Prolegomena for an ontology of place

Andrea Ballatore

Center for Spatial Studies
University of California, Santa Barbara

Chapter in: Harlan Onsrud and Werner Kuhn (eds.), Advancing Geographic Information Science, *Needham, MA: GSDI Association Press, 2016, pp. 91–103.*
Presented at Vespucci 2015, Bar Harbor, ME – AUTHOR COPY

Abstract: The computational representation of place is one of the key research areas for the advancement of geographic information science (GIScience), bridging the gap between place-based human cognition and experience, and space-centered information systems. While many conceptual schemas, vocabularies and ontologies contain some notion of place, the concept is either left implicit or articulated in widely divergent ways. Because of its ubiquity, an ontological clarification of place seems overdue. Adopting the perspective of ontology engineering, and not that of philosophical Ontology, this article paves the way towards the formalization of a place ontology in two steps. First, it provides a critical survey of how this concept is currently represented from lightweight vocabularies to formal ontologies. Second, it presents a set of prolegomena for a place ontology that would overcome the limitations of current approaches. Acknowledging the cultural dependency of place, I argue that such an ontology should be seen as a module positioned between foundational and domain ontologies. This place ontology would provide (i) a conceptual tool to support the modeling of place in any domain, and (ii) a widely applicable ontology, whose deployment would increase the interoperability of datasets, particularly in the context of Linked Data.

Keywords: place ontology, place semantics, geo-semantics, Linked Data, ontology engineering

---

1 Introduction

Place occupies a pivotal role in human cognition, language, and knowledge representation. This highly polysemic and vague notion is constantly used to structure, ground, and connect other entities. Social and cultural processes create, shape and destroy places, objects move across places, transport and communication networks interconnect places, experiences and memories are situated in places. In this sense, places are not merely backgrounds or containers of processes, but they have been long recognized as entities with distinctive characteristics that deserve investigation [10]. Although it might be unwarranted to discern a 'placial turn,' recent trends in geography [3], GIScience [26], and philosophy [9], are reaffirming the centrality of place in human affairs, while acknowledging its elusiveness and multiple meanings. In fact, despite our intuitive grasp of its meaning in different contexts, place resists formalization and dwells uncomfortably in our information systems.

Focusing on the computational representation of place in information systems, remarkable ambiguity exists about its content and relations [12]. Widely different approaches to modeling place can be observed in existing knowledge bases and ontologies [6]. While spatial grounding, typically through spatial reference systems, enjoys a high degree of standardization, place is seen as too vague and culturally-dependent to provide a stable reference frame. In general, place is rarely given an explicit representation, and is modeled either as domain-specific tessellation (e.g., electoral districts, census tracts, and counties), or as toponyms linked to footprints, as in gazetteers. My contention is that this state of affairs is problematic, as it misses the potential of place as a connector between heterogeneous data spaces.

In this article, I critically survey the models of place that can be found in existing ontologies, ranging from lightweight, semantic networks, to more formal ontologies, focusing on the context of Linked Data. Recurring issues and ontological flaws in such cases are identified. Subsequently, I identify advantages and drawbacks to the development of a place ontology, arguing that such an ontology would help the modeling process of geographic information across domains. A successful place ontology should operate between the level of abstract space and the level of domain-specific, culturally defined concepts which vary widely across information communities, providing an intelligible layers between (ideally) stable geographic coordinates and culturally defined, elusive, context-dependent entities.

To find concrete applications, a place ontology should avoid the 'scope creep' problem by taking a quasi-foundational approach, and without venturing in domain-specific semantic fields. Prolegomena to such a place ontology are identified and discussed, as well as some counter-arguments, as a step preliminary to its formalization. To design such a place ontology, fundamental questions need to be addressed: What is wrong with the representation of place (or lack thereof) in current data spaces? What is invariant in all entities that informally fall under the 'place' umbrella? What are the essential themes through which places are classified in different information communities? What are the relationships of place with relatively well-defined ontological categories such as 'spatial regions', and with GIScience core concepts, such as objects and fields? The remainder of this article tries to propose some answers.

2 Representing place in the Semantic Web

Central to human cognition and experience, notions of place emerges in various forms in online schemas, lightweight ontologies, and vocabularies in Semantic Web [6]. Linked Data is emerging as a prominent paradigm to structure, merge, and share geospatial data [17], and geography is a key element to ground and inter-connect entities. This section surveys how the concept is defined and formalized in existing linked datasets, starting from lightweight vocabularies, and then moving to formal ontologies.

