SWARM ROBOTICS

A FINAL PROJECT REPORT submitted in partial fulfillment of the requirements for the degree of

BACHELOR OF TECHNOLOGY

by

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CERTIFICATE

This is to certify that the FINAL PROJECT REPORT entitled SWARM ROBOTICS has been submitted in the academic year 2013-14 by

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Acknowledgments

It is matter of great pleasure for us to submit this project report on ”SWARM ROBOTICS” as a part of curriculum for award of ”BACHELOR OF TECHNOLOGY IN ELECTRONICS AND TELECOMMUNICATION”.

We are thankful to our seminar guide Prof. (MRS.) K.S.DEGAONKAR, Assistant Professor in Electronics Engineering Department for her constant encouragement and able guidance.

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We take this opportunity to express our deep sense of gratitude towards those, who have helped us in various ways, for our project.

At the last but not least we are thankful to our parents, who had encouraged and inspired us with their blessings.

Date: ________________

JAYENDRASINGH R.PARDESHI
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Contents

List of Figures

Abstract

Sometimes it is impossible to complete a task by a single person or it becomes quite difficult to that person to complete the work.In such cases, there is need of a team or group of members that can collaboratively work and make the work of the person or the user very much easy.

Swarm intelligence (SI) is an artificial intelligence technique based around the study of collective behavior in decentralized, self-organized systems.The concept of SWARM ROBOTICS is based on this basis of grouping of multiple robots or devices and perform the desired task.Swarm robotics is a new approach to the coordination of multi-robot systems which consist of large numbers of mostly simple physical robots.This approach emerged on the field of artificial swarm intelligence, as well as the biological studies of insects, ants and other fields in nature, where swarm behaviour occurs.

The three major advantages of SI Robotic approach, since SI systems have the following properties:

1) Scalable: The control architecture of each robot is same, no matter the number of robots.

2) Flexible: The robots may be inserted or deleted to/from the environment, no requirement for any change in the task operation.

3) Robust: Not only due to unit redundancy but also through minimalist unit design.

Swarm Robotics have varied applications in all fields like communication , military services , civil engineering , building construction etc.

The aim of our project is to make a group of robots which will construct an input schematic given by the user on a given platform. The construction will include moving blocks on the arena to form the pattern as mentioned in the schematic.This project includes study of various fields in Electronics and Computer Science like Embedded Systems,Wireless Sensor and Computer Networks,Artificial Intelligence,Swarm Robotics.

Chapter 1

Introduction

1.1 Need of Swarm Concept

Sometimes it is impossible to complete a task by a single person or it becomes quite difficult for that person to complete the work.In such cases there is need of a team or group of members that can collaboratively work and make the work of the person or the user easy.The concept of the SWARM ROBOTICS is based on this basis of grouping of multiple robots or devices and performing the desired task.

1.2 Swarm Robotics-The Concept

Swarm robotics is implementation of Swarm intelligence.Swarm Intelligence (SI) is an artificial intelligence technique based around the study of collective behavior in decentralized, self-organized systems.Swarm robotics is a new approach to the coordination of multi-robot systems which consist of large numbers of mostly simple physical robots.It is supposed that a desired collective behavior emerges from the interactions between the robots and interactions of robots with the environment.This approach emerged on the field of artificial Swarm intelli- gence, as well as the biological studies of insects, ants and other fields in nature, where swarm behaviour occurs.The main objective of Swarm robotics is to reduce the work load and increase the efficiency of the system.

1.3 Features and Applications

- The research of Swarm robotics is to study the design of robots, their physical body and their controlling behaviors.
- It is inspired but not limited by the emergent behavior observed in social insects, called Swarm intelligence.
- Relatively simple individual rules can produce a large set of complex swarm behaviors.
- A key-component is the communication between the members of the group that build a system of constant feedback.
- The Swarm behavior involves constant change of individuals in cooperation with others, as well as the behavior of the whole group.
- Unlike distributed robotic systems in general, Swarm robotics emphasizes a large number of robots, and promotes scalability, for instance by using only local communication. That local communication for example can be achieved by wireless transmission systems, like radio frequency or infrared.
- Video tracking is an essential tool for systematically studying swarm-behavior, even though other tracking methods are available.
- Recently Bristol robotics laboratory developed an ultrasonic position tracking system for swarm research purposes.
- Both miniaturization and cost are key-factors in swarm robotics.These are the constraints in building large groups of robotics; therefore the simplicity of the individual team member should be emphasized.This should motivate a swarm-intelligent approach to achieve meaningful behavior at swarm-level, instead of the individual level.
- Potential applications for swarm robotics include tasks that demand for miniaturization (nanorobotics, microbotics),like distributed sensing tasks in micro-machinery or the human body.
- On the other hand swarm robotics can be suited to tasks that demand cheap designs, for instance mining tasks or agricultural foraging tasks.
- Also some artists use swarm robotic techniques to realize new forms of interactive art.

1.4 Swarm Robotics the Idea

Figure 1.1: Swarm System

Figure 1.2: Swarm Robots performing task.

Chapter 2

Literature Survey

The concept of Swarm Intelligence (SI) was first introduced by Gerardo Beni, Suzanne Hackwood, and Jing Wang[8] when they were investigating the properties of simulated, self-organizing agents in the framework of cellular robotic systems.In Proceedings of the Seventh Annual Meeting of the Robotics Society of Japan, Tokyo, Japan.Eric Bonabeau, Marco Dorigo and Guy Theraulaz extended the restrictive context of this early work to include any attempt to design algorithms or distributed problem-solving devices inspired by the collective behavior of social insect colonies, such as ants, termites, bees, wasps, and other animal societies.Swarm Intelligence - From Natural to Artificial Systems. Eric Bonabeau, Marco Dorigo, and Guy Theraulaz. Oxford University Press.

They give the three major advantages of SI Robotic approach, since SI systems have the following properties.

1) Scalable: The control architecture of each robot is same, no matter the number of robots.

2) Flexible: The robots may be inserted or deleted to/from the environment, no requirement for any change in the task operation.

3) Robust: Not only due to unit redundancy but also through minimalist unit design.

