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Autonomous Agents Modelling Other Agents: A Comprehensive Survey and Open Problems

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Abstract

Much research in artificial intelligence is concerned with the development of autonomous agents that can interact effectively with other agents. An important aspect of such agents is the ability to reason about the behaviours of other agents, by constructing models which make predictions about various properties of interest (such as actions, goals, beliefs) of the modelled agents. A variety of modelling approaches now exist which vary widely in their methodology and underlying assumptions, catering to the needs of the different sub-communities within which they were developed and reflecting the different practical uses for which they are intended. The purpose of the present article is to provide a comprehensive survey of the salient modelling methods which can be found in the literature. The article concludes with a discussion of open problems which may form the basis for fruitful future research.

Keywords: autonomous agents, multiagent systems, modelling other agents, opponent modelling

1. Introduction

A core area of research in modern artificial intelligence (AI) is the development of autonomous agents that can interact effectively with other agents. An important aspect of such agents is the ability to reason about the behaviours, goals, and beliefs of the other agents. This reasoning takes place by constructing models of the other agents. In general, a model is a function which takes as input some portion of the observed interaction history, and returns a prediction of some property of interest regarding the modelled agent (cf. Figure 1). The interaction history may contain information such as the past actions that the modelled agent took in various situations. Properties of interest could be the future actions of the modelled agent, what class of behaviour it belongs to (e.g. “defensive”, “aggressive”), or its current goals and plans.

An autonomous agent can utilise such a model in different ways, but arguably the most important one is to inform its decision making. For example, if the model makes predictions about the actions of the modelled agent\textsuperscript{1}, then the modelling agent can incorporate those predictions in its planning procedure to optimise its interaction with the modelled agent. If instead the model makes predictions about the class of behaviour of the modelled agent, then the modelling agent could choose a precomputed strategy which it knows to work well against the predicted class.

\textsuperscript{1}We will use the term “modelling agent” to refer to the agent which is carrying out the modelling task, and “modelled agent” or “other agent” to refer to the agent which is being modelled.
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