Object detection and feature recognition using ultra wide 2-18Ghz bandwidth SAR

Abstract

Remote investigation and classification of objects is important for many reasons. In defence roles the identification of suspicious objects can enhance both security and safety. For potential civilian application, non-invasive crop health monitoring can improve crop yields, and detect plant stress. The aim is to develop a prototype open-source system of radar-based target detection and feature extraction. Capable of varying radar horn polarizations and monostatic and bistatic horn separations. Experimental targets consisted of three examples of military ordnance. These represent real world examples, chosen due to differing composition of materials, structure and dimensions.

Methodology Pipeline

Data Collection → Image Formation → Feature Detection

Data Collection

Data is collected using Cranfield University's Ground-Based SAR Laboratory mini-GBSAR system, a highly adaptable experimental tool for radar data gathering. This tool enables sub-surface sensing by measuring the backscatter of electromagnetic waves in the microwave region. Key features of the mini-GBSAR includes:

- Adaptable to many sizes of radar horn
- Monostatic and Bistatic measurement
- Changeable horn polarization
- Dynamic scanning aperture
- 2D and 3D scan capable
- Deployable in the field

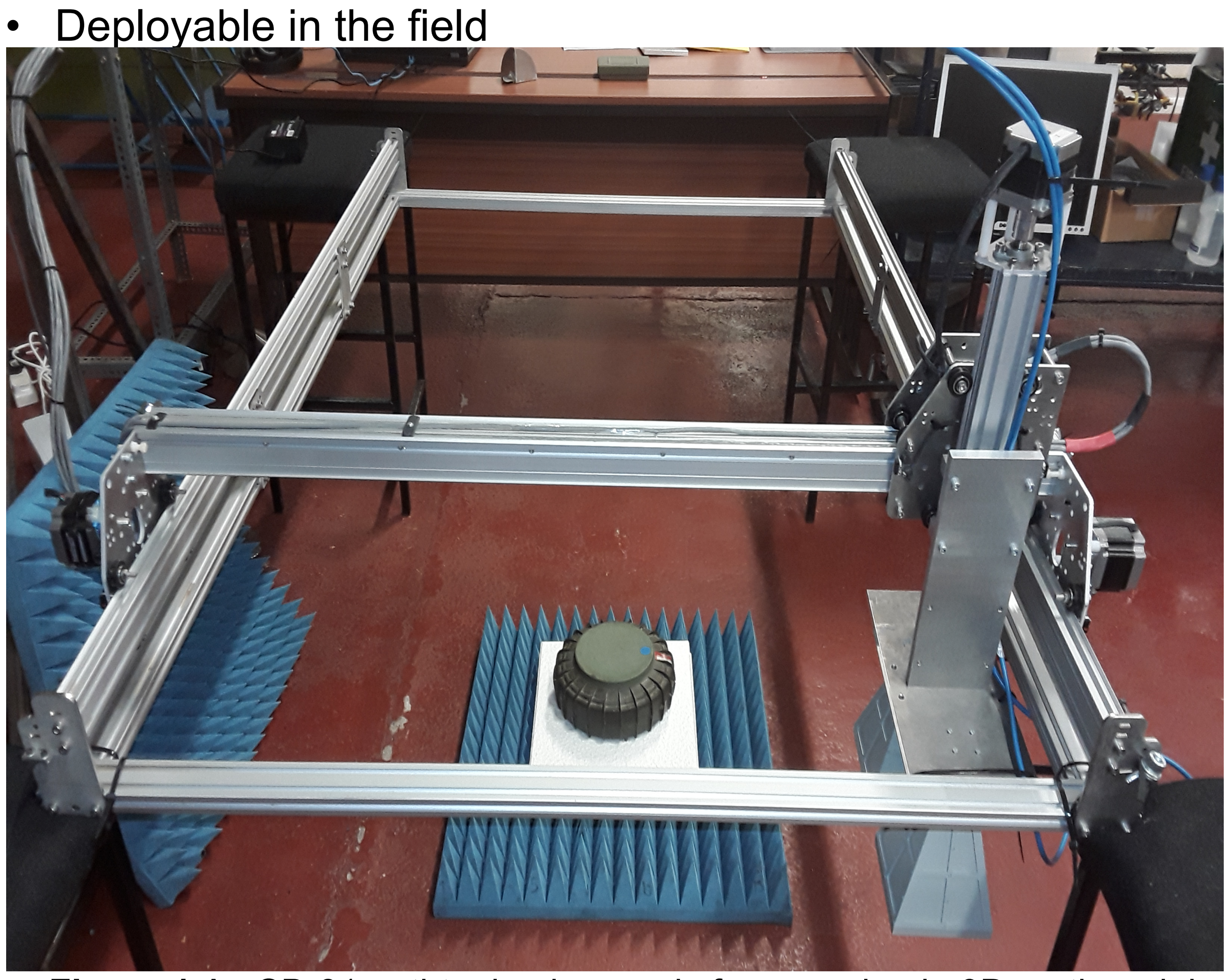


Figure 1 An SB-81 anti-tank mine ready for scanning in 3D on the mini-GBSAR system

Image Formation

Image formation of SAR data involves the processing of "*range-profiles*", ρ, the measured time domain data into a spatial image. Pre-processing begins with a two stage **FFT** (fast Fourier transform), which performs range compression in both the range and azimuth domains, a standard method of SAR image reconstruction. The resultant phase model is back projected onto the imaging grid one pulse at a time. Forming an intensity image dependant upon the spatial orientation, roughness , permittivity and conductivity (dielectric constant).

