American University of Sharjah

ELE494-08
Autonomous robotic systems

Final CTE Document

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May 13, 2019

Submitted To: *Dr.Shayok Mukhopadhyay*

American University of Sharjah

ELE494-08
Autonomous robotic systems

Midterm 1 - Project CTE Document

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March 4, 2019

Submitted To: *Dr.Shayok Mukhopadhyay*

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1 Initial Goal Statement

The goal of our group project is to create a robot which will navigate in a region while avoiding obstacles to find the spot with the most sunlight.

2 Team Formation

For the project my group member is Yousif Khaireddin (@63618). We have worked together previously as lab partners and on projects in other courses. Therefore, we understand each others strengths/weaknesses and since our hobbies are quite similar it is easier for us to get along.

Youssif got in touch with me during our class and we decided to form the group and discuss what timings we have to work on the project.

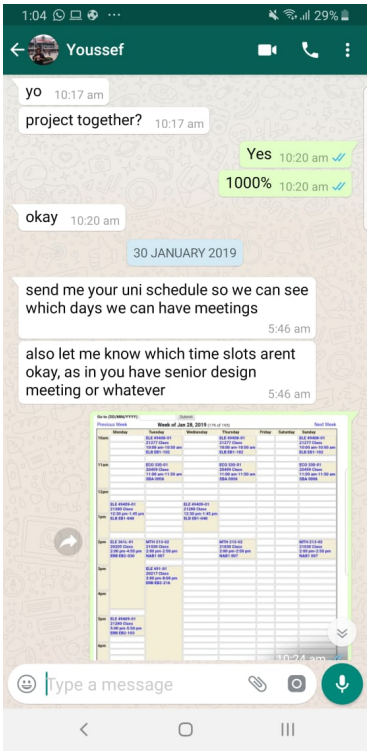

Figure 1: Forming group and planning meetings

After this we decided to have meetings on Thursday after 3 pm and during this time we will work on the project.

2.1 First Meeting

Our first meeting took place in the library and during it we brainstormed on possible ideas for what the project will be. At the end we had a list of projects that we thought were suitable and these included:

- Drink Pouring Machine

- Light Detection for Solar Panels
- A Plotter that could draw shapes
- Robot that will follow the path of a line on the floor
- A software simulation of a robot that will stay in lane

We then arranged for a meeting with Dr.Shayok and through the discussion we decided on developing a robot that can move freely within a region while avoiding obstacles and at the end of its journey it returns to tell the user the location with the brightest sunlight.

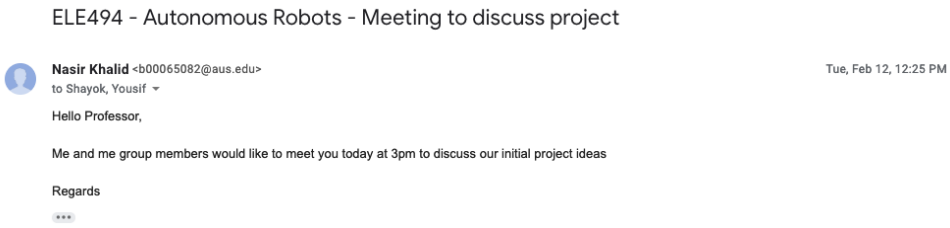

Figure 2: Arranging First Meeting with Professor

2.2 Meeting 2

During our second meeting me and Youssif discussed how we could realize the project goal. We ultimately decided that we would create a physical robot and through our discussions we planned some of the basic circuitry and also placed orders for the components needed.

