Networked Navigation for Mobile Robots in Industrial Applications

Fraunhofer IPA - Robot and Assistive Systems

13.12.2018

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IPA Navigation
Networked Navigation for Mobile Robots in Industrial Applications

Content

- Deployment Examples: IPA Navigation in Industrial Applications
  - Technology Transfer to Unmanned Material Transport Systems
  - Localization in Changeable Environments
  - Reactive Path Planning and Reactive Route Following

- Networked & Cooperative Multi-Robot Navigation
  - Cloud-based Navigation
  - Cooperative Mapping and Localization
  - Cooperative Global and Local Path Planning
  - Simulation and AR User Interfaces
IPA Navigation

What we do

- R&D in Mobile Robot Navigation using ROS
  - Perception / Sensor Fusion
  - Mapping / Localization / SLAM
  - Motion Planning and – Control in Dynamic Environments
  - Cooperative Navigation in the Context of Multi-Robot Systems

- Providing a Industrial Grade Navigation Stack
  - Applications of Automated Guided Vehicles (AGVs)
  - SW-Development: CI, Version Control, Unit Testing
  - Deployment: Automated Binary Creation and Licensing

- rob@work, Care-O-bot: Mobile Robot Platforms for Navigation Dev
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Deployment Example: AGVs of BÄR Automation
Modular Localization in Changeable Environments
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Modular Localization in Changeable Environments

- Flexible Assembly Line in Car Manufacturing

- Omnidirectional AGV of Bär Automation GmbH

- Navigation Requirements
  - Robust localization in changeable environments
  - Millimeter positioning precision at individual assembly stations
  - Sensor setup: odometry, IMU, laser scanners, RFID readers

- IPA Navigation using Natural Landmarks
  - Environment modeling + multi-sensor data fusion
  - Feature-based localization combined with relative SLAM
  - Roadmap Planning and Route-Following
Deployment Example: Smart Transport Robot at BMW
Long-Term SLAM, Reactive Path Planning and Cloud-based Control

- Versatile Mobile Robot for Autonomous Transport Tasks
- Designed to Carry Trolleys in Warehouse Environments
- Map Management, Task Management and Fleet Coordination via Azure Cloud Interface
- ROS-based Navigation and Vehicle Control
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Long-Term SLAM, Reactive Path Planning and Cloud-based Control

- IPA Navigation Tasks:
  - Localization using natural landmarks
  - Online route planning and dynamic collision avoidance

- Challenges:
  - Few static structures, highly changing environment (boxes, pallets, mobile shelves, …)
  - Dynamic obstacles and previously unknown static obstacles (fork lifts, tugger trains, workers, …)
  - Sparse sensor data (180° 2D safety laserscan data + odometry)
  - Large-scale environments (> 100,000 m²)
  - Reliability of industrial grade > 99%
Deployment Example: Smart Transport Robot at BMW
IPA Long-Term SLAM

- Long-Term SLAM Concept:
  - Continuously updating internal map while simultaneously localizing in that map
  - Providing map updates for cloud-based map server
  - Base sensor setup: 2D laser scan + odometry
  - Possible additional sensors/data: (Indoor-) GPS, 3D point clouds, RFID readings, 2D Image data

- Approach:
  - Particle-Filter-based Localization on different map layers
  - High efficient, low-resolution grid maps modeling environment dynamics and contour of objects
Deployment Example: Smart Transport Robot at BMW

IPA Elastic-Band Planner

**Planner Concept:**
- Follows global path / predefined routes in the absence of obstacles
- Optimizes path locally during runtime
- Reacts to dynamic obstacles
- Considers safety field expansions in order to provide valid velocity commands

**Approach:**
- Extends well-known Elastic-Band approach with additional forces and logic to achieve desired behavior
- Combined with model predictive trajectory planning to handle various kinematics and dynamic constraints
- Enables also cooperative local trajectory optimization
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Video and ROS Visualization
Networked & Cooperative Multi-Robot Navigation
Cloud-Navigation
Networked & Cooperative Multi-Robot Navigation

Cloud-Navigation

Objective:
- Networked & Cooperative Navigation for Fleets of Mobile Robots

Concept:
- Interconnecting Mobile Robots and Stationary Sensors using a Cloud-based IT-Infrastructure
- Cooperative Environment Modeling and SLAM
- Navigation-as-a-Service:
  Map Updates & Cooperative Path Planning for each Robot

Value:
- Reduction of Local Hardware- and Computational Resources
- Enhances Quality & Flexibility of the Overall Navigation System
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Cloud-Navigation: Cooperative Trajectory Optimization + ARviz
Thank you for your attention

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