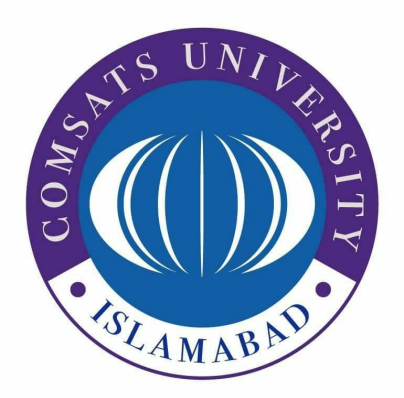

Obstacle Avoidance of Multi-Agent System using Swarm Auto-bots

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TITLE	Obstacle Avoidance of Multi Agent System using Swarm Auto bots		

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I dedicate this thesis to our Holy Prophet Hazrat Muhammad (PBUH)
&
to my family

Acknowledgements

In the name of Allah, the Most Beneficent and the Most Merciful.

With deepest gratitude, for the blessing of Allah, Which he bestowed upon us at every step of this project for all the provision which made us capable of completing this project.

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Abstract

To solve the low-design problems of difficult control, poor portability and poor stability of traditional multi-agent formation, a multi-agent formation obstacle avoidance method is proposed.Swarm Auto-bots are having unprecedented positive impact in our personal social and business operations. Swarm Auto-bots is a field in which large numbers of robots are coordinated to perform a desired task. The nature of individual Auto-bots is either heterogeneous or homogenous robots. A significant portion of research is seen to be interested in mobile Auto-bots. The main aim is to fabricate and develop an autonomous and intelligent system to perform swarming with synchronization and continuous communication. It is a system in which the moving Auto-bots perform swarming; avoiding obstacles and collisions among themselves by controlling parameters like stability and synchronization. The prototype comprises of three unmanned ground vehicles (UGVs). These UGVs forms swarm. The swarm Auto-bots are comprised of one Master the decision-making Auto-bot and two of them are Slaves which act accordingly to the alpha node in a synchronized manner. The UGVs are designed and fabricated on the same computational power to enhance ability and modification according to application. The communication channel is Wi-Fi of range 220 meters, yet well-secured Master only communicates to unique MAC address of Slave and can handle 250 bytes of data up to 20 beta nodes if attached.

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CHAPTER 1

Chapter 1

Introduction

1.1 Project Background

The field of multi-robotics is a huge interest of quite a lot of researchers in this decade. Systems are developed according to specific requirements and global applications. Our project is to make a full autonomous system of multi robots that is able to perform swarming whilst continuously communication between them. If a system has a set of capabilities that are limited and is not upgradeable to another scope; it becomes specific. This system is upgradeable to the fields of artificial intelligence and machine learning. The communication among the robots is done via wireless network. An unknown environment is provided to the robots in which they perform swarming while avoiding collision among them and also avoiding certain obstacles. In this system a number of autonomous robots are introduced with a master-slave configuration in which any single robot is a dedicated master and others a slave to it. To perform communication among the robots; each robot is installed with a separate communication channel. Here, the controllers capability which is being used is important. The controllers can perform specific techniques like line follower or obstacle avoidance etc. This the part where the controllers computational power is taking into notice. The proposed system is provided with an indoor environment which is unknown to them. These multi-robots perform surveillance in the arena in the formation of swarm and avoid any obstacles provided using ultrasonic sensors and also avoiding collision between them. If we look into the future, we shall have thousands of communication and controls system around us providing different functions and aids. If we design a full autonomous system which performs a complete application with complete synchronization and by continuously communication between them, it would be a great triumph in the Communications and Control Systems field. [1] [2].

Figure 1.1: Swarming Between Auto-Bots

1.2 Project Description

Swarming is the major part of the Communication Systems. Swarm Autobots basically provides a solution that eases the machine work with a system of full autonomous synchronized multi-robots.
The obstacles are avoided using ultrasonic sensors and ultrasonic sensors are used to avoid the inter-collision among the robots. The communication among the robots is done using ESP-32 micro-controllers which are mounted on each robot which has a built in Wi-Fi and Bluetooth module. So, there is no need to install components for a separate communication system.
Communication is done among the controllers using the MAC addresses [3].

1.2.1 Robots Assembly

Robots assembly and development is the major part of the project so we have used 4WD Robotics Chassis Kit. It uses high power DC DC gear motors at speed 125 RPM.[4].

1.2.2 Obstacles Avoidance

An unknown environment is provided to the robots in which they perform surveillance of the arena and avoid any obstacles faced. So, Ultrasonic SR04 Sensors are used for the avoidance of these obstacles[5][6].

1.2.3 Communication

This is the most challenging part of the project. Communication is done among the robots using ESP-32 micro-controllers. These controllers have a builtin Wi-Fi and Bluetooth module.
These controllers are mounted on top of each robot. The communication is done via Wi-Fi module[7].

1.3 Problem Statement

Use collaborative behaviors to achieve complex tasks beyond any individual's capability. A self-managing automated system for smart behavior of robots working in a swarm environment. The proposed system should help identify the robots in a cooperative manner to identify hurdles in the nearby vicinity and avoid collision between them without human intervention.

1.4 Project Objectives

- Designing of robotic vehicle.
- Intercommunication between auto-bots for control.
- Obstacle avoidance.

1.5 Research Questions

- How to Intercommunicate Auto-bots for control and coordination purpose?
- What system or sensor are used to implement Obstacle Avoidance in Swarm Auto-bots?
- How to identify Auto-bots in nearby vicinity and avoid collision between them?

1.6 Project Scope

The scope of our project is to design and develop multiple robots (UGVs) which have the capabilities to avoid obstacles, prevent collision amongst them and execute complex tasks in swarm formation whilst continuously communicating between them. If we look at the bigger picture, we can see that before the last decade when the concept of swarm robots was not introduced; machine did all the human work.
But now, the field of multi-robotics is a massive hobby of quite a lot of researchers in this decade since the concept of swarming amongst the robots reduces the machine effort and increase the work efficiency. In the near future, the concept of swarming will take over as to reduce machine efforts and save time for any desired project. So, using the knowledge of the fields of Communication and Controls we shall be able to develop multiple robots that will execute tasks using swarm formation.[8]

1.7 Application

- UGV Cooperative System.
- Truck Platooning.
- Robocup.
- Firefighting.
- Rescue Operations..
- Cooperative Tracking.

