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Landmine Detection Imaging Algorithm for GPR

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We are developing a dual sensor, which combines Ground Penetrating Radar (GPR) and Electromagnetic Induction Sensor (EMI sensor) for landmine detection. This handheld sensor has a capability of visualization of buried objects and has been used in mine affected countries including Cambodia, Bosnia and Herzegovina, Colombia and Ukraine. We are using standard signal processing used for GPR, but we are continuously developing the algorithm based on the real data sets acquired in mine fields.

The GPR function of our dual sensor ALIS acquires GPR signal together with the position information, while the antenna is scanned by the hand of a deminer. The data will be processed by using Synthetic Aperture Radar (SAR) processing, which is equivalent to back projection (diffraction stack) migration, assuming the constant velocity of EM wave in soil [1]. The signal processing is carried out on an Android smartphone and the images are displayed immediately after the data was acquired.

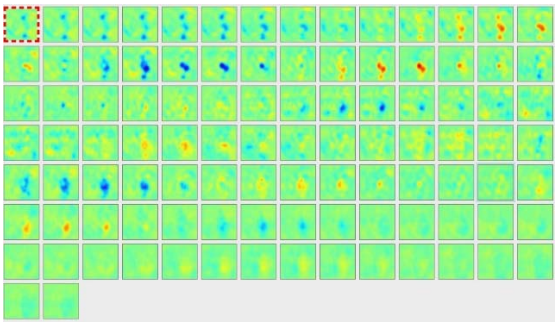

Figure 1. Horizontal slice of raw GPR signal.

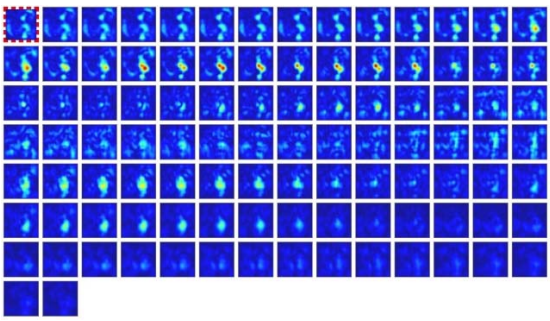

Figure 2. Horizontal slice of the envelop of GPR signal.

Figure 1 shows an example of horizontal slices, which images a anti-personnel mine PMN (ALIS0158-14-20250108). We can observe the round shape, which indicates the mine at the center of the image. The color changes depend on the slice depth, because the GPR signal has polarity, and ringing shows sequential positive and negative images. Using the same data set, Figure 2 shows the horizontal slices by ploting the envelop of the GPR signal. The envelop was generated from the original GPR signal by taking the absolute value of the analytic signal which was obtained by Hilbert transformation. We can now find the continuous shape of the mine much better than that in Figure 1.

These images also give information about the depth of the targets, and it is quite important for the safety of excavation of the buried explosive targets. We have to assume the velocity of EM wave for SAR processing, and the velocity is principally dependent on the soil moisture or the dielectric constant. The dielectric constant is one of the parameters that the operator (deminer) can change on site. We educate the deminers to set appropriate dielectric constant. We think the depth error is less than 30% in the mine field operation[2].

1.T. Kondo, K. Kikuta and M. Sato," Ground Surface Reflection Compensation for Hand-Held GPR," *IEEE Geoscience and Remote Sensing Letters*, Vol.19, 2020.

2. Z. Dong, F.Xuan, X.Haoqiu L. Zou and M. Sato,"3D Migration Depth Focus Velocity Analysis of Hand-Held Ground Penetrating Radar, " *Geosciences* , Vol.12, Issue4, 2022.