Range-Only Simultaneous Localization and Mapping using Paired Comparisons

Opportunity Research Scholars' Program

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Introduction

Range-only Simultaneous Localization and Mapping (SLAM) considers the problem of localizing a moving target along with estimating locations of fixed landmark points in an environment. Most prior works solve the problem based on the direct knowledge of a sequence of distance measurements between the target and the landmarks. We consider the scenario where the exact distance measurements are either unavailable or unreliable due to high noise levels.

Our Approach

- **Paired Comparisons**
  Measurements are assumed to be available in the form - t is closer to a than b - where t refers to the target and a,b are a pair of landmarks.
- **Particle Filter**
  A Monte Carlo approach to represent the probability distribution of the locations of target and beacons.
- **Overview**
  Landmarks are randomly placed in the test area. The distances between the target and pairs of landmarks are compared. The particle filters help to compute estimates of locations that conform to the constraints from paired comparisons.

Background

Fig 1. Self-driving cars use SLAM to safely map their paths.

- **Existing solution:**
  - Estimation of a dynamic target when the map of the surrounding environment is known.
- **Proposed solution:**
  - Build on existing solution and incorporate estimation of the landmark points.

Experiment

- **Algorithm**
  - At every time step, paired comparisons of distances between the target and the landmarks are obtained.
  - Particle filters are used to maintain the probability distributions over the locations of the target and the landmarks.
- **Testing**

Fig 2. Robotarium robots.

The Robotarium is a simulation environment where written algorithms are tested using real data.

Results

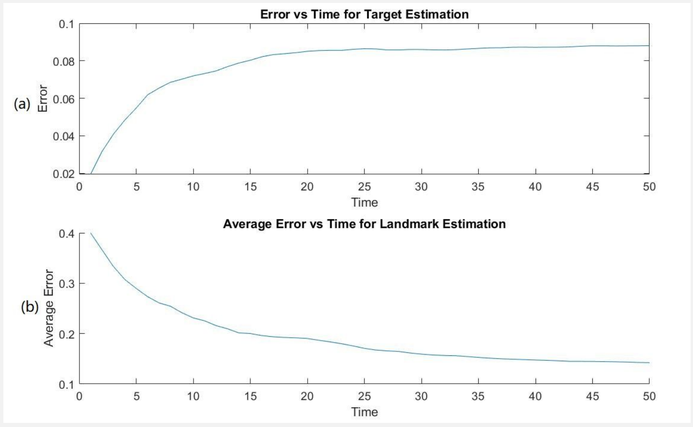

Fig 3. (a) Target estimation accuracy, shown as error $||x_t - \hat{x}_t||_2$ at each time step. Each point shows the median over 100 trials. (b) Average landmark estimation accuracy for the five landmarks used in the experiment, shown as the average of error $||b_t - \hat{b}_t||_2$ for all five landmarks at each time step. Each point shows the median over 100 trials.

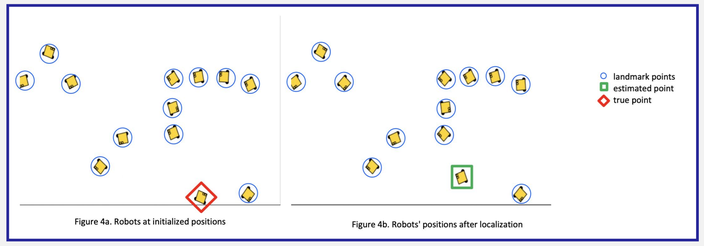

Figure 4a and Figure 4b display the Robotarium runs for stationary target within a known environment

Discussion

Synthetic Experiment

- The error of target estimation is small during the initial time steps since the initial target location is known. It converges to 0.088 as time increments, which indicates the algorithm successfully estimates the target location.
- The average error of landmark estimation decreases as time increments, which indicates the algorithm successfully estimates the locations of landmarks.

Robotarium Experiment

- Obtained a close estimate of the location of target.
- Used built-in functions to avoid collisions of beacons, which led to less accurate estimations.

Future Work

- Improving the current algorithm to work without the knowledge of the target's starting location and initial location estimates of the beacons, evaluate the algorithm under noisy conditions
- Testing the SLAM algorithm on the Robotarium simulator and extension of the method in other application areas such as recommendation systems

References

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