SPRO3 report

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1 Introduction

Throughout history a certain industrial trend has become the most pronounced it has ever been, automation. Any and all tasks that could be automated in a financially viable way have seen at least one instance of it happening. This is due to the numerous benefits that an autonomous system can provide. In a similar vein our team also aimed at contributing to this phenomenon within the scope of the third semester project. The aim of the project was to make an autonomous intelligent vehicle.

Project work started with exploring the possible fields where such a vehicle could find sensible applications. A mindmap was used to order and keep track of various ideas. Some of these include a food and beverage delivery system both in a restaurant and home settings and some were related to various

2 Problem Formulation

In the third semester our professors assigned us a project where the focus was to be the importance of sensors and actuators with autonomous vehicles being one example. Following this lead the first topic that came to mind was logistics, more precisely forklifts. To investigate the applicability of such devices in the aforementioned field our team members conducted market research starting from two separate perspectives, one being more industrial and the other more social.

2.1 more like a problem formulation???

2.1.1 Forklift related accidents and injuries

Forklift related accidents are a common occurrence, both with solid stationery objects and moving pedestrians. According to data from "article 1" there a around 34,000 injuries from forklifts in the US every year. This results in a great number of lost work days and extra strain and pressure to make up the deficit.

Out of 143 incidents, where the collision happened with a solid object 75 of them are with stationery objects. And 53 of them are collisions between forklifts. Both of these types of incidents are related to human errors, like not paying attention to the surroundings when operating forklifts.

Out of 322 incidents involving pedestrians around 50% of them have been caused by a forklift striking a pedestrian by accident.

The safety of forklifts can be greatly increased with the use for sensors that enable the forklifts to avoid obstacles on their own, even with the human error factored in. This is similar to how safety in cars has been greatly improved in recent years.

2.1.2 Is there a market for self-driving forklifts?

Most companies are always competing to maximize the quality of the product while keeping the cost as low as possible. Many companies choose to outsource manufacturing to countries where, due to the lower average salary, they could further the aforementioned goal. This could achieve lower manufacturing prices but sometimes the quality suffered in turn. After learning this some companies choose to move manufacturing back to their origin. To stay competitive despite the higher costs, automating tasks can be a lucrative investment. For example having warehouses that can work 24 hours a day can greatly reduce certain costs. All without compromising the quality of the products.

2.1.3 Real-life applications

A research paper from a japanese university revealed that in countries with aging demographics autonomous vehicles such as an autonomous forklift are required to lighten the burden on manpower and manual labor. The authors of this paper detailed an autonomous pallet handling system for forklifts, which is able to handle pallets used for harvesting vegetables with no further human input in an outdoors environment. From a paper about aging populations it is stated that 11% of the world is over 60 years of age and this ratio is expected to rise up to 22% in 2050. From a paper about aging populations it is stated that 11% of the world is over 60 years of age and this ratio is expected to rise up to 22% in 2050.

2.1.4 Conclusion

These four papers clearly indicate that there is indeed a market and an application of highly automated processes regarding logistics and forklifts as well. This is how our group came to the conclusion that an automated forklift would solve a relevant problem all the while fitting in the frame outlined by our professors.

3 Management

3.1 Team dynamics

We aimed to include everyone in all areas of the project deployment. This meant we insured that everyone got the opportunity to be involved, with a task fitting to there knowledge level.

