

## Engineering Tripos Part IIB, 4I15: Mobile Robot Systems, 2020-21

### Leader

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### Lecturer

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### Timing and Structure

Lent term. Lectures and coursework. Assessment: 100% coursework.

### Prerequisites

4M20 useful; 3F2 useful; 3F3 useful

### Aims

The aims of the course are to:

- This course teaches the foundations of autonomous mobile robots, covering topics such as perception, motion control, and planning.
- It also teaches algorithmic strategies that enable the coordination of multi-robot systems and robot swarms.
- The course will feature several practical sessions with hands-on robot programming. The students will undertake mini-projects, which will be formally evaluated through a report and presentation.

### Objectives

As specific objectives, by the end of the course students should be able to:

- understand how to control a mobile robot;
- understand how a robot perceives its environment;
- understand how a robot plans actions (navigation paths);
- know paradigms of coordination in systems of multiple robots;
- know classical multi-robot problems and their solution methods;
- Know how to use ROS (Robot Operating System, <http://www.ros.org>).

### Content

- Robot motion and control. Kinematics, control models, trajectory tracking
- Control architectures. Sensor-actuator loops, reactive path planning
- Sensing. Sensors, perception
- Localization. Markov localization, environment modeling, SLAM
- Navigation. Planning, receding horizon control
- Multi-robot systems I. Centralization vs. decentralization, robot swarms
- Multi-robot systems II. Consensus algorithms, graph-theoretic methods
- Multi-robot systems III. Task assignment
- Multi-robot systems IV. Multi-robot path planning.

## Further notes

### Requirements:

Students are expected to have laptops running Linux, with installations of ROS Kinetic and Gazebo. An installation guide will be provided.

## Coursework

Students will be expected to hand in two reports and attend an individual questioning session.

| Coursework                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Format                                             | Due date<br>& marks                                 |
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| <p><b>[Coursework activity #1 : Assignments]</b></p> <p><u>Learning objectives:</u></p> <p>The assignments will consist of two elements: (1) experimental work using a robot simulator and real robots, and (2) theory / understanding. The exercises will require data collection and analysis. The balance between practice and theory will depend on the exercise topic. Each student will submit a written report.</p> <p>Each assignment will be marked on a scale of 0-100, and will compose 30% of the mark.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <p>Individual Report</p> <p>anonymously marked</p> | <p>February 2021</p> <p>60% (30% ea assignment)</p> |
| <p><b>[Coursework activity #2 : ]</b></p> <p><u>Learning objectives:</u></p> <p>A set of proposals will be announced at the start of term. Students will form groups of 2-3 and select a project proposal. Each proposal will include a core and a set of extensions; Engineering students will be expected to complete the extensions.</p> <p>The project will compose 40% of the mark and will be evaluated on a scale of 0-100. It will be handed in as group-work in groups of 2-3, and the report will clearly state what each group member contributed. The overall project mark will be composed by a report score (60%) and a presentation score (40%). Project marks will reflect the contribution of each team member. Every team member is expected to make a similar, significant contribution to the project, and where this happens all team members will receive the same mark. The report requirements will differ for students. Engineering students will hand in 6-page double-column report (conference-formatted)</p> | <p>Individual Report</p> <p>anonymously marked</p> | <p>April 2021</p> <p>40%</p>                        |

## Booklists

Siegwart, R., Nourbakhsh, I.R. & Scaramuzza, D. (2004). *Autonomous mobile robots*. MIT Press.

Thrun, S., Wolfram B. & Dieter F. (2005). *Probabilistic robotics*. MIT Press.

Mondada, F. & Mordechai B. (2018) *Elements of Robotics*. Springer

Siciliano, B. & Khatib, O. (2016) *Springer handbook of robotics*. Springer.

Mesbahi, M. & Egerstedt, M. (2010) *Graph theoretic methods in multiagent networks*. Princeton University Press.

## Examination Guidelines

Please refer to [Form & conduct of the examinations](#) [4].

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## Links

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