2.1 Bio-Inspired Sensor Swarms

In [3]Joseph Fronczek and Nadipuram Prasad of New Mexico State University have identified the critical need for technologies for quickly locating and repairing pressure leaks in contained environments like the International Space Station. The location, isolation, and repair of atmospheric pressure leaks are one of the main emergencies on which the crew of the Space Station is regularly trained. If the crew fails to address the pressure leak in the allotted time, they are instructed to abandon the station via the escape module. Such leaks can stem from a couple of sources. Errors can occur during the operation of the ISS Environmental Control and Life Support System (ELCSS - a network of valves and piping used to create a vacuum environment within the ISS for the purposes of scientific experiments). In addition, impacts from space debris are a threat to the atmospheric integrity of the Station. While failures in the ECLSS are frequently due to a failed component that are easily identified and small in nature, leaks occurring due to debris impact are often unpredictable. By using robotic sensor swarms that can quickly locate and repair pressure leaks, critical time can be provided for the crews to make permanent repairs.

Given the task of locating pressure leaks, two questions must be answered: Where is the source of depressurization in the system, and how extensive is the leak [3]? Currently, the crew must search the entire Space Station environment, a time consuming prospect at best. Sudden pressure leaks tend to cause disturbances in the regular airflow patterns inside the Station. Consequently, if this shift in airflow patterns can be detected quickly, all on-board air circulation systems can be secured and the new patterns caused by the leak can be isolated.

Researchers often turn to the natural world for inspiration for solving problems by novel methods. The common cockroach uses a small appendage covered with thousands of tiny hairs to detect disturbances in the surrounding air alerting it to possible threats. The cockroach instinctively runs in the direction of the wind source [3]. This behavior is referred to as a positive taxis (directed movement towards a stimulus). Additionally, when the hive is threatened, bees have the ability to gather and exert defensive measures against the disturbing element [3]. Through communication, the bees contribute to the collective intelligence and enable fast response to the threat. Studies show that bees and other insects can locate food sources by sensing the odor of the food and use airflows to navigate toward the source. By mimicking these natural systems, a swarm of bee-like sensors that can detect disturbances in the surrounding atmosphere can be deployed in a loss of pressure event to locate the leak source, converge on that source, and affect repairs.

2.2 Under-Sea Sensor Networks

Although the use of manned and unmanned systems in remote ocean exploration has yielded a wealth of knowledge about heretofore-unknown oceanic processes [4], the authors have identified a lack of technologies to observe organisms and processes without disturbing them as they move with the natural motion of the oceans [4]. They propose this can be accomplished through the development of an autonomous, free-floating underwater device that can collaborate or interact with other such devices through an acoustic underwater network. [4,5]. They hope this will provide insights into the interactions between ocean currents and underwater ecosystems and our impact on them [4]. Current ocean sensing technologies use sensors that are either stationary or guided. However, the natural dynamics such as waves, tides, and currents play a major part in oceanic interactions [4]. Truly complete observation of these interactions cannot be achieved with sensors that are not subject to those dynamics.

Networked swarms of the proposed free-floating sensors could create three-dimensional maps coastal circulation. These maps could give researchers better understanding of various phenomena such as the spread of pollutants and the evolution of planktonic communities.

2.3 Satellite Swarms

Owen Brown of Defense Advanced Research Projects Agency (DARPA) and Paul Eremenko of Booz Allen Hamilton have put forth a vision for what they term responsive space. They define this as the speed with which a space system can be made to react to various forms of uncertainty, ranging from geopolitical operational requirements to technical failures to fluctuations in the acquisition funding stream or more simply, the capability of space systems to respond rapidly to uncertainty [8]. As the authors view is that large, monolithic spacecraft are notoriously unresponsive, they are proposing the adoption of a fractionated architecture where a satellite is decomposed into a set of similar or dissimilar components linked wirelessly while in cluster orbits [8]. These homogenous or heterogeneous satellite swarms would work together to provide equivalent or, in most cases, expanded capabilities. DARPAs demonstrator system for this architecture is called F6 (Future, Fast, Flexible, Free-Flying, Fractionated Spacecraft united by Information eXchange) [8].

The reason for proposing this architecture is to produce a system that can mitigate, to a certain degree, the uncertainty that is present throughout the lifecycle of a space system [8].

In the authors view, this uncertainty can be decomposed into six sub-categories. Technical uncertainty involves risks from systems internal to the spacecraft). Environmental uncertainty is due to transients beyond the normally expected range of environmental conditions [8]. Launch uncertainty stems from risks associated with the spacecraft reaching orbit. Demand uncertainty due to changes in the need for services or capabilities provided by the spacecraft. Requirements uncertainty involves risks related to uncertainty in requirements from the design phase and is caused by the interaction of unrelated requirements on separate systems on the spacecraft. Funding Stream uncertainty stems from risk due to competing programs and expense prioritization [8].

The solution put forth in this paper involves the use of free-flying modules in cluster orbits sharing power and data through a wireless network. This creates a virtual satellite [8]. This would enable a swarm of satellites where a failed (or improved) component can be replaced without the need for complex rendezvous or docking. Imagine augmenting processor resources, power generation, or payload capabilities on the fly on a temporary or permanent basis simply by adding modules to the swarm. A satellite swarm could disperse to avoid other satellites or enemy munitions.

This fractionated architecture addresses each of the categories of uncertainty. Technical uncertainty is reducing by minimizing risk due to failed or outdated components with its ease of module replacement. Environmental risks due to space junk or other objects can be avoided by dispersing the swarm. Launch uncertainty is addressed by allowing modules to be placed into orbit by separate launch sources. Payload and swarm composition flexibility mitigate risks due to Demand and Requirements uncertainty. Finally, funding uncertainty is reduced using incremental development of the satellite swarm.

2.4 Some Observations

Swarm robots were used to construct a 20 ft. high tower, composed of 15,000 bricks that weighed 1.1 lbs each, providing a window into the possible future of architecture and construction.A job that would've taken humans several weeks to complete, the little guys completed it in a mere three days.The robots were controlled by computers with complex algorithms and motion sensors. They were able to detect and adapt to any natural disturbances as well, such as turbulence, and either adjust to the issues or abort the task completely.

