Multi-Robot/Coordinated SLAM with Particle Filters

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Overview

1. Multi-Robot SLAM
2. Experimental Validation
3. Conclusions and Future Work

Single Robot/Multi-Robot SLAM

- Single Robot
  - Very slow to map a large area
  - Increase speed $\rightarrow$ increase noise/decrease accuracy
  - Not robust: single point of failure
- Multi-Robot SLAM (MRSLAM)
  - SLAM with multiple robots searching the space and communicating with each other
  - May still use slower robots
  - May have robot failure, but still achieve mapping objective

Challenges of MRSLAM

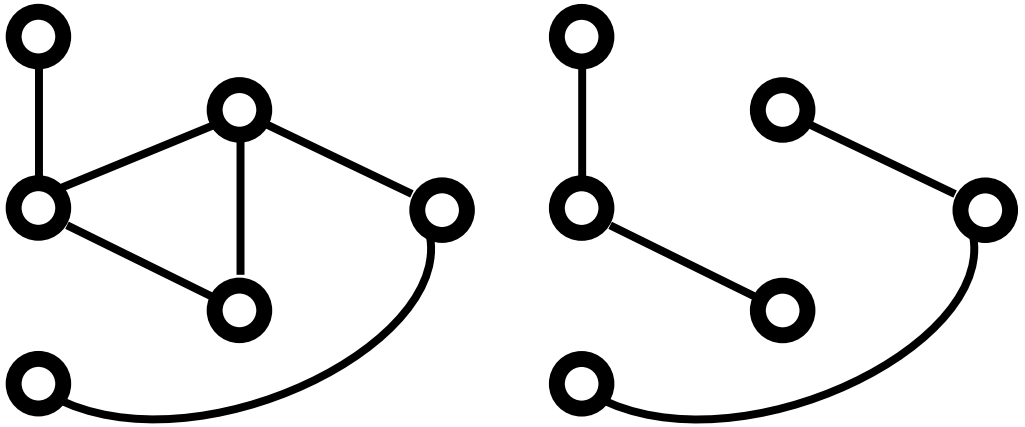
- Often do not know initial poses
  - Need to calculate relative poses
- Complexity
  - Exploration/Coordination, efficiently move with little overlap and to get as much coverage as possible
- Each robot is taking measurements in its own frame
  - How to transform the pose data?
  - How to combine the data?
  - How to create a global map?

Solving MRSLAM

- Most papers solve 1 problem at a time
  - Coordination ([Juliá et. al, 2012])
  - Map Merging ([Lazaro et. al., 2013], [Lee et. al., 2012],[Birk and Carpin, 2006], [Howard, 2006])
- Focus: [Howard, 2006]
  - Answers merging problem
  - All robots store sensor data for both odometry and measurements
  - Starts with a single robot, stored data integrated transformed data into the map posterior post encounter
  - Builds occupancy grid

MRSLAM Assumptions

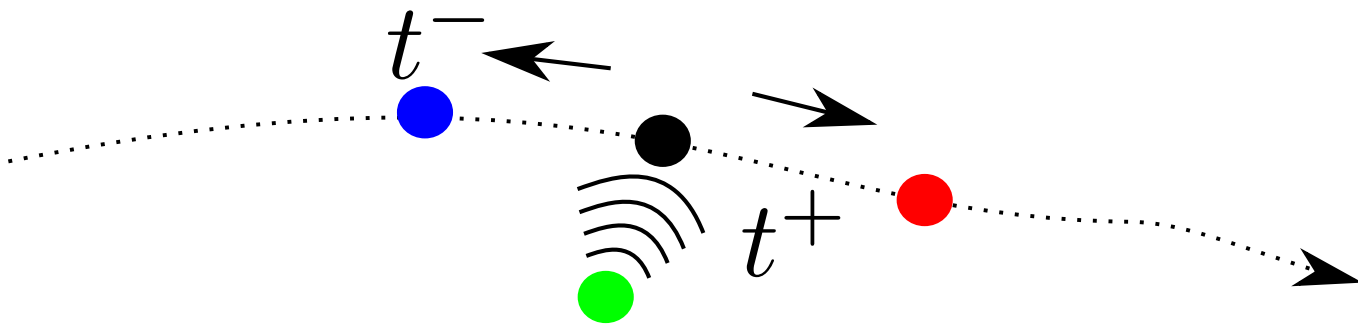
- Robots move independently of each other
- Can determine the relative poses of each robot perfectly on an encounter
- Continued communication post encounter
- Robot encounters form a connected graph



