IEEE Standard for Robot Map Data Representation for Navigation

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***Abstract*—Robot navigation comprises three fundamental technologies to guide a mobile robot to its goal position: localization, mapping, and path planning. IEEE Map Data Representation (MDR) working group is developing a standard specification for representing a map used for robot navigation. The MDR standard aims to specify a common representation of two-dimensional maps for indoor and outdoor environments. This report describes the technical scope of the MDR standard and past activities of the MDR working group with respect to the MDR standard and current status thereof.**

I. Introduction

Autonomous robots, operating without guide tracks in uncontrolled environments are becoming common and economically viable. Robot navigation, which is an essential element for a mobile robot to be called an autonomous robot, may be defined as the process of determining and maintaining a course or a trajectory of a mobile robot to its goal location [1]. As shown in Figure 1, robot navigation comprises three fundamental technologies: localization, mapping, and path planning. As the figure shows, a robot needs some form of a map to perform a navigation task.

Complying with a standard for map data representation makes a vendor's components more compatible with others and therefore makes their products more desirable and more likely to win contracts. Standards compliance is particularly important in environments with devices from diverse vendors inter-operating, such as factories and military environments, where data interchange is a common occurrence. Being able to both use and provide the common data being shared amongst such devices is essential.

As can be expected, a common representation of robot environments brings a few advantages, including easy and economic exchange of maps, convenient benchmarking, facilitation of development and deployment of robotic applications, facilitation of technology development due to performance evaluation and technology exchange in terms of the common data format, and reduction of development and deployment costs.

The MDR working group has been approved by the IEEE Robotics & Automation Society (RAS) in July, 2011 to develop an international standard defining specifications of map data format. The goal of the MDR standard is to define a common map data representation (MDR) for robot navigation and an exchange interface for map data among robots, computers, and other devices.

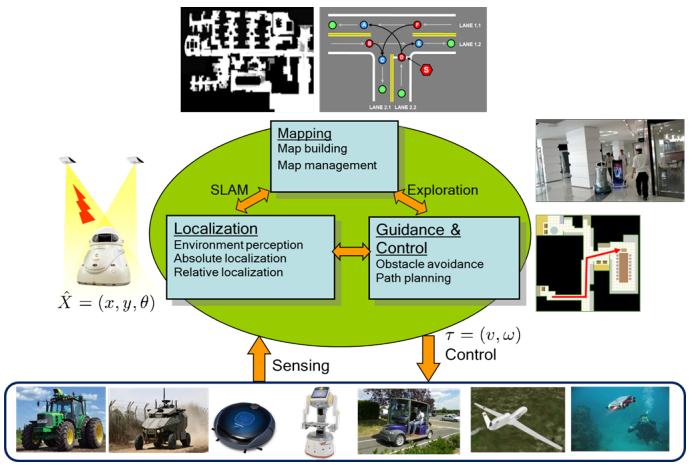

Fig. 1. The basic structure of robot navigation.

In what follows, the technical scope of the MDR standard is described in Section II. Section III describes formation of the MDR working group and policies and procedures defined in the MDR working group. Finally, Section IV provides the current status of MDR standardization activity and future actions to be made.

II. Technical Scope of the MDR Standard

Figure 2 shows a block diagram illustrating scenarios of a map creation use case. As shown in the figure, the map can be generated by a surveying tool, or given a priori in the form of a CAD file. Or the map can be generated by a mobile robot autonomously by using SLAM technology, for example. Like any other standards, the MDR standard does not limit the origin of the map, which is related to various kinds of mapping technologies; on the other hand, the MDR standard is concerned with encoding of spatial data so that exchange of maps can be carried out conveniently. Also, taking into account the industry practices and status of robot navigation technology, the MDR standard is concerned with the two-dimensional (2D) maps representing indoor and outdoor environments. No limit is imposed on the spatial complexity, geographic scale, or sensor modality.