This is a rather basic experiment, but one that shows the possibilities and prospects of swarm robotics.Researchers throughout Sheffield institutions created robots whose job was to simply push an object across the floor, from one side to another. They could also organize themselves by priority after being scattered in a room. They can do this by sensing if there is a robot in front of them, and if there is, turning immediately. If not, then the robot keeps moving around until it finds one.Dr. Roderich Gross, head of the Natural Robotics Lab, in the Department of Automatic Control and Systems Engineering at the University of Sheffield, says that swarm robots could be utilized in military search-and-rescue missions in areas unfit for humans, in micro-medicine while utilizing nanobots, and in industry to make it more efficient and safe.

”Swarming Robots Could Be the Servants of the Future.The authoritative ability over swarm robots could prove to be highly beneficial, ranging from military to medical. For military purposes, swarm robots could carry out tasks or missions that may be too dangerous for humans themselves to go on.In the medical field, the swarm robots could play a significant role in micro-medicine, in which they would be considered nanobots who would treat humans non-invasively. This miniature swarm of robots could deliver medicine to the body by traveling through ones veins.

Kent, Leo. ”Swarm Robots: The Droid Workforce of the Future.” Humans Invent.A single robot can detect obstacles in a room, since their knowledge is based on locality, upon gathering the information needed, it is shared with the rest of the swarm so that they are aware of where to go and where to avoid obstacles.Swarm robots can also be used to help out in disastrous situations, for instance after a recent natural disaster, the swarm could communicate with each other and humans by sharing what they observe[9]. A project of swarm robots called Symbrion (Symbiotic Evolutionary Robot Organisms) is currently being worked on to join the robots together as one. This could be beneficial for a natural disaster such as a flood, in which the swarm robots join together to make a raft. Though the malfunction rate of swarm robots is high, it is not much of a threat, since numbers are high, if one robot malfunctions it does not affect the rest.

Chapter 3

Proposed Work

On basis of the above survey and after referring various technical papers a new and innovative project idea was developed.The aim of the project 'Swarm Robotics' was to build a group of robots which would construct an input schematic given by the user on a given platform. The construction included moving blocks on the arena to form the pattern as given in the schematic.

The project included study of various fields in Electronics and Computer Science such as Artificial Intelligence, Swarm Intelligence, Embedded Systems, Wireless Sensor Networks and Computer Networks.It included Wireless communication between the robots. It consisted of a group or swarm of robots which were guided by a server robot using various algorithms programmed in its micro-controller, in other words the server carried out certain computations and distributed the work among various client robots.

Architects give a plan for construction of buildings. Based on the given plan, the contractor instructs his workers to construct the building.Our aim was to automate this entire construction process. Here, the contractor is the server robot and the workers are the client robots. The schematic was given as an input to the server robot, which in response guided the client robots to construct the given schematic.

Chapter 4

System Design

In the project, a server-client concept was used to perform the given task. Therefore, for creating a 'Swarm' of robots the size of the client device was decided to be as small as possible to include robustness, scalability and flexibility to the project.It should also be well equipped with abilities such as sensing ,computing and communicating with the external environment to smartly perform the task assigned by the server.

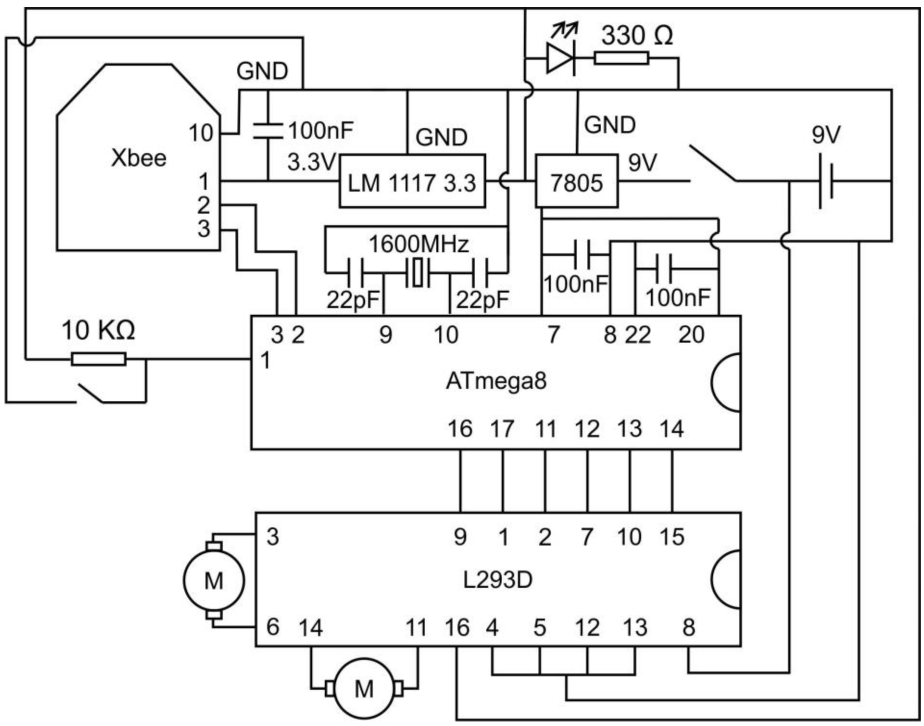

Figure 4.1: Circuit

4.1 Client Design

4.1.1 Zigbee

- XBee Series 2 is being used in the project.
- Indoor/Urban Range: up to 133 (40 m).
- Outdoor line-of-sight: up to 400 (120 m).
- Transmit Power: 2 mW (+3 dBm).
- Receiver Sensitivity: -95 dBm.
- RF Data Rate: 250,000 bps.
- Operating Frequency Band ISM 2.4 GHz.
- Supply Voltage 2.8 3.4 V.
- We are using this component for the the communication of server to client and vice versa.

Figure 4.2: Zigbee

4.1.2 Micro-controller AtMega328

- 32KBytes of In-System Self-Programmable Flash program memory.
- 1KBytes EEPROM.
- 2KBytes Internal SRAM.
- Operating Voltage: 1.8 - 5.5V.
- In this project a micro-controller is used to control the motors on the basis of feedbacks received from the analog sensors.
- It mainly controls the client robot by following the instructions received from the server.
- Micro-controller provides the control signals(Enable) to the motors and accordingly controls

the motions of the client robot.