Connected Not Connected

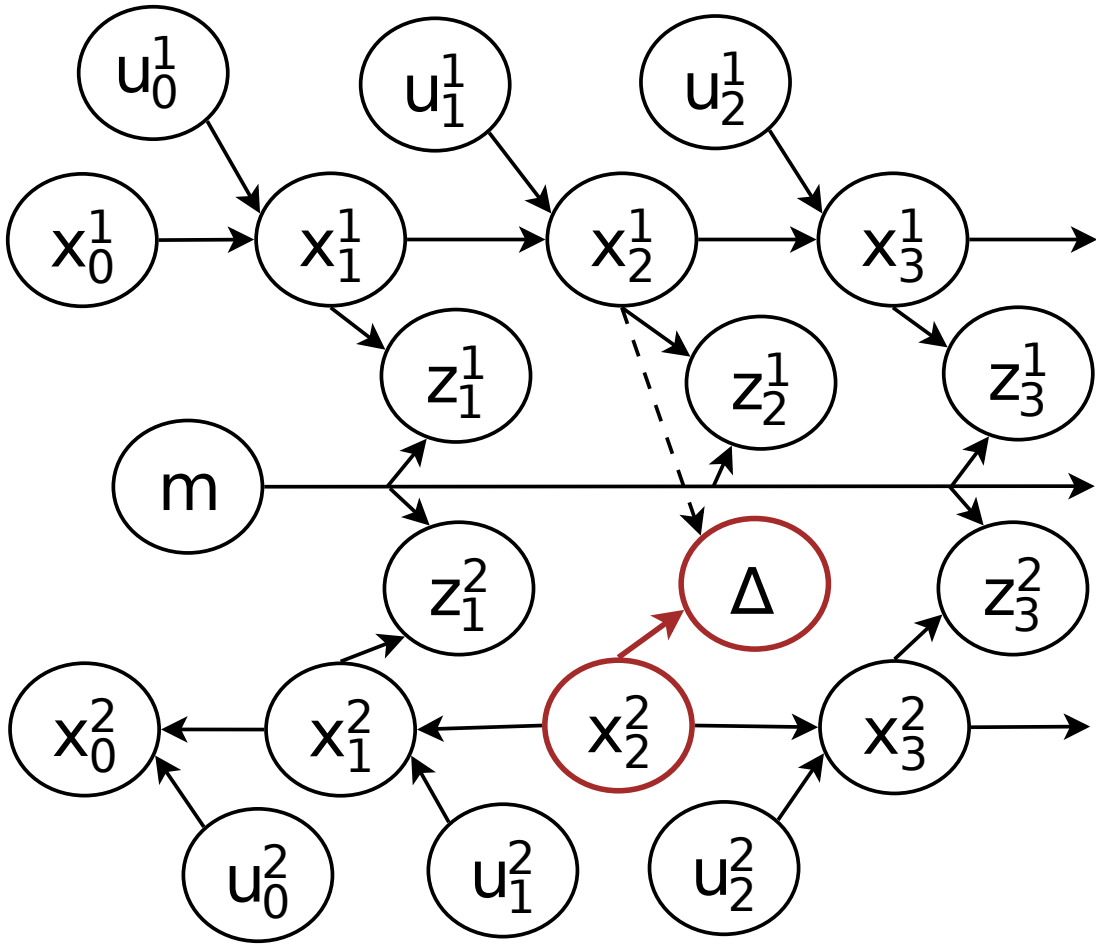
[Howard, 2006] Algorithm

- Occupancy Grid FastSLAM
- Store $(u_t, z_t, encounter_t)$ data
- On encounter, replay past data in reverse order



- Post encounter integrate stored information into the map posterior in an acausal update
- Continue communication to integrate future odometry and encounters