2.1 Place in vocabularies and semantic networks

Schema.org. In this lightweight ontology, designed to annotate web pages with microformats, place is defined as "Entities that have a somewhat fixed, physical extension."[1] The concept takes a business-oriented view, stating that place has phone number and an address, as well as customer reviews. At the same time, place is subsumed by landforms and administrative areas, which indeed are not businesses – famously, *Mountain* has a fax number. Place has several sub-types, branching out to 197 concepts, including *AdministrativeArea*, *CivicStructure*, and *LandmarksOrHistoricalBuildings*. The ontology expresses containment through *containedIn*, and geographic grounding through property *geo*.

DBpedia. In this project, place is represented both as instance, and as a class. Place qua instance[2] corresponds to a Wikipedia page, describing place encyclopedically. By contrast, place qua class[3] is part of the DBpedia ontology, and is used to structure other concepts. This class, described as "immobile things or locations," is very central in the DBPedia ontology, and is used as a domain in more than 200 properties in other classes. The class is the range of about 200 properties, including informal spatial relations (*locatedInArea*), and obscure properties resulting from noise in the data such as *red ski piste number* and *president of the general council*.

Place has a hierarchy of 135 subclasses, ranging from very general and vague concepts (e.g., *NaturalPlace*) to very specific ones (e.g., *LunarCrater*). The top level of the hierarchy includes *WineRegion, ArchitecturalStructure, HistoricPlace, Monument, Mountain, MountainPass, NaturalPlace, PopulatedPlace, ProtectedArea, SiteOfSpecialScientificInterest, SkiArea, WorldHeritageSite, SportFacility, HotSpring, SkiResort*, and *Community*. Oddly, *Mountain* is not a subclass of *NaturalPlace*.

[1] http://schema.org/Place – All URLs in this article were accessed in March 2015.
[2] http://dbpedia.org/resource/Place
[3] http://dbpedia.org/ontology/Place

OpenStreetMap. This popular crowdsourced cartographic project takes an administrative view of place, defining it as "populated settlements, including city, town, village, suburbs, neighbourhoods and hamlets etc and also unoccupied identifiable places ranging from very large (continents and oceans) down to very small features."[4] The term is specialized to settlements using concepts from the British administrative context, including *place=city*, *place=town*, and *place=hamlet*. Points and polygons can be tagged as places. Because of its intrinsic ambiguity, the term is occasionally used to describe features that do not fit other terms, such islands (*place=island*) and seas (*place=sea*). The same term can be found in linked data projects OSM Semantic Network[5] and LinkedGeoData,[6] both based on OpenStreetMap [5].

GeoNames. The GeoNames ontology[7] re-uses the place class from *schema.org* to model the feature classes at the core of the project. The *Feature* class subsumes place, and represents all features in the gazetteer, and has simple relations, including *located in*, *nearby features*, *neighbour features*, *children features*, and *parent feature*. Features are grouped into *Classes*, and classified into 690 *Codes*, representing a wide variety of specific place types, such as logging camp and asphalt lake.

ConceptNet. In MIT's semantic network ConceptNet5, *place* is a node that is connected to other concepts through labeled edges such as *isA* and *relatedTo*. e.g., city → *isA* → place.[8] Unlike lightweight ontologies, place has relations related to human purpose (e.g., place → *UsedFor* → eat to meet friend). No formal semantics is defined for the spatial or non-spatial relations between place and its neighbors.

WordNet. Because of its polysemy, the term 'place' belongs to 16 different noun synsets and to 16 verb synsets in WordNet. Excluding the metaphorical/idiomatic meanings, the two noun meanings relevant to this discussion are defined as follows: (#1) "topographic point, place, spot (a point located with respect to surface features of some region) 'this is a nice place for a picnic'; 'a bright spot on a planet;' " This synset[9] has highly idiosyncratic hyponyms, such as *rendezvous*, *hiding place*, and *solitude*, i.e., a "solitary place." By contrast, the second synset is defined as: (#2) "place, property (any area set aside for a particular purpose) 'who owns this place?'; 'the president was concerned about the property across from the White House.' " Oddly, this synset has only four hyponyms, including *sanctuary*, and *hatchery*. Despite these limitations, WordNet can be used as a common ground to inter-link vocabularies [5].

