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IEEE Standard Ontologies for Robotics and Automation

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IEEE Standard Ontologies for Robotics and Automation

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Abstract: A core ontology that specifies the main, most general concepts, relations, and axioms of robotics and automation (R&A) is defined in this standard, which is intended as a reference for knowledge representation and reasoning in robots, as well as a formal reference vocabulary for communicating knowledge about R&A between robots and humans. This standard is composed of a core ontology about R&A, called CORA, together with other ontologies that give support to CORA.

Keywords: automation, core ontology, IEEE 1872™, methodology, ontology, robotics

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Introduction

This introduction is not part of IEEE Std 1872-2015, IEEE Standard Ontologies for Robotics and Automation.

Seamless and unambiguous communication between people demands a common, well-defined vocabulary. Otherwise, misinterpretations can happen and no information or—even worse—incorrect information can be exchanged between the participants, often with negative consequences. This could happen when two people who do not speak the same language try to communicate. The same applies to human-robot and robot-robot communication, where an intermediate standard language with clear and well-defined terms is a sine qua non condition for common understanding.

The growing complexity of behaviors that robots are expected to present naturally entails the use of increasingly complex knowledge as well as the need for multi-robot and human-robot collaboration. In this context, the need for a standard and well-defined model for capturing this knowledge is becoming evident. The existence of such a standard knowledge model, precisely defining the concepts of the robotics domain, will help ensure common understanding among various stakeholders involved in the lifecycle of robotic systems, enabling efficient and reliable data integration and information exchange among them.

Ontology plays a fundamental role in this context. It formally specifies the key concepts, properties, relationships, and axioms of a given domain. Unlike taxonomies, which provide only a set of vocabulary and a single type of relationship between terms, an ontology provides a richer set of relationships, constraints, and rules. In general, ontologies make the relevant knowledge about a domain explicit in a computer-interpretable format, allowing software to reason over that knowledge to infer new information. Furthermore, ontologies are a great tool for diminishing the ambiguity in knowledge transfer among groups of humans, robots, and other artificial systems that share the same conceptualization.

In this sense, the Ontologies for Robotics and Automation Working Group (ORA WG) is actively working with industry, academia, and government organizations to develop a set of ontologies and an associated modeling methodology to be used as a standard in robotics and automation (R&A). As it is extremely difficult to develop a single ontology that covers the entire scope of R&A, the ORA WG decided to focus initially on two subdomains: industrial robotics and service robotics. This decision was based on the prevalence of robots in these markets and the standardization necessities accompanying them. Therefore, ORA WG comprises three subgroups, two of them associated with each of the above subdomains. The third subgroup, called Upper Ontology/Methodology (UpOM), is in charge of the development of a more general ontology to bring all of the subdomain ontologies together. This document is the result of the work done by the UpOM and presents a core ontology for R&A (CORA), which specifies the general notions underlying R&A and aims to provide clear definitions of the common concepts that will permeate all derived ontologies to be developed within the ORA WG. Thus, CORA focuses on defining what a robot is in the scope of the standard, along with the specification of other related entities.

This document also includes other ontologies complementing CORA. The ontology CORAX represents concepts and relations commonly found in R&A subdomains but that are too general to be included in CORA. The ontology RPARTS includes concepts useful to represent robot parts. Finally, the ontology POS captures general notions about position and orientation.

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IEEE Standard Ontologies for Robotics and Automation

1. Overview

1.1 Scope

This standard defines a core ontology that allows for the representation of, reasoning about, and communication of knowledge in the robotics and automation (R&A) domain. This ontology includes generic concepts as well as their definitions, attributes, constraints, and relationships. These terms can be specialized to capture the detailed semantics for concepts in robotics sub-domains.

This standard contains the Core Ontology for Robotics and Automation (CORA) with the representation of fundamental concepts from which the more detailed concepts belonging to other Ontologies for Robotics and Automation Working Group (ORA WG) ontologies are constructed. This standard also defines the ontology engineering methodology used to construct the ORA ontologies.

1.2 Purpose

The purpose of this standard is to provide a methodology for knowledge representation and reasoning in robotics and automation (R&A) together with the core ontology for the R&A domain. The standard provides a unified way of representing knowledge and provides a common set of term definitions, allowing for unambiguous knowledge transfer among any group of humans, robots, and other artificial systems.

The standard aims to provide a common vocabulary along with clear and concise definitions from the R&A domain. With the growing complexity of behaviors that robots are expected to perform, as well as the need for multi-robot collaboration and human-robot collaboration, the need for a standard and well-defined