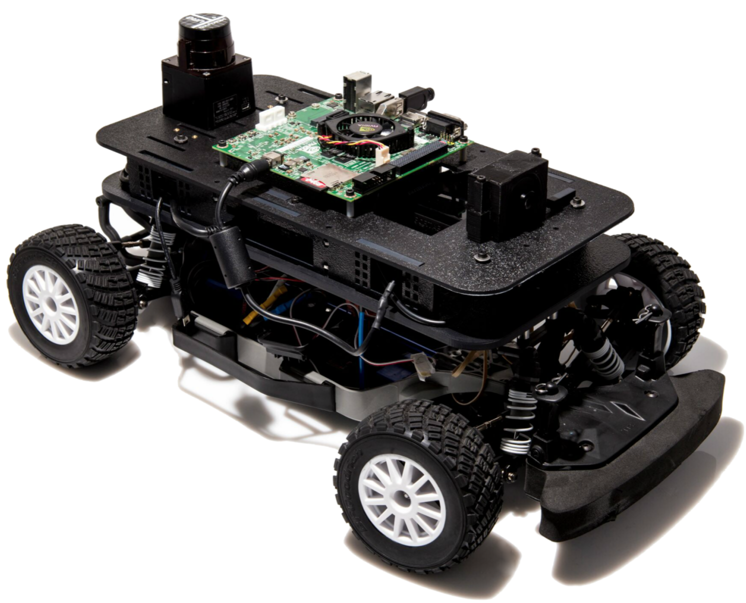
Project proposals 2018

Projects in Automatic Control (FRTN40)

October 22, 2018

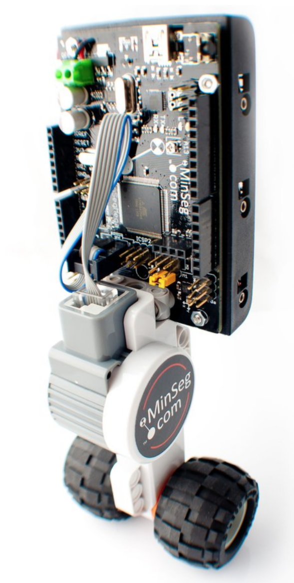
1 Autonomous Driving (f1tenth-drive)

This project's task is to write a trajectory controller for an autonomous 1/10th scale F1 racing car (http://f1tenth.org/). The car is programmed using the Robotic Operating Systems (ROS), with the objective of driving on a path and keeping a prescribed distance from a wall. The car is equipped with a LIDAR sensor to obtain information about the environment and integrate the received information with a path planner to follow a predetermined trajectory in the smallest possible time. The project also includes an additional goal to be discussed: one example could be to stop at a semaphore red light using a camera, another alternative is the use of model predictive control for the trajectory planning.



2 Choreography (minseg-choreo)

This project's task is to use four MinSeg (https://minseg.com/) and a camera to create a coreography. The segways are marked with a coloured dot of different colors, to distinguish between them. The camera captures the image and sends it to a computer, where the image is processed. The computer sends - via bluetooth - commands to the segways to create a coreography.