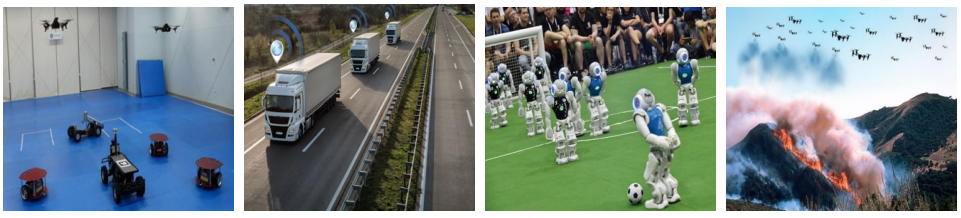

Figure 1.2: Application

1.8 UN's Sustainable Goals

This project can be considered to meet the following aims shown in figure 1.3, which are part of the 17 Sustainable Development Goals to quit poverty, guard the environment, and make certain that everybody lives in peace and prosperity with the aid of using 2030.

Figure 1.3: Targeted UN's Sustainable Goals

1.9 Thesis Breakdown

We explored the Obstacle Avoidance of Multi-Agent System using Swarm Auto-bots in Chapter 1, as well as its motives and research questions. There are several goals highlighted that are the US nation's set goals to secure a better future for humanity in 2030. In Chapter 2, we will go into further depth, discussing in terms of literature reviews and comparing all of the possible research methodologies used in the past to achieve Power Optimization. We will go to Chapter 3 where we will illustrate the Block Diagram, algorithms,Flowcharts, Component Selection in Projects with Hardware and Software Setups, and all potential project limits. In contrast, Chapter 4 will go into great detail regarding the tests that were conducted throughout the project and will explain all of our simulations and outcomes. We will wrap up the project in Chapter 5 and determine the project's future trajectory.

CHAPTER 2

Chapter 2

LiteratureReview

2.1 Literature Review

Inspired by the social behavior of animals, particularly insects, swarm robotics is emerging as an intriguing topic for multi-robot researchers. A blend is shown of swarm intelligence and robotics, which shows great prospective in multiple scenarios. Like swarm coordination and swarm intelligence of environment and modeling methods for swarm robotics. In recent years a fast enpension in swarm robotic has been experienced. Powered by generic multi-robot systems designed to gain specific collective action. The developed technology can be moved to a wide range of robotic grounds. This swarm able technology is favorably achieved in various multi-robot systems. Simulation software has a major use for swarm robotics research due to the hardware complexity of robotic platforms.But, the simulation of many of these robots is very difficult and often imprecise[9]. Autonomous robots are used in many researches and applications. These robots can be used for specific purpose such as anti-collision and path planning. Many types of sensors and actuators are used with these robots for sensing the environment and making decisions. In view of obstacle avoidance using Ultrasonic wave static sensor. An algorithm is developed inspired by nature and used in these swarming techniques. Systems are developed according to specific requirements and global application. Specifically, for one task. They are categorized in a manner to what to achieve at the end. Every system has its flaws. The main work is the development of a system according to need.[10].

Table 2.1: Literature Review.

No #	Paper Title	Proposed Methodology	Sensor	Result
1	Research advance in swarm robotics	Swarm robotics is a new research area inspired by swarm intelligence and robotics. Although several investigations have been proposed, practical application is still a long way off.	Infrared Sensors	Advances in hardware technology and collaborative approaches in swarm intelligence will drive the advancement of swarm robotic systems in the future.
2	Development of an autonomous micro robot for swarm robotics	Design of a new low-cost, micro robot for swarm robotics research.	Infrared Sensors	The observed results of the robot's individual and social behavior showed that collision is suitable for implementation in large-scale collective behavior.
3	Libot: Design of a low cost mobile robot for outdoor swarm robotics	Based on the robot specifications and the area of ??application, a decision must be made as to which robot meets the requirements.	Infrared Sensors	The experiments were designed to test Libot's performance in terms of mobility, detection, localization, and communication.
4	Line estimation for a line-following mobile robot	The position coordinate of the line is estimated using the MVU estimator. Using the estimated line position as feedback to the PID controller.	Infrared Sensors	The experiments were designed to test Libot's performance in terms of mobility, detection, localization, and communication.

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Table 2.1 – Continued From Previous Page

No #	Paper Title	Proposed Methodology	Sensor	Result
5	Design of an intelligent active obstacle avoidance car based on rotating ultrasonic Sensors	In the construction, a measurement method using rotation sensors is used, and a preferable optimal control algorithm is gaind with the difficulty of time and the difficulty of space.	Ultrasonic Sensors	In irregular shape environments with multiple barriers, it improves obstacle avoidance sensitivity, reaction speed and success rate.
6	Development of efficient obstacle avoidance and line following mobile robot with the integration of fuzzy logic system in static and dynamic environments	Development of anti-collision mechanisms and line tracking for mobile robotic navigation.	Proximity Sensors	A mobile robot was developed for collision avoidance and a line sequence with eight proximity sensors for fuzzy logic control for collision avoidance with one input and two outputs was designed.
7	Swarm enabling technology for multi-robot systems	In order to enable swarming, it's important to gain distributed communication and scattered decision-making.	Ultrasound Sensors and IR sensors	The structure of integrated hardware plus software tools that enable a variety of multi-robot environment to work cooperatively and fully distributed was presented.

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Table 2.1 – Continued From Previous Page

No #	Paper Title	Proposed Methodology	Sensor	Result
8	Survey on swarm intelligence based routing protocols for wireless sensor networks: An extensive study	Principle of swarm intelligence have been discused and survey studies on SI primarily based totally protocols became discused. Also it became concluded with a comparative analysis, mentioning the essential problems and ability for destiny directions.	-NIL-	Swarm based routing protocols in WSNs was presented.
9	Swarm robotics: From sources of inspiration to domains of application	A definition for swarm robotic, and related terms was purposed some set of criteria was forwarded that will be helpful to differentiate swarm robotic research.	-NIL-	Studies behind the motivation of this approach are the required properties and requirement for the meeting of characteristic of this approach compering with the present approches studied.
10	From Swarm Intelligence to Swarm Robotics	In the given paper, we study on swarming to help identify its presence with other robotic concepts.	-NIL-	Robotic concepts in view of swarming was made.

