MISSION-RELEVANT COLLABORATIVE OBSERVATION AND LOCALIZATION

By

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Motivation

- MISSION-RELEVANT COLLABORATIVE OBSERVATION AND LOCALIZATION by Ashley W. Stroupe and Tucker Balch
- Proposes an approach for integration of
  - Collaborative observation
  - Localization
  - Within a separate multi-robot mission
- Individually evaluate and choose a task based on the mission and the teammate
- Tasks:
  - Mission related tasks
  - Tasks for self-localization
  - Team-mate localization
  - Collaborative mapping

Introduction

- Example missions:
  - Planetary science
  - Construction
  - Surveillance/reconnaissance
  - Search and rescue
- Motivation:
  - To obtain consistent and accurate understanding of the environment
  - At the same time performing a high level mission

Related Work

- Localization maps the sensor data to robot pose using a representation of the environment
- Several approaches:
  - Simple geometry (triangulation)
    - Uses range and bearing to landmarks + previous position and motion model(optional) to find a pose
  - More complex geometry
    - Construct an 'image', and find the closest template to it
  - Probabilistic modeling of pose estimates

Probabilistic modeling of pose estimates

- Represent the pose by a distribution or density
- Gaussian distributions->allow simple updates
  - Kalman-Bucy Filter
  - Bayes Rule filter
- Any type of distributions->cost of complexity(+resolution)
  - Markov Localization
  - Monte Carlo Localization
- Leap-frog method

Mapping

- Mapping provides an environment representation for localization and task selection
- Similar to localization- done simultaneously
- Simple approach
  - Relate relative position of objects to world
- Complex approach provide:
  - a probability of grid cells being occupied or traversable
  - Templates
  - Probabilitic position estimates of objects using probabilistic methods

- Such probabilistic methods are also used to track dynamic objects
- Multi-robot approach divide the problem into single robot problems by:
  - Dividing the area
  - Leap-frog approach
- Also can jointly update a single grid cell occupancy map

Approach-Task Selection

- Tasks are specified:
  - Directly (scientific analysis)
  - indirectly (need for localization and map)
- Task vale depends on:
  - Current priorities of tasks
  - Current task status
  - Current state and pose estimate (+ uncertainity)
  - Resource availability
  - (+estimated cost to complete the task)
  - Affected by needs and availability of teammates

Collaborative Localization

- includes
  - Cooperative localization (uses observations of and by teammates to update pose)
  - Collaborative localization(explicitely moving to aid a lost teammate)
- Maximize the chance of localization by maximizing the the chance of locating land marks

Collaborative Mapping and Tracking

- Attempts to take the full advantage of multi-robot team
- improve the accuacy-> take mutiple observation of objects
- Small problems->analytical optimization
- Complex problems->aproximation techniques
  - Hill-climbing, simulated annealing,space discretization,coarse-to-fine soltions, search space reduction

- Static objects
- Dynamic objects
  - Driving force is time
  - First estimate depends on preliminary position and velocity estimate->provides range of area
  - As more information collected,
    - Uncertainity reduced
    - Range of area collapses

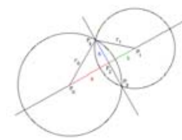
Progress

- Cooperative Observation
  - Bayes rule and gaussian distribution is used to combine obserations
  - Combining observations
    - Transforms local parameters directly obtained from sensor data into global parameters
    - So observaions can be combined by a simple matrix approach

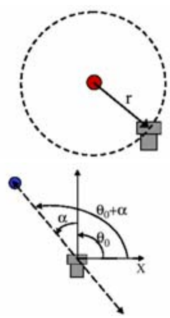
- Distributed sensing experiments
  - Locating static targets
  - Visually tracking dynamic objects
  - increasing effective field of view of agents
- Optimized Mapping Simulations
  - A team of robots is deployed to best improve a map of landmarks by optimizing
  - expected improvement
    - Predicts the distributions resuling from all observations
  - expected cost
    - Time and distance

Progress

- Localization -> Constraint based approach to landmark localization
  - Localization Updates
  - Localization Experiments



- Distance to the beacons -->give a circle with distance as radius
- Bearing of the beacons -->give a line



Conclusion

- Proposed an aproach to integrate
  - Collaborative localization and observation needs
  - Needs of a seperate, complex mission
- Task selection depends on current value of :
  - available taks
  - Mapping
  - Localization

  Of self and teammates

Conclusion

- optimize multiple simultaneous observation points for available teammates
  - Provides a team-optimized result-> Mapping
- Observation of dynamic objects
  - Optimize multiple time distribted observation points
- Results are good in
  - Combining multiple observations
  - Collaborative observation point selection
  - Collaborative localization

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