IEEE P2751
3D Map Data Representation for Robotics and Automation
3D-MDR

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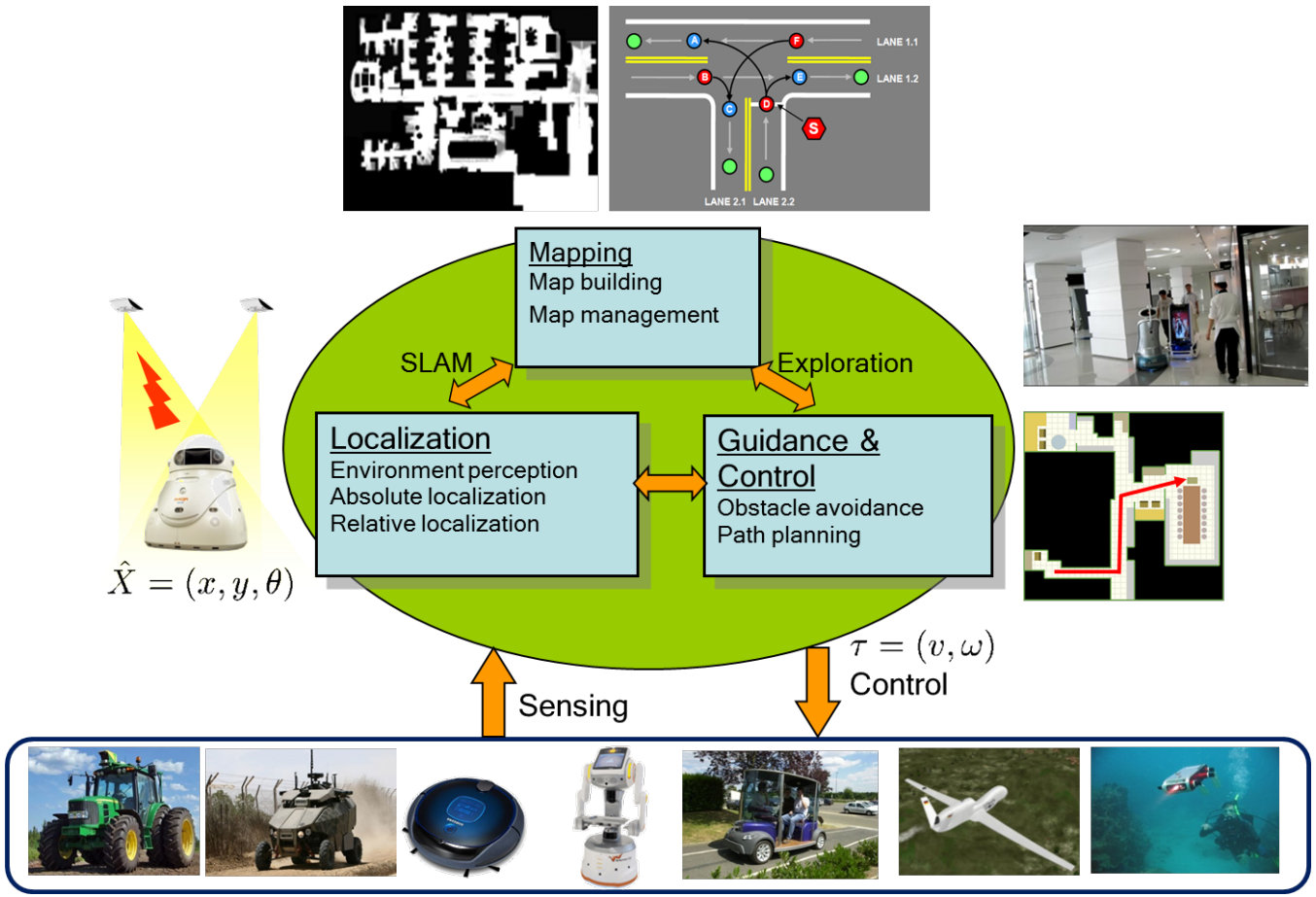
Why common map data representation?