3.2 Task management

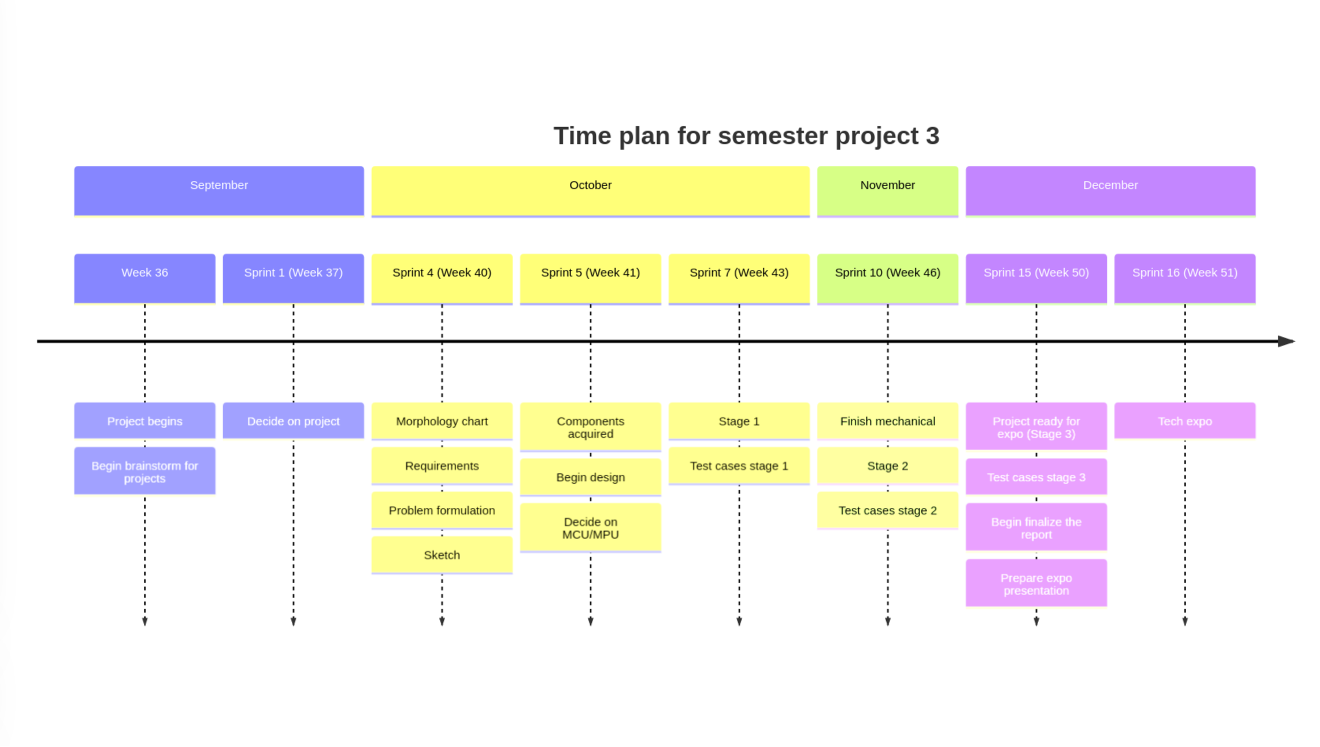
We adopted the Scrum agile management framework and customized some parts of it to fit our project and teams needs. We chose specifically this model due to the agile planing it introduces, and gradual learning curve. We defined a sprint to be 7 days, from friday to friday with an estimate of 8 hours of workload per team member. We categorized each task according to the time estimated to complete it using these tags:

- Sønderborg - 0.5 hours
- Keil - 1 hours
- Valencia - 2 hours
- Budapest - 4 hours
- Hamburg - 6 hours

We chose our home cities and sorted them by size to make it more simple to use in conversations and to give a better visual idea of the task size. We decided that the time limited on a task should be 6 hours. If a task would require more time then it should be split into multiple tasks. This was to ensure that it was possible to see if the task was possible to achieve before investing more time into it.

3.3 Individual evaluation

A short evaluation of the project from each member in their own opinion. This is used to improve upcoming projects, to prevent making the same mistakes again. **member name:** Write here **member name:** Write here **member name:** Write here **member name:** Write here **member name:** Write here **member name:** Write here



4 Consideration

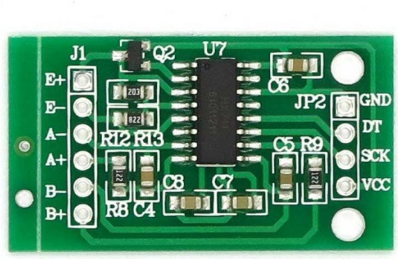
5 Electronics

Introduction

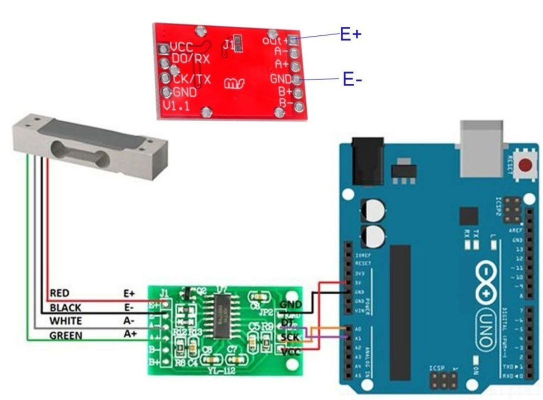
One of the main focuses of this third semester project is analog electronics. Electronics bring the software and the mechanical part together. The software needs feedback from the analog world. It needs to know how heavy the load is and whether there is an obstacle in front. Furthermore, all the smart digital electronics need to be powered. But when powering everything from a battery the current state of the battery has to be evaluated. All these tasks are necessary to guarantee safe operations.

