Semantic Mapping extension for OpenStreetMap applied to indoor robot navigation

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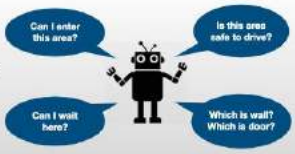
Introduction

- Indoor robots mostly rely on the spatial representation of the environment
- They also need semantic information to give meaning to spatial information
- This work presents a hierarchical & composable graph model for creating indoor semantic maps, which extends OpenStreetMap



Semantic Maps

- They contain semantic information of the environment apart from spatial information
- Most of the existing semantic mapping approaches add semantic information on top of a geometric map
- Topological graph is created based on the detected semantic features and environment geometry (bottom-up approach)

Deficits

- They lack modular and abstract design, difficult to scale & update only part of the map
- They have minimal querying capabilities for querying semantic information
- Sensors & algorithms used for mapping introduce uncertainty
- A robot has to deal with uncertainty every time it uses this map

OpenStreetMap (OSM)

- It is an open-source, collaborative mapping project
- Its model conforms to graph model and provides lots of semantic tags
- It supports modelling: vector geometry, topological graphs, semantic information, hierarchy
- It has been successfully used for outdoor robotics applications
- It provides tools supporting development (mapping) & usage (querying) of the models

Deficits

- Officially supports only outdoor environments
- Uses geographical coordinate systems
- Made for human navigation, robots require lot more details then humans

Indoor OpenStreetMap for Berlin Central Station (Source: OpenStationMaps)

Proposed semantic mapping approach

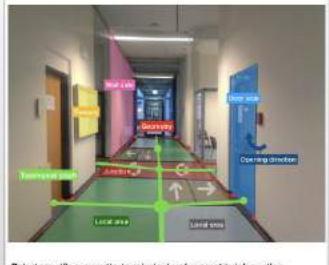
Existing indoor OSM models eg. Simple Indoor Tagging.

New models introduced in robotics context

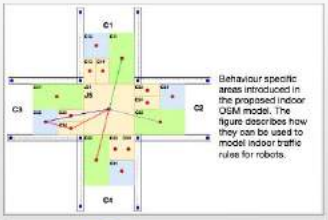
- OSM is based on the concept of Volunteered Geographic Information (VGI) i.e. its people who create, edit and use the maps
- This work presents a similar approach to create a map for robots, i.e. humans add additional information to the OSM in the robotics context so that humans & robots can use that same map (top-down approach)
- It provides a composable & hierarchical graph model for creating semantic maps for indoor environment using OSM

Modelling OSM in robotics context

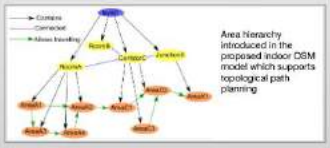
Domain specific modelling - identifying additional information required for indoor robot navigation



Robot specific, semantic, topological and geometric information modelled in proposed indoor OSM model



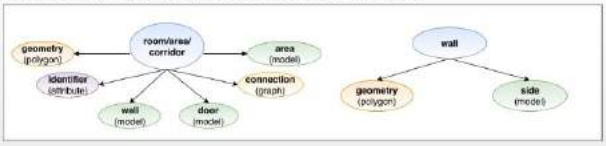
Behaviour specific areas introduced in the proposed indoor OSM model. The figure describes how they can be used to model indoor traffic rules for robots.



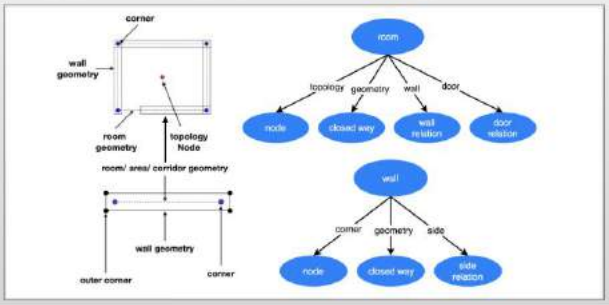
Area Hierarchy introduced in the proposed indoor OSM model which supports topological path planning

Modelling OSM in robotics context (continued)

Logical modelling - giving abstract structure to the data models

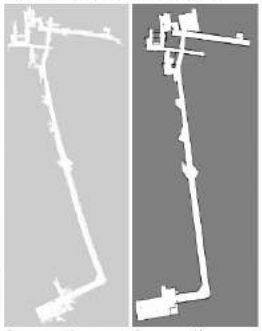


Technology specific modelling - representing data models using OSM data-structures



Evaluation

Compatibility with existing indoor navigation approaches

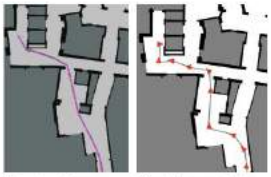


Occupancy grid map generated from SLAM

Occupancy grid map generated using OSM

Comparison between occupancy grid maps created using SLAM and OSM based approach. Both maps look similar.

Incorporating semantics in indoor navigation



Path planned using geometric information in grid map

Waypoints generated using geometric, topological and semantic information in OSM. Location of the way-points ensure that robot path sticks to the right side of corridors, according to the modelled semantics of "traffic rules".

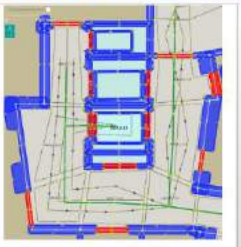
Comparison between path generated using grid maps and proposed semantic map

Efforts required for creating OSM in robotics context

	Indoor OSM model	Proposed model
No of nodes	35	643
No of ways	9	225
No of relations	0	289

Comparison between a number of OSM data-structures required to map 20m X 20m indoor area using existing indoor OSM model (Simple Indoor Tagging) and proposed model in a robotics context.

Results & conclusions



Map created using proposed OSM model viewed in JOSM editor. Blue areas are wall geometries, red are doors. The green lines indicate the connections between corridors and rooms, while the directed arrows indicate connections between areas at a lower level of abstraction.

- OSM can be **successfully used to create** semantic maps for robots
- Maps can be created using existing OSM mapping tools such as **JOSM**
- Mapped data can be queried using existing OSM querying tools such as **Overpass** and **Osmium**
- Robots require much more information then humans, this comes at the cost of **increased modelling efforts**
- Hence there is a need to **semi-automate/ automate** the process to scale it for larger environments

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