Journal of Applied Logic • • • (• • • •) • • •–• • •

Contents lists available at ScienceDirect

Journal of Applied Logic

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Extending adaptive world modeling by identifying and handling insufficient knowledge models ☆

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ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Probabilistic world modeling
Adaptive knowledge management
Object oriented methods
Object recognition
Concept learning
Cognitive robotics

ABSTRACT

Adaptive knowledge modeling is an approach for extending the abilities of the Object-Oriented World Model, a system for representing the state of an observed real-world environment, to open-world modeling. In open environments, entities unforeseen at the design-time of a world model can occur. For coping with such circumstances, adaptive knowledge modeling is tasked with adapting the underlying knowledge model according to the environment. The approach is based on quantitative measures, introduced previously, for rating the quality of knowledge models. In this contribution, adaptive knowledge modeling is extended by measures for detecting the need for model adaptation and identifying the potential starting points of necessary model change as well as by an approach for applying such change. Being an extended and more detailed version of [17], the contribution also provides background information on the architecture of the Object-Oriented World Model and on the principles of adaptive knowledge modeling, as well as examination results for the proposed methods. In addition, a more complex scenario is used to evaluate the overall approach.

1. Introduction

For the successful operations of artificial cognitive systems like humanoid service robots or systems providing support to situation assessment, one key prerequisite is the availability of appropriate information about the current state of the surroundings or real-world environment considered by the system. A world modeling component can be employed to provide and manage the required information. World modeling revolves around the tasks of representing and organizing all the information gathered from an environment.

☆ This article is an extended version of the contribution [17] presented at the 4th Workshop on Dynamics of Knowledge and Belief (DKB-2013) at the 36th German Annual Conference on Artificial Intelligence (KI-2013).

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http://dx.doi.org/10.1016/j.jal.2016.05.005
1570-8683/

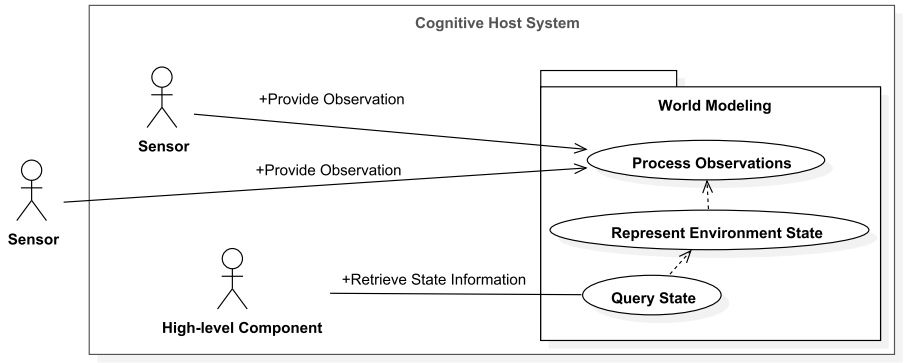

Fig. 1. World Modeling. A world model component is tasked with integrating environmental information provided by internal and external sensing systems to a cognitive host system. The acquired information has to be managed and represented consistently, allowing higher-level components in the host system to query for the information needed to fulfill their tasks.

Information is acquired by means of sensing systems integrated or connected to the cognitive host system. A world modeling component is responsible for integrating, updating and consistently maintaining the acquired information to the end of supplying higher-level components in the host system with the environmental information they require. This task of managing environmental information is summarized in Fig. 1 by a use-case diagram.

A realization of such a world modeling component is given by the Object-Oriented World Model (*OOWM*) [9,3]. The OOWM has previously been employed in different application domains, including autonomous service robotics (e.g., [2]), maritime situation assessment (e.g., [8]), and video surveillance [7]. The OOWM is designed to be a probabilistic information management framework able to organize acquired information about its environment. Using this information, a probabilistic representation is created, storing the state of the observed environment. When new information becomes available, probabilistic techniques for information integration are employed to update the stored information. The OOWM provides its information to higher-level components structured according to an object-oriented approach, describing the entities contained in a scene as objects with properties. Additionally, it allows to be queried for past states.

For enriching this symbolic state representation with semantics, an a priori compiled domain model is used as background knowledge, allowing the OOWM to classify observed entities in terms of pre-defined concepts. Based on such background knowledge, the OOWM enables a host system to semantically interact with its environment or other agents as well as to perform reasoning about its surroundings. For encoding this type of semantic knowledge into a domain model, the model is usually created by human experts prior to system operations. Following this approach, an a priori model by design can only consider and represent a limited, closed part of the application domain – the part deemed relevant at design time. However, during operations of a world modeling system, real-world entities may be observed which have not yet been represented in the domain model and, in consequence, cannot be processed semantically.

In order to handle such situations in the OOWM, an adaptive approach for modeling open environments is needed. In [18], first ideas on adaptively managing the OOWM background knowledge have been presented, as part of a proposed approach for adaptive world modeling. This approach comprises methods for evaluating the goodness of the knowledge model, i.e., its quality and ability to represent the currently observed real-world environment. In addition, methods for adapting the knowledge model to the current needs must be given in case of a decaying model quality. The adaptive world modeling approach consistently extends object-oriented world modeling by following its general principle of probabilistic Bayesian information processing. In [18], a method for evaluating the quality of knowledge models based on information-theoretic measures and the principle of Minimum Description Length [24] was introduced.

This contribution now focuses on the problem of detecting observed entities in the world model that cannot be well represented by the current knowledge model and on identifying potential starting points

Please cite this article in press as: A. Kuwertz, J. Beyerer, Extending adaptive world modeling by identifying and handling insufficient knowledge models, J. Appl. Log. (2016), http://dx.doi.org/10.1016/j.jal.2016.05.005