Project Description

The project this year is about platoon-based cleaning.

Platooning is an important focus of research for autonomous vehicles and cooperative robots. As in past years, the platooning aspect of the project is based on the Grand Cooperative Driving Challenge (GCDC), an international cooperative driving contest held between University teams, coordinated by the iGAME consortium (companies TNO in Holland and IDIADA in Spain, Eindhoven University of Technology (TU/e), and the RISE Viktoria research institute in Sweden) which occurs every few years and which Halmstad University won in 2016. One way in which platoons can be used is for cleaning in a quick manner. For example, platoons of snow machines are used at some ski resorts, and groups of snow plows in streets are often used to remove snow. After disasters such as earthquakes, fires, floods, or landslides there can also be much debris which requires teams to remove quickly. Moreover we can imagine teams of lawn mower robots removing grass from large open areas or the sides of highways, and vacuum cleaner robot teams quickly cleaning. Thus, the project is aimed to help prepare HH students to do research and development in designing embedded and intelligent systems such as robots or autonomous vehicles for some useful applications.

To deal with this complex challenge requires expertise from embedded, intelligent, and communication backgrounds and several robots, so students will form groups which will each develop a robot. In forming groups, each group should have at least one student with an embedded, and one student with an intelligent systems background (preferably it would be nice to also have a student with communication background); groups should also consist of students with a similar level of knowledge/expectations for grades. Students will get the chance to form their own groups but the course responsible might reassign group members based on these criteria.

Also, one robot will be provided to each group. Each robot will have infrared light sensor arrays pointed downwards to follow tracks, a forward-facing camera to do more complex sensing, encoders attached to its wheel shafts, and possibly other sensors such as infrared range and ultrasound sensors. Additionally robots will be able to receive some positioning information from a ceiling mounted camera, simulating GPS. For actuation each robot will have two wheel motors, and possibly other actuators which each team might wish to attach. Processing will be conducted with a microcontroller (Arduino) for low level tasks, a small computer (Raspberry Pi) running Linux with Wifi for some higher level tasks, and possibly an additional external computer if needed (project PC) for commands, debugging, or heavy calculations. Communication will be conducted with robot operating system (ROS) as a basic framework, which is designed to handle cases with multiple robots sending much information. Time synchronization among vehicles might be something to think about. Communication between robots and infrastructure will take place on the "RobotC1" network. (Students will also be able to use "eduroam" to download software.) The robots will run on top of a 1.8 x 2.4 meter table on E1, probably with four tracks. Additionally, for fun, paint brushes will be attached to the robots as they clean in a platoon on the last tollgate event to create an "artwork", to be submitted to the international robot art competition (robotart.org).

Example of a platoon cleaning snow.

HH students winning 1st at GCDC 2016

Tollgates

The student's engagement and progress in their project will be monitored by a set of "examination events" (tollgates). At these the student as part of their project group will report about their achieved results orally as a presentation (EX-1), by practical demonstration of results (the robots will be videotaped in EX2-5), and in a written report (EX-6). The tollgates together also will be used to determine the student's grade for the project (half of the grade for the course). To get a grade of 3, a student is expected to complete all basic tasks for all tollgates; for 4 and 5, a student should also complete all additional tasks described below.

EX-1 (w38: 9/19-23): System modeling.
Grade 3:
Oral presentation with powerpoint slides, and short written report within a week, specifying:
(1) functional and non-functional requirements (system and contents)
(2) a proposed system architecture/design with requirements and models for each task.
Grade 4:
+(3) an initial idea provided for each student's research step
+(4) a question about each of the other groups' presentations in the report
Grade 5:
+(5) clean/clear dissemination, with no spelling mistakes
+(6) comprehensive: uses various diagrams (e.g., those described in the course lectures) and considers various aspects: stakeholders, priorities, etc.
+(7) trade-offs for design choices should be compared

EX-2 (w42: 10/17-21): Basic robot behavior.
Grade 3:
(1) Each robot kit should be assembled, with a raspberry pi on standoffs connected to an arduino, and a shovel attached.
Furthermore capability to perform basic tasks should be demonstrated:
(2) driving along a lane
(3) sending and receiving a message via ROS to another robot
(4) accessing position data from the "GPS server" (overhead camera system)
Grade 4: +(4) driving, for a specified distance (~2m) using calibrated dead counting
Grade 5: +(5) comparing driving for a set distance using encoders vs. GPS