• It provides the signal to the motor control IC on the basis of the sensor readings.

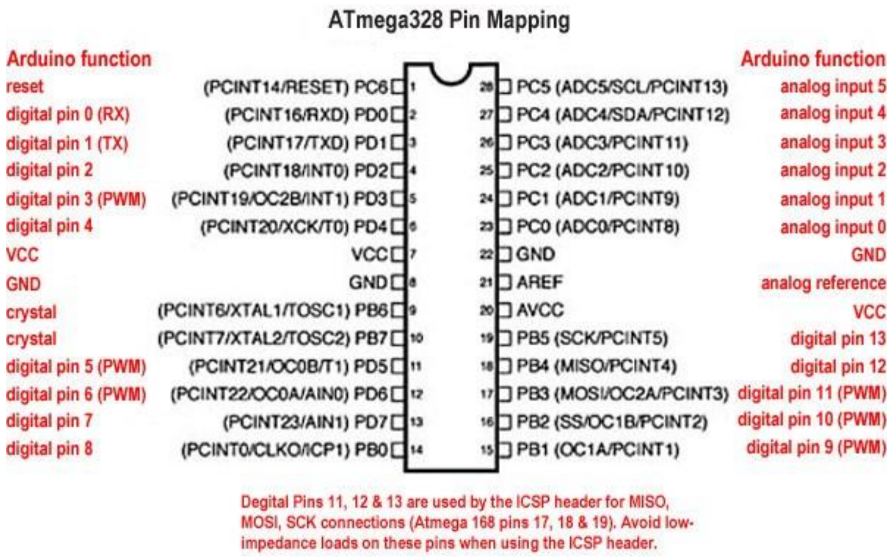

Figure 4.3: Arduino Circuit

4.1.3 Motor Driving IC L293d

• Wide Supply-Voltage Range: 4.5 V to 36 V.

• This IC is typically used to drive the DC motors rated upto 12v.

• It consists of two H-bridges that can drive one dc motor each.

• It receives the control signals from the micro-controller and accordingly the motors are controlled.

4.1.4 Regulator IC's

(a) LM7805

• Input Voltage : upto 35 V

• Output Voltage :5 V

• This IC is used in order to provide constant 5v power supply to the micro-controller and Motor driver.

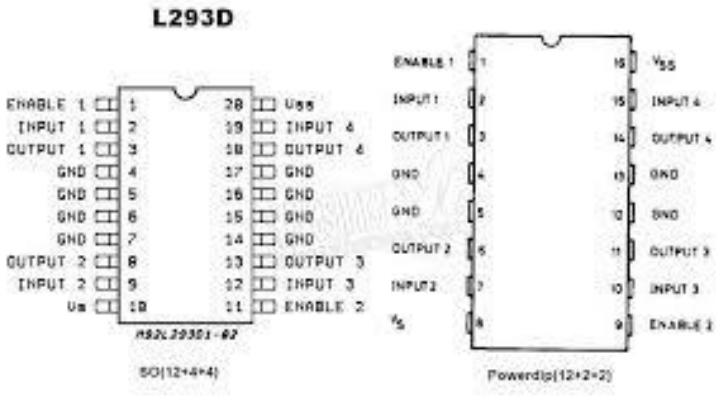

Figure 4.4: Motor Driver

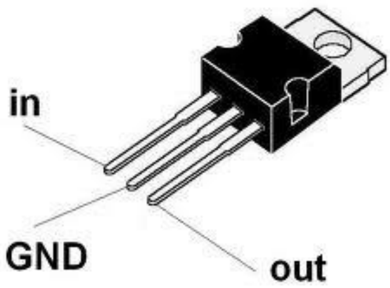

Figure 4.5: 5V Regulator

(b) LM1117.3.3

- Input Voltage (VIN to GND) : upto 15 V.
- Output Voltage is 3.3 V.
- This IC is mainly used for providing the power supply to the Zigbee.

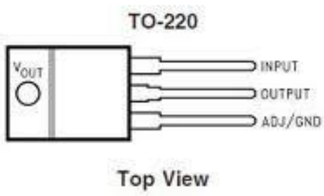

Figure 4.6: 3.3 V Regulator

4.1.5 Crystal Oscillator

• A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency.

• In our circuit we are using a 16MHz crystal.

• This crystal not only provides the proper frequency to the controller for its operation but also supports the boot loader program to program the micro-controller.

4.1.6 Capacitors

• A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electrostatically in an electric field.

• The nonconducting dielectric acts to increase the capacitor's charge capacity. A dielectric can be glass, ceramic, plastic film, air, paper, mica, etc.

• Capacitors are widely used as parts of electrical circuits in many common electrical devices.

• Unlike a resistor, a capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

• In our project we have used capacitors for the following functions:

(i) 100 nf capacitors across Vcc and Gnd in order to minimize the spikes so that constant supply is available .These capacitors must be close enough to the Vcc and Gnd pins.

(ii) 22 pf capacitors across the crystal.

These capacitors are there to resonate with the crystal inductance and cause the crystal to oscillate on its fundamental parallel-resonant mode.The reason that there are two capacitors in series is to create a network that creates a 180 degree phase inversion at resonance, because the amplifier (inverter) has a 180 degree phase inversion between its input and output. This makes the loop gain have a net phase shift of 360 degrees, which is what causes it to oscillate (Barkhausen Criterion).

4.1.7 TCRT 5000 Sensors

• Package type: leaded.

• Detector type: phototransistor.

• Dimensions (L x W x H in mm): 10.2 x 5.8 x 7.

• Peak operating distance: 2.5 mm.

• The TCRT5000 are reflective sensors which include an infrared emitter and phototransistor in a leaded package which blocks visible light.

• These sensors were used instead of general separate IR sensors in order to get the better separation of 0 and 1 values.

• These sensors give much better readings than separate IR sensors but still are not much distinguishable.

