

Mine Detection Robot and Related Humanitarian Technology

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Abstract—Robotics is an emerging technology that reduces human work. In this paper we are proposing a robot that has the aptitude to detect the buried landmines and let user control it wirelessly to avoid human causalities. There are about 110 millions around the world and between 5 and 10 million more mines are produced each year. The main idea is to design a prototype of an efficient mine detecting autonomous vehicle that can detect landmine and inform the location of landmine. This vehicle wirelessly communicates with the user to transmit the location of landmines detected. Proposed robot will also help in identifying individuals using RF tags. The proposed system will help in significantly reducing human causalities in the mine field. Automation guarantees faster scanning process.

Keywords— Landmines; autonomous vehicle; location; wireless communication; RFtags;

I. INTRODUCTION

Landmines, an explosive mine laid on or just under the surface of the ground. They are designed to destroy enemy targets ranging from vehicles and tanks as they pass over or near the landmine. There are two types of landmines—anti-tank mines and anti-personnel mines. One million people have been killed and maimed by anti-personnel mines. 26,000 people a year become victims. 300,000 children and counting are severely disabled because of land mines. As the presence of landmines has become a part of the everyday life in few countries, the problems caused on human and environment is very high. With the pros and cons of technologies like robotics and many others, these could solve a lot of problems and save a lot of lives. The main idea of the project is to design an autonomous vehicle that is capable of detecting buried landmines and inform the location. Most landmines can be detected using metal detecting sensors. All metal detectors deal with the principle of transmitting magnetic field. Transmit coil produces a varying electric current by transmit electronics. The metal detectors will consist of another coil called the receiving coil. This identifies the changing magnetic field that is caused by the presence of metallic object. There are three different detectors such as: The PI (pulse-induction) metal detector, VLF (very low frequency) metal detectors,

BFO (beat frequency oscillator) technology. As VLF can discriminate the different types of objects with the help of phase demodulator, it's the best type of detectors which can be used in identifying the landmines. The autonomous vehicle is mounted with the VLF detectors which will identify the buried landmines. Once the landmines are identified the corresponding location has to be informed to the operator. The operator will stay at a distant and control the vehicle wirelessly. We have added an additional capability to our robot, it can detect any individual dead or injured in the war field with the help the RF Tags. Each person is given a nano-size RF tags that is attached to the person's clothes. The robot will have a RF tag detector sensor that can identify RF tag and send the location of it to the operator. The autonomous vehicle can move in eight directions. The ground vehicle is programmed in such a way that it has to move in shortest possible path to detect the landmine and to locate friend lies. The main objective of the project is to ensure safety of the humans.

This paper presents:

- System Design
- Implementation

II. SYSTEM DESIGN

The autonomous vehicle is a wheeled ground vehicle that consists of 3 wheels and it is driven by Arduino board which is already programmed. The vehicle is mounted with two sensors. Metal detecting VLF sensor used to detect landmines and active RF sensor used to detect RF Tags. The autonomous vehicle can move in eight directions: Front, Front-left, Front-right, Left, Right, Bottom, Bottom-left, Bottom-right. The sequence diagram shown in figure1 explains the functionalities and design of the system. We have two actors PC and Robot. Operator should give the destination where he wants to reach and the robot initial position. PC with the destination information and robot position will generate optimal path. The instructions to reach the destination are given to the robot by the PC. As

the robot moves it will detect landmines. If it encounters a landmine, the location of the landmine is sent. The communication with PC is wireless via ZigBee. PC will reconstruct a new optimal path from the robot's current location and the process repeats until the robot reaches the destination in a mine free path.

A sequence diagram of the system functionalities is represented in figure1, which illustrates the order of execution.

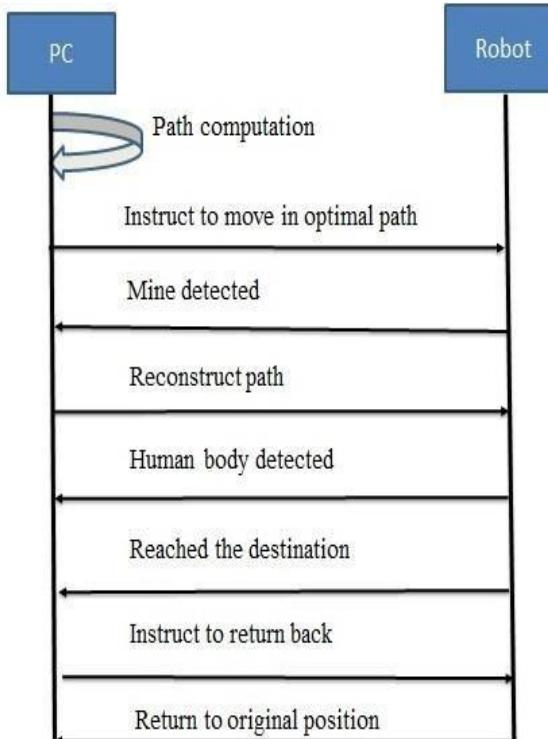


Fig. 1. Sequence diagram of detection and data transferring scenario

III. IMPLEMENTATION

We have four modules:

- Grid computation Module
- Path computation Module
- Landmine Detection Module
- RF Id Module

A. Grid Computation Module

The war-field where landmines are to be detected is converted into grid environment. There will be static obstacles like trees, huge rocks and so on. In this module, first we create grid by giving number of rows and columns. After the creation of grid, one can mark the obstacles cell and destination location. We have to estimate cost for each cell. Estimated cost is a straight line distance from destination location to that particular cell. This cost is required in the next module. Figure2 shows the formed grid and cost estimated for each cell. Red marking is the obstacles green mark is the destination where the robot should go.

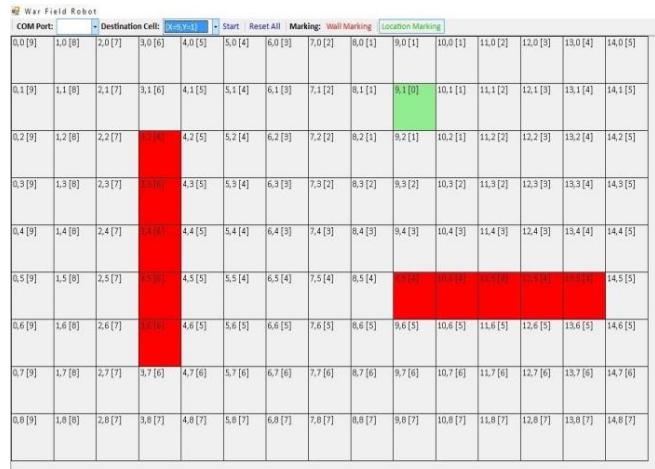


Fig. 2. Grid formation with obstacles marked red, destination location marked green and estimated cost

B. Path Computation Module

In this module PC should compute a path from robot start position to destination location given by the user. Path computation module will make use of A* algorithm (pronounced as A star algorithm). It is an algorithm basically used for path finding and graph traversal. It is the process of plotting an efficient path between multiple points. It is used widespread due to its performance and accuracy. Works have found that A* is superior to other path finding approaches.

A* is an informed search algorithm, or a best-first search, meaning that it solves problems by searching among all possible paths to find solution that has the smallest cost. And among these paths it first considers the ones that appear to lead most quickly to the solution. It formulates in terms of weighted graphs: starting from a specific node of a graph, it constructs a tree of path visited expanding paths one step at a time until one of its path ends at the goal node. At each iteration of its main loop, A* needs to determine which of its partial paths to expand into one or more longer paths, It does so by estimating the cost based on the equation 1

$$F(n) = g(n) + h(n) \dots \dots 1$$

Where, n is the node being traversed, g(n) is the cost of path from start position of robot to node n, h(n) is a heuristic that estimates the cost from node n to the destination location. The equation is called the heuristic function. The straight line distance estimated in the previous module is the h(n). A* uses a priority queue to perform the repeated selection of minimum cost nodes to expand. This priority is called the open set. At each step, the lowest F(x) value is removed from the open set; the F and g values of its neighbors are updated accordingly, and are added to the open set. The algorithm continues until a destination node has a lowest f value than any node in the open set. The F value of the destination is then the shortest path length. The figure3 shows the implementation of A* algorithm on a graph of eight nodes.

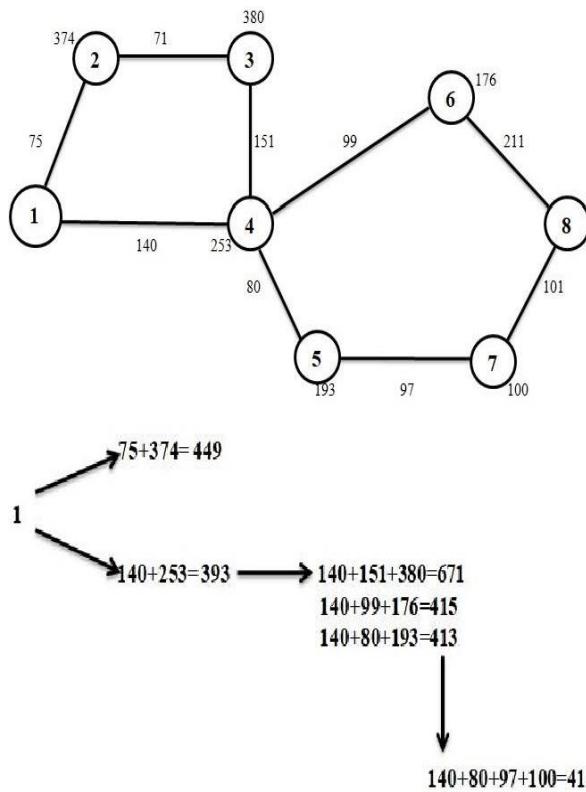


Fig. 3. Path computation using A* algorithm

In the above graph, the source node is 1 and destination node is 8. The optimal path is computed by expanding the node which has least value. The optimal path obtains for the above graph is 1-4-5-7-8. The optimal distance from source node 1 to destination node 8 is 417.