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Table 2.1 – Continued From Previous Page

No #	Paper Title	Proposed Methodology	Sensor	Result
11	Analysis of Obstacle Detection Using Ultrasonic Sensor	Ultrasonic sensor used for obstructions detection of wood, paper, cloth, plastic and metal.	ultrasonic sensor	In this study, data was collected using EV3 Lego Mindstorm, ultrasonic sensor, different types of materials and software programming.
12	Development of an arduino-based obstacle avoidance robotic system for an unmanned vehicle	Sensor used are ultrasonic and infrared for detecting obstacles in the robot's path and to avoid these obstacles.	Ultrasonic and Infrared Sensor	Circuit for detecting obstacle using infrared sensor plus ultrasonic sensor modules has been successfully implemented.
13	Obstacle Avoidance System for Unmanned Ground Vehicles by Using Ultrasonic Sensors	The idea is to apply such a methodology to small autonomous agricultural machines through the use of retrofitting techniques.	Ultrasonic Sensor	Object identification was done using neural networks and ultrasonic sensors.
14	Swarm robotics reviewed	A brief description of various robotic devices that can be integrated into swarm robotic systems is presented. Challenges to be solved in the design of robot swarm systems are identified.	-NIL-	A set of questions that need to be answered in order to overcome any issues related to swarm territory and to suggest directions for future research in swarm robotics based on the analysis of the reviewed literature..

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Table 2.1 – Continued From Previous Page

No #	Paper Title	Proposed Methodology	Sensor	Result
15	WIFI remote controlled rc car commanded by a c application and esp32 Arduino Wi-Fi module	ESP32 Wi-Fi module RC car was build, having vision through IP camera.	-NIL-	IP camera was installed for live vision.
16	Obstacle detection using ultrasonic sensor for a mobile robot	A low-cost ultrasonic distance sensor was implemented to avoid obstacles for mobile robot navigation.	Ultrasonic Sensor	Obstacle avoidance for mobile robot is done through ultrasonic sensor using Arduino Uno as a microcontroller.
17	A Sensor Fusion Methodology for Obstacle Avoidance Robot	A logical sensor blending method was presented for detecting the size and coordinates of obstacles and to move the mobile robot with precision.	Ultrasonic Sensor	Obstacle avoidance was done using two types of sensors. Kinect and ultrasonic were used for obstacles detection.
18	Design of an Intelligent Active Obstacle Avoidance Car Based on Rotating Ultrasonic Sensors	A system was designed that effectively improve the movement,speed,sensing and avoiding obstacles with success for autonomous obstacle avoidance.	Ultrasonic Sensor	A unique process for measurement of rotation sensors was used for the design, for a better optimal control algorithm.
19	Outdoor obstacle detection using ultrasonic sensors for an autonomous vehicle ensuring safe operations	Obstacle detection using sonar system was implemented for the mobile robot system.	Ultrasonic Sensor	Ultra sonic sensor for obstacle detection was designed for mobile robot system and was tested in different environment for better results.

To analyze the previous work that is related to the technique of formation of swarm robotics a list of papers were found relevant and have been studied. The essential part of each paper is described above regarding the relevance and usability of each method that was described in each research paper.

2.1.1 Multi Robot Systems

The autonomous mobile robots work together in association with each other in order to minimize the work load by performing multi-tasking. Likewise, the groups of multi robots can be assigned the task having different sensing capabilities and these tasks are assigned to the mobile robots after seeing the nature of tasks.[8]

2.1.2 Group Architecture

Cooperating agents are classified into two categories the one is called as Coordinator and the other is Cooperator. From all these cooperative robots, one robot that is the coordinator who identifies the problem and that problem is not easy to identify alone. This coordinator robot needs other cooperating robots to work in association with each other in order to resolve that problem and complete those targeted tasks. This coordinator robot will choose which robots from the cooperating one will perform these responsibilities[11]. The movements that coordinator performs by the help of communication is actually the development of the movement plan that is then transferred to cooperator UGVs to perform the given tasks according to that movement plan in company with each other. If this coordinator robot gets unsuccessful in achieving that given targeted task then all of a sudden another robot takes the responsibilities of that coordinator and becomes the new coordinator robot and perform given targeted task. However, by the help of this coordinator no clashes will happen in cooperative robots[12].

2.1.3 Geometric Problems

The role of communication is very important in this process. To eliminate one of the many issues routing protocols are developed. Many issues occur associated with the battery for example elasticity, durability, lastingness, adjustability etc[13].

2.1.4 Types of Interactions

Types of interactions that take place between the robots:

- **Collective:** These types of robots have a same goal but they are not alert of each other but their actions help in achieving the common goal.
- **Cooperative:** These types of robots are alert of each other and have a same goal. They help in achieving the main goal by separate actions.
- **Collaborative:** These types of robots are aware of other robots but have individual goals. Also, their actions help the common goal.
- **Coordinative:** These types of robots are aware of other robots but they perform individual tasks. These robots do not help in achieving the common goal.

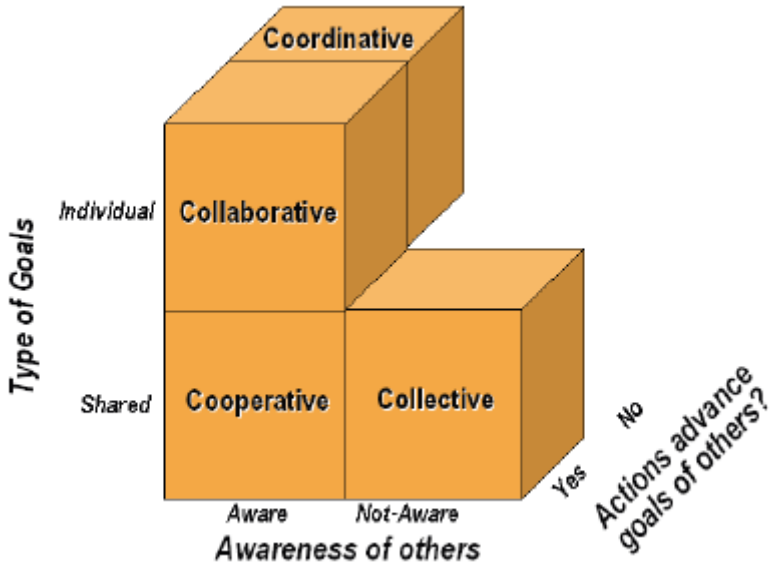


Figure 2.1: Types of interactions that take place between the robots

2.1.5 Decentralized Speed Adaptation

In a known or unknown arena, the main thing is to get the desired formation of the mobile robots when they are performing their tasks. For this some solutions have been proposed that are considered significant in getting the desired formation of multi mobile robots. These disciplines for maintaining the formation, have been divided into two categories. The first one is to evaluate the path of each robot separately in group of mobile robots. Other one is to apply the speed adaptation algorithm to the defined path of each group of robots that they are following in order to estimate the path followed by them. These robots only have two applications and that are path planning and avoiding collision between them[14]. Different sensors are being used for performing these applications. These sensors are launched on robots body, they are used for sensing and observing each obstacle that are placed in their ways, also in what speed they are moving, taking decisions for tasks and performing their actions. For these, eight sensors have been used in applying this speed adaptation algorithm and avoiding collision[4].