4.1.8 QRD 1114 Sensors

• The QRD1114 reflective sensors consist of an infrared emitting diode and an N-P-N silicon phototransistor mounted side by side in a black plastic housing.

• These sensors give high values readings for the intensity 0 and lower values for the intensity value 1.

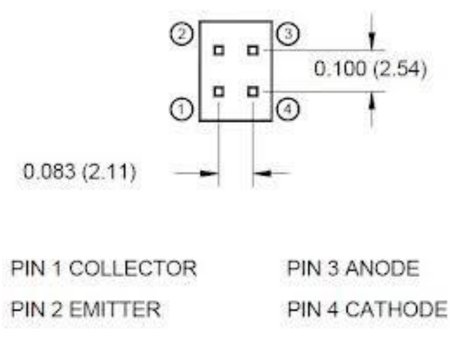

Figure 4.7: QRD Sensor

4.2 Server Design

4.2.1 Micro-controller AtMega2560

• 256 KBytes of In-System Self-Programmable Flash.

• 4 Kbytes EEPROM.

• 8 Kbytes Internal SRAM.

• ATmega2560 : 0 - 16MHz at 4.5V - 5.5V

• The ATmega2560 is a low-power CMOS 8-bit micro-controller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega2560 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

• In our project we are using this micro controller as a server because of above advantages and other features like more number of UART pins for communication.

• It has in all 3 channels for communications.

• We are using two of them one for communicating to the server i.e giving the inputs and other for communicating clients to assign the tasks.

• Due to faster operation and increased memory capacity it also computes all the parameters like shortest path and many more and accordingly assign the task to clients.

4.2.2 Bluetooth Module

• Operating Frequency Band-2.4GHz unlicensed ISM band.

• Operating Voltage-3.3 V.

• Flash Memory Size-8Mbit.

4.2.3 Other Components

• ZIGBEE-To communicate with Client Robots.

• REGULATOR IC7805 and IC1117 3.3 - For Power Supply.

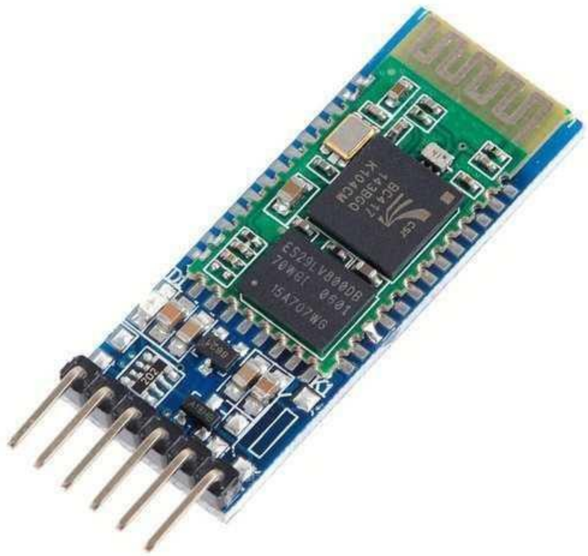

Figure 4.8: Bluetooth Shield

4.3 Mechanical Components

4.3.1 Wheel Design

• The Wheels are designed according to the size of the robot and the motor shaft that is responsible for motion of robot.

4.3.2 Design of the Block and The Grid for Navigation

• In our project as we need the object in order to place it at its particular position given by the server.

• The size of the object must be decided accordingly based on the size of the robot(client) that will carry it.

• Thus keeping in mind the size of our robot the object size was finalized.

• The robot needs a platform to move or navigate.

• In our project we are using the line tracing algorithm in order to move the robot.

• The thickness of line was finalized by considering the robot size and accordingly the grid was made.

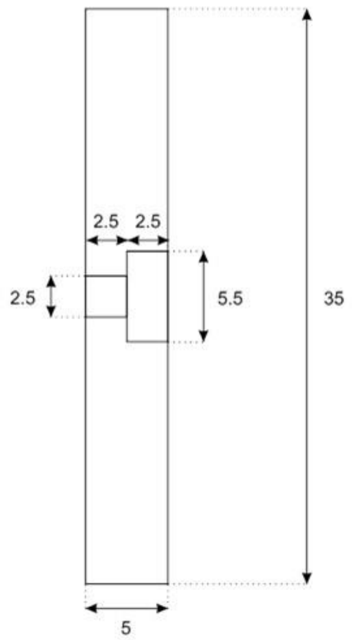

Figure 4.9: Wheel Dimensions

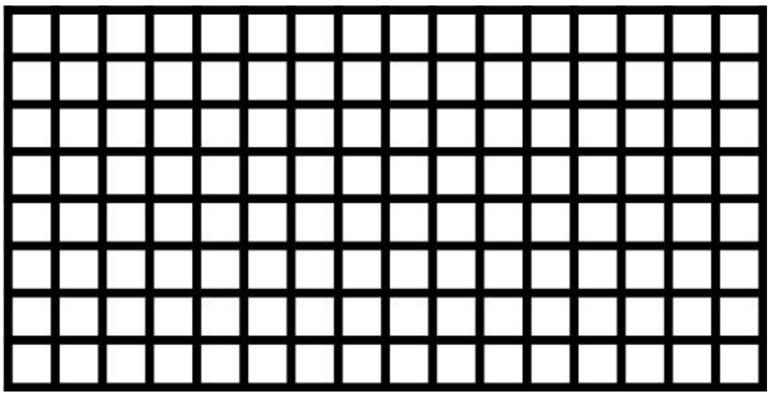

Figure 4.10: Grid

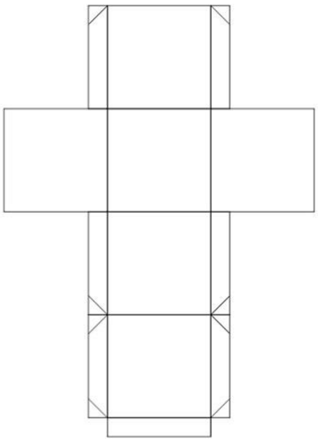

Figure 4.11: Block

Chapter 5

Printed Circuit Board (PCB) Design

5.1 Client PCB Design

- In the design process we totally designed three PCB.

