Signals, Instruments and Systems 2018-19
Course Projects

1 General information

SIS will involve a 45h course project (this should include reading, implementation, reporting, oral defense of the project, and review of the report of another student team). Students will choose a project from a list of approved topics distributed during Week 5 of the semester. Projects will be carried out in groups of three students (an ad hoc arrangement will be found in case of total number students not divisible by three). 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 TAs (Alicja Wasik, Faezeh Rahbar, Chiara Ercolani and Cyrill Baumann). The definitive assignment of project topics and team members will be communicated by Week 7, based on the preferences expressed by the students. After the lecture of Week 8, a kick-off session for the implementation of specific course projects will be organized by each project supervisor 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.

Each student will also be asked to serve as a reviewer for another student project and invited to ask questions during the defense session. Further details on the intermediate report, project report and presentation will be communicated in timely fashion.

2 Key dates / milestones

Week 5: Distribution of this course project list.
Week 6 / March 25: Send project / team preferences to Head TA (see instructions below)
Week 7: Assignment of projects / teams
Week 8 / April 11: Kick-off session after lecture
Week 11: Interim report is due
Week 15 / June 2: Final report due
June 5: 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. You will start with Webots, with a simulated robot and camera, to develop your baseline 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. Then you will deploy the developed algorithm on the real e-puck. A third stage will be done in Webots, where an obstacle avoidance method needs to be included. You should compare the performance of the baseline line-following algorithm with the two other algorithmic variants (that deployed and possibly customized for the real robot, and that able to handle obstacle perturbations on the line in simulation).

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 have to carry out the project in two phases. In the first phase students will implement their algorithm with a simulated e-puck and several signs on Webots, and make sure that it works reliably in simulation. For the second phase, students will apply their algorithm to a real e-puck robot, where they will improve their method to cope with real-world phenomena not properly captured in simulation. A qualitative comparison between the implementation in simulation and reality is therefore expected, supported by appropriate rationale for possible differences. The e-puck is already programmed to take a picture and send it to a host PC; students will also be provided with a simple Matlab script which will allows them to visualize the picture taken by the robot. The resulting algorithm's performance will be tested in terms of decisional robustness and speed, under fixed constraints (i.e. arena size, path, and sequence of road signs).

3. Finding a light source with an e-puck robot

In this project we plan to find the source of light (in a real deployment could be also any other electromagnetic radiation source) which is located somewhere in an arena that includes obstacles (e.g., in a real deployment walls, rocks, and other debris), using an e-puck robot. Your task is to design a controller for the robot to find the source of the light as fast as possible, using the belt of light sensors available on the e-puck (i.e. the light receiving component of the proximity sensors). You may use the gradient of the light field to guide the robot, but with so many obstacles around you will need to be careful in not getting stuck in dead ends. You will start implementing your algorithm in a simulated environment using Webots. Afterwards you need to deploy it on a real e-puck robot in a realistic environment using a lamp as the light source, and compare the possible differences between the real-world experiments and the simulations. The performance of your algorithm will be measured by the time it takes to find the source for a given set of initial conditions and arena layout.

4. Limitations of the e-puck's accelerometer to detect earthquakes

We plan to deploy a set of cheap sensors (the e-pucks) to detect earthquakes. In this project, you will focus on the accelerometer available on the e-puck. The goal is to characterize the sensor's response to different stimuli, process the response to filter out a specific pattern, and validate its use to detect earthquakes. You will first start on Webots by characterizing and obtain data from the accelerometer of the e-puck in the presence and absence of earthquakes. You will have to simulate an earthquake and/or its produced waves by means of using the Webots supervisor. Afterwards you will move to the real e-puck. You will need to gather real-time data and analyze them to understand the performances of your available accelerometer. Finally, you will need to evaluate and draw conclusions on your procedure's usability to spot earthquake's primary and secondary waves (P-waves and S-waves), and compare the real data obtained with that in simulation. The performance of your algorithm will depend on the quality of your data gathering and processing procedure resulting in robust and precise detection of a specific vibration frequency (e.g., the vibration of your mobile phone).

4 Choosing a topic and team

Students should indicate an order of preference (1-4) for the projects above. All teams should consist in principle by three 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 two other teammates. All these preferences should be emailed to alicja.wasik@epfl.ch with the subject "*SIS course project preferences*". **The deadline for the choice of projects is Monday March 25, 18h00.** Note that after this date we will start assigning projects and students in teams independently of whether we received all the preferences.