Ground Penetrating Radar for close-in detection

Similarities and differences between C-IED and humanitarian demining

Ground Penetrating Radar

Introduction

• GPR array technology for close-in detection of buried explosive devices first appeared in the late 90’s
• This technology never found its practical way into the field of humanitarian demining but developed into products for C-IED route clearance
• Even though humanitarian demining and C-IED route clearance scenarios imply significant differences in the technical requirements for developing dedicated GPR sensors, several design principles can be adapted for humanitarian demining as well as for route clearance
• In particular, in the case of the shallower targets typical of a C-IED operation, the presented array-based GPR system’s design exploits and combines a high probability of detection and a very low false alarm rate

Comparison of system requirements

Humanitarian demining

• Wide variety of environments/soils, typically rural with overgrown vegetation
• Targets range from small shallow-buried AP mines to AT mines and deeply-buried large UXO (devices that sink deep with time in soft soils)
• In post-conflict scenarios, targets have been lying for years (well compacted surrounding soil reducing the electromagnetic anomaly)
• High probability of detection is required for a wide range of environments and target types

• Detection speed is not a primary concern (i.e. it can be slow) since it does not impact on the safety of operations. Cutting back vegetation (e.g. bushes, small trees) is often the main factor limiting the effective speed to well below 1 km/h
• False alarm rate can be comparatively high due to the low speed requirements
• Automatic target detection is desirable but not mandatory; an operator skilled in data analysis can be involved
• Automatic target recognition (ATR) is not essential

• Raised (air launched) antenna array is desirable since ground contact is problematic on rough soil
• The GPR array’s swath may be as small as a few tens of cm hence the sensor can be mounted on a small remotely controlled vehicle
• GPR data recording and GNSS registration is essential for quality assurance
• Electromagnetic interference in a civilian electromagnetic environment (e.g. TV and radio broadcasts, GSM) is normally not problematic for GPR

C-IED (route clearance)

• Environment is relatively less variable, typically limited to barren or low vegetation and typically on well drained rocky soils or macadam (vehicular routes)
• Relevant targets are very shallow and large in size (large charges for vehicles and pressure plates must have a reasonable extension to ensure activation)
• Targets are usually recently placed (soil tampering is often visible and in any case enhances the electromagnetic anomaly)
• High probability of detection is desirable but, depending on the nature of the operation (route clearance for military or civilian use), can be traded off with operational speed (i.e. checking all detected anomalies)

• High surveying speed is required, especially for the safety of operations in the presence of hostile forces, snipers etc.
• False alarm rate must be very low, as alarm checking is the main limit to the effective mission speed
• Real-time automatic target detection is a must to meet speed and overall mission duration requirements (continuous human analysis of data over several hours is impossible)
• Automatic target recognition (ATR) is highly desirable for fast assessment of the overall risk-benefit of stopping to check anomalies (e.g. possibility of ambushes)

• Antenna array needs to be raised (air launched) since mechanical movement is difficult on non-surfaced routes at high speed
• The GPR array’s swath (physical or mechanical) must exceed typical transversal dimensions of vehicles while still allowing maneuverability
• GPR data recording and GNSS registration is essential, especially for ATR database population and change detection techniques
• Resilience to electromagnetic interference from high power military telecommunications and jammers is an important requirement

Example test results with the LUCIFER array for Humanitarian Demining

This LUCIFER array is being developed within the European Community’s 7th Framework Programme Tiramisu project under grant agreement n° 284747

Introduction

• B-scan (i.e. depth-slice) of transversal 1/2” metal pipe and Ø 5 cm metal sphere in homogeneous sandy soil after pre-processing

Example test results with the LUCIFER array for Humanitarian Demining

Conclusions

LUCIFER’s purposely developed air-launched antennas are designed to be packed in a dense array and are also optimized for deep penetration. The results so far are pleasing with regard to the requirements for humanitarian demining.

For C-IED application, technological improvements are envisaged in the following areas:

• Increase frequency and bandwidth for higher resolution at a shallow depth
• Reduce the shape of the antenna beam in the scan-direction
• Acquisition speed, real-time data processing and ATD
• Automatic target recognition
• Resilience to electromagnetic interference (especially self-jamming)