5.1.1 Board No.1

In the first PCB we encountered the problem regarding the crystal.We decided to use the internal crystal initially but as we were using the boot-loader to program the controller there was the need of the external crystal because the internal crystal do not support the boot-loader.

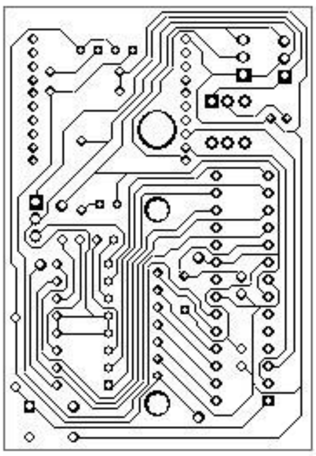

Figure 5.1: Board-1

5.1.2 Board No.2

In the second PCB the crystal problem was eliminated but now the problem was regarding the power supply to the motor driving circuit.This was due to the absence of the capacitors that overcome the spikes or the fluctuation in the supply voltage.These capacitors must be as close to the supply terminals of the micro-controller as the micro-controller provides the enabling signal to the motor driving IC.

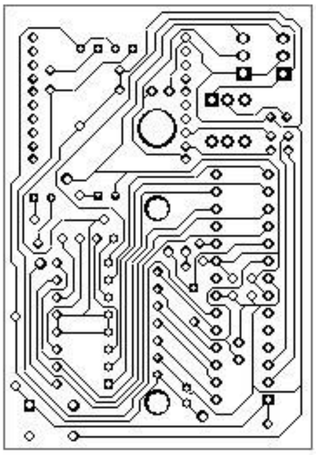

Figure 5.2: Board-2

5.1.3 Board No.3

With the necessary changes in the board regarding the capacitors and other small changes like pins for programming.The final PCB design for the client was finalized.

5.1.4 Sensor Array No.1

As discussed earlier the client must perform sensing operation it must be well equiped with the sensing devices.Hence the sensor array has to be designed.The sensor array consists of IR pair sensors with resistors to adjust the analog reading that it sends to the micro-controller.

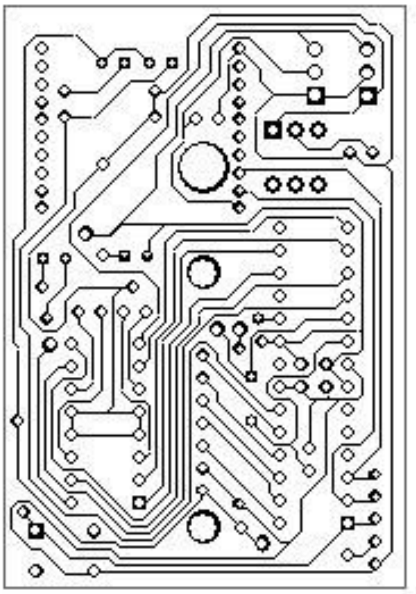

Figure 5.3: Board-3

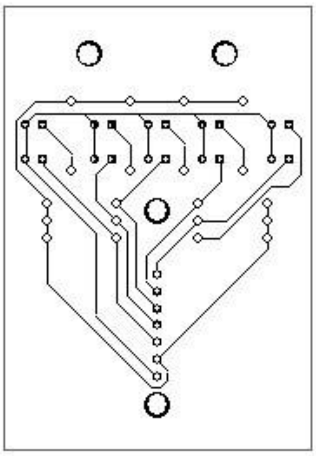

Figure 5.4: Sensor array

5.1.5 Sensor Array No.2

In this board the sensors used were TCRT 5000.The main aim was to obtain the most distinguished readings.The readings were separable but not to the extent of those obtained by QRD sensors.Hence these sensors were replaced by QRD sensors.

5.1.6 Sensor Array No.3

In the above sensor array the readings were not up to the mark ie the difference between intensity values of black and white was not distinguishable.Hence, in the new sensor array consisting of special sensors was prepared and this gave a distinguishable difference between intensity values of black and white.Hence the problem was solved.

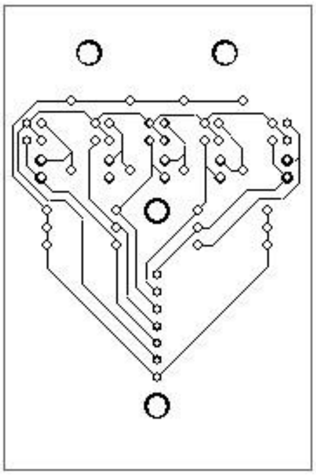

Figure 5.5: QRD Sensor array

5.2 Server Board Design

This is the main controlling station in our project.This board consists of a higher level microcontroller , Bluetooth Shield ,Zigbee and power supply circuit.This board communicates with the client and assigns it the required task to be performed.It also receives the input from the user what task is to be done.

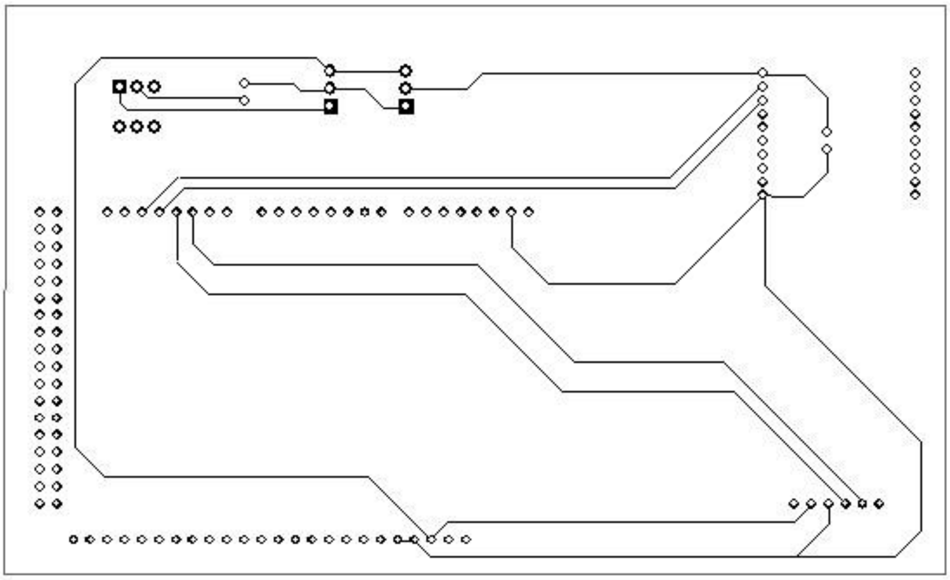

Figure 5.6: Server Board

Chapter 6

Software Specifications

6.1 Software tool

6.1.1 Open source software

Open-source software (OSS) is computer software with its source code made available and licensed with a license in which the copyright holder provides the rights to study, change and distribute the software to anyone and for any purpose. Open-source software is very often developed in a public, collaborative manner. Open-source software is the most prominent example of open-source development and often compared to (technically defined) user-generated content or (legally defined) open-content movements.

