant classes are similar concepts even if in *Urbis* a Restaurant is an Urban Artefact while in *OSBP* is a Place that has part some Building;
- Food consumption and Urban Artefact Planned Usage in *Urbis* and

Consumption of food and Purpose in *OSBP* are similar concepts; they are not the same as a consequence of slightly different conceptualizations of Urban Artefact and Place. An essential property of Urban artefact, differently from Place, is that it is unified by some design specifications. The urban artefact planned usage is encoded in the design specification implying that the urban artefact enables certain uses. The role of design specifications in the characterization of buildings is assumed in OSBP, and the planned uses instead of being enabled by the urban artefact are related to the place which has the topological purpose to host some activity.

- Urban Artefact is a similar concept of Structure since both refer to something built or constructed. In *Urbis* is also specified that an urban artefact is unified by design specification, prototyping an architectural typology, and created by an urban designer. However, Building in *Urbis* should be eventually introduced as a top-most urban artefact kind, since there are urban artefacts, such as infrastructure (i.e. road, bridge,railway) or open-space (i.e. park, square), that are not buildings.
- Place in *OSBP* is “where something happens". Similarly, Urban artefact roles are any urban artefact kinds - having a location - associated with an Usage, which is different from the Planned Usage, by a *used for* relation. In particular, Urban artefact social roles - that are shown in Figure 8.13 since are directly related to the experimentation - can be defined as “where something conventionally happen" and they result from the *socially used for* relation between urban artefact and social practice.

The two ontologies share similar conceptualization of the urban domain since in both cases purposes or planned usages are recognized; however, *OSBP* presents a possibly misleading overlapping in the conceptualization of place between *where things happen*, rough definition of Place, and the property of having some purpose, such as the latter should imply the former. In particular, this brings to: i) elude to render explicit the underlying intentionality of the designer that enables a place to have a purpose; ii) make unclear the difference between Structure and Place, both of them are kinds of topographic objects but only the latter has a purpose. As a consequence in the ontology there are at the

same time: 1) Place kinds, i.e. Hospital, Airport, that are not Structure kinds but have part building; 2) Structure kinds that have no explicit purpose, even if it is generally stated in the annotated definition i.e. Dam: a barrier constructed to hold back water and raise its level forming a reservoir or preventing flooding; 3) Places, since they are not Structure kinds, can also be non structure like i.e. river, but having a purpose. We believe that a clarification may emerge by introducing roles. Urban artefact roles, indeed, allow to render explicit the distinction between where things happen and where they are planned to happen, considering only the former as a condition to instantiate a role. While the latter is a rigid property of an urban artefact, since it seems reasonable to assume that every element of the built environment has been designed with the purpose to enable certain uses; on the contrary, the fact that things actually happen is an accidental property of an urban artefact which cannot be known a priori nor defined by typological classifications.

The generally rather static character of ontology models clearly clash with the dynamic nature of the urban environment. However, crowdsourced data provides us with bottom up information about places that need to be organized in a machine readable format. The Trip Advisor data sample we analysed gives us knowledge about how people live the city of Turin. Let's take the example of Eataly, which is the top visited restaurant by foreign tourists even if it is located quite far from the city center and in an area where there are few (comparing with more central zones) other restaurants. A typological classification, like the one provided by *OSBP*, brings as to consider Eataly as a Restaurant, which undoubtedly is, that enables Food consumption, which is also confirmed by the data, but the fact that it is a place where generally foreign tourists dine it is not captured by the ontology. *Urbis*, introducing roles as dependent of the existence of a social practice, allows a more dynamic classification of a places, such as Eataly, which is related to both their typology, i.e. Restaurant, and to their typicality, i.e. Place for foreign tourist dining.