[4] http://wiki.openstreetmap.org/wiki/Key:place
[5] http://spatial.ucd.ie/lod/osn/term/k:place
[6] http://linkedgeodata.org/ontology/Place
[7] http://www.geonames.org/ontology
[8] http://conceptnet5.media.mit.edu/web/c/en/place
[9] http://wordnet.rkbexplorer.com/id/synset-topographic_point-noun-1

Other lightweight ontologies. The *Places Ontology*[10] is a vocabulary containing 50 classes that describe natural features and man-made structures. The vocabulary includes spatial relations *in*, *overlaps*, *bounded_by*. Similarly, the *BBC News ontology*[11] contains a generic class *place*, used to described events reported in the stories, without formal semantics. Start-up Factual published a large vocabulary of place categories as part of their *Global Places* product.[12] This vocabulary contains about 460 categories, largely based on the US Yellow Pages. Drawing on WordNet, GeoNames, and DBpedia, the *PlaceVocabulary*[13] provides a vocabulary of 1,800 place types [4].

2.2 Place in formal ontologies

OSGB Buildings and Places ontology. This ontology was designed in 2008 the British Ordnance Survey to model cadastral data, described as "buildings and places that are topographically relevant, i.e., which are sufficiently important to be recognized and recorded by Ordnance Survey surveyors."[14] The OWL model contains 678 classes with 1,770 axioms, including mereological, and topological relations, as well as specifications of activities and purposes. For example, the place subclass 'castle' has a part *Building*, has historic purpose *Defence*, and has a part *Defensive Wall*. Similarly, a 'cattery' is described as follows: "Every Cattery is a kind of Place. Every Cattery has purpose Housing of Cats. Every Cattery has part a Building that has purpose Housing of Cats."

OpenCyc. In the OpenCyc project, the *Place*[15] concept is a synonym to point, site, and spot. The definition of the concept is more formal than any of the previous ontologies, and is summarized as follows: "A specialization of EnduringThing_Localized (q.v). Each instance of Place is a spatial thing which has a relatively permanent location. Thus, in a given microtheory, each Place is stationary with respect to the frame of reference of that microtheory." This concept is a type of *enduring thing localized*, *site*, *spatial thing*, *thing that is not a perceptual agent*, *thing that is not someone*, *underspecified location*. In the project's documentation, the difference between place and locations is defined as follows:

> "An important specialization of EnduringThing_Localized is Place (q.v.). The salient distinction between places (instances of Place) and locations (instances of EnduringThing_Localized) is that places are assumed to have relatively permanent locations, whereas locations need not have permanent locations. Thus, from the perspective of someone standing on a beach,

[10] http://purl.org/ontology/places
[11] http://www.bbc.co.uk/ontologies/news
[12] http://www.factual.com
[13] https://github.com/andrea-ballatore/PlaceVocabulary
[14] http://data.ordnancesurvey.co.uk/ontology
[15] http://sw.opencyc.org/concept/Mx4rvVjTtJwpEbGdrcN5Y29ycA

> the crest of a breaking wave can be a location at which foaming is occuring (thus an EnduringThing_Localized), but it cannot be such a place (i.e., it cannot be an instance of Place)."[16]

OpenCyc is organized in microtheories, and place is important to several of them, particularly to the definition of agency with respect to geo-political regions. In the knowledge base, geopolitical-entities can be viewed through two different microtheories. In a *physical geography* microtheory, geopolitical-entities are clearly distinguished from the regions they control. In these cases, the *TerritoryFn* function is used to demarcate the land mass (a geopolitical region) of a geopolitical entity. By contrast, in a *dualist geography* microtheory, geopolitical entities are viewed as being both agents and land masses.

UMBEL Reference Concept Ontology. In this interoperability project, there is an elaborate attempt to model place.[17] Several concepts that subsume place are defined following OpenCyc microtheories.

- *PopulatedPlace*: "A Place or area with clustered or scattered buildings and a permanent human population, including cities, settlements, towns, and villages. It does not include Locales."
- *Place_NonAgent*: "(Non-agent-like place) A collection of places which are not agent-like. Some things can be both places and exhibit agency; e.g., the CityOfMiamiFL is a region in Florida_State, and it also can enter into agreements with other cities (see GeopoliticalEntity). Each instance of Place_NonAgent is a Place that does NOT have any agency, e.g., LakeErie and OuterSpace."
- *GeographicPlace*: "(Site that is also a geographical thing) Point that is also a geographical thing, place that is also a geographical thing, spot that is also a geographical thing."
- *HumanlyOccupiedSpatialObject*: "(Places occupied by humans) A specialization of InanimateObject. Each instance of HumanlyOccupiedSpatialObject is a place that humans occupy. Instances include both movable things, such as cars and ships, and things having a more or less permanent location, such as houses or office buildings."
- *GeopoliticalEntity*: "A specialization of Organization and of LegalAgent and of GeographicalAgent; instances of this collection control GeographicalRegions. Each instance of GeopoliticalEntity includes a governing body, but is more than just that governing body."
- *GeographicalRegion*: "a tangible spatial region that includes some piece of the surface of a planet (usually PlanetEarth), and may be represented on a map of the planet."

