Autonomous Car
Group B9

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***Abstract*—The world population growths at an average of 1.05% a year,that represent a forecast of 9 to 10 billions people by the year 2050[1] .This all means that more people need to be fed. This put more pressure on the farmers who must increase their production output to meet this ever-increasing demand.This represents a forever challenging task to solve.Human power alone cannot be enough to solve this problem.This is were robots come into play. Using robot agriculture helps to speed up the work,improve the efficiency and decrease the rate of errors.They can be build to be completely autonomous like in our project or semi-autonomous.They can be used for applying pesticide,harvesting and tilling the soil. In this project is focused on the working of a pick and place autonomous robot which follows a line in its direction.The robot consists of three main parts which are programming (coding part), the electric circuit design and also the mechanical design. Building a robot requires that the robot is easy and independently controlled as it is expected to be optimally functional. In the project work, the robot picks and places the object; the objects are placed in location which can be identified by the robot as it moves along the paths. For functionality, multiple sensors are used to control the direction that has been lined with different colours and patterns on the floor.The robot uses two motors for its motion.**

I. Introduction

In this project,an autonomous vehicle is designed for performing the work of picking and placing object in this case a bale of straws from source point to a set location. Our vehicle has the following characteristics

(i) To move from one point to another
(ii) ability to be re-programmed
(iii) Practical and efficient for the set field of movement.

We divided our project into some basic modules which are the power supply section, controlling section sensing section and output section. In power supply part we used lithium battery which provided high performance functionality. For the control section, Arduino played an important role because it turns on IR sensors and for those input values motor get started and then follow the line by using line follower application. The vehicle while in motion performs the operation of picking and placing the object at desired location.

Identify applicable funding agency here. If none, delete this.

II. Problem Stament

It is important for us to understand the software features for this autonomous system. For this we are to develop an autonomous vehicle that can collect objects (bales of straw) following line coordination and brings the picked bales of straw to a certain position. The size of the test environment for our vehicle is 7.5 to 3.5 meters.

III. Concept Design

A. Concept Description

The concept version of our vehicular robot was quite simple. We were tasked to develop an autonomous vehicle that can collect objects by navigating through the test track. The coordination of the vehicle is given by the lines. Through brainstorming sessions and research, a concept sketch was made.

Figure 1 is a concept sketch with all the necessary components to make the autonomous vehicle function accordingly. The necessary components are as follows.

- Motors (2 units)
- Arduino (1 unit)
- Motor Driver (1 unit)
- Line sensors (2 units)
- Ultrasonic sensor (1 unit)
- RGB color sensor (1 unit)
- Battery (1 unit)

The Infrared line sensors are mounted below the chassis at the the front end of the vehicle (facing the track) as shown in Figure 1. They detect the existence of a black line by producing infrared (IR) light and measuring the amount of light that returns to the sensor. They do this through the use of an emitter and a light sensor.

The ultrasonic sensor is placed in front of the vehicle. It is an electronic device that uses ultrasonic sound waves