2.1.6 Distributed Boundary Detection Algorithms

To detect the boundary of a swarm that is based on two-dimensional configuration the algorithm must be distributed in a whole area and it requires only local system geometry. The local system geometry detecting is a model that combines the position of neighbors of robots and network connectivity relative to itself[6]. Each of the swarm robots has a localization system that provides the location of robots by using infrared communication that is able to determine the location of each UGV relative to each other. On the top of robots lights are there which indicate whether the robot is a part of exterior boundary or interior boundary. Also, for programming the robots and data collection each robot has a radio that is used[15].

2.2 Conclusion Remarks

Parameters that were studied are:

- Swarming: Inspired by nature swarm robotics is emerging as a hot topic for multi-robot researchers. It's a combination of swarm intelligence and robotics. Like the swarm cooperation and swarm intelligence of nature and modeling methods for swarm robotics.
- Communication: Different type of communication is used in swarming like bluetooth and WiFi.
- Obstacle Avoidance: Many sensors are used for obstacle avoidance like Ir sensor and ultrasonic sensor.

CHAPTER 3

Chapter 3

Proposed Methodology

3.1 Overview

Many techniques are applied to perform robot swarming. Nature has many aspects; an algorithm is developed inspired by nature and used in these swarming techniques. Systems are developed according to specific requirements and global application. Specifically, for one task. They are categorized in a manner to what to achieve at the end. Every system has its flaws. The main work is the development of a system according to need. As discussed earlier if a system has limited capability and not upgradeable to extend the scope it become specific. All existing systems or research that is available having configurations of communication via the wireless network while in a group cannot adopt the environment. A known environment is provided. Communication essential they have complex circuitry and more parts for example to perform communication separate channel is installed on each robot which increases the power consumption and requires more routing protocols. As adding more and more traffic on channel, data rate plays an important factor while performing complex data through a channel controller capability is also crucial. They have either line follower technique or obstacle avoidance or navigation or mapping which makes them very specific. The project scope is limited due to controller computational power[16].

3.2 System Architecture

Swarming is the major part of the Communication Systems. Swarm Auto-bots basically provides a solution that eases the machine work with a system of full autonomous synchronized multi-robots. Various architectures and applications of the swarming techniques have been proposed in past and many researchers are actually trying to upgrade these models according to different scenarios.
The autonomous mobile robots work together in association with each other in order to minimize the work load by performing multi-tasking. The basic algorithm on which the system relies is The Auto-bots Swarm Algorithm developed by us. It is influenced by the working techniques of small creatures. Which explain the functioning technique of a cluster of swarm collectively to perform unique tasks, as an example, surveillance, intelligence, time reducing and reducing single machine effort by grouping in the form of a swarm i.e; be in sync with each other all the time. This algorithm is written to to satisfy a couple of parameters, for example, communication, coordination, and synchronization. Here, a challenge lies which is to perform synchronization with almost zero delay but practically, ending the delay is never been

easy and is almost impossible. So, the delay would in micro seconds[5].

3.3 Component Selection

The sensors used for the project are listed below:

3.3.1 UGVs Chassis Assembly

As robots assembly is the major part of the project so we have used 4WD Robotics Chassis Kit. It uses high power DC gear motors at speed 125 RPM.It has a very easy Mechanical structure and is very easy to install.

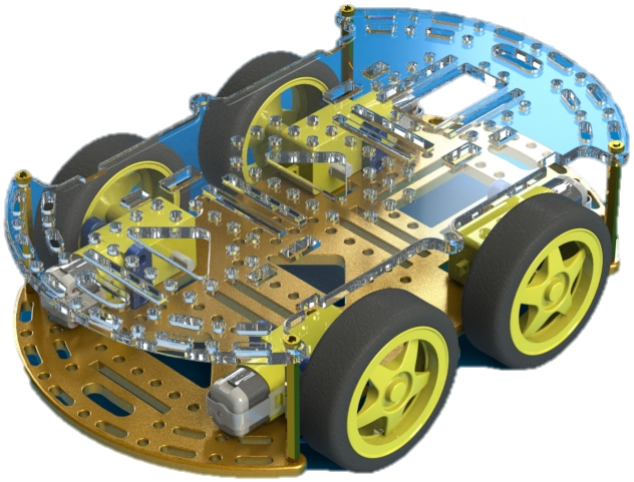


Figure 3.1: 4WD Robotics Chassis

3.3.2 Controller ESP32

ESP32 typically come in different form of modules. We have used ESP32-WROOM module.It contains 4MB of flash memory and a PCB antenna.The module can be connected to other components using its GPIO pins.This module has Bluetooth and wifi in constructed however we've used wifi. The ESP32 changed into selected as it is straightforward to put into effect it with Arduino and feature extra pins than the ESP8266 Wi-Fi module.

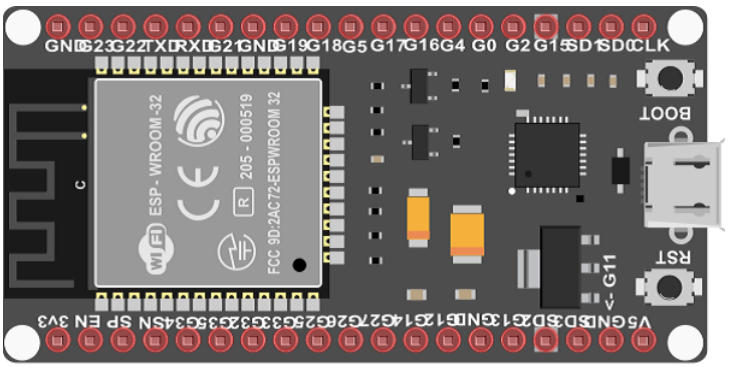


Figure 3.2: ESP32-WROOM

- Operating Voltage: DC 5V.
- Operating Current: 80mA (average).
- Current Supply: 500mA (Minimum).
- WiFi protocol: 802.11n, speed up to 150 Mbps.
- WiFi frequency range: 2.4 GHz 2.5 GHz.

