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

### Leader

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### Lecturer

Dr A Prorok [1]

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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

- [redacted]
- *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 & marks |
|---|---|---|
| **[Coursework activity #1 : Assignments]**<br><br>Learning objectives:<br><br>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.<br><br>Each assignment will be marked on a scale of 0-100, and will compose 30% of the mark. | Individual Report<br><br>anonymously marked | February 202<br><br>60% (30% ea assignment |
| **[Coursework activity #2 : ]**<br><br>Learning objectives:<br><br>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.<br><br>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) | Individual Report<br><br>anonymously marked | April 2021<br><br>40% |

## 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**
[1] mailto:asp45@cam.ac.uk
[2] mailto:fi224@cam.ac.uk
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