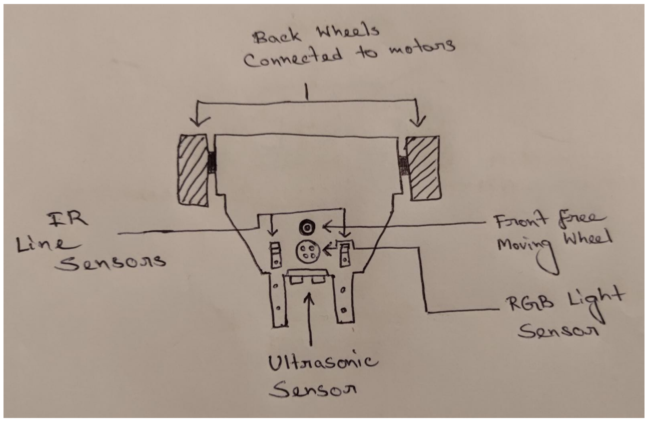

Fig. 1. Bottom view Of Skecth

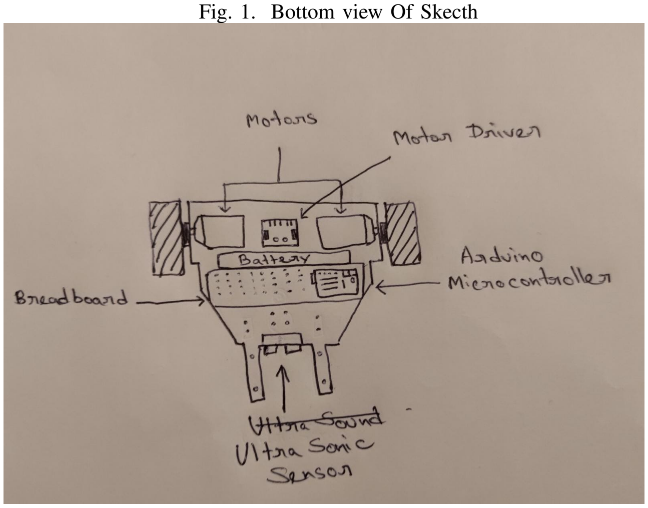

Fig. 2. Top view Of Skecth

to measure the distance between two objects and transforms the reflected sound into an electrical signal. Ultrasonic waves move quicker than audible sound. The transmitter and the receiver are the two primary components of ultrasonic sensors (which encounters the sound after it has travelled to and from the target).

We also employed an RGB color sensor to identify the color of a substance in the RGB (red, green, blue) scale while rejecting infrared or ultraviolet light. It basically means by using the RGB color sensor, the vehicle can detect the color of the track to navigate while not letting the infrared light sensor to hamper it. The RGB color sensor is placed in the middle of the chassis facing the track.

To make it move, the concept vehicle has two motors connected with the back wheels. We used two motors so that the wheels can move independently, giving the vehicle the capability to steer itself. How it works is, if the vehicle has to move right, the left wheel moves while the right wheel stays still, thus steering the vehicle right and vice versa.

Motor drivers serve as a link between motors and control circuits. The motor requires a high current, but the controller circuit operates on low current signals. The role of motor

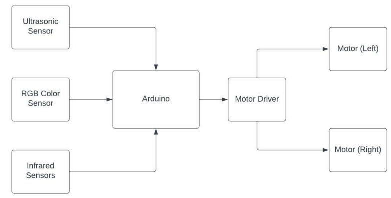

Fig. 3. Block Diagram

drivers is to convert a low-current control signal into a higher-current signal capable of driving a motor. It is placed inside the vehicle in between the motors as shown in Figure 2. And finally we have the battery placed inside the body of the vehicle to generate electricity to all the necessary components.

All of the components are connected to the Arduino to make them work as a cohesive unit. As shown in Figure 2, all of the components are placed in such way that the center of gravity of the vehicle is in the middle without putting too much weight on the front wheel. The front wheel is a free moving ball-bearing wheel which aides the vehicle to steer left or right. In the front of the vehicle there is a forklift style grabber to collect the objects from the test track. The specification and description of the hardware components are discussed more in details in the later section of this paper.

The block diagram in Figure 3 shows a simplified version of all the processes that makes the concept vehicle function. The IR sensors, ultrasonic sensor and the RGB color sensor are all connected to the arduino and they send all the data to it, the Arduino processes the data and sends the appropriate output data to the motor driver. The motor driver is connected to the motors and it makes the motors to move accordingly.

During the concept and ideation Process, we came up with 3 sketches among which two were discarded.After analysis we concluded they were not able to meet all requirements as specified.

IV. Design Of The Prototype

A. Requirements

The autonomous car that we were to develop and design had to meet the following requirements: A. REQUIREMENTS

Functional

- The system shall be able to drive on the line (vertically and horizontally).
- The system shall be able to differentiate between all colors on the track
- The system shall be able to drive on a line and count position (both vertically and horizontally).
- The system shall be able to drive on the line, turn 90 degrees and keep driving on the new line.
- The system shall be able to drive on the line for two squares, turn 90 degrees and keep driving on the new line for two squares.
- The system shall be able to drive from one point to another (keep track of position on the map). will get the starting point and the end as a multidimensional array.