[16] http://sw.opencyc.org/concept/Mx4ro3lluGJHQdiVxrZReHS-jQ
[17] http://umbel.org/umbel/sc/Place

A "super type" that aggregates many classes is *Geopolitical*,[18] defined as "Named places that have some informal or formal political (authorized) component. Important subcollections include Country, IndependentCountry, State_Geopolitical, City, and Province." Through a geographic module, UMBEL is connected to the GeoNames ontology.[19]

DOLCE. While the DOLCE [11] foundational ontology has no direct representation of place, the *CommonSenseMapping* ontology, based on DOLCE, contains a rather sophisticated formalization of place and its related concepts [19, pp. 230-1].[20] This conceptualization hinges on the distinction between physical and non-physical places:

- *physical-place*: subclass of non-agentive-physical-object that subsumes all places.
- *geographical-object*: subclass of physical-place with geographic coordinates.
- *non-physical-place*: subclass of non-agentive-figure "for non-physical (i.e., socially- or cognitively-constructed) places." Non-physical places (e.g., Italy) are the hypostasis (i.e., figurative representation) of some physical-place.
- *geographical-place*: subclass of non-physical-place. It is a hypostasis of some geographical-object.
- *political-geographic-object*: subclass of geographical-place, "conventionally accepted by a community." The class has the meronomical property *geographic-part-of*.
- *country*: subclass of political-geographic-object.

Other formal ontologies. The Basic Formal Ontology (BFO)[21] distinguishes between an ontology for continuants that captures a state of affairs at a given time (*SNAP*), and an ontology for occurrents such as processes and events (*SPAN*). According the authors of BFO, place is a sub-class of a SNAP substantial entity. Places are a kind of *site*, but can also be geo-artifacts. For example, the term 'London' can refer to "London-as-site ('John lives in London') and London-as-geoartifact ('John admired London from the air')" [13, p. 164]. However, the distinction is not further clarified and formally expressed.

In the General Formal Ontology (GFO),[22] developed by the Onto-Med Research Group, place is not specified. Its fundamental classes include *Spatial_regions*, constructed on *Topoids*, i.e., connected compact regions of space with boundaries. The Suggested Upper Merged Ontology (SUMO)[23] purports to be a standardized foundational ontology, and includes a number of domain ontologies. In SUMO, place is spuriously formalized through classes *PlaceDescriptor*, *PlaceAddress*, *PlaceID*, *PlaceOfCommerce*, and *PlaceOfWorship*.

[18] http://umbel.org/umbel#Geopolitical
[19] http://techwiki.umbel.org/index.php/UMBEL_-_Annex_J
[20] http://www.loa-cnr.it/ontologies/CommonSenseMapping#
[21] http://www.ifomis.org/bfo
[22] http://www.onto-med.de/ontologies/gfo
[23] http://www.ontologyportal.org

3 Prolegomena for an ontology of place

The previous section surveyed the conceptualization of place in actual artifacts, from lightweight vocabularies to formal ontologies. Here, I argue that we need a new ontology of place to clarify the conceptual confusion that dominates the field. The goals of such an ontology are:

1. Provide an intermediate conceptual layer between foundational ontologies such as DOLCE and domain ontologies.
2. Allow the coherent articulation of multiple viewpoints on the same place.
3. Design a general tool to model places in different domains, aiming at a cross-cultural conceptualization.
4. Facilitate the integration of heterogeneous representations of place across academic disciplines, such as geography, economics, medicine, and history.
5. Model non-integrated aspects of place such as provenance, affordances, and social roles.

To frame our work towards these goals, I outline a minimal set of prolegomena, motivating reasons to construct such an ontology.

