Contents

Chapter 1

1.1 Introduction

The application of robotics and autonomous systems in space has increased dramatically in the recent years. The ongoing Mars rover mission involving the Curiosity rover, along with the success of its predecessors, is a key milestone that showcases the existing capabilities of robotic technology. Nevertheless, there has still been a heavy reliance on human tele-operators to drive these systems. Reducing the reliance on human experts for navigational tasks remains a major challenge due to the harsh and complex nature of the terrains. The development of a truly autonomous system with the capability to be effectively navigated in such environments requires intelligent and adaptive methods fitting for a system with limited resources.

The objective of this project is to design and program two independent robotic systems that can communicate with each other in order to navigate in a static environment. The project focuses on programming and designing two independent robots – Base station and Rover. The base station is responsible for programming and deducing the shortest and the simplest path for the rover to navigate to its destination. The rover is to be programmed to communicate with the base station and follow the path suggested by it. The data about the starting point and ending point is fed into the base station through WiFi. The base station receives said information and performs the necessary computations. The base station, then gives out a LASER beam which is called spotter, to guide the rover to perform its next action. The rover then simply follows the LASER beam radiated by the spotter. Thus making it truly autonomous system.

1.2 Motivation:

Autonomous navigation by mobile robots in unstructured or semi-structured outdoor environments presents a considerable challenge. Adequately solving this challenge would allow robotic applications like daily maintenance and inspection of public infrastructure, assisting disabled people, guiding guests, and a large number of other tasks. To achieve the level of autonomy required for such operation, a robot must be able to perceive and interpret the environment, and to use perceived reality in the navigation planning.For autonomous robots to be popular, the production cost should be low, and the ability to cope with the real world should be high. In many urban as well as rural areas the Global Positioning System (GPS) has insufficient coverage to guide the robot along a desired path. Additionally the robot needs a local navigation ability to avoid obstacles. The motivation is therefore to provide the robot with a navigation capability that copes with the real world challenges.

Chapter 2

2. Component Description:

2.1 Base Station:

2.1.1 Mechanical Systems :

1) Base plate - Is used to support the rotating laser pointer system called Spotter. It helps the Spotter give an accurate projection of the laser beam on the arena.

2) Servo Motors - Servo motors are used to rotate the laser beam to direct the rover. A pan-tilt system is created using the servo motors which enable a full 360 degree rotation for the laser which covers all the parts.

Figure 2.1 - A SG90 tower pro servo motor

3)Supporting Stand - It will form a small tower kind of support connecting the base plate and the Spotter.

2.1.2 Electronic Systems:

1)Node MCU - The NodeMCU is an open source firmware and development kit that helps one prototype his IoT product using a few lines of code. It is coded here using the Arduino IDE. It works at 3.3V. A PWM input from the NodeMCU is used to run the Servo Motors via the logic level converter.

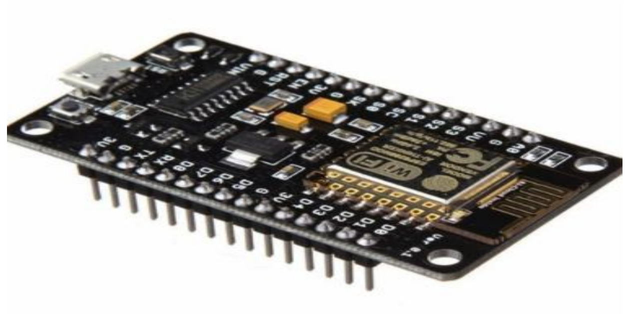

Figure 2.2 NodeMcu

2) Logic Level Converter - It is a small device that safely steps down 5V signals to 3.3V and steps up 3.3V to 5V at the same time. Thus it is used as a connector between the NodeMCU and the Servo Motors to power the servo motors.

3)Laser - The laser beam generated by the laser is used to guide the rover in covering the path and reaching the destination with minimal traversal.

2..2 Rover:

2.2.1 Mechanical Systems:

1) Wheels-A pair of wheels along with the Caster wheel provide mobility for navigation.