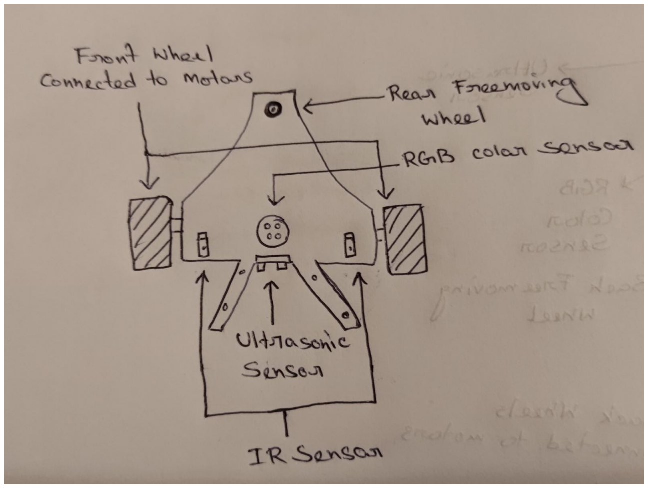

Fig. 4. 1st Discarded Skecth

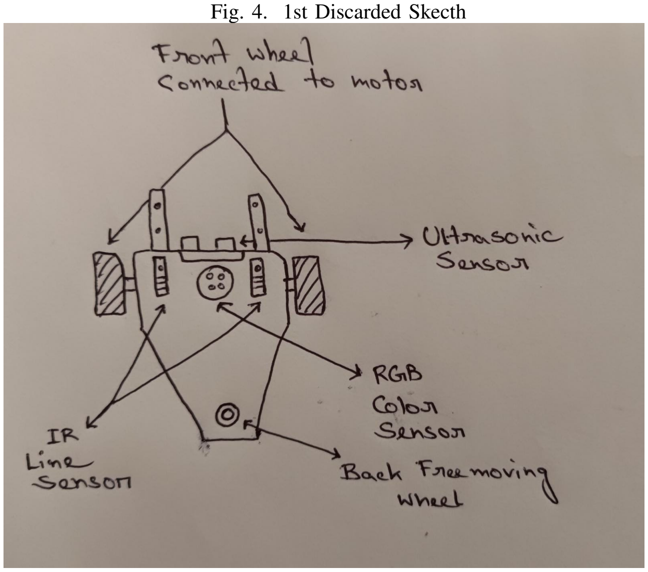

Fig. 5. 2nd Discarded Skecth

- The system shall be able to carry bales of straw from certain positions
- The system shall be able to drop bales of straw at a certain position after locating them.
- The system shall stop when an obstacle is detected within a predefined distance.

Structural

- The overall size of the robot shall not exceed a size of 1:10" The overall size of the car shall not exceed 30*20*20 cm
- The chasis shall not have a wall thickness of more than 2mm.
- The system should be able to accommodate the bread-board, a battery, a front wheel, 2 motors, 1 arduino, 2 tyres, 2 infrared and ultrasonic sensors and a motor driver

Performance

- The system shall operate in real time
- The system shall execute commands promptly

B. System Engineering Model

C. Hardware Selection

IR sensors:They detect the existence of a black line by producing infrared (IR) light and measuring the amount of light that returns to the sensor. They do this through the use of an emitter and a light sensor.in this project we use two of those for better guidance of the robot

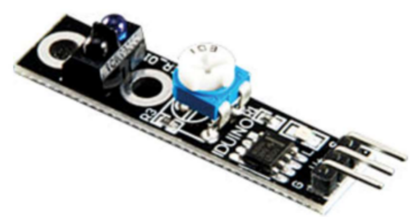

Fig. 6. Infrared Sensor

Ultrasonic sensor :The ultrasonic sensor is placed in front of the vehicle. It is an electronic device that uses ultrasonic sound waves to measure the distance between two objects and transforms the reflected sound into an electrical signal. Ultra-sonic waves move quicker than audible sound. The transmitter and the receiver are the two components of ultrasonic sensors (which encounters the sound after it has travelled to and from the target).

Fig. 7. Ultrasonic Sensor

RGB Color Sensor:TCS3200 : We also employed an RGB color sensor to identify the color of a substance in the RGB (red, green, blue) scale while rejecting infrared or ultraviolet light. It basically means by using the RGB color sensor, the vehicle can detect the color of the track to navigate while not letting the infrared light sensor to hamper it. The RGB color sensor is placed in the middle of the chassis facing the track.

Fig. 8. RGB Sensor

Gear Motor(Modelcraft) RB 35:To make it move, the concept vehicle has two motors connected with the back wheels. We used two motors so that the wheels can move independently, giving the vehicle the capability to steer itself. How it works is, if the vehicle has to move right, the left wheel moves while the right wheel stays still, thus steering the vehicle right and vice versa.

Fig. 9. Gear Motor

Microcontroller : is microcomputer on a single integrated circuit containing a processor, memory, and programmable input/output peripherals.The Arduino Uno is selected for this component. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

Motor Driver(SBC):It serves as a link between motors and control circuits. The motor requires a high current, but the controller circuit operates on low current signals. The role of motor drivers is to convert a low-current control signal into a higher-current signal capable of driving a motor. It is placed inside the vehicle in between the motors as shown in Figure 2.