3.1 Why a place ontology?

Many counter-arguments can be formulated to deny the need for a place ontology. To date, simple models have been used to describe places in GISs. For example, gazetteers have traditionally relied on associations of the form <*place name*, *place type*, *geometry*>, where geometry is either a point or a polygon. While this approach is indeed sufficient in many contexts, it has several drawbacks: (i) it cannot express multiple viewpoints on the same place; (ii) it relies on a fixed typology of places, usually a taxonomy; (iii) it is not easy to integrate with other conceptualizations.

As shown in Section 2, a concept or a class called 'place' is present, in one form or another, in the vast majority of existing geographic vocabularies and ontologies. The many different ways used to model this concept suggest that each of these efforts rely on some implicit, common-sensical notion of place. The ubiquity and obscurity of the concept calls for an ontological work of clarification, ideally resulting in a usable conceptual modeling tool that would enable many communities to specify and share their places of interest.

Other objections might come from the area of new generation, semantic gazetteers [16], and from the feature type and points of interest (POIs) ontologies, which are receiving attention in GIScience [14] and by the Open Geospatial Consortium (OGC).[24] Similarly, microformats such as RDFa and Microdata aim at providing minimal mechanisms to specify places in unstructured web pages. The fundamental difference between my proposal and existing ontologies lies in the attempt of going beyond culture-

[24] http://www.opengeospatial.org/projects/groups/poiswg

and domain-specific places. While these approaches provide lists of culturally-bound place types, such as *mountain*, *restaurant*, and *music store*, we aim at identifying and formalizing fundamental aspects of place, supporting the design of place in domain ontologies.

One final objection might be the possibility of over-engineering place, adding an unwarranted layer of complexity in the model, without reaping tangible benefits. This objection is perhaps the most serious, and is certainly a major issue that hinders the adoption of foundational ontologies. To mitigate the risk of over-engineering, my approach aims at showing that simpler models of place have many implicit assumptions, which result in difficulties in the long run. To achieve this goal, the next sections outline the prolegomena for such a place ontology.

3.2 Place cognition and place engineering

A fundamental difference to grasp in relation to place research is the distinction between place cognition and place engineering. The former approach aims at understanding how humans understand and conceptualize place, using methodologies from cognitive science and psychology. In this framework, place is one of the key geographic concepts that has been targeted for clarification with respect to cognate concepts such as region, neighbourhood, location, space, district and area [2]. In their linguistic analysis of the term 'place' in English, Bennett and Agarwal [7] identify four categories of place-related expressions: (i) count nouns (i.e., place types), (ii) locative property (e.g., 'in London,' 'on the hill,' 'by the sea-side'), (iii) place names (e.g., 'London,' 'England'), and (iv) definite descriptions (e.g., nominal expressions referring to places). The authors acknowledge that their attempt to formulate a logical theory of place clashed with the term's vagueness, polysemy, and variety of modes through which it is used in natural language.

Even in academic debates, unexamined notions of place are often used as a synonym to spatial or spatio-temporal region, relying on the commonsensical meaning of the term, making a precise definition difficult if not impossible. Geographers often refer to it as a spatial unit of analysis, as in case of demography or political science. From a philosophical perspective, Casati and Varzi's major mereotopological analysis [8] uses the term 'place' extensively, both as a noun and as a verb, carefully avoiding to define it. As fundamental assumptions about what place is and how it relates to cognate concepts, a complete formal theory of place seems a rather unlikely development.

My proposal, by contrast, falls within the area that can be defined place engineering, i.e., the modeling of the concept in computational systems to support its representation, processing, and retrieval. As well as the place vocabularies and ontologies discussed in Section 2, ontologies of place have attracted interest in the context of geographic information retrieval [15, 21, 1]. In many works, however, the term 'place ontology' is not used in sense intended in this paper, but refers to culturally-specific taxonomies of place types (e.g., *city*, *town*, etc.), without formalizing their ontological commitments. Assuming a skeptical position regarding the possibility of reaching a wide, transdisciplinary agreement on place, I believe that a place ontology should provide conceptual tools to help design places in domain ontologies, increasing their interoperability. In this sense, a place ontology should be inclusive, taking into account the multi-faceted representations of the concept across disciplines, and distilling their underlying commonalities.

3.3 Cultural and linguistic dependence of place

One of the reasons that make place difficult to formalize is its cultural and linguistic dependence. Entities that are commonly referred to as places are deeply embedded in a specific cultural context. Typically, place types present in the Anglo-American world are proposed as universal, such as in the case of *schema.org* and similar projects, which results in 'scope creep,' that is, the attempt to create all-encompassing, universal place types, which are hard to use outside the borders of the English-speaking world. Moreover, even within the same large national and linguistic contexts, different information communities can have radically different understandings of commonsensical terms.

