Spring 2022 EECE 7150: Autonomous Field Robotics

Instructor Hanumant Singh

Class 5:50-7:30pm, Mondays, Wednesdays

Office Hours TBD

In this class we will do a general survey of some of the important papers and algorithms in the area of field robotics concentrating on applications for land-based, aerial and marine applications. The class will be based on paper presentations, and the implementation of the algorithms on Northeastern robots.

Grading

20% Paper Presentation

80% Projects

Note: You are also strongly advised to attend any talks, symposium at NU in the general area of Robotics.

Textbooks: Not required, but our lectures will follow the work described in part in Multiple View Geometry by Hartley and Zisserman

The basic SLAM work will follow some of the groundwork laid out in Thrun et al Probabilistic Robots

Lecture 1

ROS background – Driving the NU autonomous car, Husky, etc with ROS

Projective Geometry in 2D (CH 2 MVG)

Warmup problem Monte Carlo techniques (Probabilistic Robotics - Ch 2)

Lecture 2

Projective Geometry in 2D (Continued)

Projective Geometry in 3D (CH3 MVG)

Project 1a Homography Mapping

Lecture 3

Projective Geometry in 3D (Continued)

Estimation of Projective Transforms (CH4 MVG)

Lecture 4

Project 1a Due; Project 1b Handed out

Estimation of Projective Transforms (Continued)

Camera Models (CH 6.1 MVG)

Lecture 5

Introduction to basic filtering alpha-beta, 1D kalman filtering.

Multi-variate kalman filtering - matrices and equations

Lecture 6

Bayesian filtering and Kalman filtering, kalman filter application for SLAM, VIO

relation between filtering techniques and smoothing

Lecture 7

SLAM in 2D

Graph based representations

Lecture 8

Problem 1b Due, Project 2 Underwater image dataset

Pizarro Mosaicking Paper

Optimization in GTSAM

Lecture 9

Multibeam calibration

Inter sensor calibration

Kalibr

Lecture 10

iSAM Paper

GTSAM understanding and review

Lecture 11

Epipolar Geometry, Fundamental and Essential Matrices

Project 2 Presentations, Project 3a handed out

Lecture 12

Epipolar Geometry, Fundamental and Essential Matrices (Continued)

Lecture 13

Bag of Words

Lecture 13-14

ORB Slam Project 3b Handed Out

Lecture 15

ICP

Lecture 15-16

Lego Loam

Project 3b Due; Final Project Discussions

Lecture 17-18

Vins Mono / Kimera

RTAB SLAM

Lecture 19

The Role of ML

Lecture 20-25

Paper Presentations

Lecture 26

Final Project Presentations

**List of papers to discuss:**

1. Longuet-Higgins, H. Christopher. "A computer algorithm for reconstructing a scene from two projections." *Nature* 293.5828 (1981): 133-135.
2. Davison. "Real-time simultaneous localisation and mapping with a single camera." *Proceedings Ninth IEEE International Conference on Computer Vision*. IEEE, 2003.
3. Strasdat, Hauke, J. M. M. Montiel, and Andrew J. Davison. "Real-time monocular SLAM: Why filter?." *2010 IEEE International Conference on Robotics and Automation*. IEEE, 2010.
4. Lowe, David G. "Distinctive image features from scale-invariant keypoints." *International journal of computer vision* 60 (2004): 91-110.
5. Harris, Chris, and Mike Stephens. "A combined corner and edge detector." *Alvey vision conference*. Vol. 15. No. 50. 1988.
6. Rublee, Ethan, et al. "ORB: An efficient alternative to SIFT or SURF." *2011 International conference on computer vision*. Ieee, 2011.
7. Gálvez-López, Dorian, and Juan D. Tardos. "Bags of binary words for fast place recognition in image sequences." *IEEE Transactions on Robotics* 28.5 (2012): 1188-1197.