

An Ontology of Place and Service Types to Facilitate Place-Affordance Geographic Information Retrieval

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ABSTRACT

In order to facilitate place-affordance queries on the Web, this work proposes the employment of an ontology of place and service types. While other works defined place-affordance by associating a place with its physical objects, the conceptual view of a place-affordance in this work is based on associating a place type with its typical service types, which is reflected in the ontology construction methodology. Preliminary results, as well as an overview of the current work, are briefly introduced.

Categories and Subject Descriptors

H.3.3 [Information Storage and Retrieval]: Information Search and Retrieval – *information filtering, query formulation, retrieval models.*

General Terms

Algorithms, Design.

Keywords

Place-affordance, place ontology, and semantic Web.

1. INTRODUCTION

Ontologies play a core role in the Semantic Web, facilitating heterogeneous data integration and reasoning [1]. Ontologies have been employed to adapt the Web search results, e.g. [4]. In Geographic Information Retrieval (GIR) on the Web, they have been used to support query disambiguation and spatial search, e.g. [2], where an instance-based ontology modeled terminology, the spatial footprint, and the type of a geographic entity. The motivation of this work is to enable the expansion and interpretation of affordance-based queries on the Web, based on associating place types with services and activities. Querying the Web for “*restaurants in Cardiff UK*” returns many positive results, while querying for “*eat in Cardiff UK*” leads to a substantial reduction in the number of results. The same argument applies for “*churches in Cardiff UK*”, compared to “*pray in Cardiff UK*”. Expanding the first query, however, into “*eat restaurants in Cardiff UK*” may provide an improvement in the results in terms of the number of the retrieved items, as well as

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their being of a good quality – the majority of which refer to eating places, e.g. restaurants and hotels, in Cardiff, UK¹. This work proposes to employ an ontology of geographic place and service types, where each place type is associated with its relative service type(s) – i.e. what a place type offers to people. While related works defined place-affordance in terms of the physical objects in place, e.g. the affordances of a road network in [3] and [5], this work associates a place type with its affordance, providing affordances for multiple place types. Moreover, while [3] and [5] follow a frequency-based cross-tabulation between noun forms and verb forms, their methods work well for formal data sources. However, such methods can lead to problematic results in free-text affordance descriptions, as the latter may contain additional noun forms and verb forms, along with a place type and its physical objects. This problem is emphasized in particular when employing multiple, heterogeneous, data sources to construct the ontology. In the following, the conceptual design of a place-affordance ontology, the ontology construction methodology, as well as a sample of the current results are briefly introduced. The work concludes with a short critical discussion, including an overview of the current work.

2. PLACE-AFFORDANCE ONTOLOGY

A place-affordance ontology is an ontology of geographic place and human-action types or the services provided in place types, with the required restriction to map each place type to its related service types. The basic components of a place-affordance ontology are the following: first, a geographic place type hierarchy featuring types such as “*school*”, which is a type of “*place of learning*”, which is in turn a type of “*place*”. Secondly, a service type hierarchy which may include an entity such as “*healing patients*”, which may be a type of “*healing*”. Finally, there is the required restriction to map each place type in the ontology with its respective service type(s). To make such an ontology as semantically-rich as possible, multiple data sources of different place types descriptions need to be employed. These range from freely available free-text documents to official structured governmental databases. Examples include a dictionary of any language, such as the Oxford English Dictionary (OED)² and the Wikipedia³. Example data entries include: “*an allotment is a small area of land, let out at a nominal yearly rent by local government or independent allotment associations, for individuals to grow their own food*”. Employing multiple data sources raised a challenge in terms of integrating the different data structures of

¹ These examples are provided employing the Google Web search engine, <http://www.maps.google.com>.