Examples of these issues abound both in traditional, top-down ontologies and classifications devised by professional geographers and in crowdsourced projects such as OpenStreetMap (OSM). Depending on the context, place types such as 'city,' 'park,' 'field,' and 'restaurant' can refer to very different concepts, and therefore should be modeled as part of domain ontologies. As Smith and Mark [24] pointed out, any of these categorizations rely on a "degree of human-contributed arbitrariness on a number of different levels, and it is in general marked by differences in the ways different languages and cultures structure or slice their worlds" (p. 312). The research program of ethnophysiography focuses precisely on these aspects, particularly for landforms [18].

Based on these considerations, a place ontology should avoid the explicit modeling of such domain-specific place concepts. I maintain that a place ontology should provide a foundational, shared platform to facilitate the modeling and integration of diverging conceptualizations of place, rather than forcing a standardization that appears politically oppressive and, incidentally, to be doomed to fail. A crucial element in this context is the possibility of expressing multiple views on a place, formalizing the provenance of a place concept, i.e., the information community that generated it. For this purpose, the PROV-O ontology can represent a promising starting point.[25]

3.4 Place in time

Much discussions about place hinge on the issue of the definition of its boundaries, which are often vague, mutable, and highly subjective. However, place is often mod-

[25] http://www.w3.org/TR/prov-o

eled without taking into account its temporal dimension. New places are relentlessly created, while existing places are updated, re-defined, and some disappear as a result of human and natural disasters. Hence, in principle, a place ontology should be able to model the temporal dimension of place, to capture its changes in a coherent framework, as happens in historical gazetteers. The lack of place temporality results in considerable confusion. For example, 'Rome' as the capital of the Roman Empire and 'Rome' as the capital of the current Italian Republic are the same atemporal instance of a *City* in DBpedia, which renders it useless for reasoning purposes. Indeed, some applications (e.g., historical analysis) and some place types (e.g., businesses) need an explicit temporal dimension for places more than others. The Linking Open Descriptions of Events (LODE) ontology constitutes a promising model to handle the temporal dimension of place and its complex relationship with events [23].

3.5 Social roles of place

As geographers in the humanistic tradition point out, place originates from the attribution of human meanings to regions of physical space [25]. The representation of place in ontologies usually conflates the social and the physical dimension, e.g., a shopping mall *qua* set of trading activities and a shopping mall *qua* collection of buildings and infrastructure. A common problem, particularly visible in OSM, occurs when the same physical structure is devoted to different activities, and when the activities change. Modeling confusion arises, for instance, when a building originally designed and used as a hospital in Victorian times currently hosts private apartments, shops, and a hotel.

Clarifying the distinction between the physical structure and social roles of place might help the maintainability and re-usability of complex place-related data. To achieve this, physical and natural objects need to be associated with their social roles through appropriate relations, representing what patterns of social interaction occurs there. To tackle the complex nature of these relations, a starting point is offered by Masolo et al. [20], in their formal analysis of socially constructed entities and roles. Acknowledging the relational nature of place, specific anti-rigid roles can be fleshed out based on human geographic perspectives, e.g., power relations between physical space and agents, through property, ownership, and control relations.

3.6 Place and scale

The intuitive notion of place includes entities located at different scales, ranging from a room ('my bedroom') to continents ('Africa'). Scale, intended as phenomenon scale, influences the characteristics of place, constraining how they can be perceived, experienced, and conceptualized. An ecological view aims at modeling place through the lens of the influential theory of affordances by Gibson [22]. Place, in its combination of physical and social structures, can enable ('afford') specific activities for human actors. While affordances are certainly a promising way to conceptualize part of human-scale places, such as venues, restaurants, parks, and barbers, they seem less useful for large-scale places that cannot be experienced in a holistic way.

Cities, seas and countries can indeed be depicted as wholes in aerial photographs and maps, but are experienced directly only in human-scale fragments, and their conceptualization can vary widely for different agents. As opposed to human-scale places, such entities cannot be characterized by a clearly defined, unmediated purposes and affordances. When comparing France and a restaurant as places, some commonalities emerge: they both have boundaries; it is possible to go to and leave them; they are social constructions; they have show stable patterns of interactions that distinguish them from other places. More importantly, they present many differences: a restaurant is presumably designed to afford food consumption, socialization, and so on, which can be observed directly in its physical structure; a country operates at a fundamentally different level, consisting in an aggregation a myriad of other directly observable heterogeneous places, and is promptly identified through administrative and political structures. It seems therefore appropriate to adopt specific approaches are needed to conceptualize large-scale places as opposed to small-scale ones.