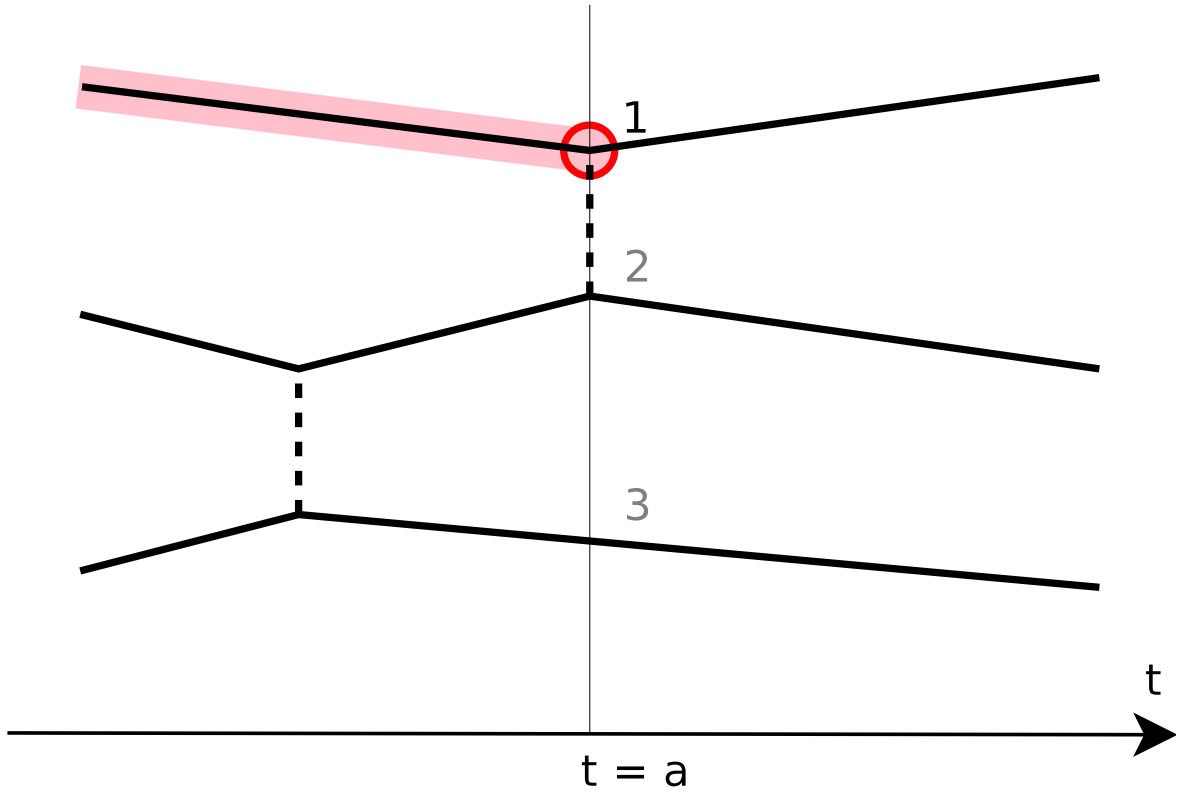
Causal/Acausal Updates



From [Howard, 2006]