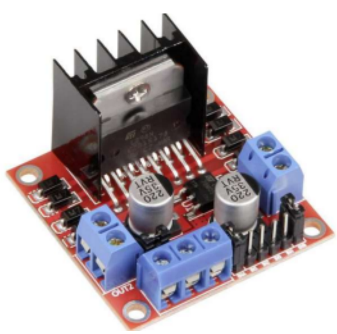

Fig. 10. Motor Controller

Power supply: 11.1V/3200 mAh Battery.placed inside the body of the vehicle to generate electricity to all the necessary components.

Breadboard:A bread board is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate

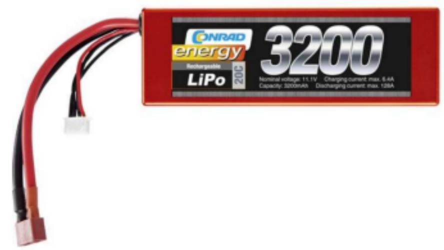

Fig. 11. Power Supply Unit

All of the components are connected to the Arduino to make them work as a cohesive unit.. The front wheel is a free moving ball-bearing wheel which aides the vehicle to steer left or right. In the front of the vehicle there is a forklift style grabber to collect the objects from the test track.

D. System Wiring Diagram

We did a first wiring diagram with the software Tinkercad.We wrote some code on Tinkercad to simulate and test the wiring

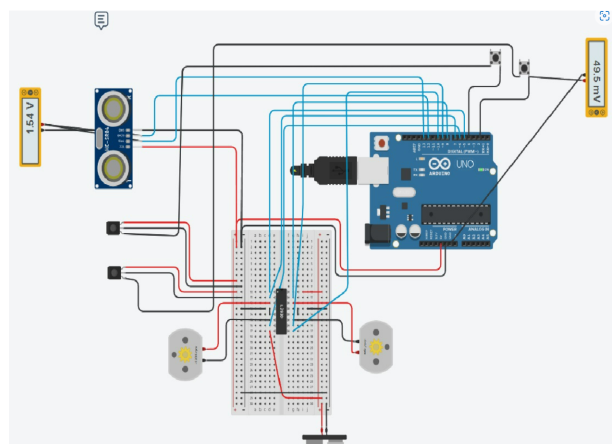

Fig. 12. First Wiring Diagram

A wiring diagram was provided to us but we made some changes to the PiN configuration to acconodate the RGB sensor.

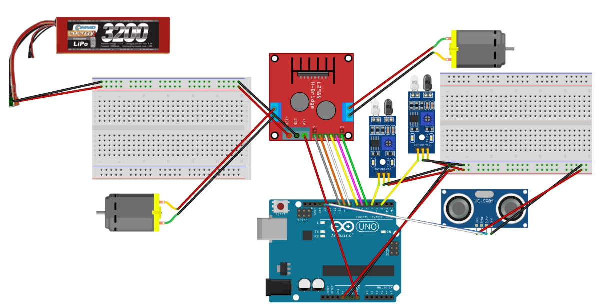

Fig. 13. Wiring Diagram as provided

PIN RECONFIGURATION ON ARDUINO		
As given to us	New Location	Modifications
PIN 6: IN4	PIN A0	PIN 6=S0
		PIN 3= S1
PIN 8: IN2	PIN A2	PIN 8= S2
PIN 9: IN1	PIN A3	PIN 9= S3
PIN 7: IN3	PIN A1	PIN 7= Out

Fig. 14. Pin Reconfiguration

E. CAD design

In this section we used the software Solidworks to do our drawings.The assembly view of system is presented in top, side,back front and isometric view.To be seen is also exploded view.

