Of Situations and Their Neighbors
Evolution and Similarity in Ontology-Based Approaches to Situation Awareness

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Abstract. Ontology-based approaches to situation awareness have gained increasing popularity in recent years. However, most current approaches face two inherent problems. First, they lack sufficient support for assessing evolutions of situations, which is crucial for informing (human) agents about emerging instances of interesting situation types. Second, they are confronted with the problem of recognizing situations that are just similar to a situation type an agent is interested in. Our approach contributed in this paper is based on conceptual neighborhoods of relations which we generalize to conceptual neighborhoods of situations. These conceptual neighborhoods turn out to be the basis for addressing both problems, the assessment of evolving as well as similar situations. The applicability of our approach is demonstrated by an in-depth case study in the domain of road traffic management.

1 Introduction

A profound basis for decision making of (human) agents in highly-dynamic, heterogeneous environments—like operators in the field of road traffic management—has to provide a perception of the available information that is tailored to the decision maker’s context. Situation awareness (SAW) aims at providing such a perception based on situations, which describe a state of affairs adhering to a partial view of the world. Our conceptualization of situations, which is motivated by Situation Theory [1], involves physical objects, their intrinsic attributes, and their relations to other objects, which altogether may potentially contribute to relevant situations, i.e. the ones an agent is interested in. These relevant situations are defined by abstract situation types that should be instantiated during situation assessment. In recent years, ontologies, i.e. their interpretation coined by Gruber [2],
have been regarded to be suitable for providing the vocabulary for describing situations and their involved concepts (e.g. [3]).

Endsley [4] points out that SAW also involves the estimation of the future of recognized situations, meaning that also the evolution of situations has to be assessed. Consequently, agents should be informed of an emerging relevant situation, in order to take pro-active action. A further problem is to inform agents about situations that are just similar to the relevant situation types (e.g. sensors still just capture a very limited image of the real world). Unfortunately, ontology-based SAW approaches face the problem inherent to the mainly symbolic representation of situations. This leaves the questions how to determine that a situation is on its way to turn into a relevant situation or that a situation is similar to a situation type? At first sight, both problems, assessing evolving and similar situations, are unrelated. In the scope of this paper, we contribute an approach based on conceptual neighborhoods of relations, which, generalized to conceptual neighborhoods of situations, turn out to be the basis for addressing both problems. Our approach is established as a case study in the road traffic management domain, which is, as indicated above, a prominent candidate for applying SAW systems. Road traffic operators have to control road traffic based on the assessed traffic situations using, for example, speed controls or warning messages. In order to elaborate a realistic setting, we collaborate with ASFINAG Traffic Telematics Ltd., a subsidiary of Austria's highways agency, regarding the interesting types of traffic situations and the actions taken by a traffic operator upon their occurrence.

The paper is structured as follows. First, we introduce an ontology for road traffic SAW and a formalism to specify situation types in Sect. 2. Next, we elaborate our approach in Sect. 3 and subsequently, in Sect. 4, apply it in the scope of a case study involving various traffic situation types and their occurrences in a complex scenario. Finally, we provide an overview of related work in Sect. 5 and conclude the paper in Sect. 6 in which we critically discuss our contribution and indicate further prospects of our work.

2 Road Traffic Situation Awareness

In order to explain our approach elaborated in Sect. 3 by means of illustrative examples, we introduce an ontology for road traffic SAW and, thereupon, a formalized description of an interesting but simple situation type in this section. The ontology and the according formalism to describe situations and situation types are also the basis for our case study in Sect. 4.

2.1 An Ontology for Road Traffic Situation Awareness

The ontology depicted in Fig. 1 is based on our previous work which focused on spatio-temporal extensions to a simple, OWL DL-based ontology for road

\footnote{Web Ontology Language, cf. http://www.w3.org/TR/owl-features}