Max J. Egenhofer
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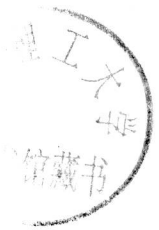

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Contested Nature of *Place*: Knowledge Mapping for Resolving Ontological Distinctions Between Geographical Concepts

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Abstract. In the theoretical literature and geographical models, *place* is defined with reference to other spatial concepts, such as region, neighbourhood and space. The boundaries and distinctions between these concepts and *place* are not clear and the overlap in the semantic fields of these concepts is representative of the vagueness that exists in geographical concepts. This vagueness is a major issue in achieving interoperability in the geographical domain and for the development of a comprehensive geo-ontology. In this paper, the principles of conceptual structures are applied for mapping semantic correspondences between *place* and overlapping geographical concepts. Knowledge mapping is carried out for meaning negotiation from lexical analysis of syntactic proximities between concepts. Experiments with human subjects were performed to elicit the cognitive semantics inherent in conceptual schema of individuals. Distance and proximity measures resolve the cognitive semantics of the concepts. The results provide an indication of the overlap and distinctions between the semantic fields of nearby spatial concepts, and a foundation for defining the relationships and classifications to specify the ontological distinctions between geographic concepts.

1 Introduction

Ambiguous meanings and fuzzy delineation between concepts causes problems in a clear definition and modelling of the geographical domain, and in the specification of a geo-ontology. The semantic heterogeneity of the terms cause problems in developing a consensual ontology for the domain [4, 12] and, therefore, the foremost requirement in the development of a geo-ontology is to clarify the meanings of such geographic terms and concepts that need better definitions [1]. Ontological theories and commitments underlie all forms of cognition, both implicitly as well as explicitly [21]. The University Consortium for Geographic Information Science, within the emerging research theme *Ontological Foundations for Geographic Information Science* [22], has proposed that the process of eliciting ontologies from human subjects, achieved by using standard psychological methods, is a key research area to establish

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the conceptual systems that people use in relation to given domains of objects. The process of eliciting ontologies from human subjects can provide guidelines for developing links between three kinds of knowledge domains, namely human attitudes and beliefs, real-world objects and features, and data models. Elicitation work has been previously described [23, 35] where commonsense conceptualisation and categorisation of the real world are investigated through application of prototypical theories within experiments on human subjects [3, 20]. These seminal works provide valuable indications of how cognitive theories and human behaviour can form the basis for ontological development. It is, however, focussed on category explication and on finding the natural categories that result from commonsense view of the world, but its potential for defining concepts and for explication of the semantic content of the categories has not been fully exploited and investigated.

Geographic theories attribute cognitive dimensions to the notion of geographic *place* [6, 13] and the meaning of *place* can be conceptualised as emerging at an embodied interface of mind, body and language. The broad aim in this paper is to apply methods of elicited ontologies to disengage ontological distinctions and commitments for *place* and neighbouring concepts. The underlying principle for the methodology adopted in this paper, developed upon theories of *conceptual spaces* [11], is that the meanings of concepts are imbibed in human cognitive conceptualisations and can be elicited by mapping the concept space existing within the cognitive domain. In this case, *conceptualisation* is used to denote the modelling of the world independent of the technology at the knowledge level, and defined as the idea of the world that an individual has. A combination of semantic proximity and categorical assessments are carried out to elicit the commonsense notions of *place*, where *commonsense* is used to imply the certain core of interconnected beliefs that form the basis for the cognitive notions of reality.

The remainder of the paper is organised as follows. Section 2 provides a background on the contested nature of *place*. A discussion of *place* meanings and its relations with neighbouring spatial concepts based on lexical analysis is presented in section 3. In section 4, a brief summary of the basic principles that form the basis for the experimental work is provided, along with a more detailed discussion of the experimental design, the data collection methods and the results from each stage of the experiment. A summary of the results along with the conclusions from the paper and implications for future work are presented in section 5.

2 The Contested Nature of Geographic *Place*

Place is a key and contested topic in geography. UCGIS has included the study of *place*, conceptualised as a cognitive category, as a priority area of research, because the "continuous physical world is understood in terms of discrete objects and *places*" and because "there are currently inconsistencies in the models for these categorisations and for these *places* that exist" [40]. Since it is shown from experiments that people exchange information and reason about locations based on *places* they conceptualise, the notion of *place* is proposed as a link between human commonsense

and the reality in design of wayfinding models [13, 17, 41]. Within information systems and in virtual societies, there is a general concern about the erosion of *sense of place* and the creation of *placelessness* [5, 25, 32]. *Place* as a geographic concept is applied in spatial models in regional geography [7, 24] and for policy and decision-making in geographical environments [36]. Many digital thesauri, such as EDINA GeoXwalk, the Alexandria Digital Library (ADL) and Getty's Thesaurus of Names (TGN), are now using *place*-based mechanisms for query resolutions. Harrison and Dourish [16] have also highlighted the significance of *place*-based information systems for generating behavioural components of space within computer-assisted cooperative virtual and simulated environments.