2) Chassis-Includes the top plate, bottom plate and a pair of side plates which forms the body of the Rover.

3) DC Motors -The wheels of the Rover are driven by a pair of D.C. motors. Soldering is done in order to provide power supply using the 5V battery pack.

2.2.2 Electronic Systems:

1) Motor Driver- If we directly connect the D.C. motors to the output of the Raspberry Pi, the pins may get damaged Also it may not provide sufficient current (40-80 mA) to drive the DC Motors. Thus Motor Driver acts as a bridge between the D.C. motors and Raspberry in order to regulate current flow.

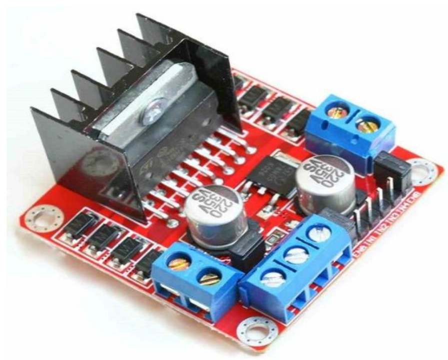

Figure 2.3 Motor Driver

2) 5V Battery Pack- Provides power supply to run the D.C. motors

3)Raspberry Pi- It is a credit card sized single board computer. It is programmed using Python here. PWM output is generated using the Pi by interfacing it with the motor driver which controls four GPIO inputs of the Raspberry Pi which enable the rover to move.

Figure 2.4 Raspberry pi

4) Camera-The camera is attached to the top of the Rover. It detects the laser beam emitted by the Base station in order to track the next location to be traversed.

Figure 2.5 Camera module

5)Power bank - The power bank is connected to the Raspberry Pi. It is used to power the Pi.