3.3.3 Motor Drivers (L298N)

L298N is a dual H-Bridge motor driver. Speed and direction control for 2 to 4 DC motors is allowed at the same time. 5 to 35V is used to drive DC motors, with 2A of peak current. To maneuver the robotic it's far had to manipulate variables of the motors, the rate and the direction. This may be carried out with the aid of using combining techniques:

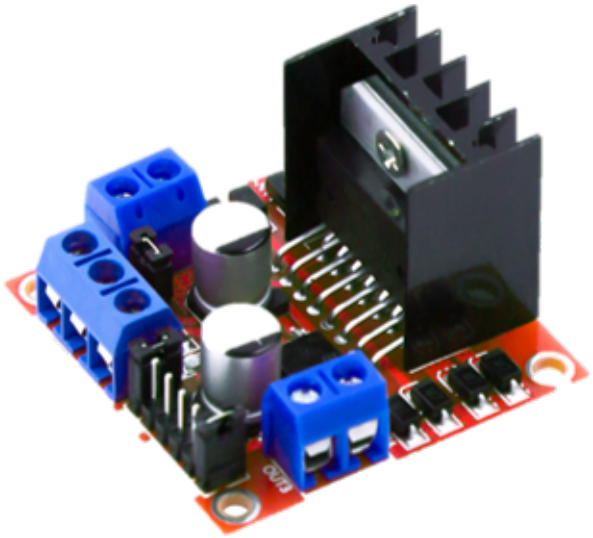


Figure 3.3: Motor Drivers (L298N)

Pulse Width Modulation (PWM)

This approach allows the person to change the common voltage by sending a series of high-low pulses. Depending on the mandatory cycle (ratio in between length of time the signal is high and low in a single period), for the common voltage changes.

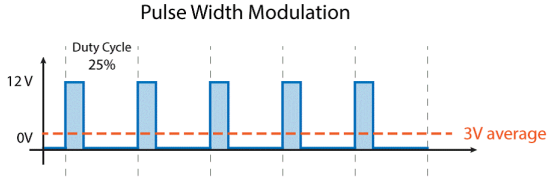


Figure 3.4: Pulse Width Modulation explanation

H-Bridge

H-Bridge technology was used to control the direction (forward and backward). This technique reverses the direction of current flow through the motor. It consists of four symmetrically arranged switches and depending on whether a pair of switches are open or closed, current flowing indicates the rotation of the motors. The switches are actually MOSFET transistors, but the schematic is an oversimplification.

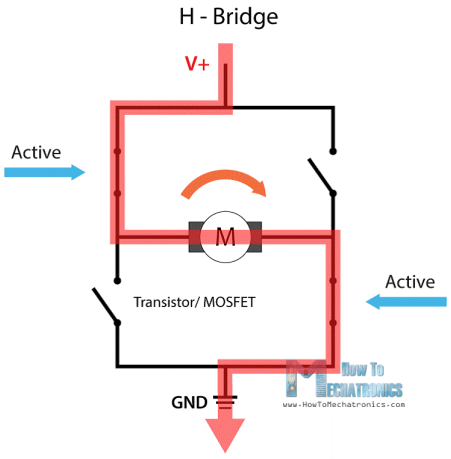


Figure 3.5: H-Bridge schema using switches to control the rotation direction.

3.3.4 Ultrasonic Sensor(HCSR04)

A distance measuring sensor and we are using it for obstacle avoidance. The sensor works by sending sound waves and detects how far the object is. The distance is calculated by the time lapses measurement between the sending and reeving of ultrasonic pulses to the target[5].

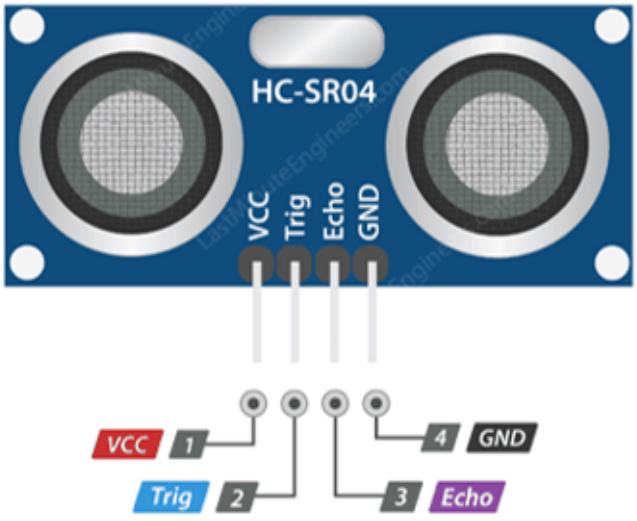


Figure 3.6: Ultrasonic Sensor(HCSR04)

3.3.5 Lipo-Battery (2200mah)

A 3 cell 11.1V Lipo battery is used to provide a suitable current. As all the components that are present in each node needs some current and voltage like motors need 2A current ESP 32 needs 27-44mA, Ultrasonic sensor needs 15mA of current.

Figure 3.7: Lipo-Battery (2200mah)

3.4 Block Diagram

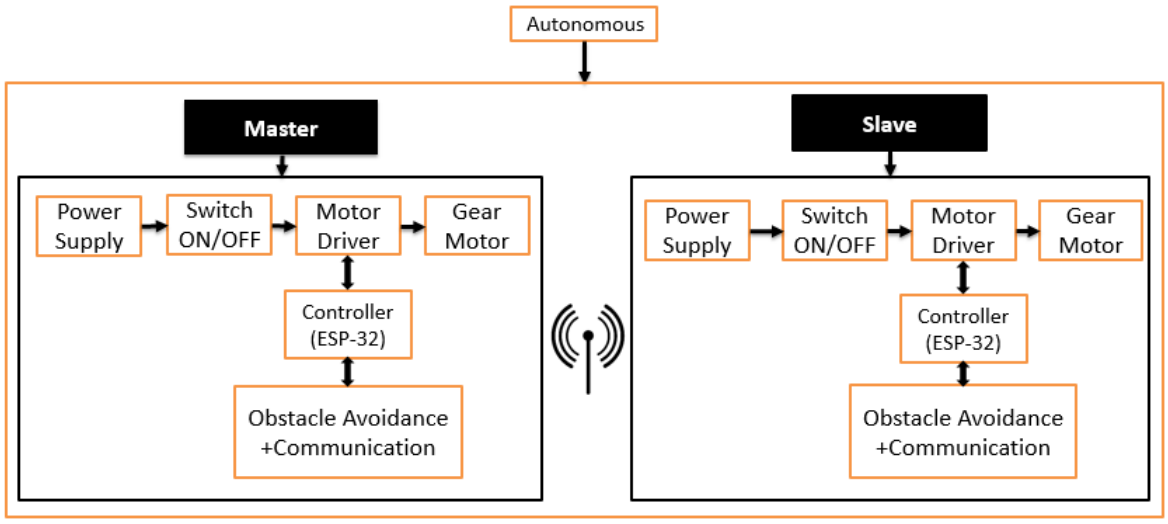


Figure 3.8: Block Diagram Of Proposed Method

The project is divided into two parts, as shown in the Fig. 3.8.

