CSE483: Mobile Robotics **Monsoon 2019**

Course Information

Course instructor

Prof. Dr. K Madhava Krishna

Course objective

The course introduces the student to fair detail on the basic modules for automating a mobile robot such as state estimation, visual odometry and mapping, planning, and collision avoidance. The course draws upon state of the art practices in probability and statistical methods, optimization techniques and shows how they are dovetailed to a robotics setting. The course has a strong coding component in the form of assignments wherein the student is expected to simulate and implement the algorithms taught in class.

Pre-requisities

Basic linear algebra, probability theory, and calculus.

Course topics

Vision

Rigid body transformations, Projective geometry, Camera modelling, Camera calibration, Two-view geometry, Stereo, Triangulation, Resection, Visual odometry, Bundle adjustment

State estimation

Bayesian filters - Kalman filter, Extended Kalman filter, Localization and Mapping using EKF

Path planning

AI-style planning, Kinematics, Randomized planning, Trajectory optimization, Collision avoidance in dynamic environments

Remark

Matrix decomposition techniques, such as SVD, QR, RQ, Cholesky, and Linear least squares and Non-linear least squares solvers which will be used throughout the course will be covered as well.

Reference books

- Hartley, R., & Zisserman, A. (2003). *Multiple view geometry in computer vision.* Cambridge university press.
  - Colloquially referred to as the *Bible.*
- Thrun, S., Burgard, W., & Fox, D. (2005). *Probabilistic robotics.* MIT press.
  - Recommended for state estimation topics.
- 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.
  - A bit more easier to read than the *Bible.*

- Trucco, E., & Verri, A. (1998). Introductory techniques for 3-D computer vision (Vol. 201). Englewood Cliffs: Prentice Hall.
  - Good for beginners; gives easy step-by-step instructions for solving common tasks.
- Solomon, J. (2015). *Numerical algorithms: methods for computer vision, machine learning, and graphics*. AK Peters/CRC Press.
  - Useful for learning matrix decompositions, basics of optimization.
- Barfoot, T. D. (2017). *State Estimation for Robotics*. Cambridge University Press.
  - Works out some common state estimation problems in 3D.
- Lynch, K. M., & Park, F. C. (2017). Modern Robotics. Cambridge University Press.
  - Good for understanding robot kinematics.
- Latombe, J. C. (2012). Robot motion planning (Vol. 124). Springer Science & Business Media.
  - Good to begin with.

Grading scheme

(Tentative)
Mid-exam: 20%
End-exam: 20%
Assignments: 50%
Quizzes & scribing: 10%

Late days policy

- All deadlines are strictly at 23:59:59 on the mentioned day. Assignments submitted at or after 00:00:00 on the next day will incur one late day. There will be five assignments in total.
- For assignments you are allowed a total of **four** free late days, with a maximum of **three** free late days per assignment.
- You can use these free late days however you want to. Any other requests for deadline extensions will **not** be entertained.
- Any additional late days (more than the limits) will incur a 50% penalty, per day.

Plagiarism policy

Any instance of highly identical code or write up with another team or the internet will result in a score of zero. While you are encouraged to **discuss** about the problems with the other teams, each team is required to write up their own solutions and implement their own code.

Course outcome

The student is expected to be aware of basic mobile robotic algorithms and should feel comfortable reading and assimilating state of the art research papers in areas covered in the course/class.

Similar courses

- *Photogrammetry* by Cyril Stachniss
  - Video lectures 14 - 16 from the Photogrammetry - I course, and all the lectures from the Photogrammetry - II course will nicely complement what's covered in class.
- *Multiple view geometry* by Daniel Cremers
  - A bit more mathematical, and closely follows the Invitation to 3D Vision textbook.

- *Vision algorithms for mobile robotics* by Davide Scaramuzza
  - Has good slides and exercises.
- *Introduction to Mobile Robotics* by Wolfram Burgard
  - Good video lectures on probabilistic robotics by the guy himself.
- *Mobile Robots* by Sanjiban Choudhury (UWash)
  - A recent course that covers "full-stack" robotics.

Other useful resources

- QUT Robot Academy - Introductory videos by Peter Corke.
- Artifical Intelligence for Robotics - Udacity course by Sebastian Thrun.
- Robotics Specialization on Coursera - UPenn
- Autonomous Navigation for Flying Robots - EdX course by TUM.
- ROS - Framework for writing robot software.
- OpenCV - Open source computer vision library.
- PCL - Open source point cloud library.
- ORB-SLAM - Open source visual SLAM package.
- KITTI - Autonomous driving dataset.
- Open3D - Open source point cloud library with Python API.
- Kalman and Bayesian Filters in Python - An introductory text

Some research groups to follow

- Robotics and Perception Group, University of Zurich
- Autonomous Systems Lab, ETH Zurich
- Robotics Systems Lab, ETH Zurich
- GRASP, UPenn
- Computer Vision Group, TUM
- Autonomous Vision Group, MPI
- Photogrammetry and Robotics Group, UBonn
- Dyson Robotics Lab, Imperial
- Mobile Robotics Group, Oxford

Conferences and Journals

- IEEE International Conference on Robotics and Automation (ICRA)
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
- IEEE Transactions on Robotics
- Journal of Field Robotics

Teaching assistants

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It'd help if you can send your queries by e-mail first before visiting.

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[0] Expect this document to be continuously updated.