² <http://www.oed.com>

³ <http://www.wikipedia.org>

the selected data sources. For example, some functional descriptions of place types included the Greek origin of the place type keyword, which is irrelevant for the purpose of this work, and required some preprocessing to handle. On the other hand, integrating multiple data sources provided more suitable results as many of the extracted service types do not overlap between the data sources. Once the corpora of place types affordance descriptions are preprocessed, the corpora are mined for frequent candidate affordance patterns. A candidate affordance pattern is a set of minimum number of tokens which appear – in a consecutive form – more than a minimum number of times, in the whole corpus. An example is “a place-keyword where”. This pattern was found frequently in many place type descriptions, such as in “a cinema is a theatre where films are shown”. Note that a place-keyword may be any word which refers to a place, e.g. “place” or “building”. When found, the corpus is accessed to find all the Part of Speech Tags⁴ (POST) for a candidate affordance pattern, in any place type description which contains the pattern. For example, for the previously shown pattern, the possible results may include: “a place-keyword where plants [NNS] are [VBP] cultivated [VBN]” or “a place-keyword where workers [NNS] manufacture [VBP] goods [NNS]”. The desired service types to be extracted here are “cultivate plants” and “manufacture goods”. A manual intervening step is then performed to craft one or more place type affordance patterns as a combination of frequent tokens and frequent POST, based on the frequent candidate affordance patterns found previously. An example pattern is “a place-keyword where ... NNS ... VBN ...”, where the service type in this case is a concatenation of “VB” and “NNS”. The corpus is searched for the matching selected patterns, extracting the affordances of each place type. Sample patterns are given in Table 1.

Table 1. Sample place affordance patterns

| Pattern | Service type(s) |
|---|------------------------------|
| place-keyword where ... NN* ... NNS* ... VBN ... NN* ... | VB*+NNS* |
| place-keyword of ... NN* ... NNS* ... | NN* and NNS* |
| place-keyword of ... VBG ... NN* ... NNS* ... | VBG*+NN* and VBG*+NNS* |
| place-keyword for ... NN* ... NNS* ... | NN* and NNS* |

In any pattern, the “*” symbol following any POST indicates one or more occurrences of that POST, and the “+” symbol between any POST indicates concatenating their respective strings (in the token set). The “...” indicates a non-consecutive presence of the tokens, i.e. other tokens may also exist between the tokens defined in the pattern. Sample results of the place-affordance ontology are given in Table 2.

Table 2. Sample results of the place-affordance ontology

| Place type | Service type(s) |
|------------|---|
| Apiary | KeepHoney, KeepBeehives, KeepHoneyBees, KeepBees |

⁴ NN: noun, singular or mass, NNS: noun, plural, VB: verb, base form, VBG: verb, gerund or present participle, VBN: verb, past participle, VBP: verb, non-3rd person singular present.

| | |
|----------------|---|
| Bowling Club | RecreationalFacilities |
| Chemical Works | ProcessChemicals |
| Court of Law | AdministerJustice |
| Holiday Camp | Holiday, HolidayAccommodation, Entertainment |
| Manse | Minister, ChristianChurches |
| Surgery | Doctor, Dentist, Vet, Advice, Treatment, MedicalPractitioner, Patients |

3. DISCUSSION

This work proposed the employment of a place-affordance ontology, with place and service typologies, to improve the results of Web GIR. The ontology design, construction method, as well as sample results were briefly introduced. The results shown are promising, and some negative results were also encountered during the course of this work. Note that the resulting service types are a hybrid of nouns and verbs, providing more descriptive and accurate terms, compared to extracting verbs-only service types. The wide variety of data sources of place affordance provided a rich source of service types. The data sources used, in were Wikipedia, OED, OpenCyc⁵, WordNet⁶, and the Ordnance Survey MasterMap Real World Objects Catalog⁷. Results show a significant improvement employing multiple data sources, compared to a single data source. Many data sources were found to provide additional or complementary service types to the other data sources, for any single place type. In reality, a place type is typically associated with more than one service types. This raises a question on the appropriate ontology encoding language. Several experimental results were produced, testing for a single data source employments and generalizations of POST – among other experiments. The results were evaluated in comparison with other ontologies, and the current work involves developing quantitative evaluation measures of the resulting ontology, considering the semantic similarity between the extracted service types, and the service types which are manually asserted by the public, for the employed place types.

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⁵ <http://www.opencyc.org>

⁶ <http://wordnet.princeton.edu>

⁷ <http://www.ordnancesurvey.co.uk/oswebsite>