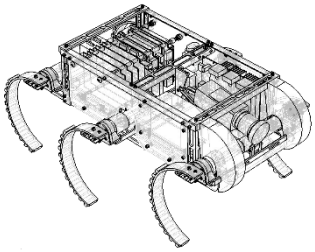
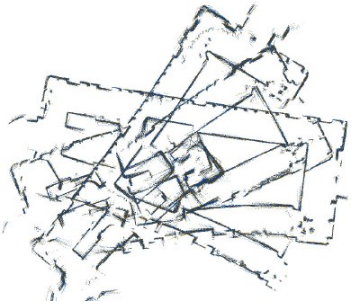


EE 585 Probabilistic Robotics
Syllabus for Fall 2025



Instructor:

Prof. Dr. Afşar SARANLI,
Room: EZ-10 **Phone:** 210-4529;
e-mail: afsars@metu.edu.tr
Office Hours: To be announced. **Course Web:** http://odtuclass.metu.edu.tr

Assistants: None

Course Objective:

The purpose of this course is to teach the use of advanced probabilistic techniques to solve canonical problems of mobile robotics and autonomous systems. These problems include localization, map building, navigation and exploration. To this end we also need to investigate noisy sensor and actuator models. By the end of this course, you will have gained theoretical and practical application knowledge about the use of the Bayes Filter for estimation and its various implementations to solve these problems. Hopefully, you will be at a point to use this knowledge to advance your research goals or to find more competitive engineering solutions in your work.

Textbook:

Probabilistic Robotics, S. Thrun, et al., MIT Press, 2005

Other References (not exhaustive):

Principles of Robot Motion, H. Choset, et al., MIT Press, 2005

Estimation with Applications to Tracking and Navigation, Y. Bar-Shalom, et al., Wiley 2001.

Artificial Intelligence: A Modern Approach, 2nd Ed. Stuart Russel and Peter Norvig, Prentice-Hall, 2002

Prerequisites:

None officially. However, good background in probability theory, matrix algebra and linear systems would be very useful. A background in Estimation Theory would also help. C/C++, Python or Matlab will be possible implementation languages. Knowledge and use of data structures and competitive knowledge in any high level computer language would also be a valuable asset.

Tentative Schedule:

We consider the following tentative schedule. The following content is quite stable now but the ordering may still change.

	Tentative Content	Textbook Chap. Reference
1	Introduction, Probabilistic Robotics	1
2	Probability theory review, Probabilistic Estimation in robotics: The basics	Ch 2
3	Introduction to Localization. Probabilistic (kinematic) models of robot motion in the plane.	Ch 7, Ch 5
4	Probabilistic models for robot perception (noisy sensors and measurements).	Ch 6
5	Non parametric filters.	Ch 4
6	Particle Filters	Ch 4, 4.3
7	Monte-Carlo Localization.	Ch 4, Ch 8
8	The mapping problem. Occupancy Grid Mapping	Ch 9
9	Kalman Filters and Markov Localization	Ch 3, Ch 9
10	Overview of Simultaneous Localization and Mapping (SLAM). EKF-SLAM Approach.	Ch 10
11	Introduction to Probabilistic Control. Markov Decision Processes (MDPs)	Ch 14
12	Exploration	Ch 17
13	The FastSLAM Algorithm for Simultaneous Localizatic and Mapping	Ch 13

COURSE POLICIES AND GUIDELINES

Professional Behavior:

This is a graduate course. I will treat you as engineering professionals and will expect to see ethic and professional behavior in return. Honest behavior is of utmost importance. Remember that respect comes mutually. Unethical behavior will not be tolerated.

Class Web Site and Resources:

The class has a web site in METUCLASS: **http:// odtuclass.metu.edu.tr** Registered students and those that I will add to the class list will have access to the course content, notices and additional materials. You will have the chance to use the discussion forums to ask each other

general questions or to exchange ideas. Check the web-site to make sure you have access (end of registration) and check periodically so that you do not miss anything. Same professional behavior is expected in these forums as would be expected in-class.

Grading:

The course will involve in-class discussions, individual and group work, a number of homeworks (theory and programming), a term project, and a final examination. The contribution of the course work to grading is given below.