It should be noted that the OSBP has not been engineered to be populated of crowdsourced data and it would provide a more static representation of the geographic domain; on the contrary, *Urbis* has been design to capture the social and dynamic character of places which could be extracted from crowdsourced data so that its core structure will remain the same, but it subclasses and roles

should be systematically revised case by case. Similarly, DBO aims at providing a semantic structure to crowdsourced data. However, it adapts as much as possible to the information collected through wikimedia projects rather than on the domain expert knowledge. The extract of the DBO to represent specifically restaurants is shown in Figure 8.13. DBpedia ontology provides restaurants' properties which are somehow more detailed than what expected, such as the chef and the dress code. Querying the dbpedia database we can hypothesize that the reasons of these properties lie in the type of restaurants mentioned in wikipedia, they are generally famous restaurants which are characterized by being run by popular chefs or by having specific dress codes (i.e. some restaurants explicitly require nudity). DBO, differently from OSBP, represents more a kind of knowledge that is derived from crowsourced data, which is a similar purpose of *Urbis* ontology. However, the design of the core classes and properties of the latter has not been derived by a data-driven approach. As it has been already described in this thesis, the core classes resulted from an assessment of the state of the art geographic ontologies against literature in social geography. This would allow to represent knowledge derived from crowdsourced data but with an explicit social bias.

8.7 Conclusions

In this Chapter we presented an experiment using the *Urbis* ontology to organize crowdsourced data and discover socio-spatial knowledge.

On the one hand, with this work we explored methods to recognize spatially located social practices. We analysed data from a platform of user generated restaurant reviews, TripAdvisor, and attempted to identify practices related to food consumption in the city of Turin, Italy. We demonstrated that, even with a single source of information providing data limited to a single domain, it is possible to identify emergent behavioural patterns associated with social groups that use the city in different ways. As Mela (2014) maintains, *the choice of a specific space implies a broader selective act, whether conscious or not: in accepting the possibility of encountering a particular set of individuals, with whom one identifies, also diminishes the probability of encountering another.*

The methods applied in this work is specifically designed to identify the selective function that people embed when choosing where to dine, looking at behaviours that are similar within a group and dissimilar to the others.

On the other hand, we addressed the data analysis to populate classes of the *Urbis* ontology. This would favor the integration and sharing of case studies framed in a generalizable representation of the urban domain. In particular, the populated ontology has been evaluated by comparison with other ontologies of the same domain (OSBP and DBO). It resulted that *Urbis* provides a better grounding for representing the dynamic character of the urban domain.

Chapter 9

Conclusions

In this thesis we have suggested ontology patterns that can be combined in a core ontology (*Urbis*) for representing the urban environment with an explicit social bias.

Our suggestion is based on introducing and defining entities to represent the social characterization of urban places. In particular, we propose new models to interpret and render explicit the semantics of urban places from the perspective of the everyday life of people. In this Chapter the outcomes, application prospects and the limits of our study are presented.

9.1 Outcomes

In Chapters 5, 6 and 7 we have provided ontology design patterns as the basic building blocks of a core ontology of the urban environment [‡]. Our analysis extends and enriches the current debates about some much discussed ontological entities, such as artefacts and roles, with new insights emerging from the specificity of the urban environment. A new collective entity has been introduced: social practice, which allows to represent peoples' social behaviour; specifically, social practices involving the use of urban artefacts

[‡]Note that the thesis outcomes - ODP, examples and the core ontology - have been encoded in the Ontology Web Language and Semantic Web Rule Language, and are available within this repository: https://gitlab.com/misplaced/Thesis-UrbisCore.git

are employed to render explicit the multiple social roles urban artefacts may play as related to peoples' collective experiences.

The main contributions of Chapters 5, 6 and 7 can be summarized as follows:

- In Chapter 5 the ontological notion of artefact has been extended to that of urban artefact. An urban artefact is endowed with a design specification which prototypes specific architectural typologies and it is realized to enable some planned uses, as well as in coherence with certain values and regulations. On the one hand, the introduction of an urban artefact entity to describe the urban environment allows to define the types of physical objects within the urban fabric; on the other hand, discussions in the field of formal ontology about human-made objects are enriched with the characteristics of the urban dimension.
- In Chapter 6 we propose a way to model the possible mismatch between the planned and the actual uses of an urban artefact applying roles theory. Introducing roles allows to specify uses of an urban artefact which are not compliant with the urban artefact's planned usage without changing its typological classification. We argue that urban artefact can play two kinds of roles: participation and social roles. The contexts where these two types of role emerge are described respectively as: i) the occurring of *use-for* relations between an *urban artefact* and an *urban artefact usage* ii) the existence of a *social practice* which involves an *urban artefact* in a *socially-used-for* relation. This provides a conceptual tool for describing several possible interactions between people and urban artefacts. In particular, with the notion of *urban artefact participation role* is possible to model contingent situations when urban artefacts are used by people in the context of specific events. This kind of role is temporally defined, insofar it is played only at the time of the participation relation. However, urban artefacts may also play an *urban artefact social role* which does not temporally depend from the occurring of a specific event, but it is the result of certain social conventions. Recognizing such social role is pivotal for two reasons: 1) to represent the tacit, and often only local, knowledge about places which specifically concerns the social uses of urban artefacts; 2) to model the multiple and diverse social uses of urban artefacts in relation with different social collectives of people. To clarify

the meaning of social uses we introduce a specific entity, that of social practice.

- Chapter 7 presents alternatives in ontology modelling to conceptualize social practice. This results in an ontology pattern representing social practice as a powertype. The problem we try to address is that of characterizing the semantic relation between actions and social practices, the former performed by a single human agent, the latter related to a social collective of human agents bearing their own properties. A social practice model may be applied to all cases where a conventional pattern of actions can be recognized. The potential of introducing a social practice entity stands in allowing the identification of the social collective associated with a practice. Within the urban environment, when a social practice classifies a class of actual uses of an urban artefact, it generates the context where an urban artefact social role emerges. Therefore, an urban artefact social role can be indirectly associated with a social collective by mean of the social practice entity. This enables to recognize the perspectives different collectives of people may have about urban artefacts in relation to their social role. In enabling this, we provide a link between the emergence of an urban artefact social role and the collective experience of people in using urban artefacts.

In Chapter 8 we extract a real dataset from the Trip Advisor platform, listing restaurants in the city of Turin and their reviews posted by users. Trip Advisor is among the web platforms which crowdsource information directly from people. The sample we extracted has served to recognize social practices related to food consumption using two approaches: 1) identifying specific social collectives (Italian tourists, foreign tourists and Turin locals) and verifying whether they show similar patterns in choosing where to dine out; 2) recognizing patterns in the data and then identifying the associated collective of users.

The experiment is a very preliminary attempt at employing a model based on social practice and urban artefact roles to classify urban places. The method we propose aims at organizing data following an ontology model of urban place which has a strong social bias. This would enable an information system to return knowledge about how urban artefacts are socially used by different

social collectives. The proposed approach has been evaluated against two other ontologies, one specifically related to the geographic domain, Ordnance Survey Building and Place (OSBP), and an other aimed at structuring crowdsourced information, DBpedia Ontology (DBO).

9.2 Application Prospects

The growing overlap between the digital and people everyday life, the spread of user friendly location based technologies, are producing a wealth of data coming from the so-called *human* sensors. Comparing to traditional sources of geographic data, this relatively new kind of information reflects much more a human-centric perspective on cities. Furthermore, it provides relevant insights on the way people use the city which researchers as well as urban policy makers increasingly relay on to reach knowledge about urban contexts. Geographic ontologies that have been developed so far mostly deal with the notion of space or with typological classifications of the elements composing the built environment. A pure notion of space or a rigid classification of place types, fail to represent the dynamic and social knowledge people have about the city which they can now express by technological means. On the other hand, geographers and urban planners have been interpreting the geographic domain in its dynamic character, following a human-centric perspective based on people experiences and everyday lives. At the core of their discussions the notion of place has been elaborated through different argumentations but they all seem to converge on the idea of place as a result of a mutual interaction between people and the physical environment. Our work goes towards a conceptualization of the urban environment as discussed in the humanities, to provide the groundings for the development of more human-centric and *socially-aware* geographic applications. The relation between people and urban artefacts has been conceptualized in terms of social practices and the underlying dynamic has been modeled by mean of roles. Our ontological models can be applied as follow:

- an Ontology Based Data Access (OBDA) approach can be applied to integrate the results of different case studies where socio-spatial behavioural patterns have been recognized from georeferenced data. As

shown in the experiment presented in Chapter 8, such an application could support the identification of places that instantiate urban artefact social roles under the open world assumption. The open world assumption implies that, through the mapping with the ontology, if restaurants listed in the database are mapped as instances of the restaurant class and it is a subclass of the urban artefact class, then restaurants are also instances of the latter. Moreover, we also have that urban artefacts may instantiate urban artefact social or participation roles, when socially used for some social practices and used for some usages respectively, therefore we can query the database for mapping these relations and identify all urban artefacts that instantiate a role independently from their specific type. Though this approach integrating data sources would not need the materialization of triples and would allow the creation of a *social* knowledge base of cities.

- the ontological models could be applied to guide the conceptual modelling of information systems of map-based applications aimed at crowdsourcing geographic data and information. Such systems would benefit from the introduction of social practice and urban artefact roles entities, the former defined as the social object whose manifestation is a behavioral pattern associated with a specific group of users and the latter as a georeferenced object which locates an urban artefact which is used for an activity or a social practice, when the activity can be classified as such. This allows to return the dynamic and social character of place, interpreting georeferenced data as expression of people experiences of the city.

9.2.1 Perspective Use Scenarios

Use scenarios of the listed applications can be:

Creating a *Social* Knowledge Base about Cities The OBDO approach can be used by researchers that have multiple studies on people socio-spatial behaviours in order to integrate them in the form of structured knowledge to represent the social character of urban places. Such studies can be made

from georeferenced data extracted from the web, as in the experiment presented in the thesis, but they may also come from questionnaires or other data sources on the way people use the city. Organizing data into knowledge about social practices and urban artefact roles would allow to identify which parts of the city are mostly used by different social collectives, i.e. young, tourists, elderly and, as a consequence, how urban artefacts are characterized by people social behavior rather than by their types. This would generate a Knowledge Base concerned with the geography of people everyday life and the social meanings associated with the built environment; such topics are relevant objects of inquiries specifically in the field of social geography and urban studies, particularly by those scholars who conceptualize place from a relational perspective embracing post-structuralist approaches (Murdoch, 2005; Gieryn, 2000).

Support of Urban Planning Urban planning consists of several phases which can be summarized as aimed at answering the following questions (Steinitz, 2012): 1) How should an area be described? 2) How does the area operate? 3) Is the area working well? 4) How might the area be altered? 5) What differences might the changes cause? 6) Should the area be changed? In a participatory process people can potentially be involved in all these phases and, given that we are living in a digital era, their involvement could be facilitated through the use of user friendly technologies. An application for crowdsourcing geographic information whose information system is based on the ontological models we propose would focus on collecting data and representing knowledge about actual usages of urban artefacts and social practices associated with specific social collectives. We believe this would significantly benefit and inform the answering of the first three questions of the planning process. In particular, pioneering studies in participatory urban design and planning have stressed the importance of recognizing the actual uses which are made of urban areas by different target groups, particularly those who are the most marginalized (De Carlo, 1972). These urban planners were explicitly against the assumption of perfect congruence between urban forms and functions (De Carlo, 1972; Steinitz, 1968), giving a pivotal role to

a representation of the *lived* rather than the *planned* city[†]. The ontological models we propose could support the organization of data collected through such application in order to return the actual activities and social practices of different groups of people in relation with the elements of the built environment. This would inform the definition of a plan grounded in the actual social roles of urban artefacts from the perspective of different social collectives. A possible framework to support such a system is discussed in Calafiore et al. (2016).

9.3 Limitations and Future work

The work we undertook is a first step towards a human-centric representation of place. The endeavour proved challenging and the result inevitably has a number of limitations, which could be partly addressed in future work.