6.1.2 Arduino

Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino projects can be stand-alone, or they can communicate with software running on your computer.

6.1.3 Arduino Development Environment

The Arduino development environment contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware such as AtMega 2560 to upload programs and communicate with them.

6.1.4 Why Arduino?

The advantages that Arduino offers over other systems are:

• Inexpensive - Arduino boards are relatively inexpensive compared to other micro-controller platforms.

• Cross-platform - The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most micro-controller systems are limited to Windows.

• Simple, clear programming environment - The Arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well.

• Open source and extensible software- The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based.

• Open source and extensible hardware - The Arduino is based on Atmel's ATMEGA8, ATMEGA168 and ATMEGA328 micro-controllers. The plans for the modules are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

6.2 Client Algorithm

• Following are the Algorithms designed for the client robots.

6.2.1 Motion of the Client

• STEP1 :- Start

• STEP2 :- Initialize all the variables.

• STEP3 :- Set the values of the input and output pins.

- STEP4 :- Calibrate the sensors according to the conditions.
- STEP5 :- Check the value at Rx ,if Rx is set to 1 then follow following steps else stop.
- STEP6:- Read the Sensor values.
- STEP7 :- Set the Motor Speed.
- STEP8 :- According to the Sensor readings control the motion as Forward , Right or Left etc..
- STEP9 :- Stop.

6.2.2 Auto Tuning of Sensors

- STEP1 :- Start the motors one after the other and collect the sensors readings.
- STEP2 :- After collecting the readings,find the maximum and minimum sensor readings.
- STEP3 :- Calculate the average of those values.
- STEP4 :- If the sensor value is above the average value it is treated as 0 else 1.

6.2.3 Reading Sensor Readings

- STEP1 :- If the value of the Digital read is less than average write 1 else write 0.
- STEP2 :- Digital reading of sensor 0 =10000*reading.
- STEP3 :- Digital reading of sensor 1 =1000*reading.
- STEP4 :- Digital reading of sensor 2 =100*reading.
- STEP5 :- Digital reading of sensor 3 =10*reading.
- STEP6 :- Digital reading of sensor 4 =1*reading.
- STEP7 :- Add the readings and you will get a 5 digit number.
- STEP8 :- According to the number the motion is decided.

6.2.4 Motor Control

- STEP1 :- M11,M12,M21,M22 are motor pins.
- STEP2 :- For Left motor

(i) If M11 and M12 are low, Left motor stops.

(ii) If M12 is high and M11 is low, Left motor goes forward.

(iii)If M12 is low and M11 is high, Left motor goes reverse.

- STEP3 :- For Right motor

(i) If M21 and M22 are low, Right motor stops.

(ii) If M22 is high and M21 is low, Right motor goes forward.

(iii)If M22 is low and M21 is high, Right motor goes reverse.

6.2.5 Forward Motion

- STEP1 :-Read the Sensors.
- STEP2 :-Following actions must be taken when the respective condition occurs.

(i) If middle sensor is not on the black line or all the sensors are on white then the client should stop.

(ii)If line is detected then according to the alignment the motors are turned on and off and the motion is completed.

6.2.6 Right Motion

- STEP1 :- Read the Sensors.
- STEP2 :- Following actions must be taken when the respective condition occurs.

(i) If the middle sensor is on black line then start the left motor.

(ii) The motor should be on till the middle sensor comes back on black.

(iii)Once middle sensor is on black stop.

6.2.7 Left Motion

- STEP1 :- Read the Sensors.
- STEP2 :- Following actions must be taken when the respective condition occurs.

(i) If the middle sensor is on black line then start the Right motor.

(ii) The motor should be on till the middle sensor comes back on black.

(iii)Once middle sensor is on black stop.

6.3 Server Algorithms

6.3.1 Server Working

- STEP1 :- Initialize all the components.
- STEP2 :- Take the Input Pattern from the user.

- STEP3 :- Calculate the hotspots ie target where blocks must be placed.
- STEP4 :- Assign the robots to particular hotspot by finding the shortest path.
- STEP5 :- Keep the track of the robot and update the position of the block.

6.3.2 Shortest Path

- Initially, all the grid points and block position are provided to the server.
- Also, the initial direction of the robot is known to the server.
- To find the shortest path we have introduced two parameters-(a)Linear Cost and (b) Turn Cost.
- Linear cost is the one that gives time taken to travel straight from one node to its adjacent node.
- Turn Cost is the one that gives time taken by robot to take one turn.
- Turning requires more time than travelling in a straight direction.
- Optimal path is the one which takes minimum time to reach the destination.
- Based on the initial direction the shortest path is determined.

6.3.3 Hotspot Generation and Assignment

- All the grid points positions of block and robots are predefined.
- A primary position and secondary position are defined and accordingly a hotspot is generated as a doublet consisting the primary and secondary positions.
- Primary position is the place where block is to be kept and secondary position is the one where block is actually present.
- The robot closest to the block is assigned the task.

