Automated Robot for Landmine Detection

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Abstract

The work illustrated in this paper presents an innovative mechanism of movement used on a robot, along with the integration of a metal detector and programmed microcontroller, to automate the landmine detection process in Sri Lanka. Work has been conducted in order to finalize the landmine detection robot – BOB – to enable traversing rough land and thick vegetation, and to withstand harsh weather conditions prevalent in target areas: North and East mined lands. BOB has been designed and made on a heuristic model. Even yet, the costs incurred are low and has proven to be safer and more effective to conventional methods of landmine detection of similar context.

1 Introduction

Landmines are the worst enemies for the soldiers in the battle field. Landmines have been so effectively used in battle fields to hinder the advancement of the enemy. This success story has now being realized in to a nightmare for the inhabitants of previous battle fields. Tragic deaths have brought about traumatic effects for these families and have had catastrophic changes in the sensitive family system! Hence, losing a life due to a mine or losing a leg to a mine is *not* just losing a life or losing a leg, it is losing the balance of many things in equilibrium.

The deminers who are putting their lives in danger in the line of their daily work are also losing their lives despite the established technology use, conventional practices, and safety measures they adopt. Looking broadly on the issue, the whole process of detection, removal and neutralization of landmines has to be rehabilitated.

In the context of Sri Lanka, landmine detection is done by human hand and with the use of trained dogs. Demining is done by many organizations: RONCO, SLA and HALO. The Sri Lankan army and LTTE also carry out humanitarian demining. The drain of foreign currency, as the payments for demining is in foreign currency, is frightening – US$1000 is the approximate value!

The defects of conventional demining methods, drain of foreign currency, and all other adverse effects of humanitarian demining have been overlooked due to the very fact that demining in itself is a dangerous and risky business. Hence, authorities, irrespective of the results obtained, have to be satisfied with prevailing humanitarian demining process. Yet, to remedy this problem or at least to minimize the effects, being proactive could bring better results: saves human lives, both officials in the line of work and civilian casualties, and retains foreign currency, and establishes a culture of localized solutions for issues in third world countries.

The bottleneck in the process of demining is the detection process – time consuming and hazardous. The possible improvements in conventional methods are the expertise of removal of landmines by hand over time, development of better landmine detectors, and breeding better dogs and training them. These developments alone will not bring out the ideal outcomes: minimizing loss of human lives, localizing the demining process and quickening the resettlement of previous inhabitants.

Partial solution for detection process is attempted by the effort described in this paper. The attempt has been to automate the detection process using a mechanical robot - **BOB**. The design is such that it can traverse rough terrains in harsh weather conditions. Ideally, robot is expected to attain information on the terrain and learn while traversing the land. Due to time constrictions, learning behaviors are not implemented and it has been restricted to a reactive machine than a proactive one. Yet, the detection process is automated and no human is involved. It is safer, faster and cost effective.

2 Objectives

Initial high optimism declined with the realization of the practical difficulties. Hence, as it is comprehended as relevant, both the objectives at the initial stages and objectives set after about a month of commencement of the project are stated below.

2.1 Initial Objectives

1. Developing a robot colony of three robots collaborating together to detect mines
2. Developing a simple system for probabilistic coverage of landmines and pattern recognition
3. Developing a sensor based simple land coverage system
4. Mapping the detected bomb pattern on to a computer screen for easy analysis
5. Reduction of cost for detection system
6. Safer and faster detection system

2.2 Objectives set after one month in to the project

1. Develop a robotic platform to automate the landmine detection
2. Develop the robotic platform in to safer and faster solution than conventional methods
3. Cost effective autonomous robot
4. Sleek design to suit rough terrains and harsh weather

Following are the other objectives of the development team.

1. Initiate research by embarking on a localized project of this nature and magnitude to facilitate future interest
2. Giving rise to research of national importance
3. To make authorities and public realize the cost effectiveness, speed and safety of this alternative solution to landmine detection
4. Expectation of other groups, probably the junior batches, developing an interest of carrying out more studies on support-studies such as probabilistic analysis of landmine patterns, positioning systems for robots, localization for the robotic colonies, alternative movements for the robots and software development to assist the behavioral programming of the microcontroller, which would vastly contribute towards demining as a whole
5. Saving human lives which would otherwise be at stake on uncleared mined lands

3 Methodology

The factors governing the type of methodology adopted were limited time frame and nature of project. From the inception, the project planning was result oriented. Hence, methodology had high influence over the latter fact, too.

