Using Conceptual Spaces for Object Recognition in Multi-agent Systems

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Abstract. The development of a system to support the mobility of blind or visually impaired users requires the development of an agent capable of performing the recognition of perceived objects as well as determining their location within the physical space. Taking into account the principle that conceptual representations can improve the object recognition process, the work presented here proposes the integration of a conceptual-space level into the BDI agent architecture. Such integration is developed on top of the resources of the Jason agent platform and the CSML API for conceptual-space models. In this paper, we present a practical example showing how to integrate conceptual representations into the agent reasoning cycle.

Keywords: BDI architecture · Conceptual spaces · CSML API · Jason

1 Introduction

The development of a system to support the mobility of blind or visually impaired users requires the development of an agent capable of performing the recognition of perceived objects as well as determining their location within the physical space. Conceptual spaces is a framework for concept representation that allows one to represent similarity between objects and concepts [7]. It is particularly interesting for object recognition and classification. Conceptual spaces can be thought of as geometric spaces, in which points represent objects and regions represent concepts. The dimensions of a conceptual space denote the qualities in which these entities can be compared. The distance metric encodes the similarity between object/concepts. In order to improve the agent's abilities in regards to object recognition, our work proposes the integration of a level of representation based on conceptual spaces into the architecture of BDI agents. We extend and use the Jason platform [3] to support the design of systems that incorporate such conceptual inference processes into the agent reasoning cycle. In our work, the representation of conceptual spaces is established with the aid of the Conceptual Space Markup Language (CSML). Based on the algebra proposed by

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Adams and Raubal [1], CSML allows users to specify conceptual databases and manage them with the aid of a programming interface.

This paper presents the first results towards the integration of these resources and its contribution to the development of a system to support the mobility of blind or visually impaired users. First, we review the main aspects of the BDI architecture, the theory of conceptual spaces, and the role of the computational platforms used in our implementation. Next, we present a practical example, through which we detail the customisations made on the existing platforms to enable our proposed conceptual inference integration. We then draw conclusions from this study.

2 BDI Architecture, Conceptual Spaces, and Related Computational Platforms

The BDI (Beliefs, Desires, Intentions) architecture is a commonly used approach for the development of systems of rational agents situated in complex and dynamic environments [15]. Agents are active entities able to analyse and act on their environment. The BDI (Beliefs, Desires, Intentions) architecture established the basis for the development of the AgentSpeak(L) programming language.

The Jason platform for the development of multi-agent systems [3] was developed based on an extended version of the AgentSpeak language. It supports inter-agent communication through performatives based on the theory of speech acts [11]. Following on ideas from the AgentSpeak language, also in the Jason variant an agent is defined through the specification of the initial state of its belief base and its plan library. In addition to supporting the basic syntax of the language AgentSpeak, Jason has support for additional features such as the use of annotations in beliefs and plans, support to customised functions developed in Java and incorporated as internal actions, a Java class for environment specification, and the possibility of customisation of agent architectural features.

In the conceptual spaces approach, concepts are represented by regions in a multidimensional geometric space where objects are projected as points or as vectors of points [7]. Conceptual space is structured by quality dimensions that are endowed with a geometric structure and a specific metric that allows one to measure distances between objects. This mechanism enables inferences on degrees of similarity between the objects represented in the space. That is, two objects may have a high degree of similarity if the computed distance between the points which represent them is small in relation to a domain-specific threshold. Otherwise, if this threshold is exceeded, these objects may not be considered (sufficiently) similar. The decomposition of space into convex regions is determined by the existence of a cell that intersects a set of half-plans and establishes the point containing the most representative element of the region. Decomposition of space into regions provides the basis for the notions of property and concept. A *property* is represented as a convex region of a domain in a conceptual space (e.g., a region denoting the red colour), while *concepts* are represented