It is acknowledged that, even within the geographic paradigm, different meanings are attributed to *place*. Theories in human and behavioural geography emphasise the importance of the humanistic and experiential dimensions in shaping the meanings of *place* [37]. The variability in the meanings of *place* gives rise to an inherent vagueness in any integration across this concept in data sources and participatory interfaces. Mapping its meanings from cognitive conceptualisations will help identify the primitives that constitute the primary theory for *place* that can act as a shared resource for interoperability across different domains of applications in GIScience. From a review of commonly used definitions of *place* in different theoretical contexts, and from mapping *place* meanings across a number of ontology and digital libraries, it is seen that the meaning of *place* is linked to meanings of other spatial concepts. The thesaurus [42] states a number of related terms to *place* as synonyms, such as *location, locality, point, spot, space, piazza, plaza, topographic point, area, situation, seat, home, neighbourhood, and landmark.* Although most of the ontologies and theoretical frameworks that were reviewed for this paper have generated a synergy between region and *place*, with regions often forming a *place* type, the discussion in categorisation of region types [28] have also stated *place* to be a sub-type of region. Both *place* and neighbourhood are syntactically linked to notions of distance, such as proximity and closeness. A critical discussion of *place* and its relations to region and neighbourhood raises a number of issues. Few of the questions that are raised are: Is *place* a type of region? Can all regions be *places*? When does a region become a *place* and vice-versa? Is neighbourhood a sub-type of *place*? And, is a neighbourhood always a *place*? What kind of *place* is a neighbourhood? These questions typify the nature of vagueness within the concept of *place*, which can be resolved once a definitive semantic framework for *place* is defined and relationships to these other concepts explored.

2.1 Mapping Reference Knowledge Domains

WordNet is a lexical reference system that is inspired by current psycholinguistic theories of human lexical memory [27]. The semantic network in WordNet is formed by nodes representing real-world concepts that comprise the synonyms and the definition (gloss) for the concept [29]. *Place* in WordNet is defined as a *concrete entity* functioning as a *location for something else.* The resulting senses from WordNet's semantic taxonomy are sixteen in total and the geographically relevant meanings of

place are closely related to concepts of *space*, *region*, *location* and *vicinity*. Semantic concordance exercises are helpful in measuring the semantic proximities between *place* and related concepts, and are useful in making the distinctions explicit (Table 1). Semantic similarity measures [29] were employed for measuring proximity between *place* and related concepts. The results from the analysis using WordNet-similarity are shown in Table 2. For Hirst and St-Onge, the highest value is 16; for Path length, Lin and Wu Palmer, the highest value is 1. In all cases, higher values indicate a higher measure of semantic similarity. These measures use different parameters for estimating semantic relatedness and, therefore, a cumulative figure from all the measures gives an effective indication of the relative semantic similarities between concepts.

Table 1. Semantic correspondence scores for *place* and related concepts

	Place	**Region**	**Area**	**Location**	**Neighbour-hood**	**Space**	**Cognition**
Place	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Region	x	1.000	x	0.750	x	x	-0.139
Area	x	1.000	1.000	0.250	x	x	0.250
Neighbourhood	x	0.111	0.250	0.062	1.000	x	x
Space	x	1.000	1.000	x	x	1.000	x
Cognition	x	x	x	x	x	x	x

Table 2. Similarity relatedness measures for *place* with correspondent concepts

	region	**neighbourhood**	**space**	**location**	**area**	**district**
Resnick	3.7552	6.0831	11.9046	3.2232	8.9089	3.7522
Path length	0.3333	0.5	1.000	0.3333	0.5	0.25
Leacock & Chodorow	2.4849	2.8904	3.5835	2.4849	2.8904	2.1972
Wu & Palmer	0.800	0.9333	1.000	0.75	0.9333	0.7273
Hirst & St-Onge	6.00	4.00	16.00	6.00	6.00	4.00
Jiang & Conrath	0.3382	0.2716	29590099	0.3033	0.3338	0.2558
Adapted Lesk	37.00	24.00	448.00	91.00	110.00	31.00
Lin	0.7175	0.7677	1.00	0.6616	0.8561	0.6576
Cumulative	**51.4291**	**39.4461**	**29505982**	**104.756**	**130.42**	**42.8401**