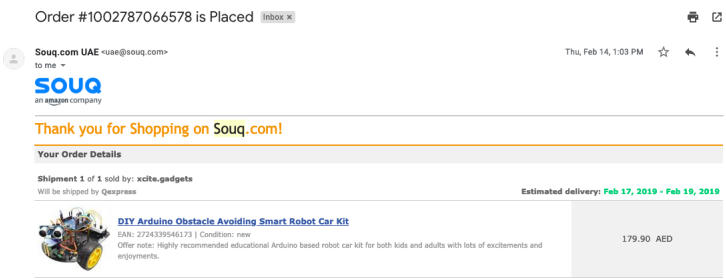

Figure 3: Ordering the robot components

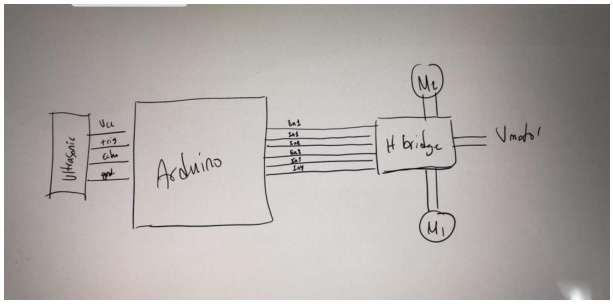

Figure 4: Understanding the connections needed

2.3 Subsequent Meetings

Once the components arrived we met again multiple times to begin assembly and testing of the components we recieved. We both worked together in building the frame and assembling the components. Yousif focused on the wiring of all the components

However, when it came to testing we split the software work between us. Youssif developed the code for testing the Ultrasonic sensor and I developed the code to test the motors and servo.

Shown below are snippets of testing code used for the motor and servo.

```
#include <L298N.h>

//pin definition
#define EN 9
#define IN1 8
#define IN2 7
#define EN2 3
#define IN3 1
#define IN4 2

int speed1 = 0;

void setup() {
pinMode(EN1, OUTPUT);
pinMode(IN1, OUTPUT);
pinMode(IN2, OUTPUT);
pinMode(EN2, OUTPUT);
pinMode(IN3, OUTPUT);
pinMode(IN4, OUTPUT);
}

void loop() {
//  The following code tests the motors by speeding them up slowly
//  and then bringing speeds back down to zero
if(speed1 == 255){
    speed1 = 0;
}

analogWrite(EN1, speed1);
analogWrite(EN2, speed1);
digitalWrite(IN1, HIGH);
digitalWrite(IN2, LOW);
digitalWrite(IN3, HIGH);
digitalWrite(IN4, LOW);
delay(500);
speed1 += 10;
}
```

Listing 1: MotorTest Code

```
#include <Servo.h>
#define SERVO_PIN 9
Servo myservo;
int pos = 0;

void setup() {
    myservo.attach(SERVO_PIN);
}

void loop() {
    //Sweeps the entire servo head. Looking left to right
    for (pos = -180; pos <= 180; pos += 1) {
    myservo.write(pos);
    delay(15);
    }
}
```

Listing 2: ServoTest Code

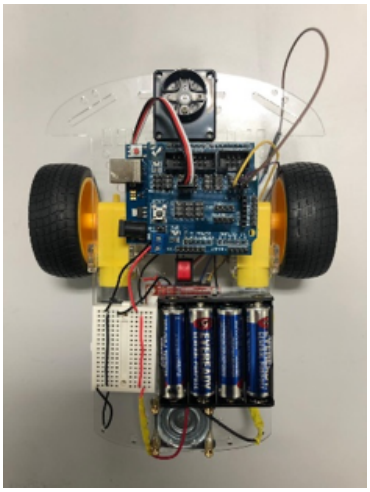

Figure 5: Top side of the robot

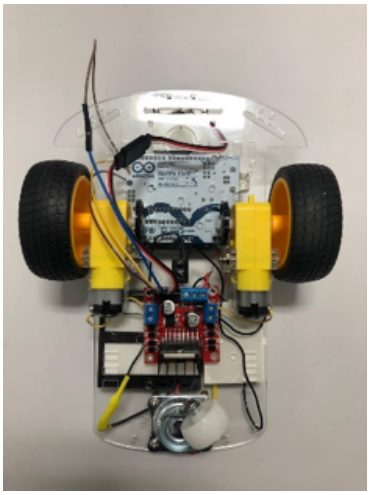

Figure 6: Bottom side of the robot

After our testing we then met with Dr.Shayok again to discuss on how we can use the encoders going forward. We also placed the order for these encoders and once they arrive we expect to continue work on the project.

3 Team strengths and weaknesses assessment

	Nasir	***Youssif***
Strengths	- Experienced with Arduino - Programming - More free time in schedule	- Better at developing circuitry - Programming - Handy work - Lives in dorms
Weaknesses	- Procrastination	- Time Management - Doing multiple projects this semester

Table 1: Strength and weaknesses assessment

4 Team Member Roles

Currently as we are in the early stages of the project and developing the ground work, we have not yet split our roles and seperated tasks. However, as we progress further it is becoming quite clear that we will be splitting up and each working on a seperate part of the robot which will ultimately come together and lead to our final project.