Chapter 3

3.1 Block diagram:

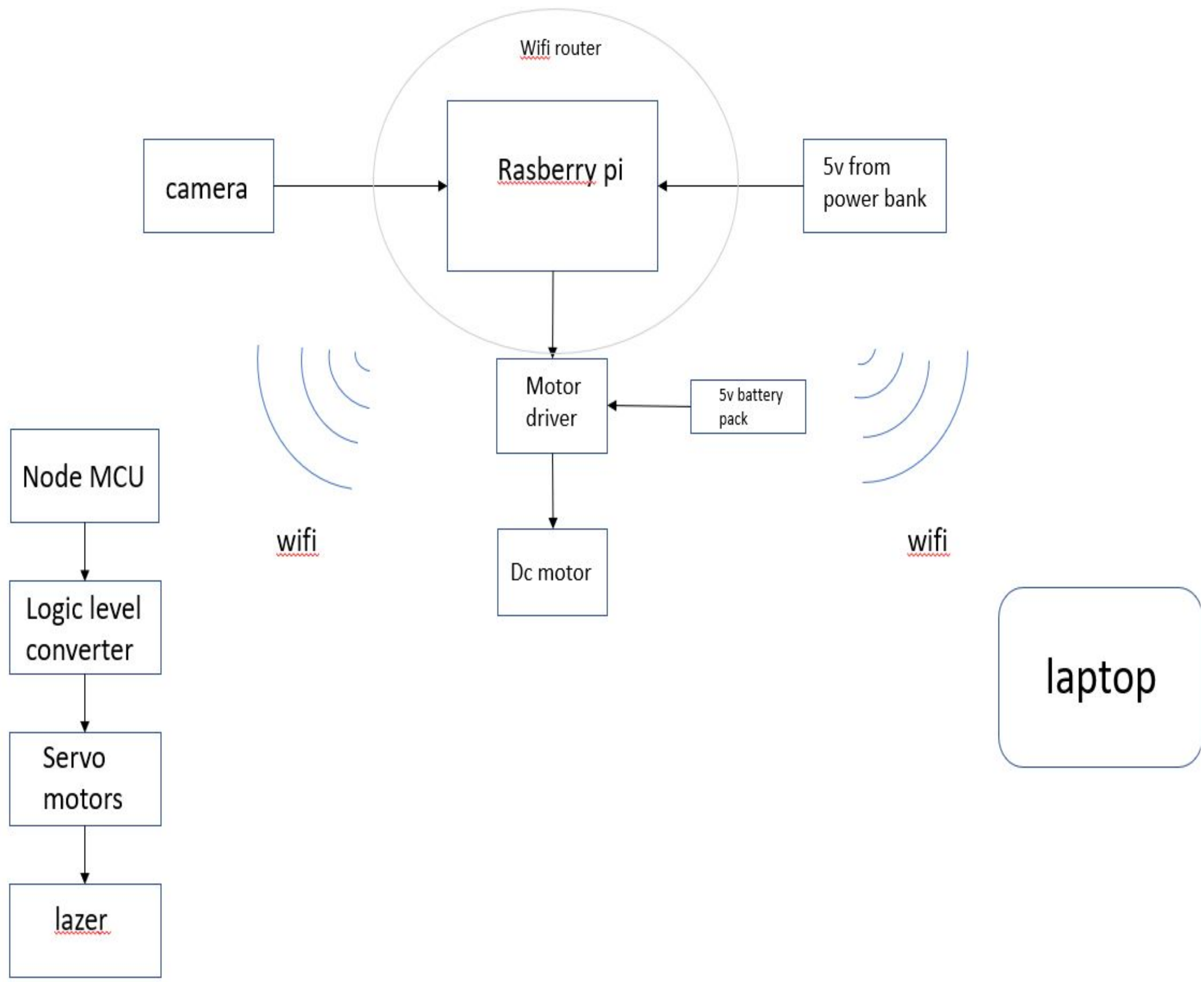

Figure 3.1 : Block diagram of working Mechanism

3.2 Methodology:

The proposed method mainly consists of three parts namely Base station, autonomous bot(rover) and a computer interface to transfer the terrain map in the form of packets of data initially. The NodeMcu which facilitates wi-fi helps in receiving the packets of data and thus removing the computer interface.

The Base Station which is an immobile Robotic System consists the following sub modules: (i) a controller (ii) a rotating laser pointer system called Spotter as shown in figure 3.1. The NodeMcu is the controller used to control the mechanism of base station. Base Station includes all the circuitry to control the Spotter. The Spotter is a pan/tilt system attached to a laser and is a part of Base Station. The Spotter projects a laser dot to guide the Rover. The main objective of the Spotter is to guide the Rover with its rotating laser beam to its destination.

The Rover is a robust device which follows the path provided by the base station. TCP/IP communication is used for communication between the robots. Initially the computer system calculates the path to the base station. It stores all the coordinates in the form of an array. The coordinates were sent one by one, only after the movement of the rover was acknowledged. As the spotter receives the coordinate, the bot moves itself to cover an area of one cell. As the spotter moves, it sent an acknowledgement back. The laptop further sent a signal to the rover to move. The rover detects the laser and moves accordingly, sending an acknowledgement once done. When both the spotter and rover were one cell forward, the last acknowledgement sent by the rover signalled the laptop to send the next coordinates to the spotter.