Chapter 7

Working

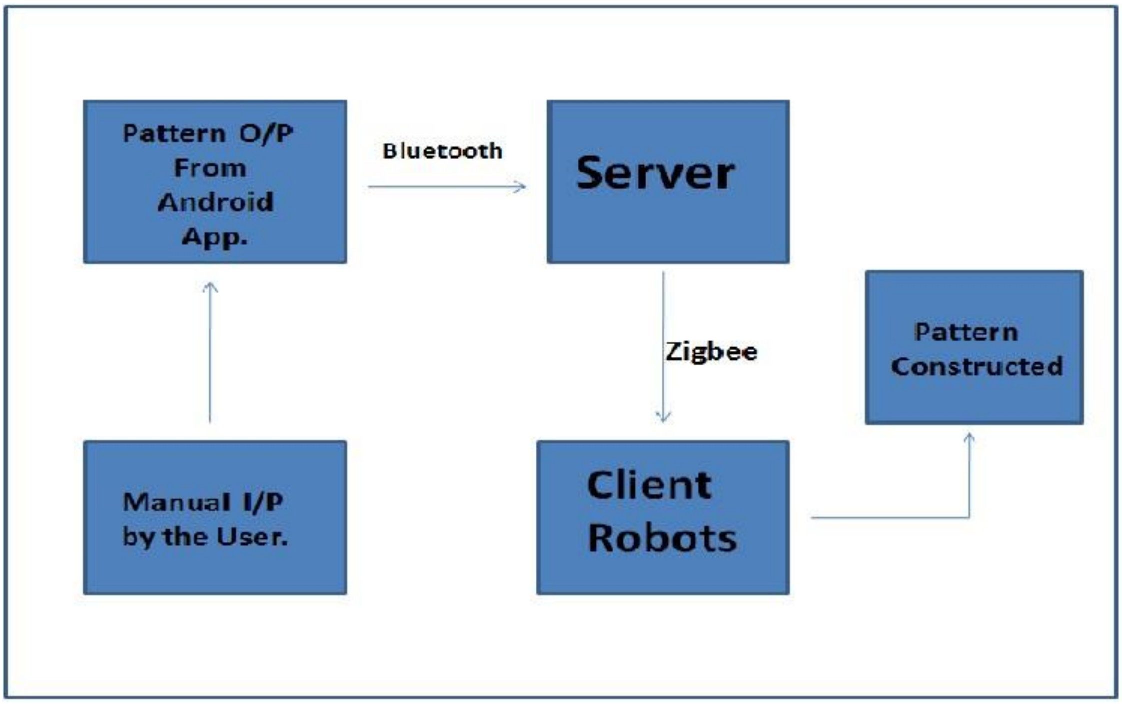

Figure 7.1: Block Diagram

- A Pattern is finalized and then given in the Android Application by the User.
- This Pattern is then wirelessly transferred to the server in a string containing 1's and 0's via bluetooth.
- This Data is hence received is then processed in the server using the designed algorithms.
- The Server then computes the hotspots and then assigns them to the clients according to the priority.
- Priority is assigned to client robots depending on the distance they need to travel to complete

Figure 7.2: Pattern Constructed

the assigned task.

• Maximum priority is given to robot that needs to travel minimum distance to complete the task.

• Work is equally distributed among the working client robots.

• Client completes the task according to the instructions given by the server.

• While completing the task a robot haults if there exists another working robot in the same line of the grid in which it is exists.In this way collision is avoided.

• After the completion of the task the robot goes to zeroth node.

Figure 7.3: Pattern Constructed

Chapter 8

Cost of the Project

8.1 Client Cost

- Zigbee - Rs. 1200 per module.
- Battery - Rs. 500 per piece.
- QRD1114 Sensors - Rs. 375 per piece.
- AtMega328 - Rs. 200 per piece.
- Motors - Rs. 200 per 2 piece.
- PCB - Rs. 160 only.
- Wheels - Rs. 150 per piece.
- Motor Driver - Rs. 40 per piece.
- IC1117 3.3 - Rs. 40 per piece.
- IC7805 - Rs. 20 per piece.
- Other Components - Rs. 175 only.
- Total Cost - Rs. 3060 per Client robot.
- For 5 robots - Rs. 15300 only.

8.2 Server Cost

- AtMega2560 Board - Rs. 2500 only.
- Zigbee - Rs. 1200 only.
- Bluetooth Shield - Rs. 800 only.

- PCB - Rs. 160 only.
- IC1117 3.3 - Rs. 40 per piece.
- IC7805 - Rs. 20 per piece.
- Other Components - Rs. 175 only.
- Total - Rs. 4895 only.

Chapter 9

Future Scope

At present,the project focusses on the collective working of the swarm robots in the direction of completing the given task by the user.Currently, while completing the task a robot haults if there exists another working robot in the same line of the grid in which it is exists.In this way collision is avoided.Although the collision is avoided by compromising the time factor.Therefore,in the future, work is required to be focussed in the direction of real time collision avoidance where the task will be smoothly in minimum time.

A Zigbee currently module is mounted on each client robot which helps in wireless communication with server upto a range of 100 m.This imposes a limited range barrier on the working of the project.Hence, a detailed study is required to remove this range barrier.

Chapter 10

Conclusion

After studying different research papers and scientific journals we found that our project Swarm robotics had many advantages over the other conventional robotics techniques.Firstly, the small size of the client robot helps us to carry the robots conveniently to any given location to perform work.Secondly, the android application which is developed makes the task of the user to assign work to the robots easy.

This concept has various applications in huge industries like Automobile Industry and Warehousing.At present, while performing a particular task as one robot is performing its work the rest of the robots are idle waiting for the first robot to complete its work which results in slow processing of the assigned task.Using the concept of 'Swarm Robotics' less number of robots can complete the assigned task collectively in less amount of time which also in turn increases the efficiency and the output at same time reducing the cost.

The turn cost plays a vital role in the functioning of the client robot.Efficient use of the zigbee buffer must be done.Collision avoidance is the most important task that must be worked upon.

Swarm Robots, because of their extreme plasticity,can find interesting applications wherever it is required a high level of physical adaptation and a low level of human intervention or monitoring.Tasks which fall in this category might be space explorations of harsh and humanly dangerous environments,assembly of space modules,handling of dangerous materials,mining and even 'harvesting' material or goods from a physically constrained location.Given such a multi-purpose nature,Swarm robots might also find further applications in future which are presently even unthinkable.

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