For the work done until now the roles can be seen in the table below:

Nasir	***Youssif***
- Assembling the Robot	- Assembling the Robot
- Soldering all wires in place	- Figuring out where to place components on the chasis
- Ordering and identifying components needed	- Developing circuitry for robot
- Writing test code for different components	- Writing test code for different components

Table 2: My caption

As we go forward we will be splitting the different functions of the robot between ourselves along with the tasks that come up.

5 Broad Objectives

Our end goal is that our robot will be able to move within any region while avoiding obstacles and it will also be able to return and inform the user about the brightest spot it finds. This entire project can be split in to two sections:

- Moving freely on ground while avoiding obstacles
- Storing light intensity data across the area it travels

We require encoders and a gyroscopic sensor along with the knowledge of path planning to fully realize the first item on the list. For the second item we are trying to develop a method of measuring total light intensity in 3D space so as to find the brightest spot. Currently our robot is capable of moving and through the Ultrasonic sensor + Servo we are able to detect obstacles in it's path. Once we discuss certain topics in the course and recieve the remaining components we will move forward.

Such a robot seems practical for real world applications. In one case it could give solar powered vehicles the ability to charge themselves by navigating obstacles and finding the area with the most light intensity.

Project CTE Document for Midterm 2

ELE494-08
April 14, 2019

Nasir Khalid
B00065082

I. Goal Statement

We aim to develop an autonomous robot that can survey a given location and return the point of maximum light intensity within that location. As it moves it will be sending back data in real time to a web browser on a phone/computer.

II. Objective

The robot will be given a predefined map and it will be given it's starting position within that map. After this it will begin planning the path it will take around this location and during it's journey it will read the light intensity of the points. As it does this it will be sending back data of it's current position on the map & the light intensity at its position. All of this will be visualized so we can watch it in real time. Once it's journey is complete it will go back and remain idle at the point which it determined to be the brightest.

III. Hardware

The main components of this device are:

1) Robot Body

Figure 1: Chassis, wheels and motors of robot [1]

2) NodeMCU Microcontroller

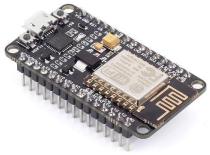

Figure 2: ESP8266 based NODEMCU microcontroller [2]

3) H-Bridge

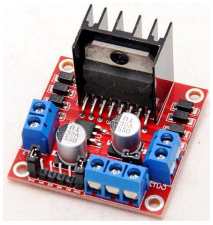

Figure 3: Dual H-Bridge motor controllers [3]

4) Speed Encoders

Figure 4: HC-020K Speed Measuring Module [4]

5) Power Bank

Figure 5: Huawei 6700 mAH power bank [5]

The final components (6 and 7) we currently do not have but we plan to purchase them soon

6) Accelerometer

Figure 6: MPU6050 3 axis accelerometer/gyroscope [6]

7) Light Dependent Resistor

Figure 7: Photoresistor LDR CDS 5mm [7]

IV. Plan of Action

A. Individual Tests

We will begin by testing each sensor independently with the NODEMCU microcontroller and try to get their output to display on a web server that can be accessed by phone or mobile. This will help us ensure that each sensor works properly and that we are using the right functions to interface with them

B. Joint Tests

After the individual tests are complete we will wire all the components together on a breadboard and create a circuit diagram for the entire system. Through this test it will be clear that all the components are working together and during this time we will be writing the preliminary code for the system.

C. Assembly

Now we will assemble all the components on to the chassis of the robot and execute the same preliminary code written in the previous section to ensure that it is operational and that wiring was correctly done.

D. Early Implementation

Now that the robot is ready we will modify it's code heavily to implement the following:

1) Path planning based on a given map
2) Kalman filtration for position
3) Visualization of position
4) Real time graphing of filtered and unfiltered data
5) All movement and robot control functions

E. Final Implementation

After the early testing stage we will implement the final part of the robot which is all the logic and control to identify the brightest spot in a given location.

