Project: Snake-like robot

# Group

The group consists of three members that studies Automation. The members are as follows;

* Håkon Bjerkgaard Waldum
* Ruben Svedal Jørundland
* Marcus Olai Grindvik

All members have a broad knowledge of different subjects. Two of the members (Håkon and Marcus) has gone through an apprenticeship and has a lot of experience from working. Marcus has completed an apprenticeship as an electrician, and has worked on boats connected up electrical systems. Håkon has completed an apprenticeship as an Automatician, and has worked with service and maintenance on different types of CNC 5-axis machines.

Ruben has no formal education, but has done a year in the military, and has a broad knowledge of programming from different private projects.

# Project assignment

The assignment chosen is the Modular Robot Locomotion Control, as in a snake like robot built from several modules (hereafter referred to as “snake”). The goal of the project is to make the snake find an object in a modular maze, with the help of a overhead camera to see the maze (but not the object), and a front-mounted camera to actually find the object. We will also want to implement remote controlling/monitoring to see what the snake does.

# Goals of the project

The project has several goals that we want to fulfill, these are as follows:

* Move freely with turning, flipping in addition to normal locomotion control
* Use front mounted camera to detect the wanted object
* Using top-mounted camera to see the maze
* Use top-mounted camera to create pathfinding
* Finding the object in a maze
* Remote control/monitoring of the snake
* Logging its movements through the maze

# Work structure

We will assign different parts of the projects to each other to have as a main focus, but will assist each other where necessary to be able to complete the project both well and in time.

## Project structure

The project is divided into three parts:

* Mechanical
* Software
* Testing

## Mechanical

The mechanical part is based on Houxiang Zhang’s concept of the snake, there has been some few changes to his concept, but because it is so heavily based on his concept the fast prototyping is not seen as that necessary.

Ruben will take lead on the modelling and printing of the mechanical parts, while Marcus will take the lead on electrical parts of the building phase.

## Software

The software part will be divided into 6 parts:

* Locomotion
* Image processing
* Communication
* Pathfinding
* Remote control/monitoring
* Logging of data

The first part of the software will be to get the locomotion down. Get it to move efficiently and be able to traverse different terrains and obstructions. This will be done in cooperation with the image processing to apply this to the movement.

The next part of the process will be to get communication down between the ESP32 and the computer that does the processing of images, pathfinding etc. Here we are planning to use UDP to communicate.

After all this is done we come to the pathfinding, which will be the most difficult part of this task. We will use the feed from the top-mounted camera to see the maze (but not the object) and create pathfinding for the snake to use.

To ensure that we can “help” the snake if need be, we will also create remote controlling to be able to take control of the snake to adjust if the need arises, this will happen through UDP as well. We will create a simple GUI for this to be able to be done. This GUI will also be used for remote monitoring of the snake.

Through all this we will create a simple logging feature which will log the commands sent to the snake from the pathfinding-algorithm. This is to be able to analyze what’s been done and what the result of this pathfinding became.

## Testing

The last part of the project will be the rigorous testing. We will of course test the snake as we go, but after we see the project as “done”, we will rigorously test the project to see that it can perform as we expect, and do it several times in different kinds of mazes.

# General overview of how the project will work

Here we will explain the general thought of how the project will work in practice. What components will be involved as well as how things will work together.

## Mechanical

The snake will consist of 5 modules, where each module will have a servo inside it to control the angle. The foremost module will have a camera mounted on it, to be able to do the image processing-part. All of this will be going to a ESP32. We will also be using a top-mounted camera mounted over the center of a modular maze. The outer walls of the maze will be constant, but the inner parts will be modular and can be changed on the fly. Our goal is that we can present the project, give the examiners the modules and let them make a maze for the snake to find the object in.

## Software / Communication:

The servos will go to a ESP32, which will control the angles. The ESP32 will be controlled from a PC, so the ESP32 will basically function as a slave. The PC will do all the image processing, as well as giving the commands to the snake.

The programming language which will be used is Arduino for the ESP32, and python for the rest of the functions. In practice the ESP32 will just send information about positioning etc. and wait for commands while we will send all commands and information about locomotion from python.

The communication between the ESP32 and the PC will be done via UDP. The ESP32 will connect to a webserver, and communicate with the PC through sending UDP-packets.

## Risks:

This is quite an interesting but difficult project to take on. There are several risks throughout which we will need to traverse.

### Image processing:

One of our big challenges will be to get the image processing just right. We will need to threshold and filter the images based on color, which can be a challenge if we don’t have consistent lighting. This is something we will need to test and take into account when doing the image processing.

One other challenge is also to be able to actually “see” the maze with edge detection. This we will try to solve by having the ground of the maze be one distinct color, while the walls of the maze will be a starkly contrasting color. Our thought is a white ground with black walls.

There are also some challenges with getting the snake to know where it is in the maze, this can be solved by either having markers on the walls, or marking the snake so the top-mounted camera can find it and be oriented of where it actually is.

### Pathfinding:

Pathfinding is another great challenge of this project. Not just getting the pathfinding right, but ensuring that it works efficiently and does not go back to where the snake already has scanned the environment for the object we are searching for.

We want to ensure efficient and good pathfinding, which will be our biggest challenge. Because the maze will be modular, the algorithm has to be smart, and not just hardcoded to find the best solution of *one* maze, but all possible mazes we will make.

It will also have to be smart enough to see where the snake can and can’t go. In our case we might want to create paths that are to narrow for the snake to actually traverse through, this must be recognized by the algorithm.