EL2320 (3320) - Applied Estimation

1 Literature

The course book is "Probabilistic robotics" by Thrun, Burgard and Fox, The MIT Press, ISBN 0-262-20162-3 covers most of the material in the course from a robotics points of view. The book will be augmented with selected papers. One must read the assignments for each lecture before coming to class.

For lectures there will be pointers to required reading that covers this material. This in combination with what is said during the lectures and contained in the labs will be the main source of information. The interested student will look for other sources of information in the course.

2 Lectures

The course consists of 12 lectures. During the lectures both theory and practice of estimation will be covered. Coming to class prepared by reading the assigned literature is a prerequisite for benefiting.

L01

- Required reading: Chap. 1 and 2 of Probabilistic Robotics.
- Topics: Course Information, the estimation problem, review of probability concepts, Bayes rule.

L02

- Required reading: 3.1-3.2 of Probabilistic Robotics.
- Topics: Bayesian Inference, Gaussian distribution,

L03

- Required reading: Chapture 3 of Probabilistic Robotics.
- Topics: Gaussian Estimation, Kalman Filter, MAP vs. MLE,

L04

- Required reading: Chapture 7 of Probabilistic Robotics.
- Topics: Extended Kalman Filter, Robot Localization,

L05

- Topics: Divergence Issues with Gaussian estimation, UKF and other Gaussian filters,

L06*

- Required reading: Lab 1
- Required writing: Lab 1, part I answers
- Topics: Lab 1, Extended Kalman Filter Implementation Issues

*Participation in class discussion of lab gives bonus point on exam.

L07

- Required reading: Chapture 4 of Probabilistic Robotics.
- Topics: Particle Filter,

L08

- Required reading: Chapter 8 of Probabilistic Robots and Monte Carlo Localization With Mixture Proposal Distribution, Thrun, Fox, Burgard, Proceedings of the AAAI National conference on Artificial Intelligence, (on course web: thrun.mclmix.pdf)
- Topics: Monty Carlo Localization,

L09*

- Required reading: Lab 2
- Required writing: Lab 2, part A answers
- Topics: Lab 2, Particle Filter Implementation Issues

*Participation in class discussion of lab gives bonus point on exam.

L10

- Required reading: Chapter 10 and 13.0-13.5 of Probabilistic Robotics.
- Topics: Extended Kalman Filter and FastSLAM,

L11

- Required reading: Chapter 3.4,7.6,7.7 of Probabilistic Robotics.
- Topics: Projects explained with examples, Report writting, Other Gaussian estimation techniques,

L12

- Required reading: Chapter 11 of Probabilistic Robotics and Square Root SAM Simultaneous Localization and Mapping via Square Root Information Smoothing, Frank Dellaert and Michael Kaess, Intl. Journal of Robotics Research (SAMDellaert.pdf).
- Topics: Other Estimation Techniques,

3 Labs

Two labs are required. One covers the extended Kalman filter and the other the particle filter. They are done individually but you are encouraged to help one another. The instructions will be posted on the web. Each lab consists of two parts. The first part includes a description of the estimation problem and an outline of its formulation as an implementation of the estimation method. There will be a series of questions both general to the method and specific to the implementation. The answers should be prepared in writing and brought to class (L06 and L09). We will check the answers in class together and provide feedback. Participation in

class gives the student clarity on the lab, the estimation method, as well as 1 bonus point on the exam. **One bonus point is given if you have written answers prepared and at least 30% are marked as correct** by peer grading in class. That essentially means some honest effort before class.

The second part of the lab consists of Matlab exercises where you will be asked to complete a skeleton implementation. The report including plots of the results, revised answers to part 1 questions and the Matlab code will be uploaded to the assignment on the course web.

Each lab completed on time (ie. without need for additional work) will earn one more bonus point on the exam. Each bonus point is worth 2% of the full point total of the exam (traditionally the exams are out of 50 so earning all 4 bonus points will add 4 points to your exam grade). These points will be very nice to have at exam time but require that the students start the lab in good time so that any problems they have can be solved well before the deadline (either by themselves, classmates, or the teacher).