V. Results

A. Current Results

As of now we have individually tested and jointly tested the sensors we already own Currently the testing includes interfacing the microcontroller with the encoder, h-bridge, and activating the webserver to see data in real time. Shown below is the current set up for joint testing and also the results we obtained from the web server based on testing of the encoders.

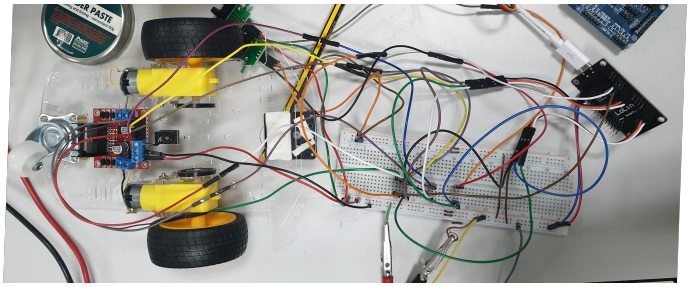

Figure 8: Joint Testing setup

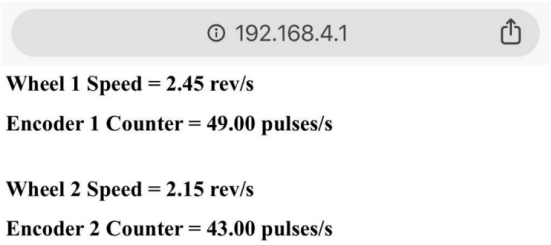

Figure 9: Encoder results from initial joint setup

Initial results from the encoders show a discrepancy between wheel 1 and wheel 2 even though the same speed is expected from both. This shows that we need to perform some filtration on the encoder results and also highlights the importance of the accelerometer because without it we would be unable to do position estimation.

B. Future Results

For the next few stages we expect the robot to display the position more accurately and also provide a live graph highlighting the filtered and unfiltered data so we can see the effects. If possible we would also like to visualize certain other state variables and create a model of the robot that moves in realtime within a 3D map

VI. Team Member Roles

Up until this stage of the project me and Youssef worked interchange on programming the robot and testing the various sensors. However the circuitry was handled by Youssef and the code for the web server and visualization was handled by me. Through this we understood our strong points and form now onwards we are dividing specific sections of the project between the two of us.

Both of us will work on programming the microcontroller, interfacing with the sensors and code for filtering data.

Youssef will work on circuitry and specific logic needed to convert sensor data to understandable readings

I will work on visualization and robot functions for movement and control

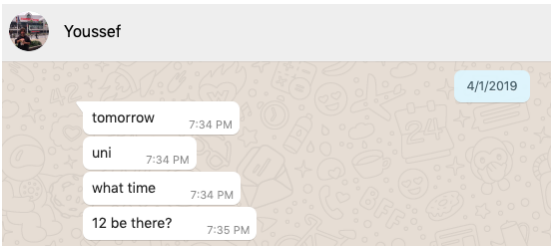

Figure 10: Planning first meeting during spring break

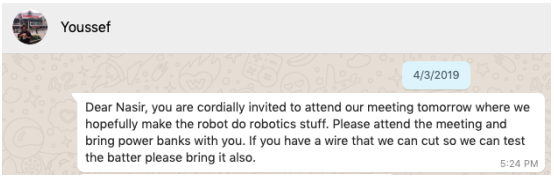

Figure 11: Planning second meeting during spring break

VII. Current State

A. Hardware

Currently the circuit is system is set up for joint testing as shown in Figure 8. The hardware is connected and are using a lab bench top power supply for testing. The set up is currently in the microwave lab and can be accessed at any time if one has lab access.

B. Software

All software is listed in the appendix. A.3 and A.4 were written by Youssef. A.5 was written by me. The remaining code was written by both of us.

