Summary of Mine Detection Team's Activities—Fall 2007

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ABSTRACT

Currently, there is approximately 170 km^2 of landmine-infested terrain in Cambodia. The Cornell MineSweeper's objective is to clear those mines with a low-cost and autonomous robot. Current technology of demining has a false positive rate of one thousand per mine. The result is a cost of a million dollars to demine a single square kilometer of land [6]. This report presents the team's methodology of detecting anti-personnel landmines that will be integrated to the robot next semester.

I. INTRODUCTION

Hours or research has been done to find the optimal configuration of mine detection technologies. The focus was on improving the status quo hit-miss rate, selecting a detection platform practical for the rover, and improving upon existing technologies for detection. The finalized the plan will be discussed in great detail: to eliminate the false alarms and maximize the accuracy of mine detection, ground-penetrating radar (GPR) and modified electromagnetic induction (EMI) technologies would be combined together. The GPR system will scan the designated area to see if there are suspicious spots first. And then, an EMI scan would be performed in those areas to obtain a more detailed scan of material composition to determine whether or not it is a mine.

II. TECHNOLOGY

A. Mechanical Solution

The entire sensor array will be planar mounted on a PCB board. This board will then be placed forward of the vehicle, to allow for some preliminary knowledge of materials ahead of the rover, preventing the rover from setting off the mine it was supposed to detect. This possibility is very likely given that the majority of mines we aim to detect are anti-personnel, with small trigger threshold. As shown in Figure 1, GPR will be mounted in the front, to allow it to scan first, followed by the EMI. These will both send data back to the DSP, located on the main body of the rover.

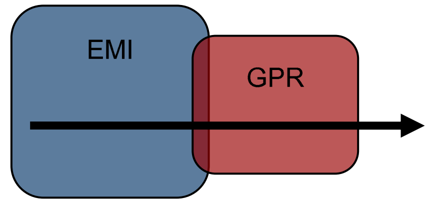

Figure 1. Layout of the sensor array

B. Ground Penetrating Radar (GPR)

GPR is commonly used in detecting instabilities in architecture and locations of minerals. GPR systems send radar pulses of energy into a material via a radiating source, often times an antenna. Then a computer records the time and the strength it takes to receive the reflected signals. It analyzes these signals' indexes of refraction, which is combined to form the reflective index of the macro-material. One of the advantages of GPR is that since GPR senses the dielectric constant, it detects both metals and nonmetals, which is critical for detecting mines with plastic shielding [4].

The type of images desired is shown in Figure 2. All the locations of detected objects with depth indicated on the side are marked on the left image. The one on the right is a wrapped image that shows several slices of different depth [6]. This kind of general map of the field will save much time.

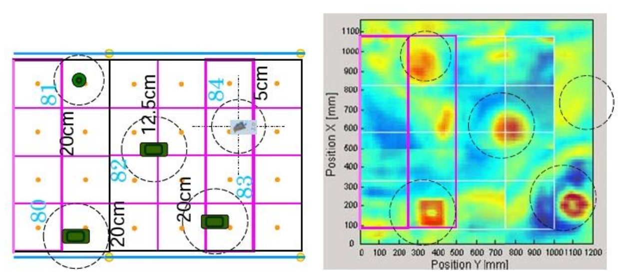

Figure 2. Examples of detection images (Courtesy of Tanaka)

Although GPR provides a decent amount of information, it is unable to produce a complete profile of the material information and contains quite a bit of noise. To compensate for these disadvantages, EMI is added to the scheme.

C. Electro-Magnetic Induction (EMI)

EMI has been used in metal detectors to find landmines since before World War II. It is currently being used for humanitarian demining around the world. EMI technology sends a stream or pulse of electromagnetic waves into a material, to analyze its metallic composition.

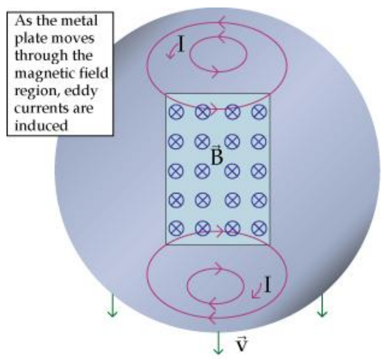

Figure 3. Eddy current formation (Courtesy of Das)

This is accomplished using the principle of electromagnetic induction. As shown in Figure 3, the metallic components within the material will be affected by the incoming electromagnetic radiation, induct and form eddy currents. These will then emit their own unique electromagnetic waves, which will radiate back to the original source, indicating the presence of metal [1].

EMI is a proven technology and it provides more material information than GPR. However, it takes a longer time and has a 1000 to 1 miss rate. Moreover, it is hard to distinguish shrapnel from a mine. This is why GPR and EMI technologies would be combined together.

D. Algorithm

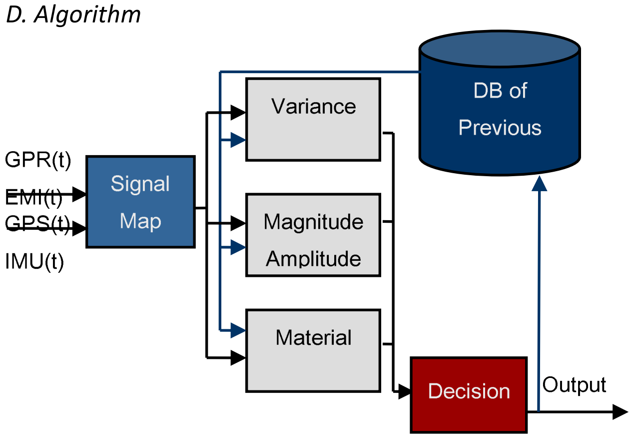

Figure 4. Block diagram of algorithm

Figure 4 is a big picture of how the technologies will be implemented. First, the designated minefield will be scanned primarily with GPR technology by a group of robots combing the land laterally, as shown in Figure 5. Upon detecting a probable patch of land, the rover will trigger its EMI detection capabilities and scan the earth's metallic composition. Combining this with GPS and IMU values, one can remap the sensor data stream to values of time to values of position.

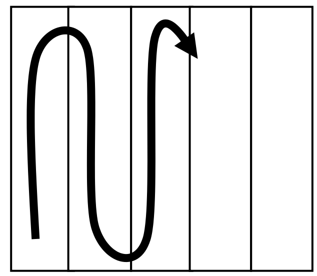

Figure 5. Path of the robot

When the array detects an object, the object will occupy an n number of little squares of area. From this, the sensor checks if the object is in the desired size range. If the number of squares does not lie in that range, the array may set it aside for the time being. It is likely that the object is not a mine. On the other hand, if the number of active squares is within the range, the object needs to be further analyzed, to determine whether or not it is a mine. Then the frequency sent from the object and material composition can be analyzed to see if they match those of a mine. Moreover, the sensor should compare the newly detected objects with a previous mine to improve its performance and accuracy. When the robot is traveling the designated path, the array might sense only half of an object. When this occurs, the array should move so that it covers the entire object.

III. CONCLUSION

For better resolution and robustness of our platform, the team will be looking into non-antennae based EMI and side-scanning GPR next semester [1]. Then, the technologies discussed here will be implemented to the robot, with any improvements added after further research.

IV. REFERENCES

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