Lab 1 upload is due Nov 17, 2016

Lab 2 upload is due Dec 1, 2016

Labs that are not uploaded by Jan 14 will be significantly delayed in being graded (several months to a year). Do the labs as soon as you can!

You have the opportunity to earn up to 4 bonus points 2 for the preparation participation and 2 for passing on time giving 4 exam points. Please note that points on the exam are very helpful for passing or improving your grade and if you skip these points you will regret it.

Bonus points count for the scheduled exam at the end of period 2 and the re-exam later in the spring. If you take the exam after that the bonus will no longer count. The bonus is for an incentive to work and study properly and so should not apply for students that have not finished this year.

4 Project

The project part of the course allows you to focus on a particular subject. The project is an important part of your final grade in the course and you should work in groups of two to solve a problem of your choosing. Groups of one or three are also allowed but two is preferred. Each person will write an individual report and receive an individual grade.

The implementation is an important part of the project but please remember that what is not described in the project report will not be taken into account in the grading. That is, we will not look for things in the code or your partner's report that will give you a higher grade, you need to tell us about them in your report. Although the reports will describe the same project and can share many of the figures and plots, the text should not be the shared in any way. Ideally each student should do the report writting alone after the project work is done.

The implementation is best presented as experimental results including plots in the report to document your achievements. These are then supported by the code and instruction for how to run it. You are free to include movie files and they can help show what you have done but they are not required.

The reports should be similar in format to published research articles. For example they might include abstract, introduction, background (including your reference citations), a description of your project, experimental results, conclusions (including reflections and insights you gained, *very important*). Maximum length is 10 pages. For many of you this will be first effort in the style of report writting you will need master later for your thesis report.

Projects can build on the labs and develop them further by using a different method on the same problems or extending the problem, for example from robot localization to SLAM. Alternatively, one can chose a different problem and an appropriate method.

- After forming groups and choosing a topic a short description should be uploaded to CANVAS.
- The final report is uploaded by the deadline in CANVAS.
- The project is expected to require between 40-60 hours of work by each student including researching the topic, implementing the method and writting the report.

Grading is based on three criteria:

1. Amount, What did you do. That can be broad, (did lots of different stuff) or deep (looked at one thing very well). Here we expect that you read and cite at least one article (besides course literature and articles on the course web).
2. Clarity, Item one will give you no credit if you fail to explain it well. The code is not any explanation. If you did something explain it. Similarly if the explanation is unclear it may give no credit. The references should be cited with enough description to prove that you have grasped the main point(s) and how they are related to and campare to the project. English grammar however is not part of the grade and these errors will be ignored if the meaning is clear. On the other hand, copy and paste of text sources without citation is always a serious offense.
3. Insight, That is show that you increased and deepened your understanding. So insight is not paraphrasing a lecture or some other source. Rather more focused on the implementation you did and the experiments you devised. Why did you do what you did. What did you expect to happen. What did happen. Why. What did you learn about the method (for example, when is it a good or bad choice). Remember, for example, that the connection between measurement uncertainty and estimation uncertainty could be discussed. What other themes from the course can you relate to your example.

So the items above are each more or less dependent on the ones before. So doing loads of work alone will not get you a higher grade without point 2. A solid result on point 3 is needed for B and A. Originality and creativity, although appreciated, is not part of the criteria so there is no advantage to claiming it falsely. Cite your sources. The code must be your own, (although some use of downloaded libraries can be sometimes be appropriate for certain projects, cite sources)

So in judging both points 1 and 3 there is some advantage to doing more challenging projects up to a point. Doing a project that requires no new learning beyond what was covered in the two labs would be the base line, that is 0 points. That said a more challenging project does not grantee a high grade nor a more straight forward one a poor grade. It is the above criteria that matters.