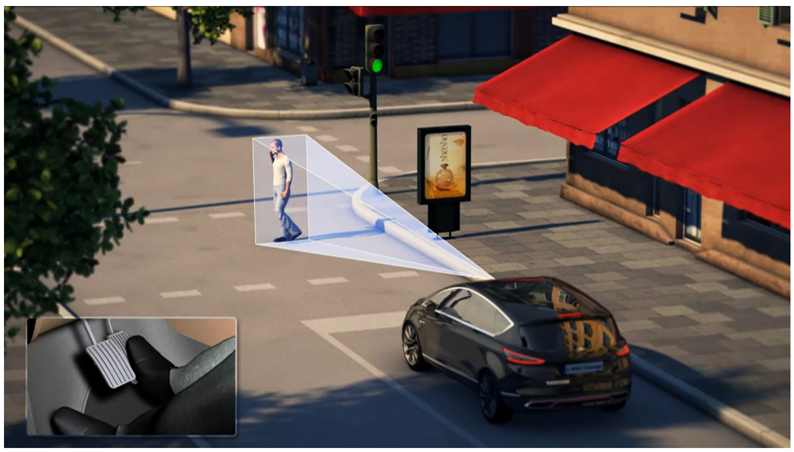


3 Autonomous Parallel Parking (Lego)

Autonomous vehicles has grown in popularity over the last couple of years. Some of the applications seldom mentioned are the smart-driving aids such as parking, automatic breaking, motion sensing, etc. In this project, your objective will be to park a semitrailer by backing up into a parking space. Using a birds-eye-view camera as one of the main sensors you could control the semitrailers movement into the parking spot (without hitting nearby objects). You are free to come up with another clever solution to this problem.

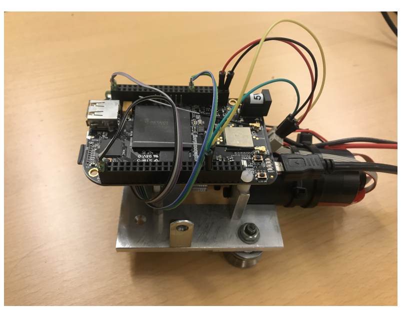
4 Obstacle Avoidance (Lego Trailer)

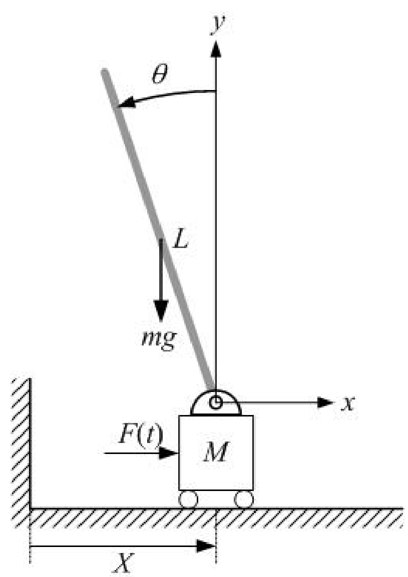
In contrast to the parallel parking lego trailer, this lego trailer should try not to stop. Following a given path (driving backwards or forwards), your objective is to make the semitrailer arrive to its destination, avoiding objects appearing in its path. Image analysis, modelling, and control are some of the things this project contains. If you have an alternative problem formulation, you are free to explore that one.



5 Linear Pendulum

The department has a prototype for a future lab process, consisting of a linear rail, woth a motorized cart. The position of the cart along the rail is measured with quadencoder, and there cart is driven by a DC motor. In this project, a pendulum, with angular encoder will be added to the cart. Sensing, control and actuation are handled by a Beaglebone black module with wireless capabilities. The objectives of the project are: 1) Model and control the cart to stabilize an inverted pendulum; 2) wite PC software for logging and real-time visualization of measurement and control signals; 3) document the model and implementation so that it can be integrated as a lab in one of the department's advanced level courses.





6 Robot Control (Robot Arm)

This project is for the group who wants a challenge and who has a mutli-field interest. You will have to handle everything from real-time systems, servo-control, image analysis, and robot trajectory planning. You are free to develop your own project but as an encouraging (and suggested) example, last year a group tried to catch balls thrown to the arm (that project is available). Advisably, you will start with a 2D-problem and (if that goes well) move over to the more difficult 3D case.

