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Ontology based Knowledge Representation Technique, Domain Modeling Languages and Planners for Robotic Path Planning: A Survey

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Abstract

Knowledge Representation and Reasoning (KR & R) has become one of the promising fields of Artificial Intelligence. KR is dedicated towards representing information about the domain that can be utilized in path planning. Ontology based knowledge representation and reasoning techniques provide sophisticated knowledge about the environment for processing tasks or methods. Ontology helps in representing the knowledge about environment, events and actions that help in path planning and making robots more autonomous. Knowledge reasoning techniques can infer new conclusion and thus aids planning dynamically in a non-deterministic environment. In the initial sections, the representation of knowledge using ontology and the techniques for reasoning that could contribute in path planning are discussed in detail. In the following section, we also provide comparison of various planning domain modeling languages, ontology editors, planners and robot simulation tools.

Keywords: Path Planning, Knowledge Representation, Reasoning, Ontology, Spatial, Temporal, Semantic Knowledge, Planners, Modeling languages

1. Introduction

Artificial Intelligence makes a machine intelligent by making them perform specific tasks to achieve the goal at the maximum level. In recent years, many research works deal with the problem of planning and sequencing a robot to provide an optimal path on a production line. Robots play a vital role in many applications such as industries, medical institutions, household maintenance and automated harvesting etc.

In Artificial Intelligence, planning a task is concerned about sequence of actions (A) that transform an initial state (S) into the desired goal state (G). An agent is given the complete description of the environment, the set of available actions and states present in the domain. But, representing and also providing the complete description of the domain knowledge is crucial as it is essential in making the robot perform actions efficiently and effectively. There are different types of domain modeling knowledge that provides a complete description of environment. This domain knowledge can be represented using Ontology, Petri Net and Finite State Machine. The availability of vast amount of Ontology-based domain Knowledge Representation (KR) techniques provide the opportunities for gaining new knowledge and better understanding of the environment.

Ontology based representation and reasoning addresses the real-world robot problems such as unreliable actions, collision, moving object interactions and other physical events (e.g. hitting and falling). Domain based knowledge can be modeled in ontology using ontology markup languages and various ontology tools like Protege [1] [1], OILed [2] [2] etc. To build domain knowledge, various planning domain models namely PDDL [3], DDL [3], NDDL [4], ANML [5] and AML [6] are used. They help in perceiving the fully and partially observable environments. This paper provides an extensive overview of Ontology based knowledge representation and reasoning techniques in modeling domain knowledge. It also discusses the different planning domain models used in path planning algorithms. We also provide the comparison of various planners, modeling languages and visual robotic simulators that are used in path planning domain.

The organization of the paper is as follows: Section 2 describes Ontology based Knowledge Representation (KR) techniques used in task planning. Section 3 presents the need for Knowledge reasoning in improving the task planning efficiency. Section 4 reviews the path planning paradigm. Section 5 describes the editors that are used to building an ontology and also provides a comparison of various planning domain modeling languages. The paper is concluded in Section 6 followed by references.

2. Ontology based knowledge representation technique

In this section, the use of Ontology in representing the structural knowledge aiding semantic, temporal, and spatial representations of a modeled environment is discussed. Every technique has some unique characteristics which can be used to represent the complete robotic environment for assigning and performing tasks successfully. The classification of ontology based KR techniques is shown in Fig.1

[1] https://protege.stanford.edu/

[2] http://oiled.semanticweb.org/download.shtml