Task Assignment and Trajectory Planning for Multiple Intelligent Vehicles

14 - October 2015

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Introduction

Cognition in robotics/autonomous vehicles?
Path Planning – Find a path from initial to goal position avoiding all collisions for the vehicle
Distinguished as:
  • (Global) Path Planning
  • (Local) Obstacle Avoidance
Global planners – Road Map, Potential field, Cell decomposition, etc.
Local Planners – Bug, VFH, Bubble band, Curvature Velocity, DWA, etc.
Multi-Vehicle Planning

- What about Multiple Vehicles?
- Two types: Centralized/Decentralized approach
- Compromise between complexity and optimality?
- Influence of the planned path with other vehicles' path?

Task Assignment and Path Planning

- Optimal (Path/time/safety/fuel) Multiple Vehicle Path Planning?
- Multi-robot Task Allocation method
- Influence of goal assignment in multi vehicle planning?
- How do you assign goals for all of the vehicles?
- Optimal (Temporal) Task Assignment?
- Planning with Via-points?
- Multiple path conflict resolution?
Motivation

- More than 60% of World's Cargo → Containers
- Transportation to trains, ships, straddle carriers, trucks
- Export, Import, Special and Storage Areas
- Ship to shore cranes for loading/unloading
- Straddled Carriers/Gantry Cranes for transportation
- Issues → Safety (Human interference), Transshipment time and Productivity
Motivation

- Automated Terminals – CTA, Hamburg and ECT, Rotterdam → Electromagnetic Grids for guidance
- Cargo handling by Automated Next generation Transportation Systems.
- Safe and efficient transportation of containers in ports and freight terminals.
- Usage of Automated Guided Vehicles (AGVs) and Automated Trucks (ATs).
- EU Project with 5 partners.

![Automated Truck](image1)

![Automated Guided Vehicle](image2)
**Algorithm**

- **Steps Involved:**
  - Computation of distance transform from each vehicle to all goals
  - Generate a costmap
  - Compute Optimal Assignment
  - Check for path confliction, reassign the priority
  - Compute path using a global planner
  - Compute trajectory
  - If path confliction - based on priority of each vehicle in the schedule/assigner
Algorithm

- Multi Robot Task Allocation problem
- Linear Assignment problem with additional constraints
- Path Conflcit - based on priority of each vehicle in the schedule
- Three Modules:
  - Task Assignment of Multiple Vehicles - Goals
  - Path Planner on each vehicle - Global dynamic path planner
  - Trajectory planner - gradient descent method

Algorithm 1: Cargo-ANTS approach
Present Work - Navigation Module

Task Assignment

Global Planner

Local Planner

Harbour World in Gazebo
Conclusions...

- This is Single Robot – Single Task – Instantaneous Assignment (SR-ST-IA) produces optimal collision free trajectories
- Multi Robot – Multi Task – Dynamic Assignment (MR-MT-DA)?
- Multiple path conflict resolution? (Impact of coupling task assignment with local planner)
- With intermediate goal points?
- Additional Constraints – Spatial, temporal?

AT and AGV in simulated environment - Gazebo

Fully Automated Container Terminal
Thank You!