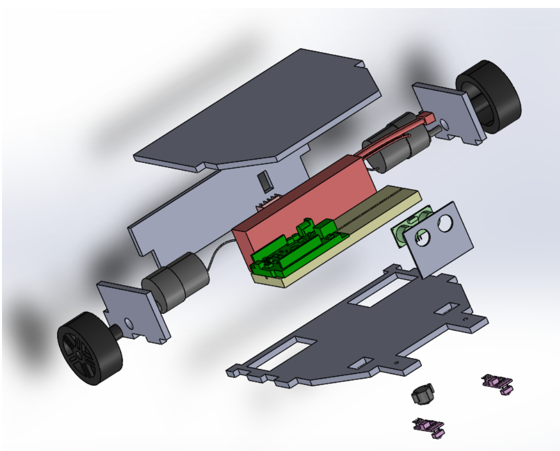

Fig. 15. Exploded view

F. Software design

Writing the code was a step by step process.That mean writing one part testing to make sure it works fine before moving to the next part.The first lines of code that was written was tested on the model that was design on the software Tinkercad.This was later also tested on a prototype model that was provided to us in the lab. This first stage of code testing served the purpose of making sure the initial part of the software was working before moving to the next must challeging task that had to be solved.It was also a good opportunity to be introduce to the programming of the Arduino Uno board.Finally we could also see if the car was being able to follow a line or not.The next step was to write the code to test the the ultrasonic sensor

G. Components placement

The battery is with 216 g the most heavy component.Its dimensions are:131 x 44 x 17 mm (L x W x H).We therefore started with it in the components positioning process on the chassis.We placed it between both rear wheels to apply a maximum amount of weight on the tires and therefore make them to grip more when robot is driving.This position is optimal as is prevent the robot from tilting backward and it leaves some spaces for the motor controller.The battery was laid dows with the side with biggest surface area so the breadboard can be placed on it.This position of the breadboard was intentionally done like that so that both Arduino and the motor controller a placed halfway to it and therefore no need for the wires to run a long way. The motor controller is position right behind the battery which puts if as close as possible to the motors.To balance the weight of the battery,we placed the Arduino right in front

H. Functionality Of the Design

At the back of the bottom part of the chassis are two rectangular cuts of 58*42mm.They are there to accomodate the two gear motors.In front of the bottom part are 2 square cuts of 18*18mm where the wires from the IR and RGB sensors will pass through to go connect to the Arduino Uno. The two sides parts of the chassis have 12mm holes where the schaft of the motor and wheel goes through.The back plate of the chasis has a rectangular cut of 10*19mm to mount the ON/OFF switch.Close to the middle of the bottom part of the chasses a 0.5 mm hole was drilled to accomodate the small front wheel.The U shaped front part of the chassis is used to collect bals of straws.All the following pictures illustrate what has just been explain.The front left and right sides are cut in angle way to reduced weight and save material

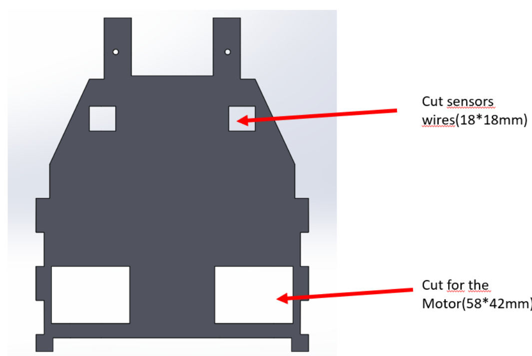

Fig. 16. Bottom of chassis.

V. Prototype Assembly

After doing the laser cutting of the following parts:Bottom ,left and right side.We proceeded as follow to put together the chassis of our car. 1st Step: we use a template to mark the mounting holes of the gear motor.We then place that same template on the side of the chassis to mark those three holes and we drilled them. The schaft of the motor and the tires go through a hole of 12mm of diameter.3 screws are going through the side of the chassis into the holes to mound the motors.

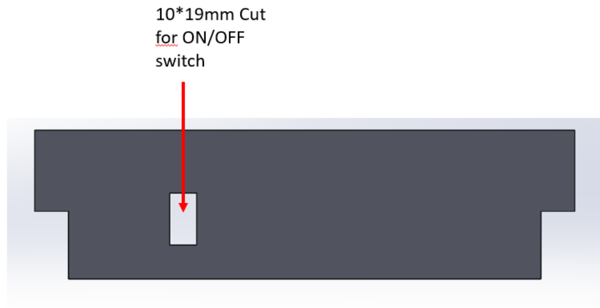

Fig. 17. back Of the Chassis.

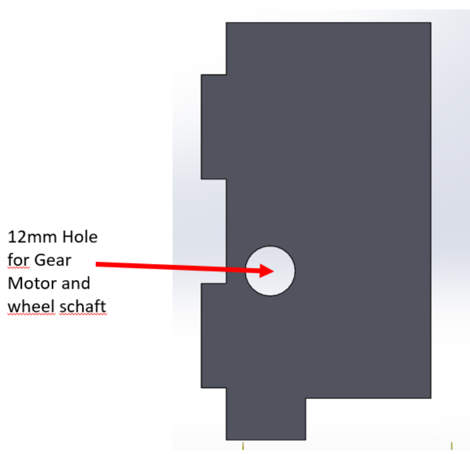

Fig. 18. side Of Chassis.