There were three distinct design phases during the development of BOB: Literary survey, Design and implementation of CrocoBot, Design and implementation of BOB. Literary survey was carried outright as *crash courses*, yet with an element of result orientation. A *heuristic* type of methodology was adopted in the second design phase. The third design phase, with the experience gathered from the second design phase, was planned and drafted strategically to achieve the desired results as described in *Section 2.2*.

4 Scope of Project

Scope of the project was bounded by the objectives. As stated in *Section 2.2*, initial scope of the project was later altered to suit the time frame – wider scope (*Section 2.1*) was narrowed down (*Section 2.2*), yet retaining space for future development.

5 Approach

A careful approach was adopted, akin to many commonly used research approaches. Hence, work began with a literature survey and background work, and then proceeded on to developing a lab model, **CrocoBot**, before embarking on the final product, **BOB**. After testing of CrocoBot, BOB was designed and implemented not on a heuristic model as CrocoBot but on a well planned strategy.

5.1 Literature Survey & Background work

Studies were conducted on Artificial Intelligence (AI), Artificial Neural Networks (ANNs), Behavior-based Systems (BBSs) and Fuzzy Logic. Understanding the concepts behind these studies aided in making better decisions on the design and implementation of CrocoBot and BOB. Studies were not concentrated only on theory but also the practical value. Hence, where possible, they were associated with real robots and compared. E.g. Programming of 'Rug Warrior', a robot made by *Robotic Institution of Carnegie Mellon University, United States of America*. Also, the group engaged in some work associated with microcontroller programming with *Assembly* language. Other programs were written for sensors connected to a robot: Tactile sensor, Bumper sensor, Proximity sensor and Photo sensors.

5.2 Design of CrocoBot

The conventional methods of movements used on many robotic platforms are wheels and actuators. Since these conventional methods were seen not to withstand the harsh condition prevailing in landmine areas, a unique mechanism for the robot was imperative.

The perception of concepts behind robotics, as conceived by the literature survey studies, helped to realize the importance of building a robot who imitates a real biological being. The creatures like crocodiles, monitors, mongoose and rats are so efficient in finding food, traversing land of thick vegetation, smelling their prey and etc. Hence, it was group's expectation to come up with a mechanical design, which imitated aforementioned beings. Building this mechanical design, of whose biological counterpart is a crocodile or a monitor, presented many problems. The lack of mechanical knowledge compensated by sheer courage and enthusiasm paid off. Finally the team built **CrocoBot** (The movement is of a crocodile + A robot = **Croco**dileRo**bot** = CrocoBot) capable of moving successfully on land, grass and rough terrain. The expectation was to pave the way to a better final product through testing of CrocoBot.

Figure 1: CrocoBot

The axial rotation of the motor is transferred on to a worm wheel to extract perpendicular movement (See *Figure X*). Worm wheel is connected to two more metal caps, which are connected to the body of CrocoBot 180 degrees out of phase. This setup moves the front and the back of CrocoBot (See *Figure 1*) in such a manner that the body pushes forward as a whole. The errors in turning and traversing ground, mechanical design failures and other were overcome in the design of BOB.

5.3 Design of BOB

BOB was designed to overcome the malfunctions, errors and failures found in CrocoBot. BOB has two CrocoBots collaborating together. This collaboration can be illustrated as a simple localization scheme between two robots, where a potentiometer is used to inform the microcontroller the number of degrees BOB has turned. A back tray carries the circuitry and power supply. A front tray carries the metal detector used to detect mines.