3.3 Proposed Design:

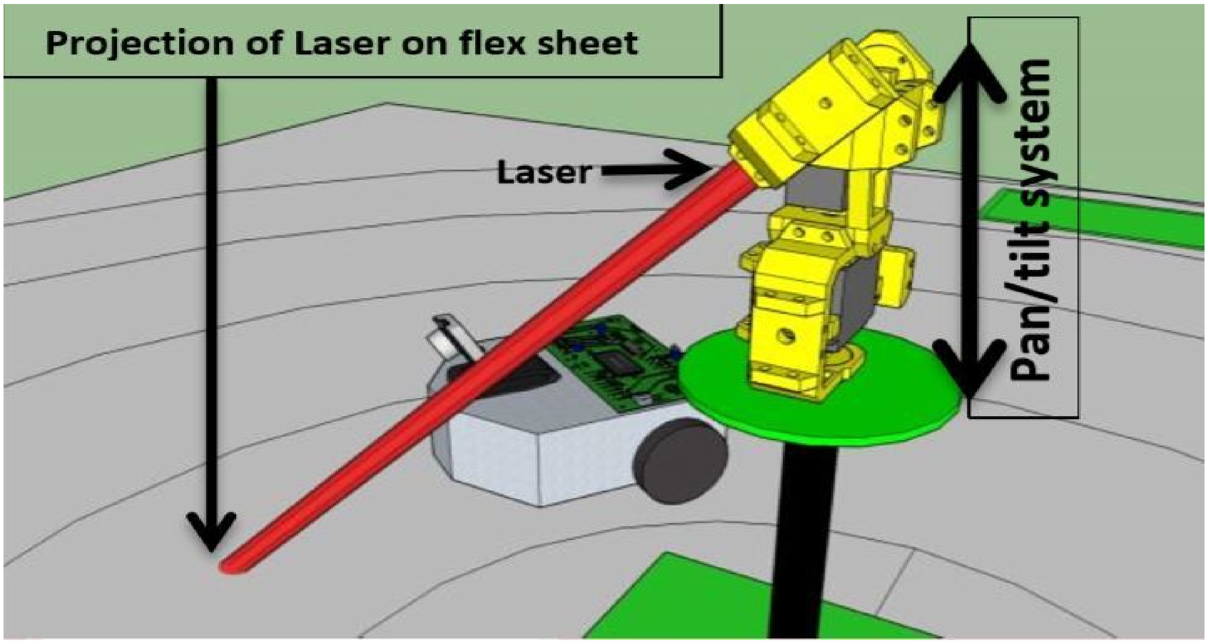

Figure 3.1 : Spotter with Pan/Tilt System

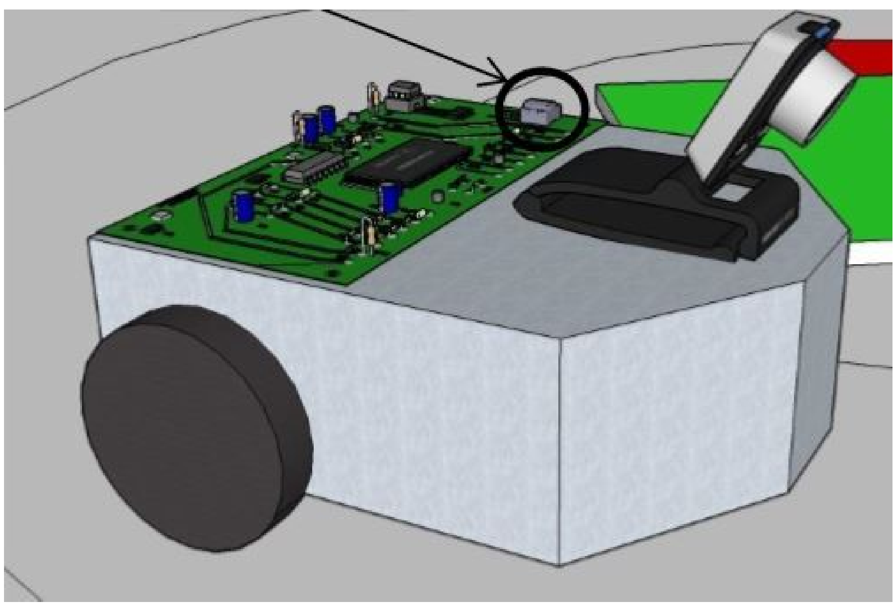

Figure 3.2 : Rover

3.4 Plan of work

At first the underlying code that instructs the Nodemcu in the laptop is designed . This initiative is taken by the whole team. The rest of the work is further divided into two halves. The first half of the team, works on the bot which consists of raspberry pi ,the code is designed to process the image received by the camera that is attached to the bot. Accordingly the dc motor are controlled . Once that is done, rest of the team works on the base station,where the code for processing the data sent by the laptop is designed so that the stepper motors are controlled as per the instructions. Once these three parts are functional, they are combined to work together ,thereby achieving the goal.