[Howard, 2006] Algorithm

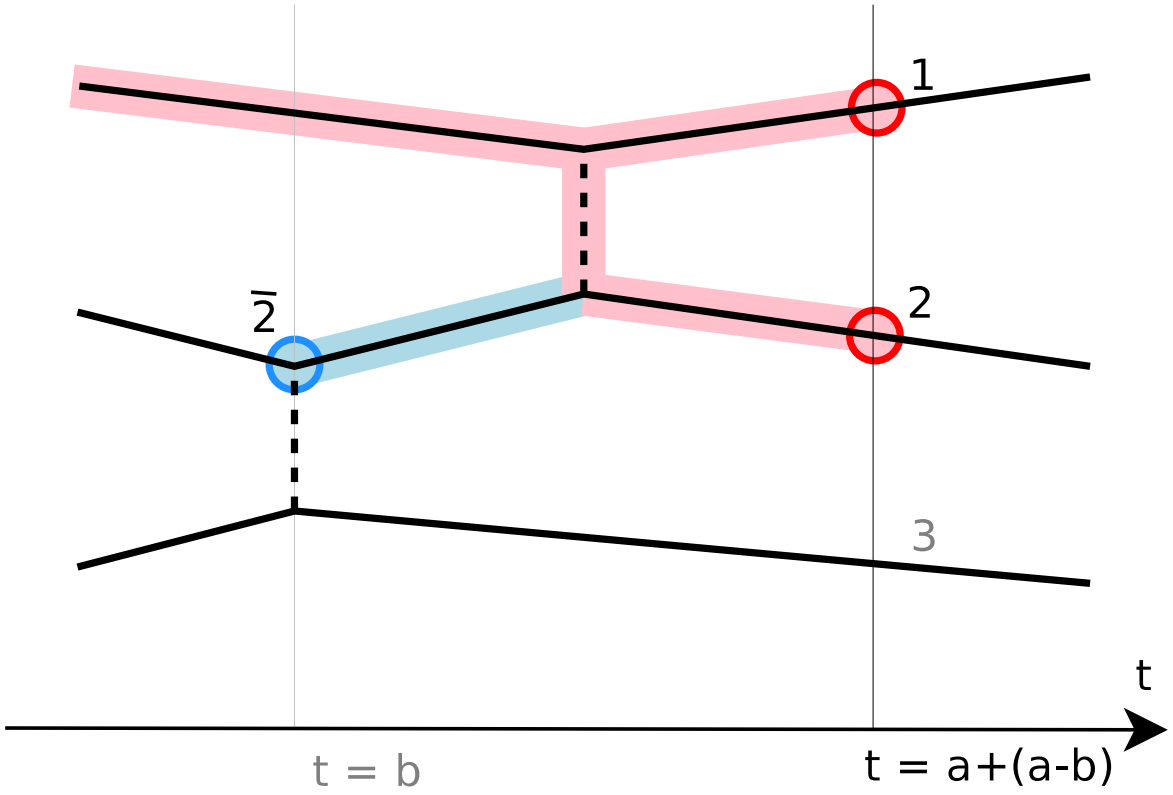
- Robot 1 observes robot 2



From [Howard, 2006]

[Howard, 2006] Algorithm

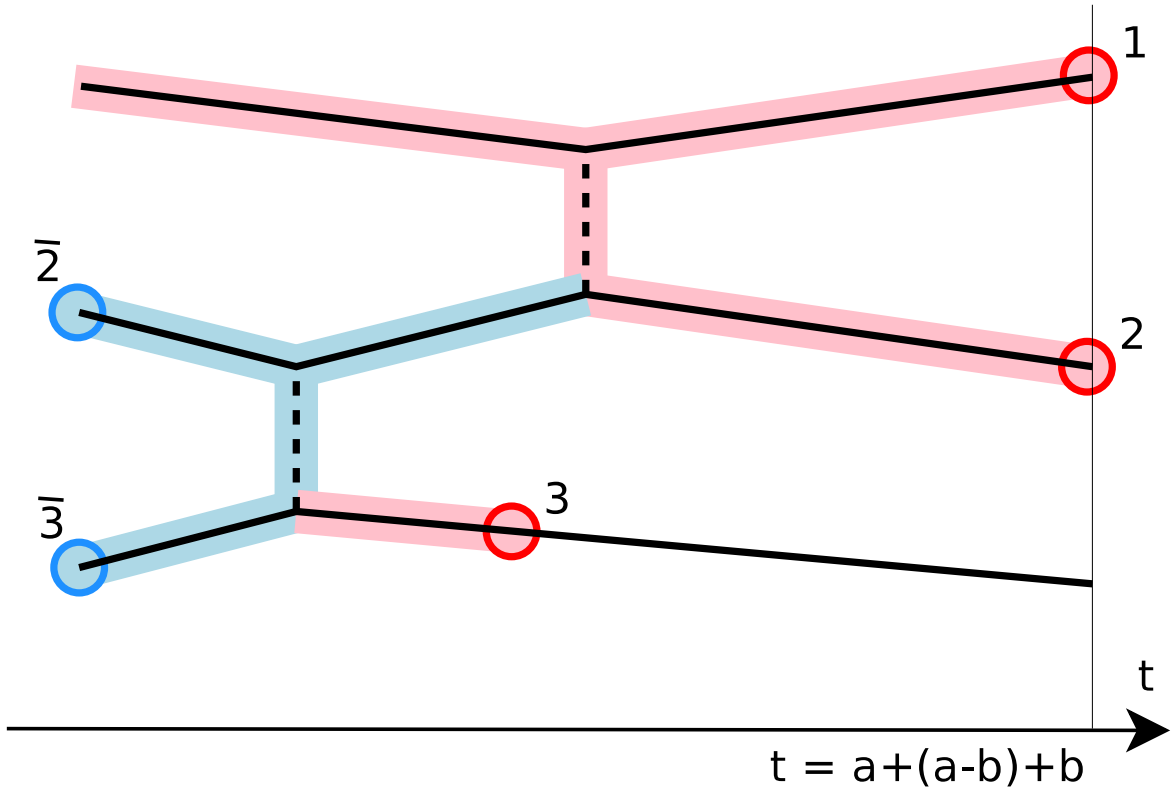
- Robot 2 observes robot 3, integrating robot 3 data



From [Howard, 2006]

