Autonomous Mobile Robots

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Introduction

Autonomous Mobile Robots - Roland Siegwart, Margarita Chli, Nick Lawrance

https://twitter.com/brianbdouglas/status/1294734347782615040

Introduction

Introduction

Control of Mobile Robots

Contents

- Kinematics of wheeled mobile robots: internal, external, direct, and inverse
  - Differential drive kinematics
  - Bicycle drive kinematics
  - Rear-wheel bicycle drive kinematics
  - Car(Ackermann) drive kinematics
- Wheel kinematics constraints: rolling contact and lateral slippage
- Wheeled Mobile System Control: pose and orientation
  - Control to reference pose
  - Control to reference pose via an intermediate point
  - Control to reference pose via an intermediate direction
  - Control by a straight line and a circular arc
  - Reference path control
- Smooth path planning in a given 2-D space for vehicles with nonholonomic constraints using Hybrid A*

Bayesian Filter

Contents

- Basic of Probability
- Probabilistic Generative Laws
- Estimation from Measurements
- Estimation from Measurements and Controls

Kalman Filter

Contents

- Gaussian Distribution
- One Dimensional Kalman Filter
- Multivariate Density Function
- Marginal Density Function
- Multivariate Normal Function
- Two Dimensional Gaussian
- Multiple Random Variable
- Multidimensional Kalman Filter
- Sensor Fusion
- Linearization, Taylor Series Expansion, Linear Systems
- Extended Kalman Filter (EKF)
- Comparison between KF and EKF

Particle Filter

Contents

- A Taxonomy of Particle Filter
- Bayesian Filter
- Monte Carlo Integration (MCI)
- Particle Filter
- Importance Sampling
- Particle Filter Algorithm

https://hess.copernicus.org/articles/23/1163/2019/

Robot Localization

Contents

- A Taxonomy of Localization Problems
- Markov localization
  - Environment Sensing
  - Motion in the Environment
  - Localization in the Environment
- EKF localization with known correspondence
- Particle filter localization with known correspondence

Multi-view Geometry

Contents

- Monocular Vision
  - Pinhole Camera Model
  - Image Plane, Camera Plane, Projection Matrix
  - Projective transformation
  - Finding Projection Matrix using Direct Linear Transform (DLT)
  - Camera Calibration
- Stereo Vision
  - Simple Stereo, General Stereo
  - Some homogeneous properties
  - Epipolar Geometry
  - Essential matrix, Fundamental matrix
- Depth Estimation

Course Logistics

- 31.08 (16:30-18:00) introduction and setting up
- 05.09, 07.09, 14.09, 19.09 (16:30-18:00) section 01 hw1
- 21.09, 26.09, 28.09, 03.10 (16:30-18:00) section 02 hw2
- 05.10, 10.10, 12.10, 19.10 (16:30-18:00) section 03 hw3
- 26.10, 02.11, 09.11, 16.11 (16:30-18:00) section 04 hw4
- 26.10 (16:30-18:00) project release
- 07.12 (16:30-18:00) project presentation

Course Evaluation

- In-class activities (10% + 10%)
- Project 40%
- Mid-term and Final Exams (10% + 10%)
- Quizzes 20%

References

Gregor Klancar, Andrej Zdesar, Saso Blazic, and Igor Skrjanc.
Wheeled mobile robotics: from fundamentals towards autonomous systems.
Butterworth-Heinemann, 2017.

Roland Siegwart, Illah Reza Nourbakhsh, and Davide Scaramuzza.
Introduction to autonomous mobile robots.
MIT press, 2011.

Sebastian Thrun.
Probabilistic robotics.
Communications of the ACM, 45(3):52–57, 2002.