- Master.
- Slave.

3.4.1 Master

Master UGV is the decision making robot. This robot has the capability to avoid obstacles and it leads the slaves UGV.Master Collect data from the ultrasonic sensor for obstacle avoidance.If master detect and obstacle it send data to slave which has a unique MAC address thorough wireless medium Wi-fi.
The Master agent avoids the hurdle on the basis of Ultrasonic Sensor and then transfer the data to Slave through serial communication. The Master takes the input from time it takes ultrasonic signals to receive an echo from an object, which indicates the range of distance present[5].

3.4.2 Slave

The slave UGV are programmed to follow the instructions of Master UGV and they perform the desired actions as commanded by Master UGV.
The slave UGV obey Master UGV as communicated where obstacle is avoided on basis of the distance, so as soon as an obstacle arrive for Master the information will be communicated to the slave UGV and the slave UGV will quickly stop the movement towards the obstacle.

3.5 Circuit Diagram

The circuit diagram is shown in 3.9. This diagram show that data from ultrasonic sensor is collected for the purpose of obstacle avoidance we have used 3 of them the data is then read by esp-32 control Which is the main heart of project then the controller perform it's roll to avoid obstacle and then it send the data through wifi medium to the slave UGVs. The controller control the motordriver for the controlling of motors. Lipo battery (2200mah, 3 cell and 11.1 v) is used to provide suitable voltage for the circuit.

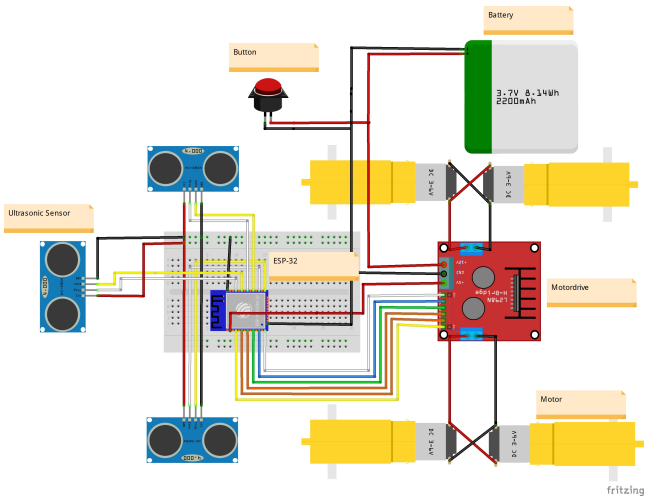
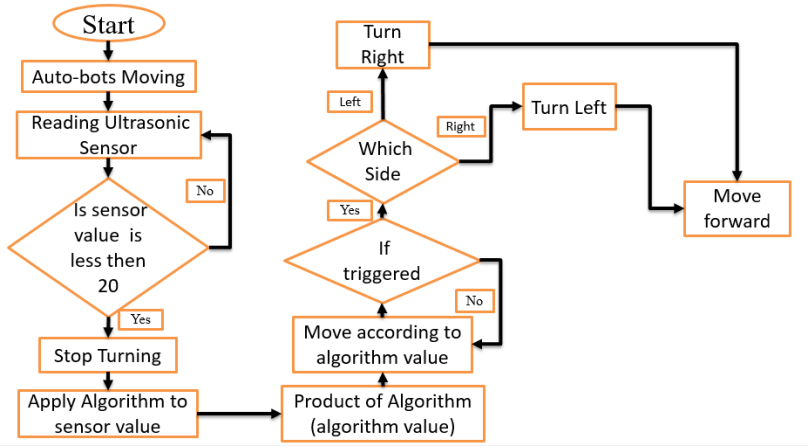


Figure 3.9: Circuit Diagram

3.6 Flow Charts

The flow diagram which is shown above describes the full architecture of the system that is being implemented. It shows how the parameters are to be looked upon involving different processes and the application that would be performed by these robots once the main goal of the system is achieved successfully.



(a) Flowchart

3.7 Implementing algorithms

Algorithm 1 Algorithm For Obstacle Avoidance

Input: Data from ultrasonic sensor.
Output: Obstacle Avoidance in UGV.

Start
Check all the sensors
if Middle Sensor is less then or equal to 23 **then**
    if Right Sensor is greater then Left Sensor **then**
        if Right sensors is less then and equal to 20 and Left sensors less then and equal to 20 **then**
            Stop and Go Back
        else
            Go right
else if Right Sensor is less then Left Sensor **then**
    if Right sensors is less then and equal to 20 and Left sensors less then and equal to 20 **then**
        Stop and Go Back
    else
        Go left
else if Right sensors is less then and equal to 15 **then**
    Go left
else if Left Sensor is less then and equal to 15 **then**
    Go right
else
    Go forward

Algorithm 2 Algorithm For Master

broadcastAddress1: 0x08, 0x3A, 0xF2, 0x8D, 0xC0, 0x64
broadcastAddress2: 0x0C, 0xB8, 0x15, 0xF3, 0xD1, 0x2C.

```
Start
Check Delivery Success
if Delivery Success then
    Send Data to Slave
else
    Delivery Fail
```

Algorithm 3 Algorithm For Slave

input: Bytes received from MASTER.

```
Start
Check incoming Data
if Receiving Successfully then
    Get data from master
else
    Receiving Fail
```

Summary of all the steps that will help robot to avoid obstacles are discussed in first algorithm. If any object is detected by any sensor it will be avoided.
Outline of the steps that how master robot will send data to slave is discussed in second algorithm.
Summary of all the steps that how will slave robot send data to master is discussed in third algorithm.

CHAPTER 4

Chapter 4

Implementation and Results

4.1 Implementation

4.1.1 System Architecture

In this chapter we will describe the general implementation, architecture and tools used in this project in detail.

Master

Master UGV and is the decision making robot. This robot has the capability to avoid obstacles and it leads slave UGV.

Slave

Slave UGV we have programmed them to follow the instructions of Master UGV and they perform the desired actions as commanded by Master UGV.