3.7 Thematic structure of place

Given the variety of entities that are normally thought of as places, a place ontology should identify fundamental themes through which any place type can be conceptualized. These themes are located between the foundational level and domain ontologies with particular, culturally-bound place types. In existing place taxonomies and ontologies, these are the top level of the classification, with broad themes like *healthcare*, *retail*, *transportation*, and *government*. This is arguably the most difficult component of a place ontology to design and formalize.

Although complete cultural independence is indeed impossible, a set of broadly, trans-cultural themes would help design place in domain ontologies, facilitating their grouping and structuring. Cross-cultural linguistic analysis is needed in order to identify invariant themes in place conceptualizations across information communities. For instance, while domain ontologies need to represent restaurants in the US and in Italy with very different subclasses and properties, the underlying theme of food consumption and socialization is invariant and can be used to conceptualize and find connections between the two ontologies. Similarly, while address formats differ widely (e.g., ZIP codes in the US and Post Codes in the UK), the underlying theme is that of logistical reference systems.

4 Conclusions

While many academic disciplines, projects, and datasets rely on some notion of place, there is no consensus on what place is, and how to represent it in a computational model. Bridging the gap between spatial and platial perspectives constitutes one of the key areas of future research for GIScience [12]. This article contributes to the debate on place representation from two perspectives. First, I carried out a survey of existing place vocabularies and ontologies, outlining the need for common foundations to represent place across different domains and contexts. Second, I outlined several prolegomena for the construction of an ontology of place.

The purpose of this ontology is to provide an intermediate conceptual layer between foundational and domain ontologies, enabling the interoperability of representations of place across academic disciplines, such as geography, history, and the digital humanities. Such an ontology can operate at two levels. Its core ideas can guide ontology engineers and conceptual modelers to model place types in their domain ontologies. From a pragmatic perspective, possibly articulated in a lightweight version or as a design pattern, the place ontology might greatly support the production and integration of Linked Data, in which place is one of the main concepts used to interlink heterogeneous datasets.

Several challenges lie ahead of this project. As place and place types are culturally-bound, the identification of cross-cultural and cross-linguistic themes require much empirical work, and research is needed to identify meaningful themes. The risk of over-engineering always looms large on foundational ontologies. In this sense, the proposed place ontology needs to be grounded on several case studies, covering multiple domains. Existing place vocabularies, ontologies, and geographic datasets could be linked through the place ontology, showing the advantages of an conceptual foundation for a ubiquitous and yet elusive concept.

References

[1] ABDELMOTY, A., SMART, P., AND JONES, C. Building place ontologies for the semantic web: issues and approaches. In *Proceedings of the 4th ACM Workshop on Geographical Information Retrieval* (2007), ACM, pp. 7–12.

[2] AGARWAL, P. Contested Nature of *Place*: Knowledge Mapping for Resolving Ontological Distinctions Between Geographical Concepts. In *Geographic Information Science*, M. Egenhofer, C. Freksa, and H. Miller, Eds. 2004, pp. 1–21.

[3] AGNEW, J. A. Space and Place. In *Handbook of Geographical Knowledge*, J. Agnew and D. Livingstone, Eds. Sage Publications, London, 2011, ch. 29.

[4] BALLATORE, A., AND ADAMS, B. Extracting Place Emotions from Travel Blogs. In *Proceedings of AGILE 2015*. 2015, pp. 1–5. in press.

[5] BALLATORE, A., BERTOLOTTO, M., AND WILSON, D. Linking geographic vocabularies through WordNet. *Annals of GIS 20*, 2 (2014), 73–84.

[6] BALLATORE, A., WILSON, D., AND BERTOLOTTO, M. A Survey of Volunteered Open Geo-Knowledge Bases in the Semantic Web. In *Quality Issues in the Man-*

agement of Web Information, G. Pasi, G. Bordogna, and L. Jain, Eds., vol. 50 of *Intelligent Systems Reference Library*. Springer, 2013, pp. 93–120.

[7] BENNETT, B., AND AGARWAL, P. Semantic categories underlying the meaning of 'place'. In *Spatial Information Theory*, S. Winter, M. Duckham, L. Kulik, and B. Kuipers, Eds., vol. 4736 of *LNCS*. Springer, Berlin, 2007, pp. 78–95.