7 Lego Segway Robot

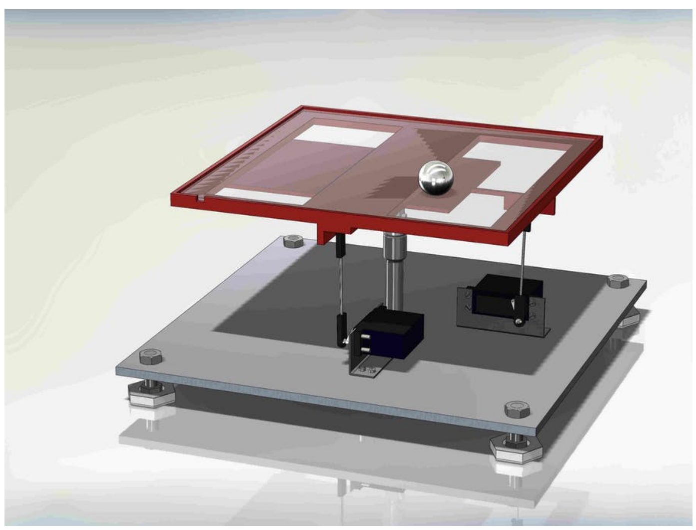
In this project you will build a segway robot using Lego Mindstorms, see Figure **??** which is the design of a previous year's project. Using servo-motors to turn the wheels and the Mindstorms brick as a micro controller, your task is to make the robot balance. There are several libraries developed to program the brick (e.g. `LeJOS` for Java and `RobotC` for C), and you are free to pick any you prefer. You are also free to build and design the robot however you like, but keep in mind that your design in the end will determine how easy it is to control...

As a first step you should be able to make the robot balance and be able to reject disturbances (e.g. it should be able to re-balance itself after a small push). When your design can handle this, you should implement sending references for speed and turning rate over bluetooth, so that you can drive the robot.

8 Ball and Plate

In this project you will build and program a ball and plate process, see Figure **??**. Two servo-motors will be used to adjust the tilt of the plate in two directions to steer the ball to its reference. The control algorithm will be implemented on an Arduino or Raspberry Pi. To measure the position of the ball, you can either use a resistive touch panel as a plate, or you can mount a camera above the plate and use e.g. OpenCV for image processing and tracking.

As a first step you should be able to balance the ball at a fixed reference, and be able to reject disturbances (i.e if you push the ball it should return to its reference as fast and smoothly as possible). Once your design can handle that, you should be able to make the ball follow given trajectories (e.g. circles, squares, figure eights...).



9 UAV Control

10 UAV Attitude Estimation

11 XC05 Adaptive Controller

The MC XC50 from First Control [1] is one of very few industrial controllers on the market today that actually implements adaptive control algorithms. In this project you should try to use the XC50 for rapid prototyping and control of a nonlinear process, like the ETH Helicopter. You should model the process using the Modelica language [2] in (e.g.) Dymola [3]. The model can then be exported to the XC05 development and simulation environment.

The XC05 should be used to control the nonlinear process model in simulation mode, testing one of the adaptive control algorithms. After successful simulation, you should then try to control the real process and evaluate the results. Can the controller adapt its parameters to different operating points?

The project will be of exploratory nature. The goal is to try out a few features and evaluate how easy it is to model and program an adaptive control system using the XC50.

It is valuable if at least one group member has taken the Predictive Control course.

N.B.: You must have your own laptop with Windows on it to program the XC50 and to run the interactive simulations and experiments.

[1] `http://www.firstcontrol.se/embedded-systems`

[2] `https://en.wikipedia.org/wiki/Modelica`

[3] `https://en.wikipedia.org/wiki/Dymola`

12 Batch Process in Continuous Mode

The Batch Process is a multivariable laboratory process developed at the department (see the project manual [1]). It features a number of actuators: two pumps (one for the inlet and one for the outlet), a heater, a cooler, and a stirrer (agitator). The sensors can measure the liquid level and the temperature in the tank. In this project you will explore the possibility to run the tank in continuous mode, thereby emulating a so called Continuous Stirred Tank Reactor (CSTR).

Using system identification experiments and/or mathematical modeling, you should model the liquid level dynamics and temperature dynamics of the tank when it is operating with a small and constant continuous flow. A simulated endothermic or exothermic chemical reaction can then be added to the model, to make the control problem more interesting.

It is valuable if you have taken either of the courses Multivariable Control or Systems Identification, but by no means necessary.

[1] `https://www.control.lth.se/media/Education/EngineeringProgram/FRT110/2015/manual2015_eng.pdf`