After path computation, instruction for the robot to move to the destination has to be given. Moore neighbor's algorithm is used to convert the path into command instruction for the robot. The designed autonomous vehicle can move in eight directions: front, front-left, front-right, back, back-left, back-right.

C. Detection Module

Mines are detected using metal detectors which work on the principles of electromagnetic induction. Metal detectors have one or more inductor coils that are used to interact with metallic objects on the ground. There are three kinds of metal detectors to choose from. It is crucial to recognize the variety prior to buying one. They are Pulse induction (PI), Beat frequency oscillation (BFO) and Very low frequency (VLF) detector. In this project we pick the VLF metal detector as it best fits and gives accurate results for our project. The VLF detector is one of the most widely-used since it has a variety of uses due in part to technological advancements shown in the figure-4. It has two wire coils of spherical shape which are called a transmitter and a receiver. The transmitter is employed to create a magnetic field with low frequency into the ground. The receiver, meanwhile, is employed for its ability to pick up magnetic signals from an item that is located under the ground. Along with this type of detector includes an electric circuit known as a tuner, which serves the purpose of filtering signals to the detector's receiver. So this is how we can distinguish between different types of metals. It relies on a

phenomenon known as phase shifting. The difference in timing between the transmitter coil's frequency and the frequency of the target object is called as phase shift. As we know Inductance and resistance varies for different metals, an object with high inductance is going to have a larger phase shift, as it takes longer to alter its magnetic field. An object which has high resistance tends to have a smaller phase shift. Phase shift provides VLF-based metal detectors with a capability called discrimination. A VLF metal detector examines the amount of phase shift, using a pair of electronic circuits called phase demodulators, and compares it with the average for a particular type of metal. Once it detects the mines it will go to inform users by specifying particular cell(area) which has mine and it will re-compute to other shortest path to reach destination.



Fig. 4. VLF metal detector

D. RF-ID Module

Our robot is also implemented with RF sensors to detect individuals in war-field. A radio frequency identification reader (RFID reader) is a device used to identify and take the information from an RFID tag, which is used to track individuals by uniquely in the war-field after the war. Radio waves are used to transform data from the tag to a reader. There are two major categories of RF-ID systems – active and passive. We have chosen active RF-ID systems because of its advantages over passive. Every active tag has its own transmitter and power source. In most of the cases, the power source is a battery. Active tags transmit their own signal with the information stored on their microchips. Active RF-ID systems typically operate in the ultra-high frequency (UHF) band and offer a range of up to 100m. Currently we have two main types of active tags, transponders and beacons. Transponders are "woken up" when they receive a radio signal from a reader, and then power on and respond by transmitting a signal back. Beacons are usually used in real-time locating system (RTLS), in order to track the precise location of an object or humans continuously. By this we can also locate exact location of an object through GPS system. So RF-ID can be used to detect individuals in war-field either dead or alive. Whenever it detects, it will send back the information of presence to the users by locating their location.

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Fig. 5. Active RF-tags

IV. CONCLUSION

As we have seen landmines have caused a lot of damage to civilians and it has become a major threat in battlefield. Detection process of landmines requires a lot of time and human effort. This paper presents the autonomous vehicle that can drastically reduce the number of casualties and ensure safety by locating landmines. The detection process of landmine is based on metal detector. It detects landmine present under the ground and alarms the user, it reconstructs the path to generate a landmine free path. The autonomous vehicle is controlled wirelessly from a safe distance. Additional feature is added, the robot can detect individuals with RF-tags using RF-sensors.

V. FUTURE WORK

To improve the performance, one can apply different future enhancements.

- Instead of autonomous vehicle which is driven on the ground, we can use unmanned aerial vehicle (drone) that flies at a fixed height. This approach will reduce the risk of accidents prior detecting the mine.
- Our plan for future work includes mounting a wireless camera on the robot so controlling the movement of the robot will be easier. By watching the video feed on a computer or mobile phone screen, the user will be able to remotely control the robot even when it goes out of sight. In addition, other enhancements can be made to the system.
- Increase the communication range for the control of the robot.
- Increase accuracy and range in detection.

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