EX-3 (w44: 10/31-11/4): More complex robot behavior.
Grade 3:

Robots should demonstrate complex behavior:
(1) changing lanes (right to left and left to right) when commanded
(2) driving diagonally behind a "robot" on a different track (e.g., 50cm)
Lead "robots" can be simulated with a spiral stuck to a stick or cardboard box, etc.
Grade 4: +(3) driving directly behind another "robot" at a fixed distance (e.g., 20cm, 50cm)
Grade 5: +(4) changing lanes automatically when there is a construction sign, "human", or tree
(images of signs, humans, and trees can be used; the robot's camera can be used for detecting)

EX-4 (w46: 11/14-18): The "research" step.
Grade 3:
Each team member from the embedded, intelligent, and communication areas should themselves
conceive of, implement and demonstrate something in their specialization. For example:
-an embedded student could add electronics (e.g., a sensor like ultrasonic or actuator like LED
brakelights)
-an intelligence student could prepare an algorithm (e.g., probabilistic positioning or estimating
distance to another robot via computer vision)
-a communication student could implement a messaging system (e.g., using sockets or ROS)
This task is intended to prepare students for research, in which it can be the case that neither the
interesting problems nor possible solutions are known to anyone. Synergies with other students can
be explored and we will offer some typical electronics parts (e.g., sensors, LEDs, resistors).
Grade 4: the work is creative (novel/relevant)
Grade 5: the work uses excellent methodology (robustness, generality, challenge, etc).

EX-5 (w48: 11/28-30, 12/1-2): Final demonstration including all groups.
Grade 3:
(1) as part of a platoon, the robot should be able to drive diagonally behind others to clean the tracks
Snow on the tracks will be simulated, possibly with some colored styrofoam.
Furthermore, as a final event, we will add paint brushes to the robots to show where each robot has
passed/cleaned, and paint on top of a large canvas on the table.
The resulting painting will be submitted to the robot art competition (robotart.org). If any prize is
won, 70% will go to a charity chosen by the class by voting (final authority: course responsible), 20%
to the university, and an equal share of the remaining 10% to each student.
Grade 4: +(2) as part of a platoon, the robot should be able to expand out from a single file formation
to the diagonal cleaning formation, and back to single file
Grade 5: +(3) the robot can enter into the middle of a platoon of robots traveling in single file.
Furthermore, as part of a platoon, the robot can slow down or speed up to create space for another
robot to enter the single file.

EX-6 (w02: 1/9-13):
Grade 3:
(1) The student's group will also submit a written report summarizing all work on the project,
including original discussion and reflections about experiences and achieved results, including
limitations and what might be done differently in the future.
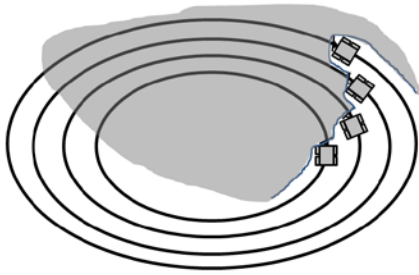Grade 4:
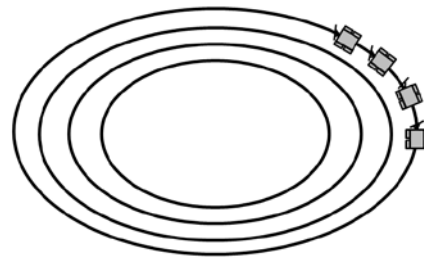(2) + Creativity
Grade 5:
(3) + Excellent methodology.

OTHER:
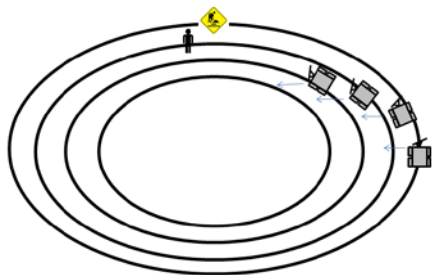**Note, there is also an oral exam which will check conceptual knowledge.**

Questions about the project can also be asked during the oral exam.

Example of four robots in a diagonal formation on the tracks on the table on E1 to clean "snow" (gray).

Example of robots in a line formation, travelling to a place where snow removal will be needed.

Example of robots changing lanes to avoid a construction sign and a human.