VI. Design Changes and Improvements

A. Software

Throughout the project changes were made to meet the requirements as given to us.

B. Hardware

We drill some holes at the front of the chassis to put through the pins of the RGB sensor.We mounted a rectangular plastic piece right next to the object collector to hold the ultrasonic sensor

When we started testing the robot on the track we realised that the left and right IR sensor needed some calibration.We wrote some lines of code and used the serial monitor of the Arduino IDE to do the job

VII. Retro Vs Modern Design

Here we as group member all agree that we would like to have a retro design.This retro design had to be based on the initial prototype that we have been working on.We added some sides covers to close the front section.We also added a nose, bigger forks and a rear spoiler.The front nose channels the flow of air on top of the robot car right to the back spoiler which

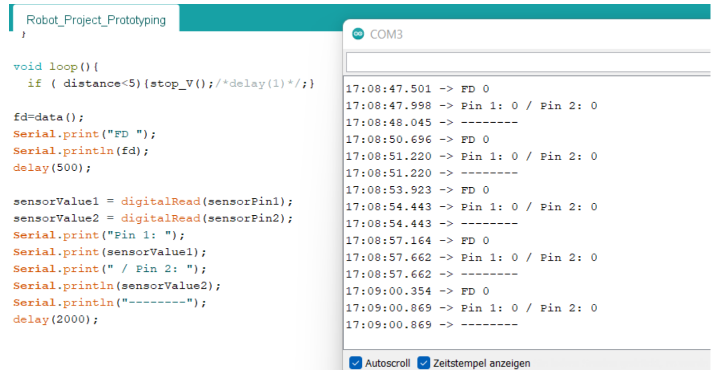

Fig. 19. IR sensor calibration

serves the purpose of creating more downforce.The front left and right covers are there also to redirect the flow of air and give the car better aero-dynamics capabilities.At the middle of the car are rectangular openings at the left and right side that allows air to circulate so the motor controller and other electrical components can cool down

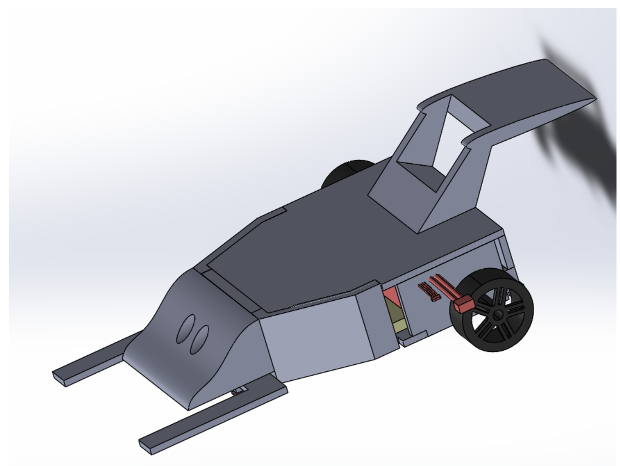

Fig. 20. Retro Design

VIII. Outcome

By the time of submission of this report we had a functional robot that was able to follow a black line.We were still busy doing software changes to meet the requirements.We created nonetheless a realised Version 1.0 on Github which will be subjected to changes by the time of the final presentation

IX. Future Work

There is a lot of room for improvement for our project. We used two line sensors (IR sensors) for the vehicle, in the future we can use five sensor arrays for detecting black line quickly and efficiently. We can also mount more ultrasonic sensors on both the sides of the cars to detect objects nearby. Also, we can mount cameras on the cars and implement IOT to connect the vehicle with smartphones or computers. It’ll allow us to control the vehicle remotely and give it instructions about where the robot have to pick the next bals of straw.

X. Conclusion

This project was challenging but at the same time we learned that a design process need iterations steps.A prototype does not get design from beginning to the end without adjustments being made.Design Decisions are not done made through a trial and error process but have to follow the rules of engineering.We have learned that a prototype can be build with the help laser cutting of plywood or the printing of 3D parts.