Autonomous robots have their own internal (efficient!) representations of space

The standard is used to represent maps for data exchange (e.g., sharing maps)

The standard does not intend to substitute internal representations

Benefits:

- Benchmarking
- Facilitating development and deployment of robotic applications
- Reducing development and deployment costs

IEEE 1873-2015

IEEE 1873-2015 Standard for Robot Map Data Representation for Navigation

Specifications for representing two-dimensional (2D) metric and topological maps to ease exchanging map data among robots, computers, and other devices

The standard focuses on maps used for navigation of mobile robots, which usually include representation of free space and obstacles and of related uncertainty

The standard:
(a) defines data models for elements of 2D robot maps and
(b) defines an **XML data format** for map data exchange

Extension to 3D maps

The IEEE **Robot 3D Map Data Representation** (RAS/SC/3D-MDR) **Working Group** is currently extending the standard to 3D maps

A new standard will be proposed, probably in 2020 (IEEE P2751, 3D Map Data Representation for Robotics and Automation)

The Working Group includes members from academia, research centers, and industries (e.g., Lockheed Martin, Roboception, Scania, Volvo CE, X, …)

3D maps included in the standard

Point clouds, grids (voxel maps, including octrees), polygonal meshes

Each maps type has elements and properties that can be mandatory or optional

For example, a grid is represented by:

- voxels (with coordinates and properties, like occupacy)
- resolution (lengths of the voxels' edges)
- size (number of voxels along the three axes)

How does your group define terminology (e.g., ontologies, glossaries, something else)?

Glossaries

3. Definitions, acronyms, and abbreviations

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause. [6]

The terms are categorized according to functionalities and are listed in the respective categories in an incremental order of use. Along with the definitions, Figure 2 is introduced to help understand the structure of the map data model, illustrating the map hierarchy adopted in this document.

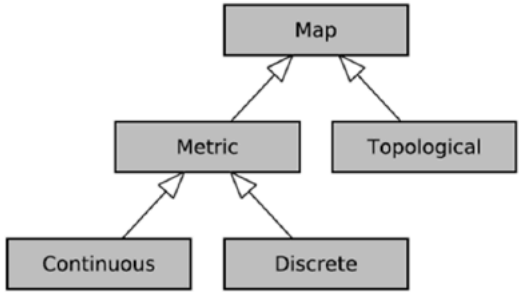


Figure 2—Hierarchy of map classes defined in this standard

3.1 Coordinate systems and transformations

Cartesian coordinate system: A coordinate system that gives the position of points relative to n mutually perpendicular axes.

NOTE—See ISO 19111:2007 and ISO/IEC 9899:2011. Since this standard focuses on 2D maps, n=2. [7, 8]

Definitions

Definition of terms used later in the document (incomplete list).

Absolute pose: … a geo-referenced pose ...

Coordinate system: a coordinate system gives the position of points relative to n=3 mutually perpendicular axes. The standard assumes right-handed coordinate systems with X forward, Y left, and Z up. The coordinates of a point p in a coordinate system are a vector of three elements $<x_p, y_p, z_p>$.

Global map: graph whose vertices are local maps and whose directed arcs are transformations between the coordinate systems of the two connected local maps.

Local map: map ...

Node: … element of an octree ...

Octree:

Transformation:

Uncertainty:

Voxel:

How do you define the following terms (as appropriate): robot, automated robot, teleoperated robot, environment, pose?

- **Robot**: not formally defined, but intended as a navigating entity that builds, maintains, or uses an internal representation (map) of the environment
  - Devices are capable of gathering environmental information
- **Environment**: not formally defined, but intended as indoor or outdoor workspace in which robots operate (with objects, …)
- **Pose**:

pose: A combination of position and orientation in space. In a two-dimensional (2D) map, the pose of a mobile robot is represented by 2D position (x,y) and one-dimensional orientation (θ) with respect to a given coordinate system. A **pose** is also used to represent the coordinate transformation between two coordinate systems.

NOTE—See ISO 8373:2012.

How did you determine these definitions (e.g., adopted from other standards, consensus among group members, something else)?

- The definitions of **robot** and **environment** come from consensus among group members
- The definitition of **pose** is consistent with that from ISO 8373:2012 «Robots and robotic devices – Vocabulary» and with that from CORA

References and contacts

For a description of the IEEE 1873-2015 standard see:
Amigoni, F.; Yu, W.; Andre, T.; Holz, D.; Magnusson, M.; Matteucci, M.; Moon, H.; Yokotsuka, M.; Biggs, J.; Madhavan, R.
A Standard for Map Data Representation: IEEE 1873-2015 Facilitates Interoperability Between Robots.
IEEE Robotics & Automation Magazine, 25(1), 2018, p. 65-76.

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