Robot-mounted Ultra-light electromagnetic array for unmanned unexploded ordnance detection and Classification

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Currently, the unexploded ordnance (UXO) classification problem using digital geophysical data is divided into three sequential parts: 1) data collection and anomalies detection, 2) extracting targets’ intrinsic and extrinsic parameters, and 3) classification. The latter part essentially depends on the data quality and the data inversion; In the past two decades, there have been significant advances in data collection and target detection, thanks to the development of new electromagnetic induction sensors such as TEMTADS, Metal Mapper (MM), and Man-portable Vector (MPV) instruments. The sensors record target responses with unprecedented spatial resolution and a spectral range that allows a rather complete characterization of buried objects by utilizing a set of transmitter coils (circular or rectangular) and vector receiver coils. The transmitter coils produce a primary magnetic field, which extends into the soil, penetrates inside any metallic objects, and induces eddy currents in the conductor. This induced current produces a secondary magnetic field, which is detected by the receiver coils. Some of the biggest hinderances to the current UXO detection and classification system are the processing time, cost, and safety, particularly during active military operations.

This paper presents a robot-mounted ultra-light electromagnetic array (ULEMA-R). The ULEMA-R system consists of four rectangular transmitter coils. A simpler analytic solution for the primary magnetic field is developed for calculating both the primary and secondary magnetic fields, which in return allows inversion and classification in near real-time. The sensor is mounted to a robotic system for autonomous area interrogation. With a waypoint mission for the robot to follow, the sensor collects data over an area of interest. As the data are collected, they are inverted, and targets’ classification parameters are extracted. The inverted intrinsic and extrinsic parameters are analyzed and used for locating and classifying underground targets. The ULEMA-R system, along with data inversion and classification results are presented.