The tasks include the following:

- Interfacing the analog load cells
  - Loadcell PCB Design
- Power Supply and monitoring
-
  - VeroBoard Design
- Motor Drivers
  - Motor Driver PCB Design



(a) HX711 Interface Module



(b) HX711 Interface Module and Load cell using Arduino-microcontroller

6 Mechanical

7 Code

7.1 FreeRTOS

7.1.1 Why FreeRTOS

When designing a autonomous vehicle factors like: precise timing, responsiveness, and predictability are crucial for the software. If the software dose not process inputs from sensors fast enough it could result in a accident. These factors can be forfeited by using a real-time operating system like FreeRTOS. With RTOS task scheduling, actions like stopping movement when a obstacle is blocking the way, is executed within a specified time constraint. Meaning that the action of stopping the vehicle is not blocked by another action, thus preventing accidents.

7.1.2 FreeRTOS flavor

One of the reasons we choose the ESP32 MCU was to utilize its capability with FreeRTOS. The ESP32 liberty uses a custom made flavor made for the ESP32 by Espressif. One of the key difference for this flavor is its support for Dual-Core processors. Meaning that tasks can be distributed across two cores, instead of the original one core support in FreeRTOS.

7.2 ADC

When programming the ability to use a ADC (Analog to digital converter) to read a analog value on the microprocessor is of crucial impotents. In our project the ADC is use for reading values from our infrared and load sensors. On the ESP32 a total of 18 ADC channels are available with a config resolution options of 9,10,11 and 12-bits.

7.2.1 Configuring

It is impotent to ensure when using RTOS that functions are Thread safe. If not it can result in RTOS not being able to handle a task in the desired time frame. For this reason we have chosen to use libraries that are include in the ESP-IDF environment that are designed with thread safe in mind. The particular library used to facilitate ADC is called *esp_adc/adc_oneshot.h* that replaced the previous one in version 5.0.4 of ESP-IDF.

To configure a ADC unit:

```
        adc_oneshot_unit_handle_t adc1_handle;
        adc_oneshot_unit_init_cfg_t init_config1 = {
            .unit_id = ADC_UNIT_1,
            .ulp_mode = ADC_ULP_MODE_DISABLE,
        };
        ESP_ERROR_CHECK(adc_oneshot_new_unit(&init_config1, &adc1_handle));

```

Listing 1: Configuring ADC unit 1

7.2.2 Reading

8 Testing

8.1 Test cases

Stage 1

#	Objective	Steps	Expected result	P/F
1.1	Forward movement	1.Flash stage 1 code 2.Place forklift down on the floor 3.Press start	The forklift moves forward a arbitrary distance	
1.2	Backward movement	—"—	The forklift moves backward a arbitrary distance	
1.3	Forward right movement	—"—	The forklift moves forward and right a arbitrary distance and angle	
1.4	Forward left movement	—"—	The forklift moves forward and left a arbitrary distance and angle	
1.5	Stationary right turn	—"—	The forklift turns right a arbitrary angle	
1.6	Stationary left turn	—"—	The forklift turns left a arbitrary angle	
1.7	Read battery voltage	1.Measure the battery voltage with a multimeter 2.Flash stage 1 code 3. Read displayed voltage in display	The multimeter measurement and display value should be the same with a tolerance of 2%	
1.8	Battery voltage low	—"—	The forklift should not start when the start button is pressed. Instead it should prompt the user that the battery needs to be charged.	

Stage 2

#	Objective	Steps	Expected result	P/F
2.1	Movement following the line path	1.Flash stage 2 code 2.Place the forklift on line 3.Press start	The forklift should follow the line path when moving at a arbitrary speed.	
2.2	Detected obstacle stop	—"—4.Place obstacle on path	The forklift should stop before hitting the obstacle	
2.3	Detected obstacle start	1.Run test case 2.2 first. 2.Remove obstacle for the path	The forklift resumes it movement along the path	

Stage 3

#	Objective	Steps	Expected result	P/F
3.1	Move fork up	1.Flash stage 3 code 2.Place the forklift on line 3.Press start		
3.2	Move fork down	—”—		
3.3	Move fork to minimum	—”—		
3.4	Move fork to maximum	—”—		
3.5	Detected pallet	—”—	The forklift should detected and move into position of the pallet	
3.6	Move pallet up	—”—	The forklift should move the forks under the pallet and move it up a arbitrary distance	
3.7	Move with pallet	—”—	The forklift lift should move with the pallet to the destination point along the path	
3.7	Move pallet down		The forklift lift should move the pallet down to ground level	

9 Conclusion

10 Appendix

10.1 Acronyms

OS	Operating system
RTOS	Real-time operating system
MCU	Microcontroller

10.2 Glossary

FreeRTOS	A open source real-time operating system
base10	Decimal numeral system
base16	Hexadecimal numeral system
base2	Binary numeral system
c language	General purpose programming language
DevOps	A means for improving and shortening the systems development life cycle.
Flash memory	An electronic non-volatile computer memory storage medium
Gantt chart	A bar chart that illustrates a project schedule.
Github	A DevOps software package
git	Distributed version control system
Microcontroller	A small computer on a single VLSI IC chip.
Scrum	An agile project management framework