M-BOTS: Reconfigurable Modular Robots with Bluetooth Control

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Abstract - *When natural disasters like flooding, hurricanes, wildfires, there are situations where people get trapped and in many cases nobody can get into that areas for rescue. There comes the need for smaller, reconfigurable and modular robots to analyze the terrain of such areas, to collect data needed for rescuing them etc. To address these types of issues, we are introducing an innovative modular robot which can be used for surveillance when needed by attaching cameras, sensors to it. These modules can be controlled with Bluetooth terminal apps that can be installed in mobile phones. The idea of modular robots is they can adopt any shape based on the requirements and their size can be increased by using more number of modules. Also, the identical modular design makes it easier to manufacture in bulk and because of these qualities, M-BOTS will be the perfect choice for all kinds of rescue and search operations.*

***Key Words*: Modular, ATmega328P, Fusion 360, VREP, MG90B**

1. INTRODUCTION

The usual approach in robotics for designing surveillance robots is to study the terrain characteristics and then, designing a robot according to the requirements [1]. This conventional procedure cannot be followed when moving through unexplored areas like some natural disaster affected area. In those scenarios, M-BOTS can be really useful.

Adaptability is the key concept we aimed at while designing M-BOTS [2]. Motivation achieved from fire ant colonies. A number of modules with a master who communicates with the user and other modules follow the instructions given by the master module. These modules can link together to form the necessary structure. The advantage is that if one module fails, its place can easily be replaced by the other one.

By changing the codes, the user can make the modules to form different shape formations like that of a snake, centipede, Wheel to suit the need. The modules are designed to contain almost all the electronics and motors in one half, so there is a necessary space for attaching equipment like cameras in the future.

Our M-BOTS have the following features

1. Smaller size.
2. Fully 3D printable.
3. Bluetooth and RF communication
4. Rechargeable batteries.
5. Low cost (below 75 USD).

2. DEVELOPMENT OF M-BOT MODULES

The design concepts, various software used, hardware Implementation will be explained in this section.

2.1 Basic Concept of an M-BOT Module

An MBOT module composed of two blocks and a link [3]. The blocks are half cubic and half cylindrical in shape. One block is called Male Block (Active) and the other called Female Block (Passive). There is a link in between them. The face of male block can attach with face of female block only. Both the block can rotate 180 degree about the pivot joint at the ends of the link like as shown in fig 1.

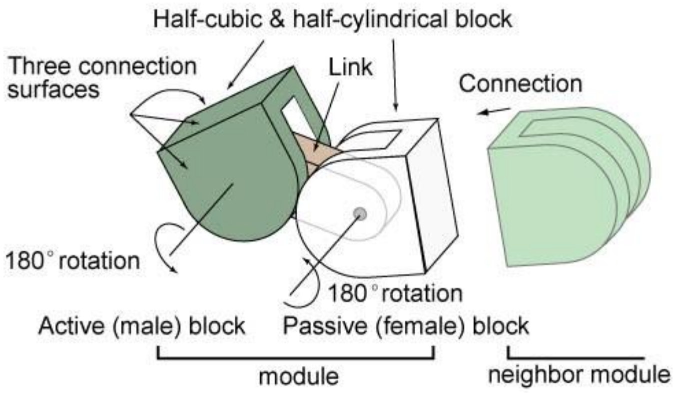

Fig -1: M-BOT Single Module Model

2.2 Mechanical Design

To create a single module shown in figure 1, we designed twenty two 3D printed parts. All the parts were created using Fusion 360 software. Fusion 360 is a cloud based 3D CAD modelling software with many advanced features [4]. The parts designed in Fusion 360 were printed using Ultimaker 3D Printer. The parts were printed at 0.2mm layer height, 0.4mm nozzle size. Some parts require sanding in order to fit/slide properly.

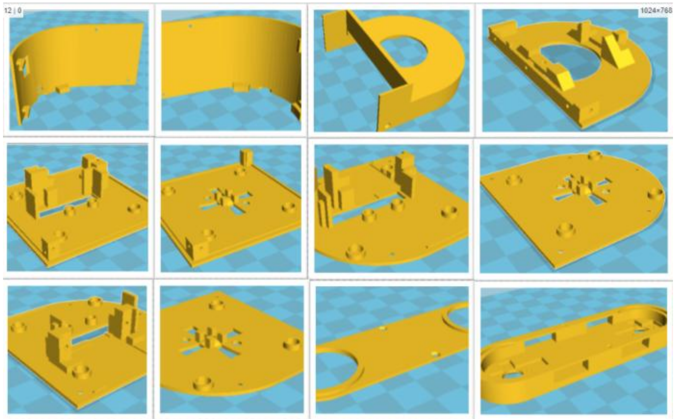

Fig -2: Few Parts Designed in Fusion 360

2.3 Electrical Design

Single module contains an LM317 IC, HC-05 module, NRF24L01 module, ATmega328P and 5 servo motors. Out of 5 servos, 2 of them are metal geared MG92B servos. Other 3 servos are ordinary SG90B servos. The MG servos are used for main motion and are attached to the ends of the link. Other servos helps in locking and unlocking of neighboring modules. There are four neodymium magnets [5] on the face of male block with polarity opposite with respect to the magnets on the face of female module. These magnets helps in proper alignment of the modules to get locked correctly.

