A robot can only achieve tasks and perform missions based on what it knows, which is primarily captured within the robot’s internal knowledge representation. This representation is usually very specialized to the individual robot and often very loosely defined. With the growing complexity of behaviors that robots are expected to perform as well as the need for multi-robot and human-robot collaboration, the need for a standard and well-defined knowledge representation is becoming more evident.
IEEE Ontologies for Robotics and Automation

Goal

To develop a methodology for knowledge representation and reasoning in robotics and automation, together with the representation of concepts in an initial set of application domains, to allow for unambiguous knowledge transfer among any group of humans, robots, and other artificial systems.
Study Group Participants
(78 subscribed to mailing list)
Scope (Robots)

Ground
Air
Underwater/Surface
Space
Different Kinds of Robotic Knowledge

Cost-based Models

LADAR and Color Camera Images

Layered Terrain Maps

Databases

State Tables

Ground Truth

Autonomous Vehicle Ontologies

Prediction Equations
Glossaries & Data Dictionaries

Thesauri, Taxonomies

MetaData, XML Schemas, & Data Models

Formal Ontologies & Inference

Terms

Thesauri

structured Glossaries

XML DTDs

Principled, informal hierarchies

DB Schema

Data Models (UML, STEP)

Formal Taxonomies

Description Logics (DAML+OIL)

General Logic

ad hoc Hierarchies (Yahoo!)

‘ordinary’ Glossaries

Data Dictionaries (EDI)
What is an Ontology?

“a specification of a conceptualization”*
Ontologies explicitly represent key concepts, their properties, their relationships, and their rules and constraints. Ontologies often focus more heavily on the meaning of concepts as opposed to terms that are used to represent them.

Vocabulary + Structure = Taxonomy
Taxonomy + (Relationships and Constraints) = Ontology

*Tom Gruber, Stanford Univ.
Ontology Application Scenarios

Common Access to Information
Information required by multiple agents

Provides a single source of information for multiple applications

Ontology used as agreed standard

Benefits: knowledge reuse, maintainability, long term knowledge retention

• Ontology as Specification
  - build ontology for required domain
  - produce software consistent with ontology
  - manual or partially automated
  - **Benefits: documentation, maintenance, reliability, knowledge (re)use**
Ontology as an Exchange Language
Provides an interlingua among disparate applications

Ensures semantic-based interoperability

Solves the point-to-point integration problem

Benefits: systems integration, semantic interoperability

• Ontologies for Reasoning
  - Allows one to run queries through a reasoning engine
  - Helps to identify information that is not explicitly represented
  - Benefits: knowledge inference
Ontologies for Robotics and Automation

Approach

Top down
- Develop/identify an upper ontology to serve as the overarching structure that information can “hang from”
- Develop a methodology to add new information to the ontology

Bottom Up
- Develop detailed ontologies for a small set of domains
  - Service Robots
  - Autonomous Robots
- Domains are intentionally broad to allow for overlapping concepts

Tying it all together
- Incorporate the domain ontologies into the upper ontology using the defined methodology
- Reconcile any discrepancies that exist among concepts
Upper Ontology and Framework Subgroup

Goals

Define a framework for building ontologies that allows robot designers to build domain-specific ontologies in a controllable way
Define linguistic framework so that expressions using the ontologies can be communicated and so that it is possible to translate between different ontological realms (e.g. human and robot)
Define top-level categories as a foundation for further extension
Service Robot Ontology Subgroup
Types of Service Robots

“A Service Robot is a robot which operates semi- or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations” - International Federation of Robotics (IFR)

- Industrial robots (e.g., radiographic inspection of welds)
- Defense robots (e.g., autonomous scout vehicles)
- Healthcare robots (e.g., surgical manipulation, wheel chairs)
- Prosthetic robots (e.g., prosthetic arms, legs, etc.)
- Scientific robots (e.g., gene sequencers)
- Domestic robots (e.g., floor cleaners, lawn mowers)
- Diffused robots (e.g., parallel park assist systems)
- Military and law enforcement robots (e.g., drones, UAVs)
Phase 1: Identify and summarize the different definitions and glossaries used in the different Service Robots - bibliographical research

Phase 2: Requirement analysis to extend /modify the glossaries to meet the needs of industries and scientific communities

Phase 3: Aims at describing the robots in terms of well-defined ‘taxonomy’ by its components and operating environment

Phase 4: Defines and elaborates on the different knowledge layers - for high level Human-Robot/Robot-Robot Interaction
Autonomous robots are robots that can perform desired tasks in unstructured environments without continuous human guidance.

- aerial photography using flying robots
- customs and border security
- electricity companies, who can inspect power lines, nuclear power plants, wind turbines, and other facilities using robots
- gas and oil supply companies, who can use robots to inspect, maintain, and guard pipelines
- local civic authorities
- meteorological services, who can use UAVs to carry weather stations
- river authorities and water boards
- landmine detection and destruction.
Description of robot hardware, software
Description of the activities that need to be performed
Description of the environment in which the robot needs to work
Understand of cause and effect of performing actions
Relationship among other robots and/or people
...
Investigate standards from other SDOs (ISO, ALFUS)
Investigate existing efforts and formalisms and list the advantages/disadvantages
Collect practice in academia/industry (interview business management)
Collect academia/industry requirements for standardizing autonomous robots ontology
How to represent the terminology? Dictionaries, Glossaries, XML schemas, Databases, Logic-Based approaches, Others?
Define ontology/glossary for autonomous robots
  Define glossaries specific to autonomous robots

Define ontology for autonomous robots (air, ground, water, space)

Define ontology for sub-domains, sensor, perception, fusion, actuator, control, guidance, navigation, motion planning, mission planning, decision making (or software, hardware, electrical, mechanical, performance, …)

Define ontology for human machine interactions

Use of ontology to *describe* autonomous robots.

Set up a long-term roadmap for autonomous robots ontology
PAR Procedures

PAR (Project Authorization Request) is the documentation necessary to start the process of turning a Study Group into a IEEE-Recognized Working Group.


Mid-October - NesCOM (New Standards Committee) will review the PAR and make recommendations to the IEEE-SA Standards Board regarding approval.

Responsible for ensuring that proposed standards projects are within the scope and purpose of IEEE, assigned to the proper Society or other organizational body, and interested parties are appropriately represented in the development of IEEE standards.
How To Get Involved

Come to our meeting tomorrow (Sept 26th)!
Union Square Rooms 23&24 (4th floor), 9am-12:30pm

Contact me:
Email: craig.schlenoff@nist.gov
Phone: 301-975-3456

Join our Google group
IEEE RAS Ontologies for Robotics and Automation
https://groups.google.com/forum/#!forum/ieeeraswg

Visit the Web site set up for Autonomous Robots Group (http://aro.svn.sourceforge.net/)