UGVs Chassis Assembly

First step in implementation is the assembly of robots chassis, firstly we will assemble these chassis then move on to next steps. The chassis that we are using are 4WD Robotics Chassis Kit. It uses high power DC DC gear motors at speed 125 RPM.

Controller ESP32 Installation

After assembling the chassis the next step is to install the ESP32 controller. This controller is installed with the help of breadboard and each pin of this controller is use by all other components that we are using and connected to it through wiring. Wiring is done through jumper wires. Each pin of ESP32 is specified for a specific component. Arduino IDE compiler is used for it with ESP32 libraries installed.

Motors Installation

After assembling the chassis the next step that comes is to control the motors. These motors operate on 150mA to 200mA current and 3v to 6V DC. Their no load speed is 350rpm. For controlling the motors we have to control its PITCH and YAW.

- Controlling Pitch. Controlling pitch means that we are controlling the forward and backward movement of motors. For this we will use PWM technique that is

a signal of specific rate is generated from controller to encoder and encoder will count the rpm of motors according to the signal that our controller is generating.

- Controlling Yaw. Controlling YAW means the control of left and right movement of motors. Same technique will apply here. According to this data encoder will move our motors in left of right direction.

- Motor Drivers. Motor drivers we are using on each node as they acts as an interface between control circuits and motors Motor needs a high current to operate whereas a controller circuit works on low current signals now here motor drivers play there role by converting low current signal into high current signal that is needed for driving a motor.

Sensors Installation

After installation of ESP32 controller next step is to install the sensors. We are using ultrasonic sensor for object detection.

- Ultrasonic Sensor(HCSR04). We have implemented an Ultrasonic sensor on front of our nodes. This sensor is a distance measuring sensor and here we are using it for obstacle avoidance. Ultrasonic sensor works by sending sound waves and detects how far the object is. It calculates the distance by measuring time lapses between sending and receiving of ultrasonic pulse to a target. And here it is taking data at a distance of 20cm.

Lipo-Battery (2200mah) Installation.

A 3 cell 11.1V Lipo battery is used to provide a suitable current. As all the components that are present in each node needs some current and voltage like motors need 2A current ESP 32 needs 27-44mA, Ultrasonic sensor needs 15mA of current.

4.1.2 Communication Channel

Wi-Fi

WiFi is the technology that is able to provide our devices an internet of high speed without having physical wired connection. We are using WiFi of ESP32 controller as a communication channel between our nodes as this controller has building WiFi and Bluetooth but we are using WiFi here. Its WiFi range is 220m, having frequency of 2.4 GHz.

Mac Address

A hardware devices identification no that can uniquely recognizes that device on a network is called its MAC address. For having a communication with a Wi-Fi network, that device should have to identify itself to the network using a unique MAC address. We are providing MAC addresses to controller of each nodes so that controller can send data to that MAC address.

4.2 Testing and Results

4.2.1 Controller Testing

In our project we are using ESP-32 controller for performing communication between our Master and Slave UGV. This controller has integrated Wi-Fi and Bluetooth through which we can done our communication. As this is the main component of our project for achieving its objectives so we have to do testing of this microcontroller first. During its testing we have to check for its installation whether it is successfully installed or not, then after its installation we have to check if it is sending and receiving signals through its Wi-Fi and Bluetooth channel or not. We can check this through our software installed (Arduino IDE) by seeing the data sending and receiving in form of packets from one ESP-32 controller to other. After successful transfer of signals our testing of controller gets done and we can move on to our next components for their testing.

4.2.2 Ultrasonic Sensor Testing

As object detection is one of our major objective of this project so it is essential to test whether our Autobots are avoiding obstacles or not as if this gets fail our whole project will get fail. We are using Ultrasonic sensor for this objective and keeping in mind its range we have selected this sensor so when any obstacle will come in ways of our Autobots they will avoid it with the help of this sensor. Steps that include in testing this sensor are:

- Connect the ESP32 VCC pin to 3.3V.
- After that connect ground pin of ESP32 to GND pin.
- Connect the D2 on ESP32 to trig pin.
- Connect the D5 on ESP32 to Echo pin.

After that plugin esp32 on PC and burn the code and by blocking the sensor with your hand or ceiling wall check the values if they are changing accurately and precisely then the testing becomes successful.

Ultrasonic Sensor Results

Ultrasonic Sensor taking data at a distance of 20cm.

Figure 4.1: Distance at which HCSR04 is taking data.

4.2.3 Mac Address of slave

For having a communication with a Wi-Fi network, that device should have to identify itself to the network using a unique MAC address. We are providing MAC addresses to controller of Slave UGV.

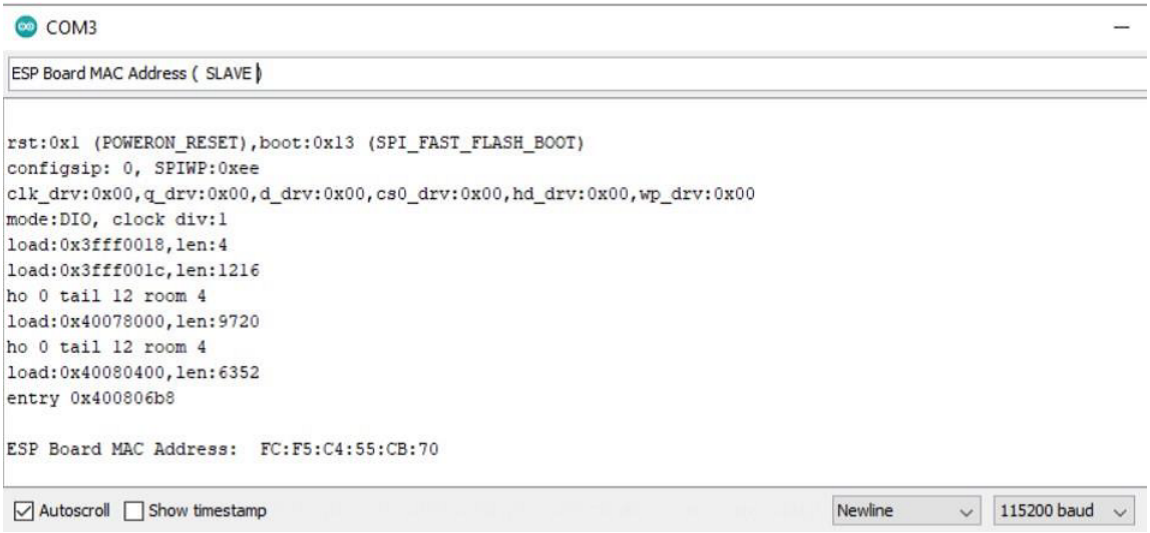


Figure 4.2: MAC address of slave.