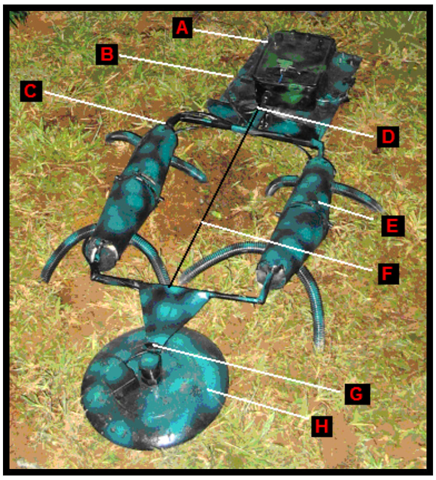

Figure 2: BOB

A – Detector circuitry and BOB's circuitry
B – Back tray
C – Ball joint
D – Potentiometer (i.e. Volume controller)
E – One CrocoBot of BOB
F – Rod connecting the front tray and the back tray
G – Bumper sensor
H – Metal detector

Following figures illustrates the mechanism used in CrocoBots of BOB.

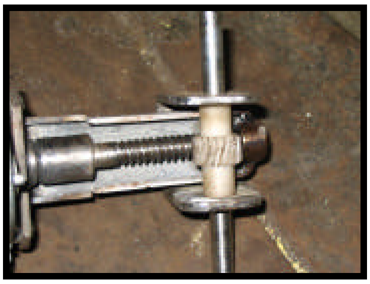

Figure 3: CrocoBot

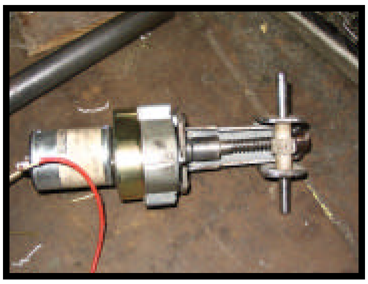

Figure 4: Motor, Gear train & Worm wheel

Figure 5: Motor, Gear train & Worm wheel

BOB carries three sensors: Bumper, Metal detector and Potentiometer. Special circuits were designed for the integration of potentiometer and metal detector. Special precautions were taken to alleviate electronic spikes in the circuits as spikes causes the microcontroller to reset itself. Troubleshooting BOB was challenging, and debugging the program of BOB's microcontroller was another challenge that the group overcame.

BOB's Attributes

1. Ability to turn right, left or reverse
2. Leg design enabling better movement
3. Sleek body design
4. Ability to traverse rough terrains
5. Sustainable in harsh conditions
6. Internal power source
7. Stand alone system

6 Results and Analysis

BOB, the automated landmine detector platform, has achieved the objectives stipulated in *Section 2.2*. The deployment of BOB in the target areas – North and East of Sri Lanka – has not yet been implemented. However, testing on ground, populated with reasonable vegetation, has proved to achieve the expected results. BOB has proven its capability of detecting metals within 3 to 5 inches below ground level. BOB's dependency on the used metal detector has limited BOB's accuracy of detection and its efficiency. It has caused some hindrance to the development of the project. A better detection system would have cut down the work load of troubleshooting in the detection system, and more time could have been devoted to circuitries and injecting some more intelligence in to BOB.

Avoiding spikes in the circuitry injected in by the metal detector required heavy concentration. Despite the latter issue, circuitry presented no other complications, except the main program. BOB is programmed to pose as an intelligent robot. Handicaps of a mechanical robot, compared to its biological counterpart – Monitor, were inhibited by the proper programming techniques. Programming methods ceased to comply with the circuitry, due hardware limitations. After many trials and testing, fine balance between software and hardware was achieved.

7 Conclusions

The work presented in this paper has been a unique and distinct attempt made by the authors. Realms of robotics has not been envisaged in BOB, hence it goes to prove simple techniques can do what is comprehended as impossible. The work maintains the proportionality to man hours devoted to the project, despite the fact that the project was first of its kind in Sri Lanka !

BOB has proven its success during normal ground testing, hence holds an upper hand over any lab prototype of its kind. BOB requires some overall alterations, which would have been possible if not for the small time frame, before deploying it in target areas. The body orientation is sleek and the movement of BOB is ideal in exploring any terrain. Further development in its legs will increase BOB's traversing capabilities. Localization aspects are also not forgotten in BOB's design. The simple potentiometer design represents the concept of collaboration – Localization – between the two CrocoBots. The heavy back tray ensures BOB's balance and upward pointing front tray glides over irregularities of land.

As it is seen, BOB presents itself as an excellent candidate for further development and it certainly complies with the objectives set at the inception of the project. The group's wish was to stimulate a robotic culture of this nature, hence to develop a successful model of this nature to arouse the enthusiasm within the interested parties.

8 References

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