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Appendix

```
#include <ESP8266WiFi.h>
#include <WiFiClient.h>
#include <ESP8266WebServer.h>

//Pin Definitions

#define ENCODER1 5 //[D1]
#define ENCODER2 12 //[D6]

#define EN1  4   //[D2] 44 ON BREADBOARD
#define IN1  3   //[rx]
#define IN2  1 //[tx]

#define EN2  14 //[D5] 35 on BREADBOARD
#define IN3  16 //[D0] 43 ON BREADBOARD
#define IN4  13 //[D7] 42 ON BREADBOARD


const char* ssid = "Robot";

float count1;
float count2;
float rev1;
float rev2;
float rev1_f;
float rev2_f;
String message;

ESP8266WebServer server(80);
```

Listing 1: Initializaion Code

```
void setup() {
  delay(1000);

  //Defining PIN directions

  pinMode(EN1, OUTPUT);
```

```
  pinMode(IN1, OUTPUT);
  pinMode(IN2, OUTPUT);
  pinMode(EN2, OUTPUT);
  pinMode(IN3, OUTPUT);
  pinMode(IN4, OUTPUT);

  delay(1000);
  WiFi.softAP(ssid);

  IPAddress myIP = WiFi.softAPIP();

  analogWrite(EN1, 512);
  analogWrite(EN2, 512);
  digitalWrite(IN1, HIGH);
  digitalWrite(IN2, LOW);
  digitalWrite(IN3, LOW);
  digitalWrite(IN4, HIGH);

  server.on("/", handleRoot);
  server.begin();

  pinMode(ENCODER1, INPUT);
  pinMode(ENCODER2, INPUT);

  attachInterrupt(
      digitalPinToInterrupt(ENCODER1),
      High_Callback,
      RISING
    );
  attachInterrupt(
      digitalPinToInterrupt(ENCODER2),
      Low_Callback,
      RISING
    );
}
```

Listing 2: Setup Function

```
void loop(){
    rev1 = 0;
    rev2 = 0;
    for(int j=1; j<11;j++){
        count1 = 0;
        count2 = 0;
        delay(100);

        rev1 += count1 / 20; //number of revolutions
        rev2 += count2 / 20; //number of revolutions

    }
    rev1_f = rev1;
    rev2_f = rev2;
    server.handleClient();
    delay(100);
}
```

Listing 3: Encoder Counter Math

```
void High_Callback(){
  count1 += 1;
}
void Low_Callback(){
  count2 += 1;
}
```

Listing 4: Callback Functions for Encoders

```
void handleRoot(){
    message = "<h1>Wheel 1 Speed = ";
    message += String(rev1_f);
    message += " rev/s";
    message +=  "</h1>";

    message += "<h1>Encoder 1 Counter = ";
    message += String(count1);
    message += " pulses/s";
    message +=  "</h1>";
    message +=  "<br>";

    message += "<h1>Wheel 2 Speed = ";
    message += String(rev2_f);
    message += " rev/s";
    message +=  "</h1>";

    message += "<h1>Encoder 2 Counter = ";
    message += String(count2);
    message += " pulses/s";
    message +=  "</h1>";
    message +=  "<br>";

    server.send(200, "text/html",  message);}
```

Listing 5: Server Code to display Encoder Data

American University of Sharjah

ELE494-08
Autonomous robotic systems

Project CTE #3 Document

Nasir Mohammad Khalid
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May 13, 2019

Submitted To: *Dr.Shayok Mukhopadhyay*

1 Result Achieved

Through the project I was able to develop a deeper understanding of autonomous robotic systems and the theory behind them. Working with the hardware was a new opportunity to learn how to interface with sensors and configure a different microcontroller to them. It also gave me the opportunity to learn programming languages I had little experience with previously. However, the most interesting part of the project was developing an entire system from scratch because this was not done before in other courses, figuring out the components, body, programming, software etc. By the end of the project I had been successful in my attempts to get real time data and configure sensors as well as helping my partner in developing the system code for the Robot and assembly.

2 Contribution

While the items listed below are things I dedicated most of my time to, it is important to note that my partner Youssef and me would work at the same time so there was constant input by both of us on the tasks that each person was doing. Therefore, although I had 'worked' on these parts it in no way discredits the efforts of my partner in development:

- Identifying components to order for Robot
- Soldering work and Robot assembly
- Developing all code to interface with the Encoders and Accelerometer
- Developing code for connection of microcontroller to server
- Developing code for frontend/backend (All Visualization)
- Setting up Github Repository for Project

By examining our Github Repository and it's commits it also shows our contributions to the code of the project over time (https://github.com/NasirKhalid24/ELE494-08-Project). In terms of novelty, from our research we were unable to find a system like ours where data was transmitted in real time the same way we had done it through a front and back end.