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| Title: |
| Snake-like Robot |

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| Summary: |
| [The summary here will be identical to the SUMMARY section of the report] |

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*[This report contains predefined styles that you can use for the most common sections. The following styles are defined:*

*Heading 1 Heading for level 1 (hotkey Alt-1)*

*Heading 2 Heading for level 2 (hotkey Alt-2)   
Heading 3 Heading at level 3 (hotkey Alt-3)   
Body Standard text in a paragraph. Use this for all "normal" text (Shortcut Alt-A)   
Definition used mainly in the section entitled "TERMINOLOGY"   
References used in the Reference section.   
AppendixList used in APPENDIX section.   
Comment in blue text. Remove all the text of this type of report.]*

*[NB! This template provides a suggested structure of the main report. The main structure shall be followed.. However, the report must be structured by creating sub-chapters under main shapters. To some extent uou are free to decide how many sub-chaøpters and levels you want. Try anyway to avoid too many levels – normally 3 levels are enough. The level is meant the number of under-the chapter, for example, chapter 4.3.4 is on level 3, while section 3.2 is on level 2]*

summary

*This report is the final project report of Best Practice Course – System engineering. The project of our team is about*

# terminology

# introduction

*[This is the first chapter in the scientific report. It should treat the background for the project, the contractor, the problem / problem history and / or task to be solved. Here you should also say something about the scope or boundaries of the project.*

*Finally, you should briefly describe what the report further includes, amongst other things, what can the reader expect to find in the report.*

*Comment: This is where you will provide an introduction or a kind of presentation of the whole assignment. And it is also where you are going to present the issue to be resolved and any refinements made.*

*If the task has been dealt a specification of requirements, the main features from the requirements should be outlined here, with reference to the full requirements.]*

The project is based on modular robots. The task is to craft a modular snake-like robot that can find an object in a maze with the help of a overhead-camera as well as a front-mounted camera.

This is a task given to us by Houxian Zhang in the course “Introduksjon til Mekatronikk” as a final project for the course.

The goal is that the snake-like robot will be able to find its way around a maze to find an object, by having pre-existing knowledge of the maze by getting a feed from the overhead camera. During a new search after successfully finding the object, it should still be able to find its way around the maze if the maze has been changed, and the position of the object is changed.

There is also a goal of remote monitoring/control GUI. We want to be able to remotely control it via WiFi/Bluetooth, and remote monitor what happens with the robot.

In this report we will go through our entire process for the task, from the beginning with building a theory for how this all should be achieved, till the final steps of testing and seeing it through to the end.

# Background and theoretical basis

## Power Consumption

When choosing the amount of batteries and their size, there are several things to take into account. The power consumption of the ESP32, as well as the 5 servos, the boost converter and the front facing camera will all factor into how long the battery time of this snake-like robot will be.

The ESP32 has several different modes it can run in to save on power consumption. For our purpose where we want access to its WiFi-capabilities we have to run it in what’s called “Active Mode”, which is the mode where its power consumption is biggest. According to documentation online this will be in the range of 160-260mA (Last Minute Engineers, 2018). For simplicity’s sake we will say its consumption will be 250mA.

The servos power consumption will all depend on how much torque it will need to apply to change its position. The producer of the servo has documented that the idle power consumption is 170mA, and at stall it will consume 1200mA (Tower Pro, 2019). From our experience we can see that it generally pulls around 200-300mA.

When it comes to what camera is used, it ended up being an ESP32-CAM, which has a OV2640 camera installed onto an ESP32. From what documentation is found about this unit, it seems that the maximum draw from it will be around 310mA (AI-Thinker, 2019). This is with flash on, as well as brightness set to maximum. So realistically it will draw less, but it’s better to calculate with the worst case scenario.

The boost converter has an efficiency of 90% according to the manufacturer (Texas Instruments, 2019).

We can therefore summarize the power consumption;

|  |  |  |  |
| --- | --- | --- | --- |
| **PART** | **POWER CONS.** | **AMOUNT** | **TOTAL CONS.** |
| ESP32 | 250mA | 1 | 250mA |
| ESP32-CAM OV2640 | 310mA | 1 | 310mA |
| MG995 | 300mA | 5 | 1500mA |
|  |  |  |  |
|  |  | TOTAL: | 2060mA |

The total draw at constant power consumption will be around 2060mA. When accounting for the boost converter we have to calculate this over to Watts, and see how much watt the boost converter will have to produce to reach this amount.

This is the general formula for calculating power. The voltage this all will run on is 5V.

With an efficiency of 0.9, the boost converter will have to produce;

Which then brings us back to;

So our current draw will be 2289mA.

Our snake-like robot has mounted four 2000mAh batteries. This means that our snake-like robot will in ideal situations run for just about 3.5 hours before running dry.