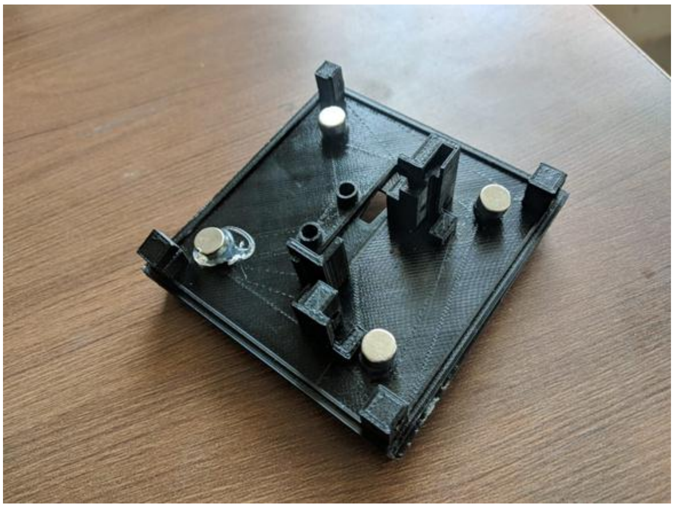

Fig -3: Neodymium Magnets on Face piece of blocks

The HC-05 module should be connected to the 5V supply from ATmega328P whereas the NRF module should be connected to 3.3V supply. Motors are driven by the Voltage regulator LM317. The ground of all components should be interconnected. LM317 connected to Li-Po battery of 500mAh output. The voltage input of ATmega328P is connected to the input of LM317 directly. ATmega328P can be programmed using Arduino Nano. The code is written in Arduino IDE. Make sure to use ribbon type wires for connecting parts for durability. Only one servo and battery placed in female block. In future cameras can be attached to the free space provided in the female block.

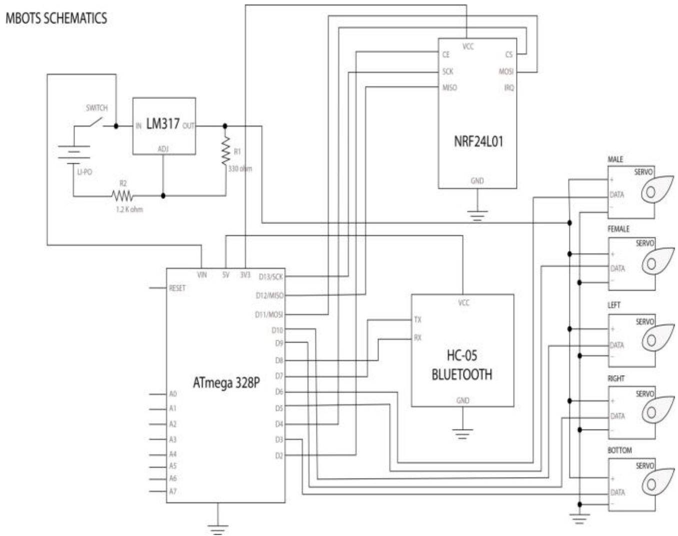

Fig -4: Schematic of Single Module

2.4 Operation of Modules

Modules created using the schematic shown in Fig 4. In the program, one variable called type of the module defines the module either as master or slave. If type is zero, then the module is master. For any other type, the module behaves as slave. For master module, it can scan with Bluetooth where as slaves scan via NRF module. When powered, Bluetooth of master module can be connected to Bluetooth terminal app installed in android mobile phone.

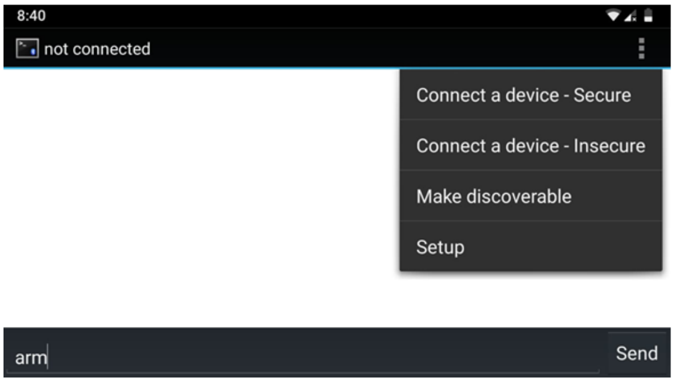

Fig -4: Bluetooth Terminal App used as Controller

When they are connected, each module gets a number depending on the connection order. The Bluetooth command are defined in the program. The characters used and their functions are listed below.

