Antipersonnel Landmines Detection by Holographic Radar Imaging: An Experimental Study of Soil Effects

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Abstract— Subsurface radar is a mature technology for use in dual-sensor (metal detector and radar) systems [1]. Such devices generally use ultrawideband impulse radar with a center frequency near 1 GHz in a bistatic array. The large bandwidth of these radars allows adequate penetration and depth resolution in some soils. However, the effects of soil properties on the radar response require investigation. The aim of this work is to study the effect of soil conditions on RASCAN type holographic radars. This unique type of subsurface radar produces grey scale images with plan view resolution of about $1/4\,\lambda$. This allows RASCAN to delineate the shape of buried objects at shallow depth ($< 2\lambda$) in low loss soils [2]. In order to investigate the radar's ability to detect dielectric targets with small dimensions ($\Phi = 7.5$ cm, $h = 1.9$ cm), a cylindrical plastic box filled with RTV epoxy was buried in a sand bed together with clutter objects. These targets were scanned with a RASCAN 4/4000 radar operating at five discrete frequencies close to 4 GHz, with two receiving antennae in parallel and cross polarizations relative to the transmitter. The radar head was in contact with the soil surface during scanning through a thin plastic mat. The images acquired in different soil conditions reveal some difficulty in the detection of such small dielectric targets in damp sand. With dry sand, the radar had no difficulties in delineating the shapes of all shallow objects. In another experiment, we compared the radar performance in sand versus a gravel test bed with metal and plastic targets at different depth and positions. In this case, we used RASCAN radars with discrete operating frequencies near 4 GHz and 2 GHz, with the latter providing increased penetration depth. Experiments with the same plastic mine simulants at different depths and orientations gave negative outcome due to a combination of unfortunate (but realistic) factors such as: high attenuation in damp sand, low dielectric contrast, target tilt, and irregularities in the dielectric properties of the gravel. The latter lead to false targets or noise which partially mask the target reflections. Finally, we evaluated RASCAN over uneven surfaces that more closely resemble an actual minefield. In these experiments, metal and plastic mine simulants were buried in sand and the surface was intentionally disturbed with ripples and deep footprints. The data acquired during this experiment reveal that an uneven surface and elevation of the radar head above the surface do not deteriorate the reflected signal significantly, and the buried targets were visible.

REFERENCES

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