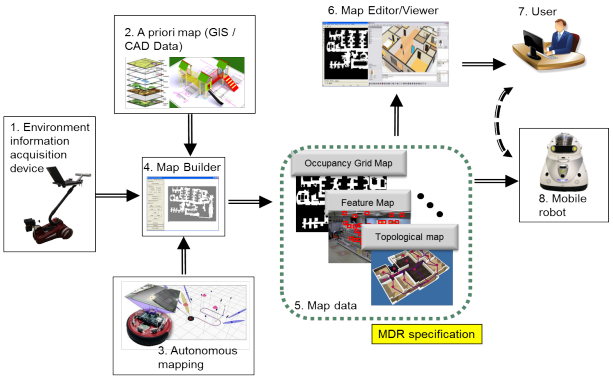

Fig. 2. The block diagram illustrating generation and use of a map for robot navigation.

In the MDR specification, we define a hierarchy of terminologies related to 2D robot maps for indoor and outdoor environments (see Figure 3). Based on the hierarchy of terminologies, the MDR standard defines a data model for each element of the hierarchy. To this purpose, a concept of a local map is introduced, which acts as an abstract base class representing a metric map or a topological map. LocalMap data type contains data types for map id, offset, map type, and coordinate system. Also, LocalMapTransform class is defined to deal with coordinate transformation between two different local maps. LocalMapType and CoordinateSystemType complete the LocalMap data type to describe a local metric or topological map. At this point, it should be noted that the MDR standard further defines pose uncertainty and coordinate transformation which are essential for mobile robotics but are not defined in other similar standards coming from ISO or OGC, for example.

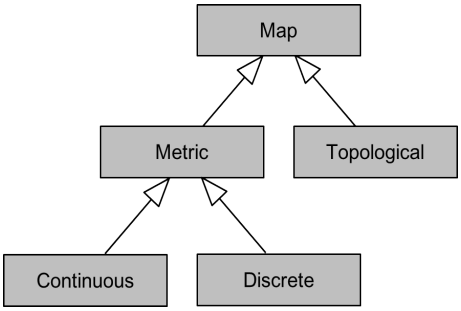

Fig. 3. The hierarchy of map classes defined in this standard.

Finally, the MDR standard specifies an XML format for map data exchange. To check validity (or conformance) of the map with respect to the MDR standard, an XML schema is defined. Implementation-specific extension of the base MDR specification includes definition of mdr_version, Metadata (meant for storing meta information related to a map, including author, email, license, map location, etc.) and MapArray is intended to store instances of LocalMaps.

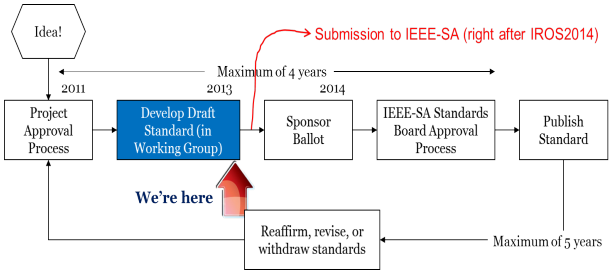

Fig. 4. IEEE-SA standards development process.

III. MDR Working Group

The Standing Committee for Standards Activities (SCSA) of the IEEE RAS is the technical sponsor of the MDR working group. The MDR working group submitted a project authorization request (PAR) to the IEEE-SA and obtains an approval for the project P1873 Standard for Robot Map Data Representation for Navigation" in November 2011. Since then the MDR working group members have been involved in developing the MDR standard, meeting two times a year at the conference weeks of ICRA and IROS. The MDR working group membership is automatically granted for those who attend the MDR meeting. The membership is granted for the participant attending at least one meeting of the MDR working group.

Currently, the MDR working group has two collaboration tools: Google group on IEEE RAS MAP Representation Standard and IEEE-SA central desktop on 1873 working group (https://ieee-sa.centraldesktop.com/1873workinggrouppublic/).

IV. Current Status and Further Actions

As of Sept. 2014, the standard abstract data model and concrete data format are almost defined. Some examples of APIs and protocols for translating map representations between the MDR standard and other formats are being developed. A graphical illustration of a current status of the MDR standardization is shown in Figure 4. The MDR standard draft is supposed to be submitted for a sponsor ballot around the end of 2014.

Once the MDR standard is successfully approved by the IEEE-SA, MDR standard for three-dimensional maps or semantic maps may be considered as the next item. As usual, selection of a new project will be determined by taking account of industry practices and needs.

References

[1] M. O. Franz and H. A. Mallot, "Biomimetic robot navigation," Robotics and AUtonomous Systems 30, pp. 133-153, 2000.