DETECTION OF LANDMINES IN A VARIETY OF SOIL CONDITIONS USING A GROUND-PENETRATING RADAR AND A METAL DETECTOR

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Landmine detection is a hazardous operation. To reduce the human casualties during landmine detection, unmanned ground vehicles (UGV's) can be used. There are many landmine detection modalities that can be used with a UGV. However, the ground-penetrating radar (GPR) and the metal detector (MD; electromagnetic induction sensor) are fast and may be the most reliable means of landmine detection. In addition, GPR and MD sensors can easily be combined. In such a system, the UGV scans the GPR and MD sensors at a constant height over the ground. Because the height of the sensors affects the target responses significantly, the sensors must be scanned at an optimal height to detect landmines efficiently. Moreover, the optimal height may vary depending on the soil conditions. Thus, in this paper, the optimal height for the GPR and MD sensors is determined through a number of experiments.

To determine the optimal height for the sensors, a series of experiments has been performed. The GPR and MD combined sensor is scanned over a 2m x 2m x 1m soil box at a constant height. The soil box contains soil and a landmine. The control parameters for the experiments are sensor height, landmine depth, landmine type, soil moisture, and soil composition. The sensor height is varied from 2cm to 10cm with 2cm increment from the soil. The landmine depth measured from the soil surface to the top of the landmine varies from 0cm to 30cm with 5cm increment. The soil moistures considered in the experiments are dry, wet, and saturated. The soil compositions considered in the experiments are sand, sandy soil, and stony soil. The experiments are performed for all control parameter combinations. The GPR and MD responses are recorded and later analyzed.

The GPR and MD responses are used to generate target images. The GPR images are generated using a reconstruction algorithm used in synthetic aperture radar signal processing. The MD images are generated by calculating the energy of the imaginary part of the MD response. The image qualities of both sensors are compared for the soil conditions. An identification algorithm is presented, which can identify four landmines used in the experiments. The identification algorithm uses both the GPR and MD sensor responses. The optimal height of the sensors is empirically determined, which is optimal for the identification algorithm presented in the paper. The algorithm is validated by confirmation tests under soil conditions that are not used in the experiments.