4.2.4 Sending data from master

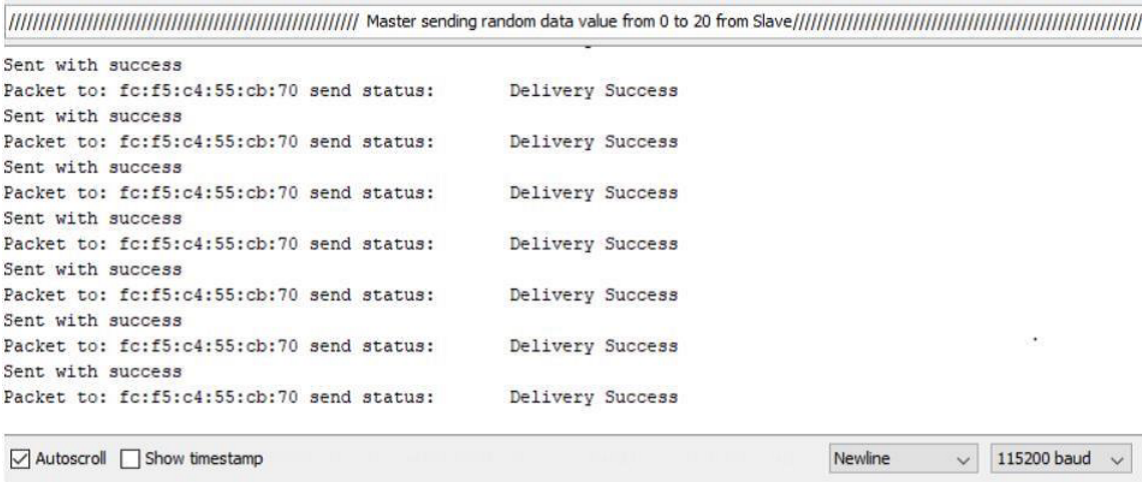


Figure 4.3: Master sending data in form of packets.

4.2.5 Reciving data from master

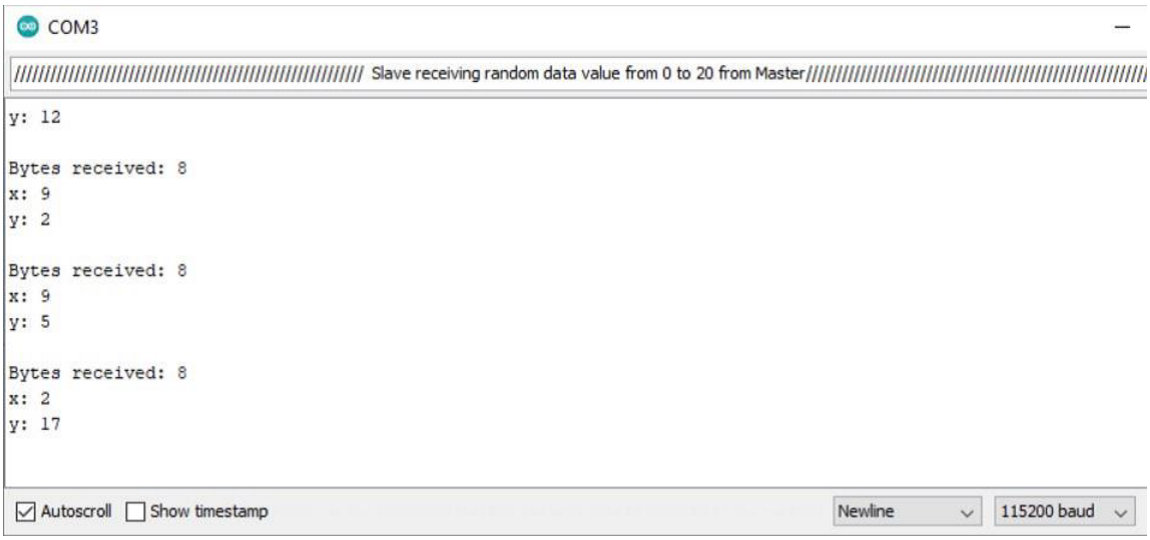


Figure 4.4: Slave receiving data in form of packets.

CHAPTER 5

Chapter 5

Conclusions And Future Work

5.1 Conclusions

Swarming of the robots is generally a rare a quite rare innovation. It involves the use and understanding of the concepts of Swarm technology. A deeper insight to this new field gives us the information about how we can change the factors of the human work into robotic terms. Now a day, every other work that humans used to do in the past has been overtaken by the machines slowly and gradually with time. As we progress through time, the main innovations would be using machines and robots in every other field we see today. Human work load would be close to nothing. People may find innovative ways to perform their work via robots which includes this project of swarming through robots.
Swarm Autobots requires various concepts to perform swarming. It included the factors of controlling testing, sensors testing. It required an acute synchronization and communication between the nodes. These parameters are very essential if we are to perform swarming whenever[17].
The hardware prototype of the Swarm Autobots required many modules. The first and foremost thing is the communication of the Master and the Slave among them. As we are motivated to use our system as a optical avoidance , our system is capable of performing the tasks. Master will lead the task and Slave will help performing the task according to the situation. For this communication, the use of ESP-32 micro controller completed all our requirements to perform the desired communication. The use of ESP-32 controller was much more convenient and better[18].

5.2 Future Work

Whether it is performing an application of surveillance or extinguishing a fire, this would always ease the human work load and this technology could be a formidable invention to that.Also UAVs can be used for future work.

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Appendix A Project timeline

Date	

PROJECT ID	3	TOTAL WEEKS	33
TITLE	Obstacle Avoidance of Multi-Agent System using Swarm Auto-Bots		

S NO	STARTING WEEK	DESCRIPTION OF MILESTONE	DURATION (IN WEEKS)
1	04-10-21	Literature Review and Proposed Defense	4 weeks
2	15-11-20	Hardware Requirement Analysis	3 weeks
3	15-12-20	Designing of Robot	3 weeks
4	15-01-21	Obstacle Avoidance	4 weeks
5	20-02-21	Training of Robot	2 weeks
6	15-03-21	Communication between Robots	3 weeks
7	10-04-21	Training of Robot	2 weeks
8	30-04-21	Report Writing	2 weeks
9	15-05-21	Final Presentation	2 weeks

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