[Howard, 2006] Algorithm

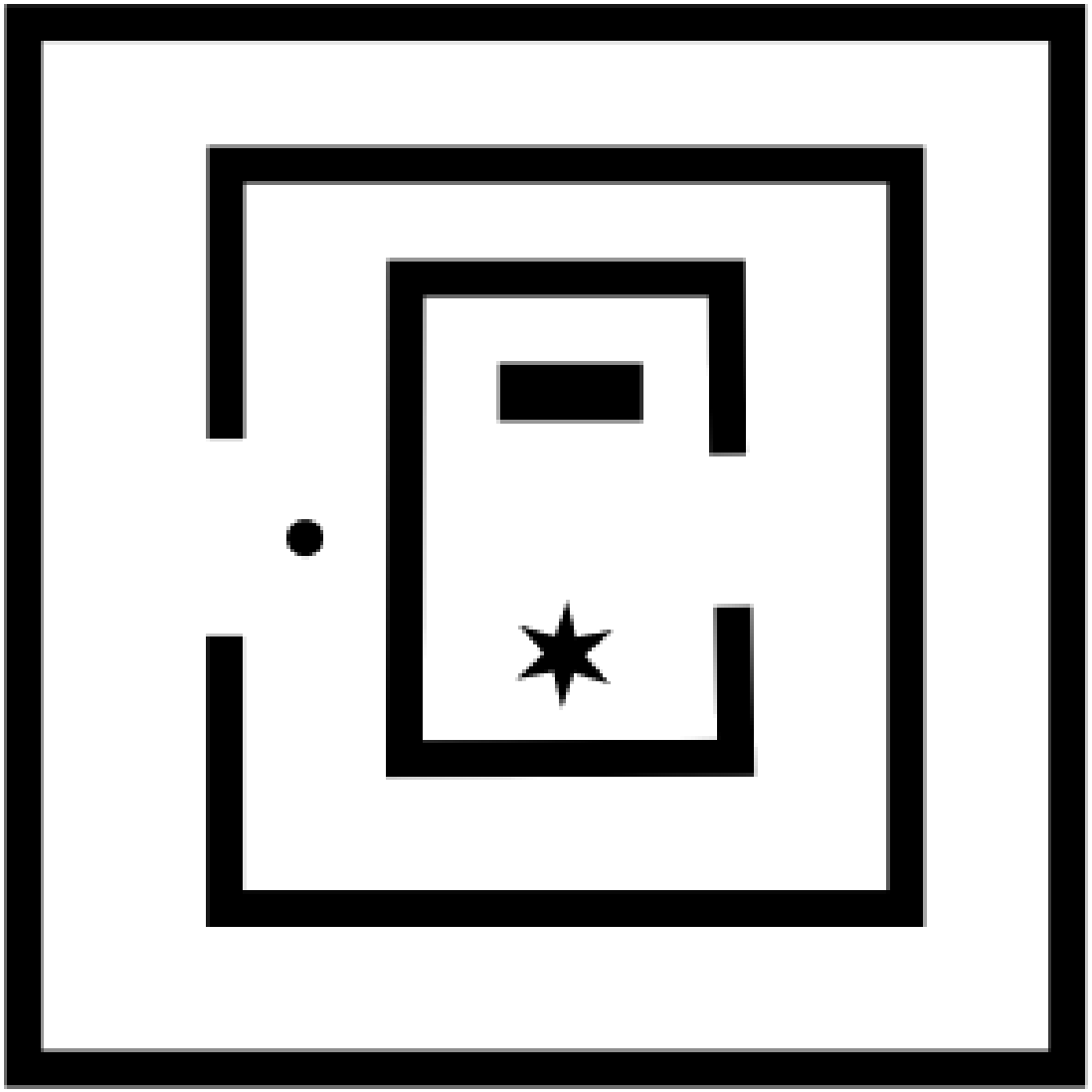
- Data is propagated, now all data is used for map