Acknowledgment

We would like to thank Prof.Dr Stefan Henkler, Mr Gido Wahrmann,Kristian Rother for the help,guidance and advices they gave us during this design project

Task Distribution and Github link

Mr Joshua wrote:requirements,system engineering,Hardware selection

Mr Justice wrote:Introduction,Motivation,Problem statement

Mr Abir wrote: concept description,future work, outcome and ,Design changes and improvements

Mr Donfack wrote: CAD design,Software design,Components placement,Functionality of the design,Retro Vs Modern Design,Abstract

https://github.com/abmabir/Prototype-and-Systems-Engineering/releases/tag/V1.0

References

[1] United Nation,"Global Population Growth and Sustainable Developmentt" 2022,P.39

Appendix

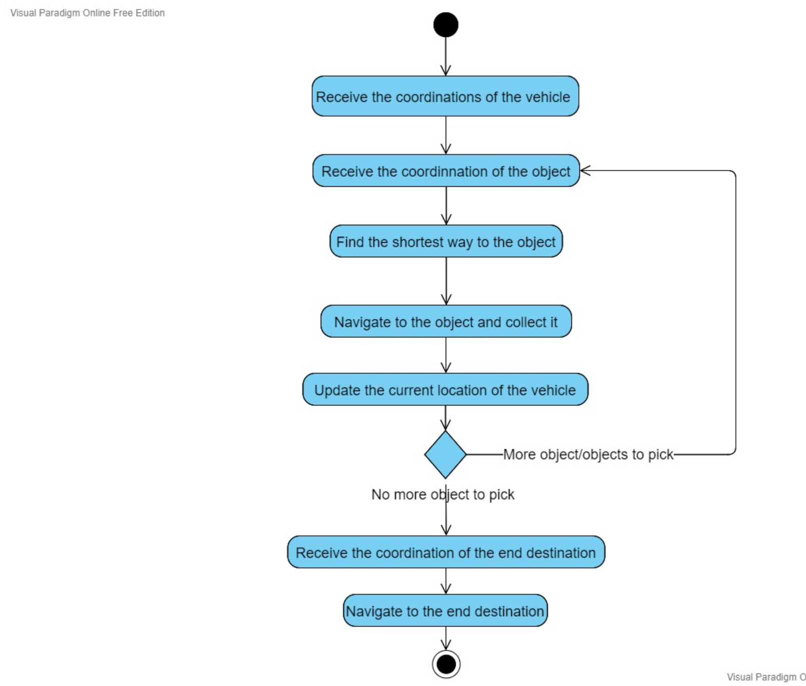

Fig. 21. Activity Diagram

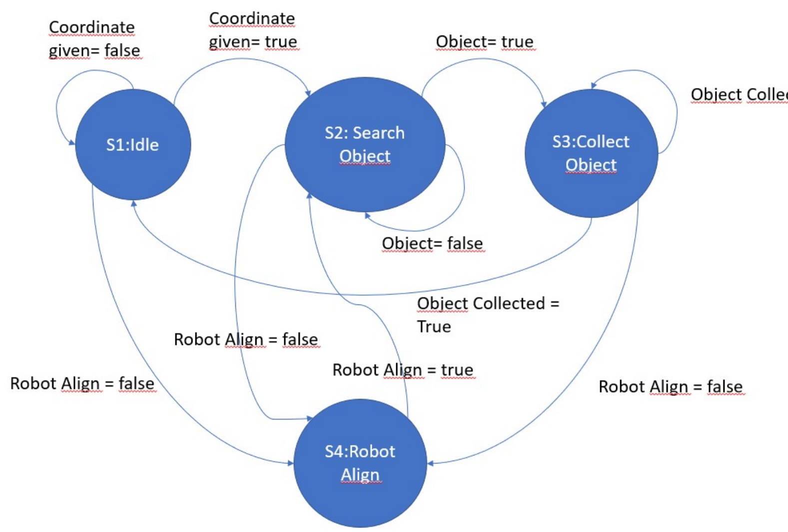

Fig. 22. State Machine Diagram

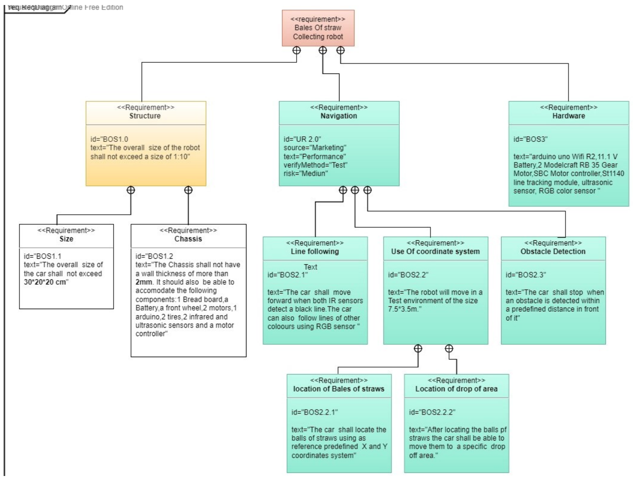

Fig. 23. Requirement Diagram

