Advancing Successful Autonomous Robot Development and Adoption Through Standards

Autonomy is the ability to perform tasks without help. In the case of autonomous robots, obstacles may arise internally (like an electrical short or a broken part) or externally (such as encountering debris). These obstacles can cause mission interruption or failure. Greater autonomy requires adaptive mechanisms to overcome disturbances that affect a robot's ability to complete objectives. Programming for various ways of accomplishing the same tasks can prevent non-performance.

To add redundancy, the obstacles require representation when designing robots and during their operation. Ontologies are specifications for concepts. A more complex definition is that ontologies are a formal knowledge base of terms, definitions, concepts, and the relationships between these concepts to guarantee conformance in specific situations.

Some robots encounter a problem and are rigidly programmed to move to an alternative method so they may continue their assignment. This technique does not allow reasoning. The purpose of implementing autonomy features is to allow flexible reconfigurations when impairments arise, i.e., sets and subsets of options with which to respond when faced with disturbances.

For example, if a robot uses a laser to traverse an area and its laser isn't functioning in a particular environment or becomes broken, all operations in which the laser is utilized are suspended if using rigid programming.

The ontology-driven adaptation allows the robot to evaluate which operational parts it can substitute and instantly filter through the predetermined series of design alternatives. Based on the pre-perceived highest percentage of completion, it reconfigures behavior, i.e., switches from the laser to a camera or ultrasound, so it may resume and realize its mission.

However, the chosen specifications also recognize the camera is not as quick as the laser so the robot must slow its speed to perform safely. If, at a later time, the laser becomes operational, the system can restore that option along with its collaborations thereby reinstating the laser and speed to its functionality. This type of deep reasoning to switch back and forth between concepts can be used in more complex tasks to complete jobs at maximum performance.

Robot recovery time can be reduced when ontologies are used as they prevent stopping a mission for human assisted maintenance. Shareable ontologies could streamline

autonomous robot development and offer cooperation between different types of robots that may need to work together, for example, ground and underwater robots. Further development and implementation of ontology capabilities to raise performance success rates can foster greater human trust in autonomous robots and more quickly encourage their acceptance.

IEEE Standards for Robotics and Automation

IEEE Standards Association (IEEE SA) is at the forefront of standards development that can advance the reusable, scalable, more expedient, and less costly evolution of trustworthy autonomous robots. In conjunction with the IEEE Robotics & Automation Society (RAS), IEEE SA has published four standards focused on computer ontology, a key component of autonomy.

- IEEE 1872™-2015 – IEEE Standard Ontologies for Robotics and Automation is composed of a core ontology about robotics and automation (R&A), called CORA, together with other ontologies that give support to CORA. Interested in implementing this standard?
- IEEE 1872.2™-2021 – Standard for Autonomous Robotics (AuR) Ontology extends IEEE 1872-2015 to specify the domain knowledge needed to unambiguously describe the design patterns of autonomous robotics systems, represent AuR system architectures in a unified way, or as a guideline to build autonomous systems consisting of robots operating in various environments. Interested in implementing this standard?
- IEEE 1873™-2015 – IEEE Standard for Robot Map Data Representation for Navigation is a map data representation of environments of a mobile robot performing a navigation task and provides data models and formats for two-dimensional (2D) metric and topological maps. Interested in implementing this standard?
- IEEE 7007™-2021 – Ontological Standard for Ethically Driven Robotics and Automation Systems focuses on the robotics and automation domain without considering any particular application or robot, and can be used during the development of robotics and automation systems as a guideline; or as a reference "taxonomy" to enable a clear and precise communication among members from different communities that include robotics and automation, ethics, and correlated areas. Interested in implementing this standard?

Get Involved in Standards Development in Robotics and Automation

Going forward, IEEE RAS has formed working groups to develop standards on multiple fronts like exchanging map data, verification of autonomous systems, measuring robot agility, human-robot interaction, and ethics.

- Ontology - Development of a common lexicon will more quickly and efficiently advance robot implementation. The IEEE P1872.1™ Working Group is developing a standard that defines an ontology allowing for the representation of, reasoning about, and communication of task knowledge in the robotics and automation domain.
- Mapping - Defining a common representation for robot map data is imperative if robots are going to be able to communicate. The IEEE P2751™ Working Group has the goal of compiling a standard to allow robots to exchange 3D maps in a common format, which is different from the private internal representations that robots use to build, maintain, and use their maps.
- Verification - Sometimes missions do not go as planned. IEEE P2817™ Working Group is developing guidelines to enable the user to define a customized process for verification of their autonomous system based on their available resources.
- Agility - Today's robots are adept at doing the same thing over and over. However, when unexpected or unforeseen circumstances arise, robots often struggle. IEEE P2940™ Working Group is working towards a future standard promoting agility for industrial robot systems, enabling industrial robots on shop floors to be more productive, more autonomous and require less time from workers.
- Interaction - Human robot interaction (HRI) is happening. These standards development groups aim to lay the framework for this to evolve more quickly and ethically via replicability of researched best practices.
    - IEEE P3107™ Standard Terminology for Human-Robot Interaction defines terms relevant to human-robot interaction in service, social, education, industrial, and research robotic applications.
    - IEEE P3108™ Recommended Practice for Human-Robot Interaction Design of Human Subject Studies outlines best practices and requirements for the development of designs of human-subject experiments in human-robot interaction research.
    - IEEE P7008™ Ethically Driven Nudging will provide guidance for developers and ethicists involved in the design of autonomous, intelligent systems that seek to “nudge” humans; that is, influence choices made by humans through subtle means.

Interested in participating or following IEEE standards working groups? Log into or sign up for IEEE SA’s myProject.

In addition, IEEE RAS has a study group to evaluate whether sufficient interest and resources exist to develop IEEE standards:

- Semantic Maps is developing a common understanding for the need for standard semantic maps for autonomous robots.

The IEEE Robotics and Automation Society (RAS) is encouraging anyone interested, including industry professionals and college students, to become involved with robotics standardization. Learn more and express your interest here.

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*Certain commercial software and tools are identified in this paper in order to explain our research. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the software tools identified are necessarily the best available for the purpose.