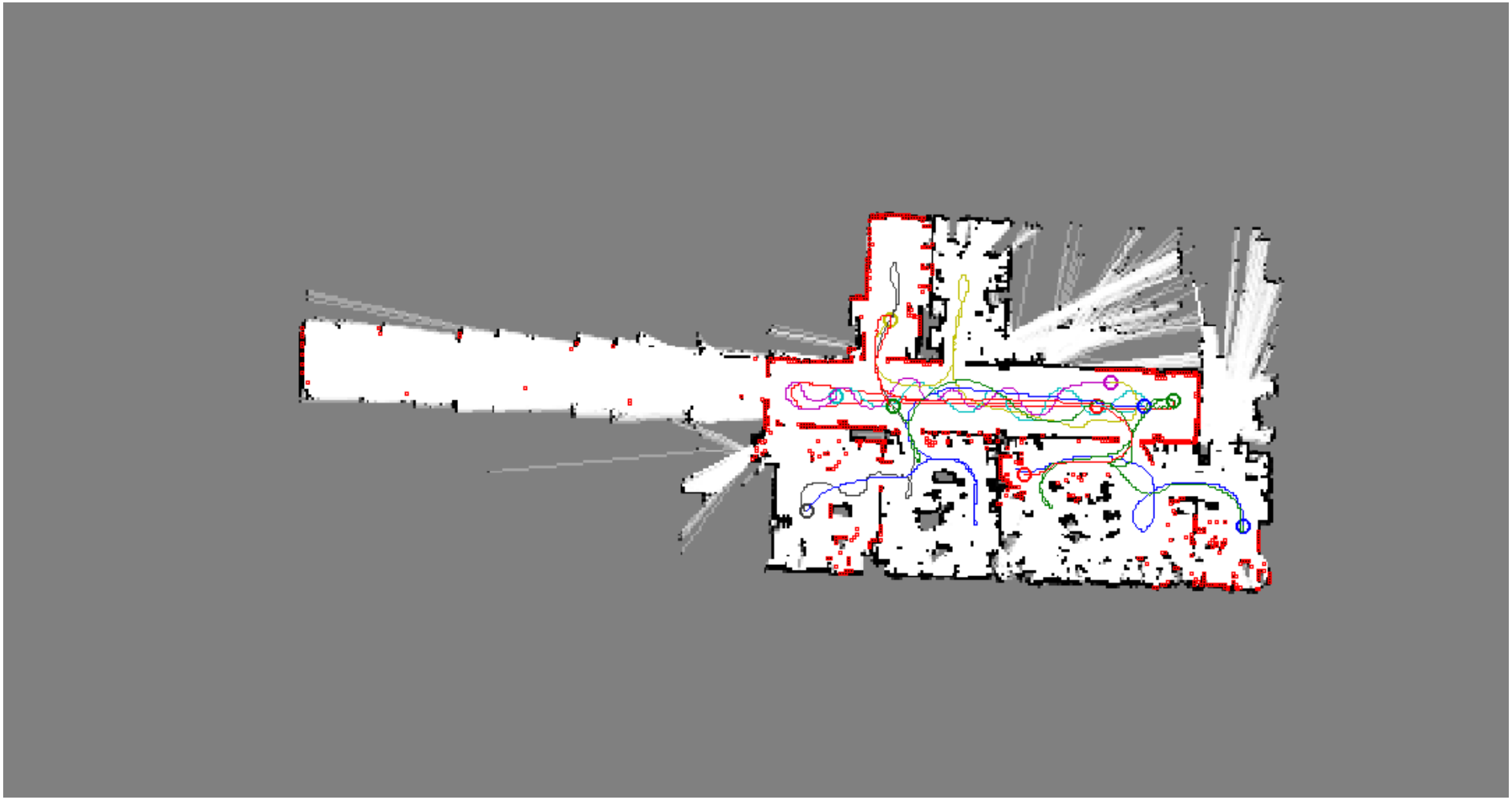
From [Howard, 2006]

The Tests

- Occupancy Grid
  - Custom Map
  - m robots



Validation



Conclusions

- Conclusions:
  -
- Future work:
  - Decrease
  - Make it work on Albert B data set

Further Reading

[1] M. Juliá, A. Gil, and O. Reinoso
"A comparison of path planning strategies for autonomous exploration and mapping of unknown environments."
Autonomous Robots, 2012.

[2] M.T. Lazaro, L.M. Paz, P. Pinies, J.A. Castellanos, and G. Grisetti
"Multi-robot SLAM using condensed measurements."
International Conference on Intelligent Robots and Systems, 2013.

[3] H.C. Lee, S.H. Lee, M.H. Choi, and B.H. Lee
"Probabilistic map merging for multi-robot RBPF-SLAM with unknown initial poses."
Robotica, 2012.

[4] A. Birk, and S. Carpin.
"Merging occupancy grid maps from multiple robots."
Proceedings of the IEEE, 2006.

[5] A. Howard.
"Multi-robot simultaneous localization and mapping using particle filters."
The International Journal of Robotics Research, 2006.

[6] S. Thrun, W. Burgard, and D. Fox
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Questions...