MCE 564 Robotic Perception

Monday 9:40-11:30
Spring 2021

Instructor Information:

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Office Location	TBD
Office Hours	TBD

Course contents

State-space representation of a mobile robot, various orientation representations, rotational velocity, orientation estimation using an IMU in presence of noise, camera models, image (un)distortion, vision-based pose estimation, optical flow estimation, optical flow based velocity estimation, image features, point cloud and scan processing, point cloud registration, sensor fusion techniques.

Course Objective

This course is intended for students interested in autonomous mobile robotics systems research. The objective of this course is to expose the students to the working principles of mainstream sensory devices used in robotic automation as well as state-of-the-art techniques to process data collected with these devices.

Learning Outcomes & Competences

Successfully completing this course a student will be able to

- Process information gathered using IMU, camera and lidar for state estimation, mapping and navigation of a mobile robotic platform,
- Implement techniques for orientation estimation, vision and range based pose estimation and point cloud / scan alignment.

References Books

- Ma, Y., Soatto, S., Kosecka, J., & Sastry, S. S. (2012). An invitation to 3-d vision: from images to geometric models (Vol. 26). Springer Science & Business Media.
- Hartley, Richard, and Andrew Zisserman. Multiple view geometry in computer vision. Cambridge university press, 2003.
- Botsch, Mario, et al. Polygon mesh processing. CRC press, 2010.

Assessment Criteria

Quizzes	%5
Assignments	%10
Projects	%55
Final Exam	%30

Course Plan

Week	Subject
1-2	Representation of position and rotation (axis-angle, SO(3), quaternions, exponential map, Euler angles), rigidbody transformations, homogeneous transformations, angular velocity
3	Inertial measurement units, calibration, characterisation and estimation
4	Camera model, lens distortion and intrinsic calibration
5-7	Projective geometry and transformations, objects in projective space, homography, PnP problem, pose using projective transformations
8-9	Visual features (edges and corners), feature matching, epipolar geometry, xxxSAC family of algorithms, optical flow, velocity from optical flow
10-12	Lidars and point clouds, data structures and algorithms for point cloud processing, scan matching, point cloud registration
13-14	Sensor fusion techniques, odometry using range-inertial-visual sensors, environment assumptions (2D, 2.5D, 3D)