Place and *space* share maximum semantic relatedness based on the WordNet lexical database and the corpus of concepts created from it. Results from this analysis also show that, lexically and semantically, *place* and *region* are more closely related

than *place* and *neighbourhood*. A high measure of semantic relatedness is also seen with *location* and *area*. It is worth considering that these measures are dependent on concept definitions and the nature of hierarchical is-a relationships, specified in WordNet. However, WordNet is constructed based on the distinctions determined from human reasoning and knowledge [9] and can be viewed as a reliable source of ontological distinctions based on commitments for the concepts in the real world. The lexical analysis provides important indications for the way these concepts are distinguished semantically. It also facilitates a framework for aligning and coordinating different ontologies by defining points of articulation based on the concepts that are semantically related to *place* in cases where *place* does not exist naturally in a particular knowledge base. A comparison of the proximity measures generated from syntactic space in WordNet, with the results from the experimental work with human subjects, will also be indicative of the discrepancies between commonsense semantics and that conceptualised in reference systems.

3 Theoretical Framework and Hypotheses

Meaning is a much discussed subject in psychology as well as philosophy, and several theories have been proposed to explain meanings, concepts and their formation in the real world [2, 19, 30, 31]. The principal idea in the theory of *conceptual space* is the existence of a conceptual structure that facilitates the grounding of meanings in the cognitive models formed in the real world [10, 11]. The semantics are primarily dependent on the individual nature of internalised spatial representations and cognitive structures. The meanings for concepts can, therefore, be realised from an understanding of the relations between the conceptual structures and the real world. *Similarity* is one of the most fundamental notions in concept formation, and is defined simply as "concepts group together things that are similar" [11 p. 109]. The notions of proximity and similarity are also applied in prototypical theories that are used as a basis for elicitation experiments in the geographic context. The theory of conceptual spaces extends the theory of prototypical effects by introducing the notion of properties that have a partitioning effect within the concept space [10]. The meaning of the concept emerges from an inter-relationship of the different domains and dimensions in it, evolves and changes in different contexts, and is represented as a measure of the salience of the different domains that act in the determination of the meanings.

In the methodology used here, salience and correlation factors are applied to categorisation experiments for similarity assessment between concepts. The key idea is that a *core* (essential) property of a concept is a property that belongs to a dimension with high salience, while a *peripheral* property is associated with a dimension with lower salience. Extreme salience is attributed to the essential dimensions while determining the content of the concept. The partitioning of the concept space, from the different dimensions, results in the discretisation of space using a finite number of classes that define the concept. The classes are psychologically determined and the classification metrics are context-determined. Therefore, the properties are represented as regions in a conceptual space, and the metrics for representation are exter-

nally imposed. Previous theories [14, 26] proposed that similarity judgement is based either in shared properties or distance assessment in the conceptual space. The notion of shared properties assumes that a set of properties are identifiable for a concept [14]. This can be problematic in the case of a cognitive concept, where the properties of the concept are often linked intrinsically to the meaning of the concept itself that creates an "inherent circularity" in this argument [11, p. 111]. There is also the problem of identifying which properties or instances are significant in determining a concept. On the other hand, the use of distance assessment, employed in the methodology developed for semantic similarity in this paper, does not suffer from these limitations. Compared to other semantic theories, the use of the principles of conceptual space to explain the variability and context-dependence of meanings of concepts, requires less dependence on perceptual similarity in shared properties for explaining the distinctions between concepts, and more on the distances from the core set of properties, forming a primary theory in the domain.

Two primary and other subsidiary hypotheses are defined for the experimental setup that is described in the next section.

H1: The ontological distinctions between spatial concepts can be generated from empirical tests with human subjects.

1. Distance metaphors can be employed to explicate the relative semantic relatedness of geographic concepts.
2. *Place* is semantically closer to neighbourhood than to region in meaning.
3. Hyponymn and hypernymn taxonomic relations for *place* can be generated from tests of cognitive semantic relatedness.

H2: Semantic heterogeneity is context-dependent.

1. Semantic relatedness assessed based on domain specification in similarity matrix varies significantly from that carried out solely as distance measures between concepts.
2. Domain saliency influences the meanings of concepts in the conceptual space.

4 Experimental Design

The questionnaire-based experimental design is aimed at finding the similarity relations between concepts to define (1) ontological distinctions based on semantic proximity and (2) the relations elemental in determining the meaning of *place*. Semantic priming relates terms that are semantically close, and the notion of similarity and distance is used to judge categorical distinctions and boundaries between concepts [33]. Methods of semantic similarity assessment have faced criticism that symmetrical relationships are assumed in either direction for similarity judgements [38]. On the other hand, it has also been shown that for semantic similarity assessment, the asymmetry effect is less prominent when the set of stimuli provided in the experiment is devoid of any concept that is a super-ordinate concept for many others in the set

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