- In-class work and attendance: % 5
- Homeworks % 15
- Term projects–Intermediate Rep % 15
- Term Projects–Final Rep & Pres. % 25
- Final Exam % 40

In-Class Discussions and Group Work:

There will be in-class discussions and, occasionally, individual and group work to probe your understanding of the topics. You will sometimes work as teams (usually a pair of students) and submit one output with all names. You will share the same grade for the work you have produced. You are free to form your team and both persons will be expected to equally contribute. Team members will alternate in presenting their ideas and results. In-class work and homework may also be assigned for individual work.

Homeworks:

Homeworks will cover the theory and will involve substantial programming to practice the theory in a chosen simulation environment. The implementation medium will most likely be C/C++, Java, Python or Matlab. You will experiment with the algorithms explored in the course.

Term Projects:

Programming intensive (sometimes open ended) projects will be completed with teams of two students. You will have a chance to make a preliminary search, think about your desired area of research (if related with probabilistic robotics) and propose your own term project. The project topics may be chosen from later chapters of the textbook (that we will have less or no time to cover) or from recent research papers. When you have candidate project topics of interest, you should bring them to me for a preliminary discussion. The ideal project report should be of quality publishable in an academic conference.

The projects will require programming effort, written reports and a presentation. Implementation medium/language will most likely be C/C++, Python or Matlab and may also require some GUI design. The intermediate reports are to help you focus your effort and organize your timing. Final report and presentation will present all your work. In particular, the following will be expected:

- ***Intermediate report:*** Definition of the problem/task, Summary of previous efforts (papers, web references). An outline of what/how you will implement. What the outcome will look like? Performance measure planned. Work allocation for team members.
- ***Final report/presentation:*** Both a report will be submitted and a presentation will be given where both members will present I turn. *The report will have the double-column IEEE conference format*. There will also be a demo. You will include the definition of the problem, algorithmic details, some level of implementation details and the Work breakdown for team members. If the work is open ended and could not be completed within the course, then a convincing plan of how it can be finalized.

- **Quality of Reports:** You are considered to be engineering professionals. You will be expected to present a well structured, quality report that has

an introduction and conclusion as well as all the relevant information and results in a well organized manner. If you are not familiar with a well written document format, please examine published papers from journals and conferences. The report will have double-column IEEE Conference format and should contain all the extra details that might be left out of the presentation. There is no upper page limit but 10-15 pages (double column) for the final report is a good guide.

- **Presentations:** You will present the material in a 15-20 minutes PowerPoint presentation (electronic). There will be an additional 5 minute period for questions. Another 5 minutes will be allocated for term project demonstrations. Each team member will present a section of the presentation and they will answer the questions together. The time and place for the presentations will be announced later in the class web site.

- **Term Project Programs/Demos:** You will be expected to produce a presentable program or model to solve the problem that you have chosen. This may have a concise but functional GUI interface that makes all the relevant points/results about the task clear. Basic GUI work is possible with reasonable effort in any computer language. Over-polished interfaces are not necessary and will not be considered as a contribution. You are all intelligent people. If you feel good about it, then the chance is high that it will be of acceptable quality. Source package of your work (in zipped format) as well as all support materials will be submitted electronically together with your reports in a well organized zip file through Metu-Class.

- **Submissions:** The date for submitting the intermediate term project reports will be announced later at the course web site. Final reports will be submitted some time before the date for the presentations (again to be announced). The reports will be submitted electronically together with all working code and sources. Late submissions are strongly discouraged. They will be graded at most %80 of full value for up-to 2 days late and %50 full value for up-to a week late. Reports later than that will not receive any credits.

- **Operational Program:** Your output should consist of a program that includes all necessary libraries and should operate on your demo computer (most likely a laptop) during your demo. If there are additional requirements that you cannot overcome, you should come and speak to me in advance.

Policy on Collaboration:

You will work in teams and will be expected to contribute equally to the team's performance. Collaboration between teams is possible out-of-class at a level where general ideas and algorithms are discussed. In-class discussions will be a necessary part of the class. Cheating, copying work from each other or from the web without citation will not be tolerated. Remember that I am not that bad in searching the web!

Good wishes note:
This is a rich, mature and exiting field. I hope you will enjoy it as much as I enjoy teaching it. Good luck and have a nice fall term.