Towards Ontology-based Pragmatic Analysis

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Abstract

In this paper we describe an ontological model of pragmatic knowledge - using an example from the domain of navigation - that is based on the Descriptive Ontology for Linguistic and Cognitive Engineering and employs a specific ontological module called *Descriptions & Situations*. This framework establishes so-called *ontological patterns*. We employ such a pattern for modeling schematic knowledge of the pragmatics of spatial navigation.

1 Introduction

Spoken multi-modal dialogue systems equipped with the ability to understand and process natural language utterances commonly employ a formal, explicit specification of shared conceptualizations (Gruber, 1993) for machine encoding. At the same time the emerging Semantic Web (Berners-Lee et al., 2001) bases on such formal conceptualizations, called *ontologies* to add semantic information to textual and other data available on the Internet.

In the mobile multimodal dialogue system SmartWeb (Wahlster, 2004) a navigation ontology is necessary, which represents knowledge about the locomotion of the intended user to support car, motorcycle and pedestrian navigation. Existing navigation ontologies (Malyankar, 1999; Gurevych, 2003) describe route mereologies, which do not capture contextual dependencies. Given a single application-specific context, e.g. guiding only pedestrians - always on foot and always on the shortest path, we can employ such a *context-free* ontology. However, if we wish to make use of the many tunable parameters offered by today's route planning and navigational systems, as we will describe below, one must provide the means to find the right setting depending on the actual situation at hand in the least invasive way, i.e. minimizing the amount of parameters and role settings obtained by asking the user.

In the following we describe how the SmartWeb navigational ontology attempts to provide a principled approach to encode pragmatic knowledge about possible dependencies between the specific contextual factors, such as the actual weather, and other settings such as the choice of road type.

2 The SmartWeb Project

Mobile broadband communication technologies - ranging from wireless local area networks to UMTS - and the evolving semantic web technologies set the stage for intelligent web-based services. Together these services provide the means for novel ways of interacting with and accessing semantically described information. Based on these developments the SmartWeb project seeks to realize ubiquitous interaction and semantic access via multimodal human-computer interfaces.

The goal of the greater research effort behind this work is to lay the foundations for multimodal user interfaces to access distributed and composable Semantic Web services employing a wide range of mobile devices.

3 The Need for Pragmatic Knowledge

In a mobile dialogue system context information is of high significance as the user expects the offer of topical services, while navigating through a dynamically changing environment (e.g. changing precipitation- and temperature levels and/or traffic- and road conditions), which makes the adequate representation of context knowledge inevitable for the task of natural language understanding (NLU).

In the field of NLU ontologies are a well established instrument for expressing domain knowledge and have been employed in state of the art multi-modal dialogue systems (Gurevych, 2003). Still, the following settings demonstrate the necessity of including extra-linguistic situative knowledge for the domain of human navigation in real space:

- For instance, a pedestrian might prefer public transportation over walking when it is raining even for smaller distances.
- A motor bicyclist might prefer to use winding country roads over interstate highways when it is warm and sunny, but not, when road conditions are bad.
- A car driver might like to take a spatially longer route if shorter ones are blocked or perilous.

4 Integrating Pragmatic Knowledge in the SmartWeb Foundational Ontology

The SmartWeb foundational ontology (Cimiano, 2004) employs the highly axiomatized Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE)[1]. It features various modules, e.g. an ontology of plans and a module called *Descriptions & Situations* (Gangemi, 2003). As the focus of our work lies on an application and elaboration of the latter mentioned module, it will be described more closely in the next chapter. Additional to the foundational ontology a domain-independent layer is included which consists of a range of branches from the less axiomatic ontology SUMO (Suggested Upper Merged Ontology; (Niles et al., 2001)), which is known for its intuitive and comprehensible structure.

4.1 Pragmatic *Descriptions & Situations*

The module *Descriptions & Situations* (D&S) is an ontology for representing a variety of reified contexts and states of affairs. In contrast to physical objects or events, the extension of the ontology by non-physical objects poses a challenge to the ontology engineer. The reason for this circumstance is the fact that non-physical objects are taken to have meaning only in combination with some other entity. Accordingly, their logical representation is generally set at the level of theories or models and not at the level of concepts or relations (see (Gangemi, 2003)).

An example for a **situation** could be the instance of some specific person, e.g. `Rainer`, playing the *functional role* of a motorcyclist driving on the `B3` playing the role of a country road on a day whose weather region was valued by `sunny` and `warm`.

In our elaboration an example for a **description** would be a generalization over such

[1] More information on this descriptive and reductionistic approach is found on the WonderWeb Project Homepage: wonderweb.semanticweb.org.

instances, e.g. the description of locomotion would use roles - such as locomotor and path and a parameter such as environment, which adhere to the constraints established by D&S, i.e. that roles are played by endurants, e.g. physical objects and that they are parameterized by regions, e.g. the region encompassed by all weather conditions.

Figure 1 sketches out how this is realized in the D&S module.

