Use of Affordances in Geospatial Ontologies

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Abstract. Affordances are important constituents of our knowledge about geospatial artifacts. They should be seen as complementary to the knowledge of functions of various agents in respect to the geospatial artifacts. While functions combine to form complex activities in which agents can participate, affordances can be nested, or sequential in nature. We extract nested and sequential affordances based on statistical analysis of formal texts to construct hierarchies. Our approach considers affordances of classes of artifacts and thus is relevant to specifications of ontologies. The use of such affordances in function based ontologies is demonstrated using a Road ontology example. The implication of this work can be seen in the building of ontologies used by a robotic vehicle for autonomous driving.

Keywords: Affordances, geospatial ontologies, text analysis.

1 Introduction

The term affordance refers to those uses of an object which can be readily perceived. In the context of a human agent, such uses are closely related to the experiences of the objects. This notion of experience of any object has strong relevance to the meaning of “places”. “Places” are reported to be a combination of the concept of a “space” along with the “meaning” implied by that “space”. The “meaning” of “places” is expressed by a combination of factors but which are primarily related to the perception related to uses and experiences of a human in that “place”.

Simply put, affordances are core constituents of what defines a place. Geospatial ontologies which seek to provide semantic interoperability among users of geospatial information from different domains [1] need to include such information and such a need has been discussed by [2]

The notion of affordance was first suggested by Gibson [3] in his theory of perception and was later re-articulated by Norman [4] in the field of interface design. For Gibson, affordances are objective, actionable properties of objects in the world. For an animal to make use of the affordance, it must of course perceive it in some

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1 The term ‘affordance’ is used in a broader sense which encompasses the notion of functions and perceived affordances of entities. Normally, ‘functions’ are used to represent designed behavior of entities and ‘affordances’ to represent perceived uses or functions of the same. In this paper we shall use the term ‘affordance’ to accommodate both based on the assumption that designed behaviors or ‘functions’ are usually a part of the perception. We provide some further discussion in section 4.
way, but for Gibson, the affordance is there whether the animal perceives it or not; an unperceived affordance is waiting to be discovered. For Norman, affordances become perceived and culturally dependent. That is, rather than viewing the relationship between sensory object and action as an independent property of the object + animal system, this relationship is contingent, dependent on the experiences of the perceiver within some cultural framework. For example, for a person who has spent the last 10 years driving on expressways in the US, expressways afford the action of driving up to 65 mph. It would not be possible for such a person to perceive a road where the maximum speed limit is 40 km/h as an expressway.

Extracting knowledge about affordances is a difficult process and the first challenge is to understand that such knowledge is probabilistic in nature and differs from person to person. The affordances are perceived at a certain point in time and are amenable to revision. Some affordances are not yet learnt and some are “unlearnt” over time (and also the learning of ‘non-affordances’). At the same time it is important that communities have common notions about publicly shared entities. Public places and affordances of such places have such shared notions. Formal texts such as traffic code texts are important sources of such shared knowledge. Traffic code texts have both legal binding as well as an instructive sense which defines what actions should be done (or not be done) in relation to elements of the road network.

The notion of affordances allows two possibilities in the process of identifying objects in a given environment with respect to a human agent. The first option concurs with conventional categorization principles which identify objects as members of certain categories based on their physical structures such as boundaries and features. Such categorization results in classes such as Footpaths, Motorways, etc. According to this first option human agents visualize the environment as objects and attach affordances as we learn them.

Contrastingly a second option is to see the environment in terms of the affordances (and non-affordances) and identify objects based on them. The distinction of categories could be based on a single affordance notion (for example we can categorize walkable and non-walkable areas on a road network as opposed to Footpaths and Roads) and also bundles of affordances in the form of multiple affordances which could also be nested in one another (for example ‘non parkable areas’. Parking entails ‘stopping the car’ and ‘walking’ and hence is an example of nested affordance).

In this paper we present a case study of extracting knowledge about affordances of road network entities, which includes notions of nested and sequential affordances. We conduct analysis of two traffic code texts based on a word co-occurrence model and discuss the possible options to integrate such information in geospatial ontologies. The work of Kuhn [2] serves as an inspiration of this work but has several extensions to the original approach including automated text analysis and quantitative values for affordances discussed later in the paper.

The remaining of this paper is arranged as follows. In this § we provide further introduction to the motivation of this work and some background of previous work in this area. § 2 describes concepts of text analysis useful for extraction of affordances. The case study involving extraction of entity terms and the functional terms from two traffic code texts is described in § 3. We discuss the results of the case study and difficulties to integrate the different levels of affordance in the subsequent section. Finally we present some conclusions and outlook for future work in this area.