$$Im(x, y, z) = \sum_{n=1}^{N} \rho(r, n) e^{\frac{i4\pi F}{c}}$$

$$r = \sqrt{\sum_{m=1}^{3}} (X_m - A_m)^2$$

Figure 2 the back projection algorithm

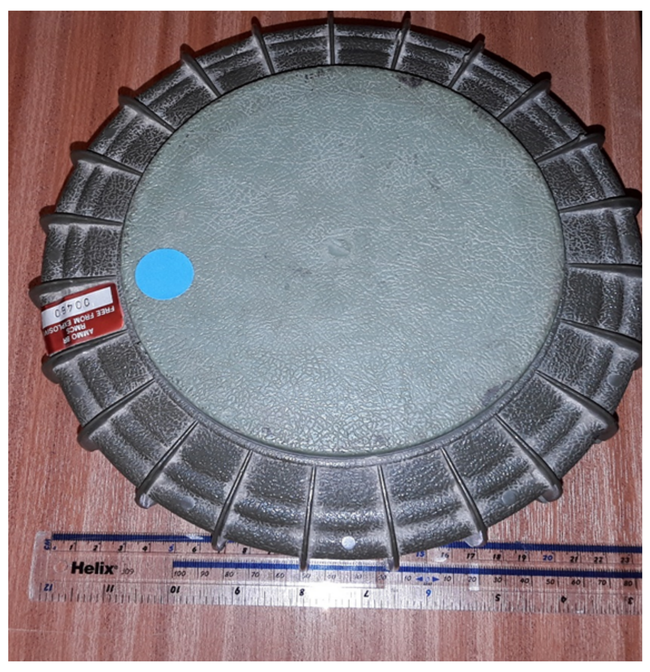


Figure 3 The SB-81 AT test mine

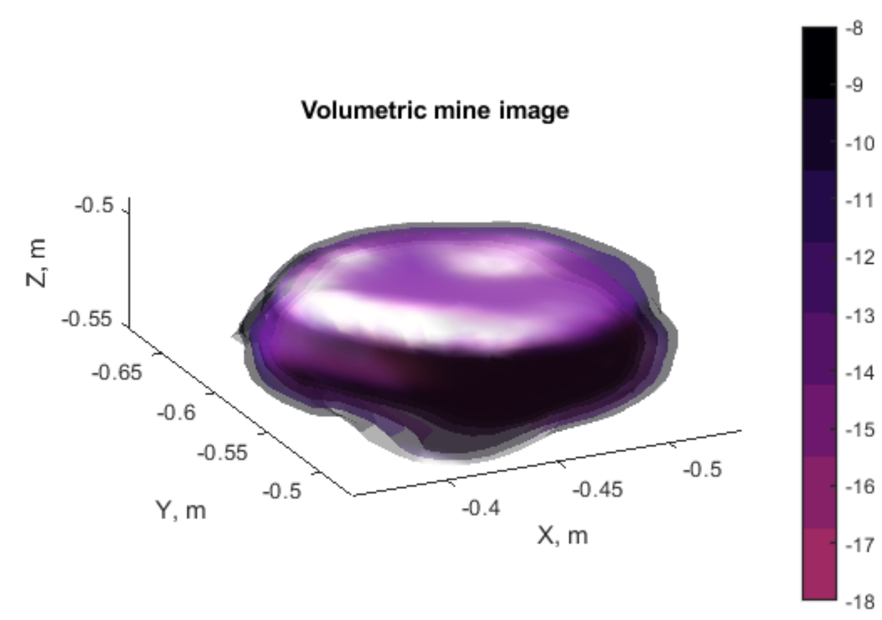
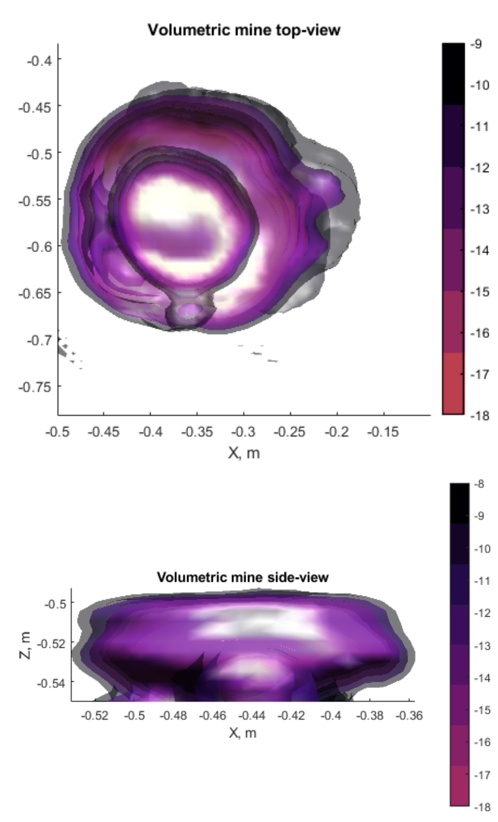


Figure 4 The radar image formed from the mine in **Figure 3**

Feature Detection



Various characteristics of the mine can be visually identified given prior knowledge of the objects structure.

- Pressure plate
- Circular body
- Different circumference between body and pressure plate
- Distance to the top of the pressure plate
- Approximate height and width of mine

Figure 5 a) Top down view with clutter visible b) side view

Conclusion

Key features for different mines are identifiable, the next stage involves detecting these features while the mines are occluded by sand or soil. With a future goal of automatic feature extraction.
Further development of the mini-GBSAR would allow for additional capability's to be refined and added. A further future goal requires the use of the mini-GBSAR to image both downwards and sideways.

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