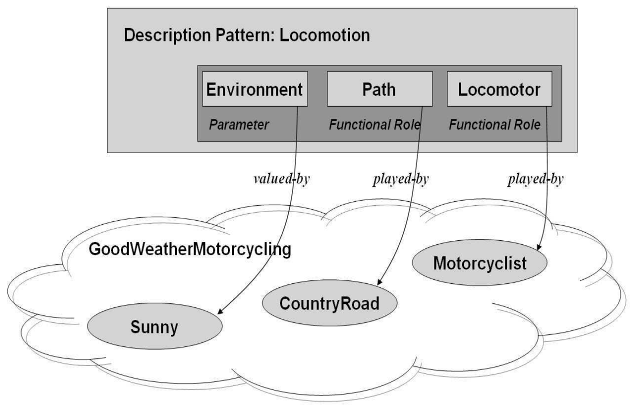

Figure 1: D&S example

One modeling choice that arises hereby concerns the question of how fine-grained such a description and relation hierarchy linked to corresponding roles and parameters should be or if a corresponding axiomatization should bear the burden of associating the pragmatically grouped items of the ground (domain) ontology, e.g. SUNNY, COUNTRYROAD and MOTORCYCLIST for describing the context in which country roads are the filler of choice for motorcyclists on sunny days. In the latter case the corresponding axioms would be the following in the context of GOODWEATHERMOTORCYCLING (GWM) using the predicate situationally_connected (s_c)):

$$\forall(x) \rightarrow GWM(x) \rightarrow$$
$$s\_c(GWM, Sunny)\wedge$$
$$s\_c(GWM, CountryRoad)\wedge$$
$$s\_c(GWM, Motorcyclist)$$

In either case this elaboration of the *Descriptions & Situations* module extends the notion of deriving an instance (situation) from a description by modeling a more general pattern of pragmatic knowledge. Figure 2 shows a corresponding simplified extract from the contextually enhanced ontology with the D&S plug-in.

4.2 Employment in the SmartWeb Project

As the described work will find practical employment in the SmartWeb Project our navigation ontology will be applied to:

- understanding navigational request
- context-dependent route planning.

5 Conclusion

Until now we have done a lot of work on finding the appropriate description for each situation in the D&S module. Unfortunately an axiomatization poses difficulties to most NLP systems and more systematic ways of populating the ontology with the needed description patterns, e.g. by means of learning, need to be found. The next step will be an appropriate quantitative evaluation as proposed by (Porzel & Malaka, 2004). In the future we will, therefore, be concerned with the semi-automatic learning of descriptions from collected situation instances and their consecutive population and quantitative evaluation in the ontology.

Acknowledgments

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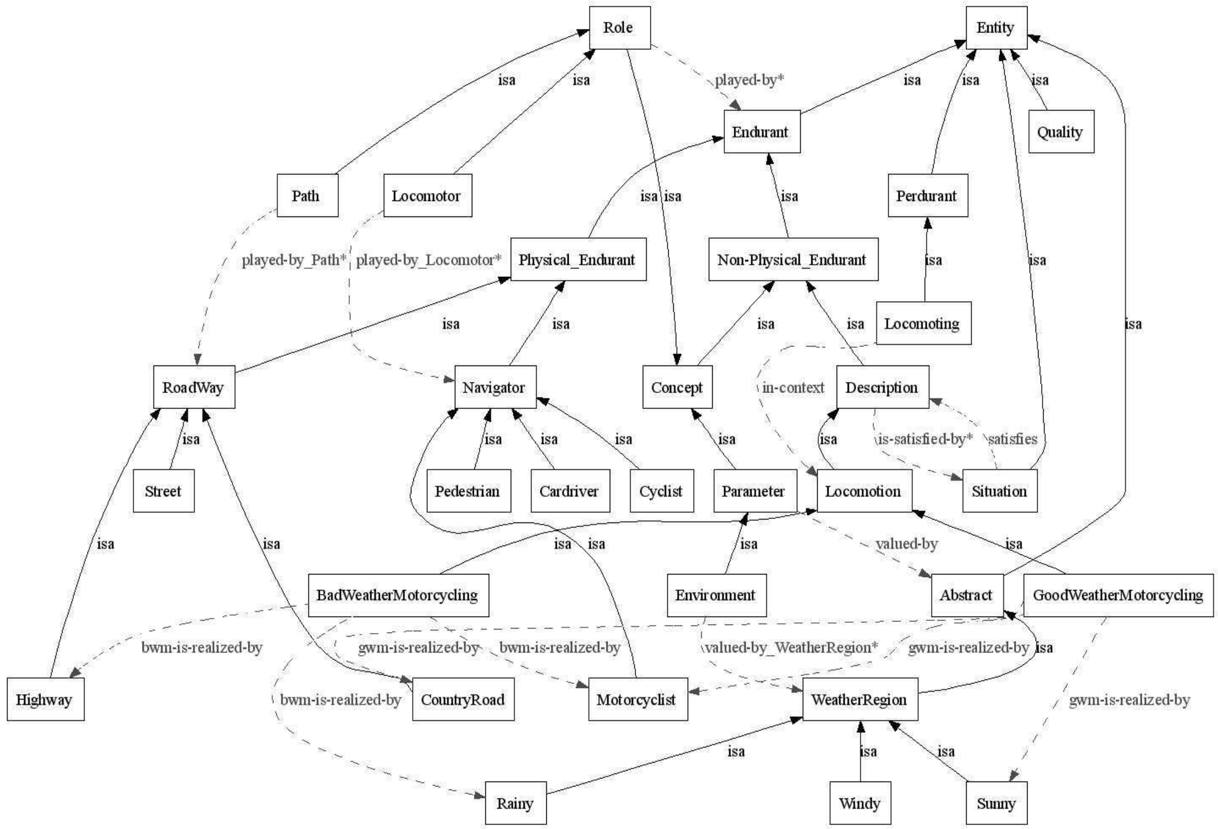

Figure 2: Navigation Ontology extract

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