Signals, Instruments and Systems 2019-20
Course Projects

1 General information

SIS will involve a 60 h course project (this should include reading, implementation, reporting, and oral defense of the project). Students will choose a project from a list of two approved topics distributed at the beginning of Week 8. Projects will be carried out in groups of two students. Each member of the student team will have to defend part of the project in front of the audience. Each project will be supervised by two TAs (Chiara Ercolani, Faezeh Rahbar, Anwar Quraishi and Kagan Erunsal). The definitive assignment of project topics and team members will be communicated by the end of Week 8, based on the preferences expressed by the students. During the lecture hours of Week 9, a kick-off session for the implementation of specific course projects will be organized by the project supervisors and will involve all the teams working on the very same topic.

Students will be required to submit a brief intermediate report on their project progress by the end of Week 11, showing a clear understanding of the project topic and its related literature, a concrete implementation plan in terms of time, task breakdown and role of each member, familiarization with the needed tools, and preliminary implementation results. This will allow their project supervisor to give them feedback in terms of implementation progress, problem and tool understanding, and time planning. The concepts learned during the course will help the students to find solutions to the tasks required for achieving the project goals. Students are asked to reason about the decisions and choices made during the project and show the effectiveness of their methods by repeated experiments and therefore statistically significant results. Students are encouraged to start from a carefully thought-out plan that takes into account the system requirements, limitations and constraints, sources of noise, etc.; it should leverage simple software abstractions (e.g., flowcharts, behavioral blocks) and tentative performance evaluation metrics. This plan should be included in the intermediate report mentioned above. For each project, a reference document will be provided by the project supervisor on the same topic, to help the students gain a deeper understanding of the concepts behind the project. This document, can serve as an example of how the final report is expected to be. Further details on the intermediate report, project report and presentation will be communicated in timely fashion.

2 Key dates / milestones

Week 8/April 6: Distribution of this course project list.
Week 8 / April 8: Send project / team preferences to Head TA (see instructions below)
End of Week 8: Assignment of projects / teams
Week 9 / April 23: Kick-off session during lecture hours
Week 11/May 1: Interim report is due
Week 14 / May 24: Final report due
May 26/28: Presentations

3 Topic list

1. Line following using the e-puck's camera

In this project, an e-puck robot is given the task to follow a line drawn on the ground. The robot should detect the line using its built-in camera. The line following behavior should

be continuous and robust to obstacles placed on the line. The project will be carried out in Webots, with a simulated robot and camera, where your aim is to implement a perception-to-action loop: image acquisition, processing, and robot actuation. By processing the camera image, you will detect the direction of the line, which you will be able to follow using a controller for the robot's differential wheel speeds. Afterwards, an obstacle will be added on the line and an appropriate avoidance method needs to be included in the control algorithm. In order to design a controller robust to various line qualities (e.g., different thickness and continuity) and type of obstacles (e.g., round/square, convex/concave), localization techniques can be leveraged to achieve an improved performance. The project will therefore involve the implementation of odometry-based localization which combined with exteroceptive features will allow the robot to achieve additional robustness and possibly efficiency in solving the task. Before inserting the on-board localization module in the line-following behavior, its performance should be assessed by comparing it with ground-truth position implemented at the supervisor level. Students should provide statistics on how well their robot is performing while executing the overall task and corresponding sub-tasks. Bonus points will be awarded for implementations in more complex environments.

2. Road sign recognition with the e-puck robot

An e-puck robot is given the task to read and analyze a simple "road sign" (e.g., black stripes on a white background). The e-puck should read the sign with its camera, analyze the picture on board, and decide what action to perform; for instance, turn left if the stripes are horizontal and right if they are vertical. The students will implement their algorithm with a simulated e-puck and several signs in the robotic simulator Webots, and make sure that it works reliably with clear signs and a simple maze. Afterwards, the algorithm robustness should be tested on signs of degraded quality (e.g., different thickness, line continuity, inclination) and maze complexity. Localization capabilities might help the robot to achieve an improved performance, especially in such degraded settings. The project will therefore involve the implementation of odometry-based localization which combined with exteroceptive features will allow the robot to achieve additional robustness and possibly efficiency in solving the task. Before inserting the on-board localization module in the overall behavior, its performance should be assessed by comparing it with ground-truth position implemented at the supervisor level. Students should provide statistics on how well their robot is performing while executing the overall task and corresponding sub-tasks. Bonus points will be awarded for implementations in more complex environments.

4 Choosing a topic and team

Students should indicate an order of preference (1-2) for the projects above. All teams should consist in principle by two students. Multiple teams for a given project topic are allowed (with a balance between topics). If students wish to work with other specific teammates, a team representative should communicate this information as well, copying the other teammate. All these preferences should be emailed to chiara.ercolani@epfl.ch with the subject "*SIS course project preferences*". **The deadline for the choice of projects is Wednesday April 8, 12h00.** Note that after this date we will start assigning projects and students in teams independently of whether we received all the preferences.