The first set of limits and the consequent need of future work concerns the conceptualization of urban place. In particular, we focused on the specific social character of urban places through introducing the *urban artefact social role* entity as dependent on the everyday *social practice* of people. To provide a comprehensive representation of a more human-centric notion of place we need to integrate other aspects that can be summarized as follows:

- the cognitive and perceptual dimension is crucial in the way people interact with physical objects in various contexts; in our work we explicitly put aside this dimension since we were specifically interested in the collective/social rather that individual/subjective relation between people and the built environment. However, our work, employing the notion of social practices, and related work, employing the notion of affordance (Scheider and Janowicz, 2014), ideally should be bridged. In particular the question of whether (and how) affordances and social practices influence each other should be addressed. Recent works focus on extending the idea of affordance to that of social affordance. From the humanistic perspective a framework to define social (or cultural)

[†]This is the assumption that motivated the “zoning" approach to urban planning.

affordances is proposed in Ramstead et al. (2016). Their framework considers the participation of an agent in social practices as the basic mental processes to acquire cultural content. We believe that an ontology to describe the urban environment may greatly benefit from a deeper understanding of the relation between those social practices involving urban artefacts and the concept of social affordance [†].

- emotions and place attachment are fundamental aspects to describe humans' sense of place. We define the social roles that urban artefacts may play as dependent on the conventional way they are used. However, people interactions with urban artefacts are also combined with certain sets of emotions. Therefore, the emotional dimension of people experiences should be introduced for a more comprehensive description of urban places; in particular, it may be interesting to: i) isolate emotions which specifically refer to place attachment (i.e. happiness, pride, nostalgia); ii) relate the emotions of specific people collectives with social practices involving the use of certain urban artefacts; an example of work aimed at detecting emotions associated with place types has been undertaken by Ballatore and Adams (2015). This work extracts emotions from travel blogs, therefore it refers to a specific social collective, that of tourists. Further analysis may be done to explore relations among social collectives, emotions and the social practices and activities which trigger those emotions.

Other limitations are related to the definition of social practice. In this thesis we propose a social practice entity which is spatially and temporally located and has a social collective who recognizes its existence. At least two other characteristics of social practices need to be considered:

- the semantics of the relation between social practices and objects should be further specified. Studies going in this direction are related to the concept of socio-materiality. This body of study is reviewed by Leonardi (2013) who underlines the ongoing philosophical debate about what is the social, the material and therefore the socio-material. A first attempt

[†] The need of introducing the notion of social affordances, intended as conventional/appropriate behaviour, can be also found in robotics, such as in the logic-based framework proposed in Sarathy and Scheutz (2016b a)

to formalize the relation between the social and the material is in terms of *entanglement* and can be found in Ferrario and Porello (2015).

- criteria to classify social practice types are needed. In particular, the notion of social practice can be related to either recurrent collective activities (i.e. social habit), conventional behaviour (i.e. social norms), or collectively coordinated activity (i.e. projects). The ontological commitment of our work was to introduce an entity to represent collective behaviour, therefore we retain the most general definition of social practice. Future work should be aimed at better categorizing social practices through a specific set of criteria.

Finally, we introduce urban artefacts in our domain of discourse as directly related to architectural typologies. This choice allowed us to restrict the scale of spatial reference to the buildings level. However, the geographical scale of people experiences may vary from the interaction with a single urban artefact to the experiences within a neighbourhood, an entire city or a country. People spatial experiences concern also their movements from a point to another (i.e. commuting). An interesting work investigating the relations between human cognitive scales and spatial information can be found in Hervey et al. (2017). It focuses on human cognition; however, the way people experience spaces and, consequently, their perception of the geographical scale may also vary across social and cultural collectives. Conceiving people experiences in terms of social practices may be a preliminary step to explore the relationship between cognitive and social structures in relation to geographical scale.

