Imaging of Landmines by GPR and EMI Sensor

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Since Ottawa Treaty, the Anti-Personnel Mine Ban Convention established in 1997, humanitarian demining has actively been conducted in more than 50 mine affected countries in the world. Although the threat by buried landmines has drastically been removed in many countries last 20 years, it is still not easy to demolish all the buried mines in many countries. In order to achieve this clearance, we need more advanced technique.

EMI (Electromagnetic Induction) sensors have been used for landmine detection, because small amount of metal contained in anti-personnel (AP) mines can be detected. However, since EMI sensor is quite useful, major cost and time for landmine clearance operation is used for prodding the buried targets, but not for detection the buried objects. Introduction of Ground Penetrating Radar (GPR) is quite useful for this purpose, because GPR can be used to understand the properties of the buried objects, such as shape, before excavation. A sensor combining GPR and EMI sensor is referred as a dual sensor in humanitarian demining.

We have developed a dual sensor "ALIS "since 2002[1]. The technical novelty of ALIS is its capability of imaging of buried objects. The sensor head of ALIS shown in Fig.1, is composed of GPR antennas and an EMI sensor, and it is also equipped with a 3-axial accelerometer and a gyroscope. Using the sensor tracking information, GPR data can be used for image re-construction. We use the back-projection algorithm, and found it is quite useful. The GPR and EMI data acquired by the ALIS sensor is sent to an Android PC via Wi-Fi and processed in a few second to be displayed on the PC screen. Figure 2 shows a GPR image of an anti-personnel mine "Type-72", which has a diameter about 8cm, acquired in Cambodia. The shape of the plastic case of the mine is clearly imaged. 3-D GPR images are provided to the operator for judgement of the shape of the buried target and its depth immediately. The importance of the image reconstruction is not only to obtain the shape of the buried targets, but also for clutter reduction. The soil in typical mine fields is strongly inhomogeneous. It contains many small gravels, tree roots and in addition, the soil moisture is quite inhomogeneous. We have found that in many cases, clutter can be drastically reduced by image re-construction. We think that back-projection algorithm has an effect of spatial averaging, and small size clutter can be ignored in the processed images.

Figure 1. ALIS in operation in a mine field in Cambodia

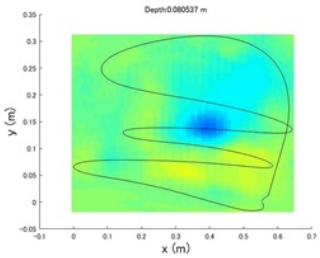

Figure 2. GPR image of ALIS.

Currently, ALIS is used in mine clearance operations in Cambodia, by operators from a Japanese NPO IMCCD[2]. We trained several Cambodian deminers for operation of ALIS. We can set appropriate value of the dielectric constant of the host soil, but it would contain more than 10-20% error. We think that the robustness of the imaging algorithm is very important in practical use. Currently 7 units of ALIS are working in Cambodia by CMAC (Cambodian Mine Action Centre), a collaboration work with National University and CCCM in Colombia started in October 2019 and NATO SPS project started in December 2020 for activities in Bosnia and Herzegovina. We are also developing software which can also compensate irregular sensor head movement, and we plan to introduce machine learning for understanding the buried objects.

References

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