A Study of Trade-off Between Communication Cost and Accuracy of Trajectory Estimation in Distributed SLAM

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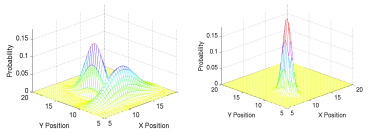
Problem

In robotics, the Simultaneous Localization and Mapping problem or SLAM problem has been a long lasting debate in the best way for a robot to create a map of an unfamiliar environment and move through it. Studies have shown that whenever multiple robots have worked cooperatively using a distributed SLAM algorithm that it scales better with a decentralized solution [2]. In addition, it leads to higher accuracy of landmark locations [1].
However, there is little work on studying a trade-off system between communication cost and the accuracy of a combined trajectory estimation [3]. There needs to be an optimal policy for communication times, amount of information, and accuracy of trajectory estimations.

Communication

In a multi-agent SLAM system, there could be a possibility of overlapping landmarks that both agents observe. If there is, the robots could communicate to one another, merging the Gaussian distributions, which greatly improves the accuracy



Two separate observations | Merged observation

Acknowledgments

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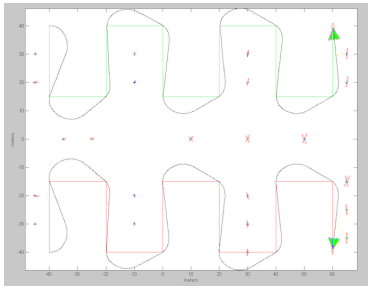
System

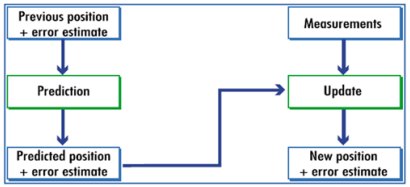
Currently, the multi-agent SLAM is simulated on MATLAB.



As the robots make observations of landmarks, ellipses are formed around the landmarks observed. These ellipses represent a Gaussian distribution of uncertainty for the position of the landmark.

Kalman Filtering

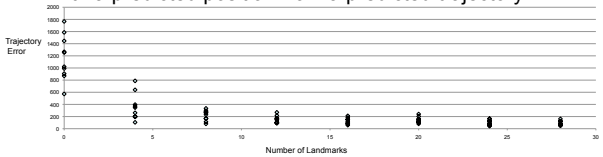
In SLAM, Kalman Filtering is used whenever you are trying to predict where the next position of the robot will be.



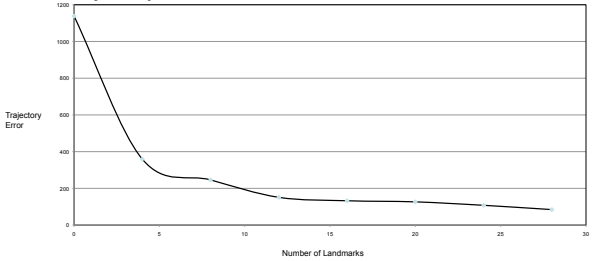
Because the Kalman Filtering system relies on the accuracy of the rover's location, it is crucial to keep an accurate position of the robot.
With the use of landmark recognition, robots have a higher certainty of their position, making trajectory estimation more accurate.

Trajectory Estimation

To lower the uncertainty of a robot position, it is combined with a predicted position from a predicted trajectory.

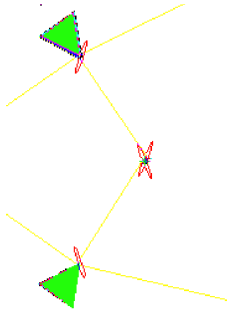


Plots were made showing the relationship between the amount of landmarks and the amount of error in trajectory estimation.

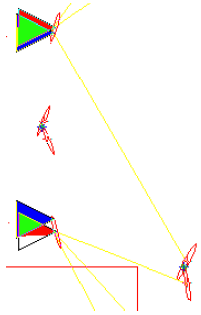


Scenarios

In order to gain empirical data for an optimal policy, we ran a series of scenarios that differ in patterns of communication times and the amount of information sent. To evaluate, we used the differences in accuracy of trajectory estimations.



When vehicles Are both in a radius from the landmark

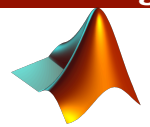


When one vehicle is close and the other is far away

Future Work

- Create more scenarios to gain more empirical data to create a more-defined optimal policy
- Implement algorithm in simulation and see the impact of the optimized communication policy
- Implement optimal communication policy on actual robots and compare with simulation

Technologies



Contributions

- Showed the need for an optimal communication policy for robots in a distributed SLAM environment
- Designed scenarios and determined how much benefit there would be if the robots communicated
- With an optimal communication policy, SLAM systems can now strike a balance between accuracy and the cost of communication

References

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[2] *Intelligent Robots and Systems, 2003. (IROS 2003). Proceedings. 2003 IEEE/RSJ International Conference on* , vol.1, no., pp.212,217 vol.1, 27-31 Oct. 2003
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