DRIVES

Development and Research on Innovative Vocational Education Skills

SENSOR FUSION EXPERT

SFE.U4.E6 - FEATURE-BASED SLAM (SIMULTANEOUS LOCALIZATION AND MAPPING) METHODS AND ITS EKF (EXTENDED KALMAN FILTER) SOLUTION

Data and Sensor Fusion Applications, Use Cases and Real-Life Examples

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LEARNING OBJECTIVES

The student is able to …

SFE.U4.E4.PC1	The student is able to define and understand SLAM.
SFE.U4.E4.PC2	The student recognizes and critically understands the challenges behind the SLAM problem.
SFE.U4.E4.PC3	The student is able to acknowledge the EKF solution and understand each step of its operation.
SFE.U4.E4.PC4	The student can examine and analyse concrete examples of the application of the EKF to solve the SLAM problem.
SFE.U4.E4.PC5	The student is able to setup an EKF for SLAM.
SFE.U4.E4.PC6	The student recognizes the existence of other SLAM algorithms (UKF SLAM, Fast SLAM, ...) and briefly defines and distinguishes their approaches.

SLAM - SIMULTANEOUS LOCALISATION AND MAPPING

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Introduction

- SLAM - Simultaneous Localization and Mapping
- SLAM is necessary for a range of applications, whether internal or external, namely
  - Autonomous and Crewed Vehicles
  - For home applications: Self-contained vacuums
  - Air: Surveillance for unmanned vehicles
  - Underground: Mine Exploration
  - Space: Terrain mapping for localization

SLAM - SIMULTANEOUS LOCALISATION AND MAPPING

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Problem

- To use SLAM it is necessary:
  - Localization: inferring location given a map
  - Mapping: inferring a map given locations
- It's complicated because:
  - A map is needed to assign locations and a good estimated position for mapping.

Why is it a problem

- The mapping between landmarks and observations is not known.
- Choosing the wrong data association can have devastating consequences.

Extended Kalman Filter representation

- There is an EKF for SLAM
  - For the construction of the Map it is necessary:
    - 1) State prediction (odometry)
    - 2) Measurement prediction
    - 3) Observation
    - 4) Data Association
    - 5) Update
    - 6) Integration of new landmarks

Representação da Extended Kalman Filter

- There is an EKF for SLAM
  - For the construction of the Map it is necessary:
    - 1) State prediction (odometry)
      - A formula is created for Odometry:
      - Robot-landmark cross-covariance prediction is required

Representação da Extended Kalman Filter

- There is an EKF for SLAM
  - For the construction of the Map it is necessary:
    - 2) Measurement prediction
      - Make a Global-to-local frame transform

Representação da Extended Kalman Filter

- There is an EKF for SLAM
  - For the construction of the Map it is necessary:
    - 3) Observation
      - Create a template with (x,y)-point landmarks

Representação da Extended Kalman Filter

- There is an EKF for SLAM
  - For the construction of the Map it is necessary:
    - 4) Data Association
      - Associates predicted measurements with observation required

Representação da Extended Kalman Filter

- There is an EKF for SLAM
  - For the construction of the Map it is necessary:
    - 5) Update
      - Use the usual Kalman filter expressions

Representação da Extended Kalman Filter

- There is an EKF for SLAM
  - For the construction of the Map it is necessary:
    - 6) Integration of new landmarks
      - Calculating State Augmented and Cross-covariances

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EKF SLAM Examples

- Make Datasets
- Make Landmarks
- Make Data Acquisitions

SLAM TECHNIQUES

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Existing SLAM Techniques

- EKF SLAM
- Fast SLAM
- Graph-based SLAM
- Topological SLAM

REFERENCIES

Burgard, W., Stachniss, C., Arras, K., & Bennewitz, M. (2010). Introduction to Mobile Robotics SLAM: Simultaneous Localization and Mapping. University of Freiburg.

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Thank you for your attention

DRIVES project is project under **The Blueprint for Sectoral Cooperation on Skills in Automotive Sector**, as part of New Skills Agenda.

The aim of the Blueprint is **to support an overall sectoral strategy and to develop concrete actions to address short and medium term skills needs.**

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