Signals, Instruments, and Systems 2020-21
Course Projects

1 General information

SIS will involve a 60h 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 7. 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 of the four TAs (Hugo Grall, Cyrill Baumann Anwar Quraishi and Kagan Erunsal). The definitive assignment of project topics and team members will be communicated by the end of Week 7, based on the preferences expressed by the students. During the lab hours of Week 8, a kick-off session for the implementation of each course project 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 team 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 by Week 8, 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 7 (October 28): Distribution of course project list
Week 7 (October 30, midnight): Send project/team preferences to Head TA (see instructions below)
Week 7: Assignment of projects / teams
Week 8: Distribution of reference project documents
Week 8: Kick-off session during lab hours
Week 11 (November 30, midnight): Intermediate report is due
Week 13 (December 12, midnight): Final report is due
Week 14 (December 15-17): Presentations

3 Topic list

1. Line following and localization with the e-puck robot

In this project, an e-puck robot, simulated in Webots, is given the task to follow a line drawn on the ground while localizing itself in a confined environment. The robot should detect the line using its built-in camera. By processing the camera image, you will detect the direction of the line, which you will be able to follow using a controller by driving the robot's differential wheel speeds. In other words, you will implement a perception-to-action loop: image acquisition, processing, and robot actuation. The line following behavior should be robust to the obstacles and discontinuities placed on the line. Therefore, another task is to implement an appropriate avoidance method in the control algorithm. Finally, you also would like to make sure that the robot can estimate its location while navigating, so a localization technique based on odometry and exteroceptive sensing (i.e. exploiting environmental features and a sparse a priori known map of their location) should be leveraged. The obstacles can be detected using the proximity sensors and the camera. The robot's performance will be evaluated by two dedicated metrics associated to its localization and navigation capabilities. While the navigation metric will reveal the accumulated deviations between the line and the robot's actual trajectory as well as assess the overall time needed to follow the line, the localization metric will show the accuracy of the simulated robot in estimating its own pose during the mission. Note that the navigation algorithm should be robust to various line qualities (e.g., different thickness and continuity) and type of obstacles (e.g., square, rectangle with different sizes). You can utilize the implemented localization technique to improve the navigation performance (e.g., when the robot encounters a discontinuity and cannot detect any further feature with its exteroceptive sensors, it might rely on localization). Students should provide statistics on how well their robot is performing while executing the overall task and corresponding sub-tasks.

2. Road sign recognition and localization with the e-puck robot

In this project, an e-puck robot, simulated in Webots, is given the task to escape from a maze by reading and analyzing road signs while localizing itself inside the maze. The robot should sense the road signs by using its built-in 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. In other words, you will implement a perception-to-action loop: image acquisition, processing, and robot actuation. The robot's navigation through the maze should be robust to walls. Consequently, another task is to implement an appropriate avoidance method in the control algorithm. Finally, you also would like to make sure that the robot can estimate its location while navigating, so a localization technique based on odometry and exteroceptive sensing (i.e. exploiting environmental features and a sparse a priori known map of their location) should be leveraged. The road signs can be detected by using the proximity sensors and the camera. The robot's performance will be evaluated by two dedicated metrics associated to its localization and navigation capabilities. While the navigation metric will reveal how many correct actions have been taken and the time invested to escape from the maze, the localization metric will show the accuracy of the simulated robot in estimating its own pose during the mission. Note that the navigation algorithm should be robust to the road signs of degraded quality (e.g., different thickness, line continuity, inclination) and maze complexity. You can utilize the implemented localization technique to improve the navigation performance (e.g., how to turn exactly right or left, how to stop at the exact same distance from a road sign). Students should provide statistics on how well their robot is performing while executing the overall task and corresponding sub-tasks.

4 Choosing a topic and team

Students should indicate an order of preference (e.g., 1>2) for the projects above. All teams should consist of two students. Multiple teams for a given project topic are allowed (with a balance between topics). If a student wishes to work with another specific teammate, a team representative should enter both names into this excel sheet. **The deadline for expressing preferences is Friday October 30, 24h00.** Note that after this date we will start assigning projects and students in teams independently of whether we received all the preferences.