9.4 A final remark

This thesis is an attempt at providing the basic entities for a human-centric characterization of urban places with an explicit social bias. The ontology patterns we propose can be used to guide the development of geographic information systems based on a notion of place which includes information about the social differences across people and their multiple perspectives. However, our task has been greatly challenged by the complexity of people socio-spatial behaviour and, as we have detailed in this chapter, there are

still many open issues. Nevertheless, we believe that, given the growing role geographic information is playing in contemporary cities, there is the urgency of undertaking the hard work of integrating new technologies with knowledge about the social world.

Appendix to Chapter 8

Tables summarize descriptive statistics on the evolution in the use of Trip Advisor platform to review restaurants in Turin.

Table .1: A - Users registered on Trip Advisor and the distribution of contributions among users by year

Year	Usr	New usr	Cum. new usr.	Min	Median	Max	Mean	St. Dev.
2007	1	1	1	3		3		
2008	66	65	66	1	1	19	1.606	2.429
2009	139	135	201	1	1	5	1.259	0.725
2010	314	303	504	1	1	13	1.398	1.232
2011	2235	2153	2657	1	1	41	1.690	2.038
2012	8414	7729	10386	1	1	60	1.792	2.057
2013	17125	14755	25141	1	1	49	1.705	1.928
2014	25169	20581	45722	1	1	40	1.682	1.848
2015	36013	28206	73928	1	1	83	1.776	2.126
2016	45022	33699	107627	1	1	45	1.83	2.228

Table .2: B - Number of reviews and their spatial distribution (9017 hexagons) by year

Year	Rev.	Cum. rev.	FB users rev.	Min	Median	Max	Mean	St. Dev.
2007	10		7	0	0	2	0.009	0.109
2008	374	384	268	0	0	20	0.373	1.423
2009	202	586	27	0	0	15	0.199	0.858
2010	439	1025	0	0	0	16	0.430	1.507
2011	3777	4802	0	0	0	95	3.734	9.913
2012	15082	19884	1	0	0	346	14.920	30.841
2013	29212	49096	6	0	7	424	28.874	52
2014	42382	91478	47	0	14	578	41.752	71.122
2015	64109	155587	139	0	24	933	63.296	102.071
2016	82807	238394	403	0	32	1143	81.802	129.89

List of publications

The following publications are included either in parts or in an extended version in this manuscript:

- Alessia Calafiore, Guido Boella, Elena Grassi and Claudio Schifanella "Modelling the Relational Concept of Place in Urban Contexts: an Ontology-based Data Access approach", Journal Article in review. In ISPRS International Journal of Geo-Information, 2018, 7(9), 346, Special Issue Place-based research in GIS-science and Geoinformatics.
- Alessia Calafiore, Guido Boella and Leender van der Torre. "From Georeferenced Data to Socio-spatial Knowledge. Ontology Design Patterns to discover Domain-specific Knowledge from Crowdsourced Data. ". To appear in *Knowledge Engineering and Knowledge Management - 21th International Conference, EKAW 2018, Nancy, France, November 12-16, 2018, Proceedings.*
- Alessia Calafiore, Guido Boella, Elena Grassi and Claudio Schifanella "Turin's foodscapes: exploring Places of Food Consumpion through the prism of Social Practice theory. ". To appear in *Proceedings of the workshop on PLATIAL analysis, September 20-21, 2018, Heidelberg, Germany.*
- Alessia Calafiore and Guido Boella "The social role of Geographic Information in light of technological advances". Book Chapter in review. In *Smart City at Play.* Konstantinos Papangelis, Michael Saker, Chatrine Jones, Elsevier.
- Alessia Calafiore, Guido Boella, Stefano Borgo and Nicola Guarino. "Urban Artefacts and Their Social Roles: Towards an Ontology of Social Practices". *13th International Conference on Spatial Information Theory, COSIT 2017, September 4-8, 2017, L'Aquila, Italy.*
- Alessia Calafiore and Guido Boella. "Towards an Understanding of Place Forms through the Lens of Social Practice Theories". *Proceedings of the Joint Ontology Workshops 2017 Episode 3: The Tyrolean Autumn of Ontology, Bozen-Bolzano, Italy, September 21-23, 2017..*