1. Character 's' to start and move all servos to central position.
2. Character 'r' to start snake like movement.
3. Character 'e' to stop all the functions.
4. Character 'g' to get locked/unlocked by moving hooks.

Working methodology is shown using the block diagram in

Fig 5 shown below.

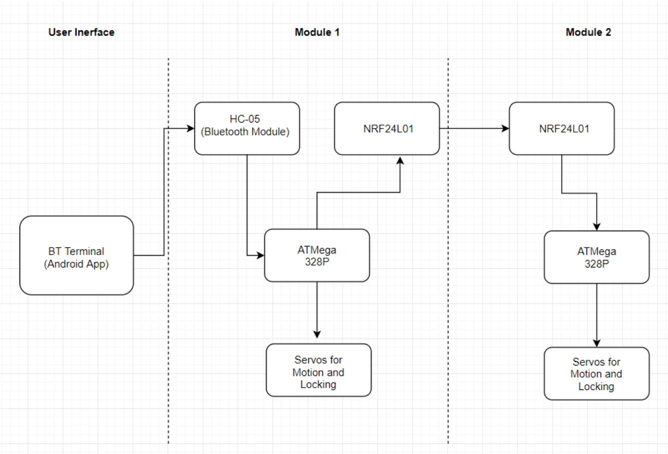

Fig -5: Block diagram showing connections

User can connect with master module (module 1) using the Bluetooth terminal app. The characters sent are received by the HC-05 module and sent to slave module (module 2) with NRF24L01 and at the same time interpreted by ATmega328P of master module. Then the respective motor is driven to perform the corresponding action.

2.5 Motion Simulator

A robotic simulation software called VREP is used to analyze the motion of one or more blocks and the locomotion modes. The module model created in Fusion 360 as STL file can be imported into VREP and can be moved using LUA programming language. VREP is capable of emulating the motion of an actual robot in a real work envelope.

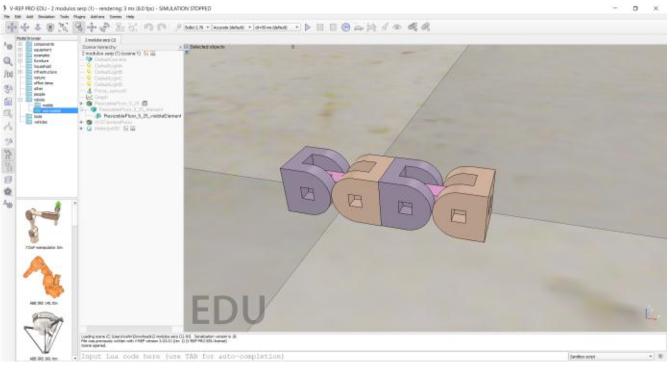

Fig -6: Bluetooth Terminal App used as Controller

The actual sinusoidal motion required to create snake like movement is simulated by changing variables in LUA script added to VREP simulator. Different laws of physics applied and real time analysis is done to get the actual movement.

3. EXPERIMENTAL RESULT

Our model for surveillance robot named M-BOTS has been successfully implemented and shown desired snake locomotion in our laboratory. The modules can communicate with each other in the entire room in a radius of 100 meters. The alignment using neodymium worked fine and the locking was a bit difficult. With a small helping the locks to attained the result that we wished for.

4. FUTURE SCOPE

As no sensors are embedded in our current module hardware, the modules have no ability to sense the surrounding environments. We plan to install sensors like proximity sensors, angle sensors and thermal cameras in the future prototype. The face rotation mechanism under planning can also make module more flexible.

5. CONCLUSION

In this paper, we have described the design concepts, hardware and software used, schematics, simulator details and experimental results. We have tested the different configurations for the current modules designed. We are now planning for a more advanced prototype with integrated sensors and cameras keeping the size same.

REFERENCES

[1] Widodo Budiharto, "Intelligent Surveillance Robot with Obstacle Avoidance Capabilities Using Neural Network", 2015.

[2] Juan Gonzalez-Gomez, "Toward the sense of touch in snake modular robots for search and rescue operations", 2013.

[3] Akiya Kamimura, "Self-Reconfigurable Modular Robot-Experiment on reconfiguration and Locomotion", 2001.

[4] Fusion 360, https://academy.autodesk.com/course/126271/introduction-3d-modelling .

[5] Sumio KOZAWA, "Trends and Problems in Research of Permanent Magnets for Motors-Addressing Scarcity Problems of Rare Earth Elements", 2016.

[6] Pratibha Singh, "A Modern Study of Bluetooth Wireless Technology", 2011.

[7] Eric Rohmer, "V-REP: A versatile and scalable robot simulation framework", ieee conference paper, 2013.