[8] CASATI, R., AND VARZI, A. C. *Parts and Places: The Structures of Spatial Representation*. MIT Press, Cambridge, MA, 1999.

[9] CASEY, E. S. *The Fate of Place: A Philosophical History*. University of California Press, Berkeley, CA, 1997.

[10] CRESSWELL, T. *Place: A Short Introduction*. Short Introductions to Geography. John Wiley & Sons, Oxford, UK, 2004.

[11] GANGEMI, A., GUARINO, N., MASOLO, C., OLTRAMARI, A., AND SCHNEIDER, L. Sweetening ontologies with DOLCE. In *Knowledge Engineering and Knowledge Management: Ontologies and the Semantic Web*, V. R. Benjamins, Ed., vol. 2473 of *LNCS*. Springer, 2002, pp. 166–181.

[12] GOODCHILD, M. F. Formalizing place in geographic information systems. In *Communities, Neighborhoods, and Health*, L. Burton, S. Kemp, M. Leung, S. Matthews, and D. Takeuchi, Eds. Springer, Berlin, 2011, pp. 21–33.

[13] GRENON, P., AND SMITH, B. SNAP and SPAN: Towards dynamic spatial ontology. *Spatial cognition and computation 1*, March (2004), 69–103.

[14] JANOWICZ, K., SCHEIDER, S., PEHLE, T., AND HART, G. Geospatial Semantics and Linked Spatiotemporal Data – Past, Present, and Future. *Semantic Web 3*, 4 (2012), 321–332.

[15] JONES, C., ALANI, H., AND TUDHOPE, D. Geographical Information Retrieval with Ontologies of Place. In *Spatial Information Theory*, vol. 2205 of *LNCS*. Springer, Berlin, 2001, pp. 322–335.

[16] KESSLER, C., JANOWICZ, K., AND BISHR, M. An agenda for the next generation gazetteer: Geographic information contribution and retrieval. In *Proceedings of the 17th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems* (2009), ACM, pp. 91–100.

[17] KUHN, W., KAUPPINEN, T., AND JANOWICZ, K. Linked Data: A Paradigm Shift for Geographic Information Science. In *Geographic Information Science*, M. Duckham, E. Pebesma, K. Stewart, and A. U. Frank, Eds., vol. 8728 of *LNCS*. Springer, Berlin, 2014, pp. 173–186.

[18] MARK, D. M., TURK, A. G., AND STEA, D. Progress on Yindjibarndi Ethnophysiography. In *Spatial Information Theory*, S. Winter, M. Duckham, L. Kulik, and B. Kuipers, Eds., vol. 4736 of *LNCS*. Springer, 2007, pp. 1–19.

[19] MASOLO, C., BORGO, S., GANGEMI, A., GUARINO, N., OLTRAMARI, A., AND HORROCKS, I. WonderWeb: Ontology Infrastructure for the Semantic Web. Tech. rep., 2001.

[20] MASOLO, C., VIEU, L., BOTTAZZI, E., AND CATENACCI, C. Social Roles and their Descriptions. In *9th International Conference on Principles of Knowledge Representation and Reasoning* (2004), pp. 267–277.

[21] SANTOS, D., AND CHAVES, M. The place of place in geographical IR. In *3rd Workshop on Geographic Information Retrieval, SIGIR* (2006), ACM, pp. 5–8.

[22] SCHEIDER, S., AND JANOWICZ, K. Place Reference Systems: A Constructive Activity Model of Reference to Places. *Applied Ontology 9*, 2 (2014), 97–127.

[23] SHAW, R., TRONCY, R., AND HARDMAN, L. LODE: Linking Open Descriptions of Events. In *The Semantic Web*, A. Gómez-Pérez, Y. Yu, and Y. Ding, Eds., vol. 5926 of *LNCS*. Springer, Berlin, 2009, pp. 153–167.

[24] SMITH, B., AND MARK, D. M. Ontology and geographic kinds. In *Proceedings of the 11th International Symposium of Spatial Data Handling* (Vancouver, 1998), T. K. Poiker and N. Chrisman, Eds., International Geographical Union, pp. 308–320.

[25] TUAN, Y.-F. *Space and place: The perspective of experience*. University of Minnesota Press, Minneapolis, MN, 1977.

[26] WINTER, S., KUHN, W., AND KRÜGER, A. Guest Editorial: Does Place have a Place in Geographic Information Science? *Spatial Cognition & Computation 9* (2009), 171–173.