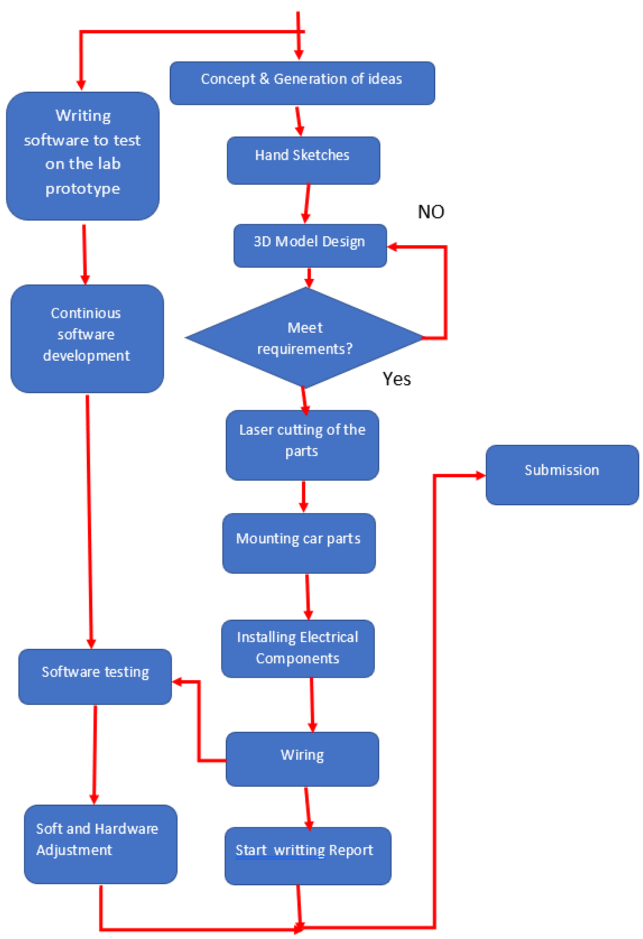

Fig. 24. Design Project Process

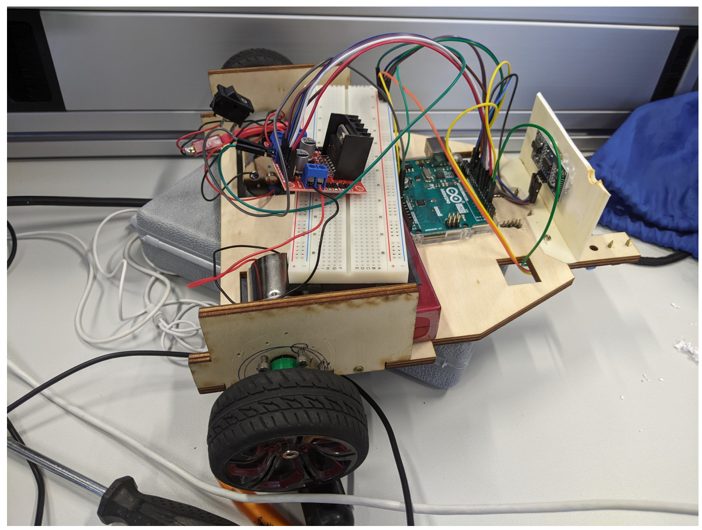

Fig. 25. Assembly process

Eidesstattliche Erklärung

Hiermit bestätige ich, dass ich diese Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen sowie Hilfsmittel genutzt habe. Alle Ausführungen, die anderen Quellen im Wortlaut oder dem Sinn nach entnommen wurden, sind deutlich kenntlich gemacht. Außerdem versichere ich, dass die vorliegende Arbeit in gleicher oder ähnlicher Fassung noch nicht Bestandteil einer Studien- oder Prüfungsleistung war.

Affidavit

I hereby confirm that I have written this paper independently and have not used any sources or aids other than those indicated. All statements taken from other sources in wording or sense are clearly marked. Furthermore, I assure that this paper has not been part of a course or examination in the same or a similar version.

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