ENV-719

Localization and Navigation Methods

Botteron Cyril, Martinoli Alcherio, Merminod Bertrand, Skaloud Jan

Cursus	Sem.	Type
Civil & Environmental Engineering		Obl.

Language of teaching	English
Credits	4
Session	
Exam	Multiple
Workload	120h
Hours	**56**
Courses	30
Exercises	6
TP	20
Number of positions	**12**

Frequency

Every 2 years

Remark

Next time: Fall 2018

Summary

Transmitting to the student state-of-the art methods and research topics in localization and navigation algorithms and systems. Students will be able to put in practice their knowledge in a course project and by three labs involved in the course. Lectures are concentrated in the first 5 weeks.

Content

Week 1: Satellite positioning (Prof. Bertrand Merminod)
- Satellite orbit motion, Kepler's laws, broadcast and precise ephemeris
- Description of GPS signal structure and derivation of observables
- Inventory of error sources, random and non-random effects
- Derivation of mathematical models for absolute and differential positioning.
- Estimation of the position and its precision based on least-square principle analysis
- Overview of GNSS
- Lab assignments: Absolute GPS positioning with and without approximation

Week 2: Wireless location and state-space estimation (Dr. Cyril Botteron)
- Fundamentals of radio-frequency propagation and positioning
- Time and angle observables and associated error sources
- Kalman filtering applied to kinematic positioning
- Location with wireless computer network
- Ultra-wide band positioning principles
- Outdoor and indoor personal location, asset tracking
- Lab assignment: Kalman Filtering in kinematic positioning

Week 3: Trajectory and attitude determination with INS/GNSS (Dr. Jan Skaloud)
- Inertial sensors, inertial systems
- Linear dynamical systems, stochastic differential equations
- Inertial strapdown mechanization equations in (i,e,n) frames
- INS strapdown error equations and calibration states
- Alignment models
- Redundant IMU configurations
- Prediction, filtering, smoothing and calibration
- No lab assignments

Week 4: Trajectory and attitude determination via optical positioning and dynamic networks, integrated sensor orientation (Dr. Jan Skaloud)
- Colineraity condition for 0-D, 1-D and 2-D optical sensors

- Sensor models and observations, feature matching
- Principle of integrated sensor orientation. Orientation vs calibration
- Formulation of INS/GNSS/optical-sensor case in dynamic networks, numerical issues
- Lab assignment to select among visionary sensors; 1. oscillating cams & ALS; 2. 1-line-camera and ALS; etc.

Week 5: Localization and Navigation in Mobile Robotics (Prof. Alcherio Martinoli)

- Overview of localization techniques in mobile robotics (off-board/on-board; absolute/relative)
- Basic kinematic models (differential drive, Ackerman steering vehicles)
- Odometry
- Feature-based localization
- Kalman filtering and particle filtering techniques applied to mobile robots
- Multi-robot localization
- Fundamental of navigation (path planning, landmark-based navigation)
- No lab assignments

Keywords

Navigation, Localization, Kalman Filtering, Estimation Methods

Learning Prerequisites

Required courses

-

Recommended courses

Recommended Bachelor courses:
Advanced Satellite Positioning and/or Sensor Orientation.

Learning Outcomes

By the end of the course, the student must be able to:

• Compute user position from observed ranges using satellites. Compute user position from observed ranges using beacons of ultra-wide-band. Implement Kalman Filter. Predict position precision via covariance propagation. Integrate inertial signals. Formulate collinearity equations for optical sensors of different types. Understand robot localization techniques and formulate kinematic models for robots.

Resources

Websites

• http://moodle.epfl.ch

Moodle Link

• http://moodle.epfl.ch/course/enrol.php?id=8911