Exploration Algorithms in a Polygonal Domain

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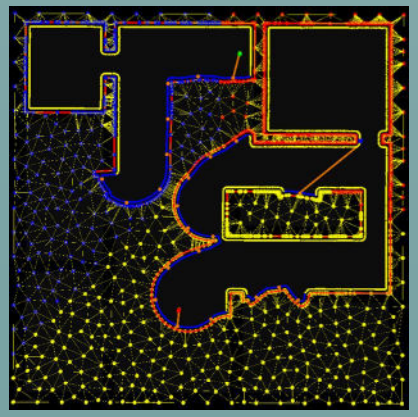
Introduction

This work is focused on the exploration of an unknown environment by a team of mobile robots. Each robot in the team discovers its neighborhood and contributes to a global map. The aim is to explore the environment with minimal effort (e.g. time, distance traveled, fuel consumed, etc.)

Used tools and algorithms

- Robot Operating System (ROS)
- Clipper - clipping library
- Triangle - triangular mesh
- Visibility graph
- Dijkstra's algorithm
- K-means clustering



K-means exploration strategy

Exploration

The mobile robot exploration is the process in which robots autonomously operate in an unknown environment. The robots are navigated through the environment in order to create a map of it. The map is incrementally built and serves as a model of the environment for further exploration steps. The process consists of a goal selection and navigation towards the selected goals. This is repeated until unexplored areas in the map exist.

- Comparison of polygonal approach against the commonly used occupancy grid.
- Polygons have 1226 vertices vs. 12 076 800 cells in the grid.

[m²]	Polygons t_plan [ms]	Polygons t_total [ms]	Occupancy grid t_plan [ms]	Occupancy grid t_total [ms]
1000	10	35	274	471
3000	22	50	985	1224
5000	14	70	2141	2410
10000	45	116	3369	3854
13000	36	132	4902	5611

Goals

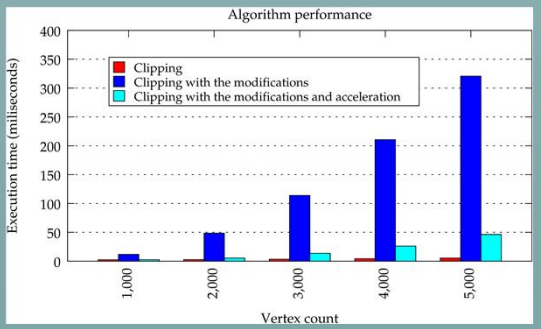
- Use a polygonal representation instead of an occupancy grid
- Modify clipping library to work both with polygons and their attributes
- Reduce computational complexity to represent large environments
- Handle problems in coordinated multi-robot exploration
- Compare selected exploration algorithms on various maps

Experiments

- Comparison of state-of-the-art exploration strategies
- 4,6,8,10 robots
- Exploration strategies: Greedy, Hungarian, BLE, K-means
- 4 testing environments
- Number of experiments: 1440
- Total time of experiments: 240 hours

Results

- A framework has been implemented using ROS in C++ language
- The clipping library was modified
- The polygonal approach proved to be a feasible method for the map representation
- With a quite low number of points it is possible to represent really big environments
- All the parts of exploration were successfully adapted to the polygonal representation which was proved by the experiments
- The results were presented at ICAPS 2013 conference in Rome



Hospital map 271x110m explored with 10 robots

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