# METHODS

## Applied Theories

## Test Setup and Plan

## Computer Analysis Programs

## Communication

### Communication between ESP32 and PC

Our initial plan for communication between the ESP32 and the computer was to use WiFi and send information via TCP. This is because TCP sends a message back when receiving packets to give notice if the package does not arrive or there is any other problem (receiver not connected to the internet etc.). But during the testing phase we saw that sending just a 100x200 array could take up to 9s one way. This would take way too much time to be able to actively send pictures and get information back to the snake to tell it if it has found the object.

It was quickly decided to try out UDP to check the time for sending information via this protocol instead. The downside to using UDP is of course that it is “fire-and-forget”. It does not care if the receiver is not online, it send the packet and is quite happy with the result regardless of what happens with the packet.

During testing here it was found that sending the same array as earlier took less than 1ms. This is a drastic improvement and it was quickly decided that this is the protocol to use. We do not see it as a huge risk, as the PC and the snake will not be far from each other, and we will also make a checksum-kind of check to see that the package is received as it is expected.

As for how to send the pictures from the front-facing camera to the PC, after testing the first camera that was supplied (a VC0706 UART Camera) it was found that it did not want to communicate with anything. Therefore it was changed with a ESP32 with integrated camera. This camera creates a webserver which it “streams” its content to. This makes it quite easy to use Python to send requests to the server, which makes the camera take a snapshot.

# results

## Theoretical Analysis

## Experimental Results

## Design Alternatives

### Mechanical

### Hydraulic

### Control System

## Challenges and Problems

### Communication challenges

During the programming of the Arduino the program was sliced into separate modules to easily be able to test each module to see that everything worked as expected. During the merging of the programs there came some challenges that were not expected.

Specifically during the merging of the movement and the communication modules. When initializing the Arduino program during the testing here, everything went as expected. The module initialized and attached the servos to the right pins, and then connected to the WiFi and sent the test-package to a given IP and Port. But during the parsing of an incoming packet the ESP32 raised a Guru Meditation Error (the ESP32’s variation of a BSOD), saying “LoadProhibited” and gave a dump of information.

From what we could deduce from documentation found online this was because the application attempted to access a member of a structure, but the pointer to the structure was NULL (ESPRESSIF, 2019). After a lot of testing and debugging we found that if we changed the pins the servo attached to, everything went fine. After this worked, we realized that one of the pins we attached the servo to was pin 16, which is an RX-pin, which probably is what caused our problem.

# discussion

# Conclusion

*[Here you should present the main results of the work together with the experience you've gained in the process. Here you will summarize the most important chapter discussions, and arrive at a conclusion. Did you solve the problem as required or expected with the chosen methods? Was the result according to the mission stated bye the employer? What did we learn from this project, both scientifically, and not least in relation to the work process of a project? ]*

# REFERENCES

ESPRESSIF. (2019, 10 22). *API Guides: Fatal Errors*. Hentet fra ESP-IDF Programming Guide: https://docs.espressif.com/projects/esp-idf/en/latest/api-guides/fatal-errors.html

ITEAD. (2019, 10 16). *Wiki: VC0706 UART Camera*. Hentet fra https://www.itead.cc/wiki/VC0706\_UART\_Camera\_%EF%BC%88Supports\_JPEG%EF%BC%89

Last Minute Engineers. (2018, December 23). *Insight Into ESP32 Sleep Modes & Their Power Consumption*. Retrieved from https://lastminuteengineers.com/esp32-sleep-modes-power-consumption/

Texas Instruments. (2019, 10 16). *LOW INPUT VOLTAGE SYNCHRONOUS BOOST CONVERTER.* Hentet fra https://www.sparkfun.com/datasheets/Prototyping/tps61200.pdf

Tower Pro. (2019, 10 16). *Products: MG995*. Hentet fra Tower Pro Online Shop: https://www.towerpro.com.tw/product/mg995/

*[Authors, title of book or article, name of journal or publisher / publisher, or no date for the journal, year, place as referred to in the report. Course lectures can also be referred to, as with the title on the subject and the name of the presenter. Internet pages must also be included. Even oral discussion partners can be included in the reference list, when this is a source of important or detailed information used in the report*

*see example below]*

1. *Design of Propulsion and Electric Power Generation systems* – H.K. Woud and D.Stapersma
2. Matlab. Wavelet Toolbox. Users Guide. The Math Works Inc., 1997
3. Pugh, D T., Tides, Surges and Mean Sea-Level. John Wiley & Sons. New York, 1996
4. http://dieselmarine.com/

Appendix

*[Material and data prepared or collected in connection with the project, but not natural to include in the main part of the report. The reason cam be the level of details, volume or format.*

*Typical examples are: detailed calculations or analysis, set of design drawings, supporting information, computer code etc…. ]*

Appendix A Test data from engine testbed

Appendix B FEM analysis of cylinder liner

Appendix C Design drawings

Appendix D Material properties

Appendix E etc….etc…..