- Alessia Calafiore, Junia Borges, Ana Clara Moura and Guido Boella. "Integrating a VGI system in a Participatory Design Framework". *Proceedings of the International Conference on Innovation in Urban and Regional Planning, September 14-15, 2016,Turin, Italy.*
- Alessia Calafiore. "Designing an Ontology of Social Place". *Proceedings of the Doctoral Consortium of AI*IA 2016 co-located with the 15th International Conference of the Italian Association for Artificial Intelligence (AI*IA 2016), Genova, Italy, November 29, 2016.*.
- Alessia Calafiore. "Representing and Reasoning about the social character of places". *Booklet of the Doctoral Consortium of the 15th International Conference on Principles of Knowledge Representation and Reasoning, Cape Town, South Africa on April 25-29, 2016* .

Furthermore, the following publications were written during the course of my Ph.D, but are not covered in this manuscript because they were not part of my core research:

- Alessio Antonini, Guido Boella, Alessia Calafiore and Vincenzo Mario Bruno Giorgino. "FirstLife: From Maps to Social Networks and Back", Book Chapter. In *Co-Designing Economies in Transition.*, Giorgino, Vincenzo Mario Bruno, Walsh, Zachary David, 2018.
- Amon Rapp, Federica Cena, Claudio Mattutino, Alessia Calafiore, Claudio Schifanella, Elena Grassi and Guido Boella. "Holistic User Models for Cognitive Disabilities: Personalized Tools for Supporting People with Autism in the City". In *Adjunct Publication of the 26th Conference on User Modeling, Adaptation and Personalization, UMAP 2018, Singapore, July 08-11, 2018.*
- Giacomo Pettenati, Alessia Calafiore, Alessio Antonini, Guido Boella and Egidio Dansero. "Enabling Youth Geographies in the Digital Smart City. An Action-Research Approach." In *AESOP 2017 Congress eBook of Proceedings, 11-14 July Lisbon, 2017.*
- Boella Guido, Calafiore Alessia, Dansero Egidio and Pettenati, Giacomo. "Dalla cartografia partecipativa al crowdmapping. Le VGI come strumento per la partecipazione e la cittadinanza attiva". *Semestrale di Studi e Ricerche di Geografia*, Fascicolo 1, gennaio-giugno, 2017.
- Francesca De Filippi, Cristina Coscia, Guido Boella, Alessio Antonini, Alessia Calafiore, Anna Cantini, Roberta Guido, Carlo Emilio Salaroglio, Luigi Sanasi

and Claudio Schifanella. “MiraMap: A We-Government Tool for Smart Peripheries in Smart Cities". *IEEE Access*, 2016.

- Alessia Calafiore and Amon Rapp. “Gamifying the City: Pervasive Game Elements in the Urban Environment". In *Proceedings of the Workshop on Fictional Game Elements 2016 co-located with The ACM SIGCHI Annual Symposium on Computer-Human Interaction in Play (CHI PLAY 2016), Austin, Texas, USA, October 16-19, 2016.*

- Alessio Antonini, Guido Boella, Alessia Calafiore, Carlo Emilio Salaroglio, Luigi Sanasi and Claudio Schifanella “First Life, the Neighborhood Social Network: a Collaborative Environment for Citizens". In *Proceedings of the 19th ACM Conference on Computer Supported Cooperative Work and Social Computing, CSCW 2015, San Francisco, CA, USA, February 27 - March 2, 2016, Companion Volume.*

- Alessio Antonini, Guido Boella, Alessia Calafiore, Federica Cena, Ilaria Lombardi, Carlo Emilio Salaroglio, Luigi Sanasi, Claudio Schifanella and Agata Marta Soccini. “SEeS@W: Internet of Persons meets Internet of Things for Safety at Work". In *Proceedings of the 19th ACM Conference on Computer Supported Cooperative Work and Social Computing, CSCW 2015, San Francisco, CA, USA, February 27 - March 2, 2016, Companion Volume.*

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