Background:
One of the greatest impediments to the efficient cleanup of unexploded ordnance (UXO) sites is the prohibitive cost of excavating all geophysical anomalies. Innovative discrimination techniques that can reliably distinguish between hazardous UXO and nonhazardous metallic clutter are required. A wide range of sensor technologies currently are being used or developed, including magnetometers (total field and gradiometers) and various types of time-domain (TEM) and frequency-domain (FEM) electromagnetic sensors. The advantages of dual sensor systems also are becoming increasingly apparent. From these data sets, UXO discrimination methods typically proceed by first recovering a set of parameters that specify a physics-based model of the object being interrogated. A subset of these parameters is used as feature vectors to guide either a statistical or analytical classifier. In all cases, the parameters that define the physics-based model are proxies for the fundamental parameterization of the object. The relationship between the derived parameters and the fundamental parameterization is neither obvious nor straightforward, such that one cannot unambiguously determine the object's size, shape and physical properties given the physics-based parameters recovered by inversion. It is the task of the classification algorithm to unravel this relationship. Ideally, fundamental parameterization of the object should guide discrimination.

Objective:
The overall objective of this project is to develop iMAS, a general inversion methodology based on the Method of Auxiliary Sources that can be used to invert any combination and configuration of magnetic, TEM and FEM induction data. Specific objectives include: (1) determine the feasibility of using the MAS forward model as the basis for the inversion of total-field magnetics, TEM and FEM induction data; (2) investigate the feasibility of using the MAS forward model as the basis for joint and/or cooperative inversion of any combination of magnetic, TEM and FEM induction data; and (3) determine the discrimination capability of the physical parameters recovered by the iMAS for different combinations and configurations of sensors.

Process/Technology Description:
MAS is a robust, easy to implement, and accurate method for studying a wide range of electromagnetic problems and has been used successfully for analysis of low-frequency electromagnetic induction scattering phenomena. Boundary value problems are solved numerically by representing the electromagnetic fields in each domain of the structure under investigation by a finite linear combination of analytical solutions of the relevant field equations, corresponding to sources situated at some distance away from the boundaries of each domain. The “auxiliary sources” producing these analytical solutions are chosen to be elementary currents/charges located on fictitious auxiliary surfaces, usually conforming to the actual surface of the structure. The method only requires points on the auxiliary and actual surfaces, without resorting to the detailed mesh structures as required by other methods (e.g., finite element).

Expected Benefits:
The MAS forward model represents an increased level of sophistication relative to the dipole models that are used in current inversion algorithms. The development of a general inversion formulation utilizing the MAS has the potential to provide improved discrimination ability when processing magnetic and electromagnetic data. These improvements in discrimination will lead to fewer excavations of non-UXO geophysical anomalies, thus reducing cleanup costs. (Anticipated SEED Project Completion - 2006)

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