Chapter 4

4.1 Advantages and applications:

Autonomous robots are finding widespread applications in several fields like mining, manufacturing, underwater exploration, space missions and as service robots. Mobile robot need to move around and interact with different environments. The fundamental requirement in motion planning of an autonomous robot includes trajectory tracking and obstacle avoidance. One of the main advantage of this bot is automation.Most of the industries prefer Automation of machines.Automation in the manufacturing industry is the process of integrating industrial machinery to automatically perform tasks such as wielding, packing, palletizing, dispensing, cutting, etc. Utilizing hardware and software automation increases productivity, safety and profitability. Automation brings many advantages when incorporated properly.The main purpose of this bot is automation of transportation of products from manufacturing area to storage area.

4.2 The Benefits of Automation:

1) Reduction in Production Cost - A quick return on investment outweighs the initial setup costs. All of the following automation advantages reduce production cost.

2) Decrease in Part Cycle Time - A lean manufacturing line is crucial for increasing efficiency. Robotics can work longer and faster which increases production rate.

Improved Quality and Reliability - Automation is precise and repeatable. It ensures the product is manufactured with the same specifications and process every time. Repairs are few and far between.

3) Better Floor Space Utilization - By decreasing a footprint of a work area by automating parts of your production line, you can utilize the floor space for other operations and make the process flow more efficient.

4) Reduced Waste - Robots are so accurate that the amount of raw material used can be reduced, decreasing costs on waste.

5) Saves Local Jobs - Instead of moving your company to a location with lower labor costs, incorporate automation in a few key areas. This will increase your product throughput and increase your profit so you can keep your company in the current location.

Other than industries, this bot can also be used in many fields where human cannot intervene directly due to threat for his life.This type of bot can play vital role in space exploration too. After the success of Mangalyaan Mission, India has taken a huge leap in deep space exploration. As we know, humans are utilizing the resources of the planet Earth on an accelerated rate. This has led us to a problem of resource scarcity. One possible solution to mitigate this problem is to search for viable planetary options that can support human life. It is better to start early in this direction of exploration of planets which can sustain human life as our population is increasing rapidly. We are limited by the technology of our time and the targeted planets might be more than 300 million km away from Earth. It is not possible to send a manned mission to these planets. The only option we are left with is robotic technology. Automated robotic technology will not only obviate risking the lives of human beings but also help in the reduction of overall cost for such exploration.

Chapter 5

5.1 Related Works:

1) Vision Assisted Laser Scanner Navigation for Autonomous Robots describes a navigation method based on road detection using both a laser scanner and a vision sensor.. The front looking camera is used to classify the road from this distance and forward, taking a seed area from the laser scanner data and from this estimate the outline of the visible part of the road.[1]

2) Autonomous Driving in Structured and Unstructured Environments is a hybrid navigation system that combines the benefits of existing approaches for driving unstructured environments .When driving in unstructured environments, the system employs a global map and planner to generate an efficient trajectory to a desired goal. The combined system is capable of navigating a passenger car to a given goal position without relying on road structures, yet it makes use of such structure when it is available.[2]

3) Autonomous bots are complex system that requires the interaction or cooperation of numerous heterogeneous software components. Nowadays,robots are getting closer to humans and as such are becoming critical systems that must meet safety properties including logical, temporal, and real time constraints.[3]

4) Vision-based terrain classification has been an attractive solution for perceiving nearby objects for planetary rovers. Visual data often provides information at a further range than other types of sensory data.It takes advantage of the binocular disparity between two rigidly mounted cameras pointing at the same scene, similar to the human visual arrangement.[4]

5) In order to achieve autonomous operation of a bot in industrial area with unpredictable obstructions, several real time systems must interoperate, including environment perceptio, localization, planning, and control. In addition, a robust vehicle platform with appropriate sensors, computational hardware, networking and software infrastructures is essential.[5]

6) The internet of things is a network of physical object that contain embedded technology essence communicate with extrinsic environment. The industrial internet of thing is part of internet of thing that focuses on devices and object used in business setting. It helps to connect everything around you to internet including wearable devices, metering devices and environmental sensor. These devices will connect to internet to share different types of data.[6]

Chapter 6

6.1 Reference:

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