INTRODUCTION

Until recently, detection algorithms could not reliably distinguish between buried UXO and clutter, leading to many false alarms. Over the last several years, geophysical techniques have been developed that merge more sophisticated sensors, underlying physical models, and statistical signal processing algorithms. These new approaches have dramatically reduced false alarms, although for the most part they have been applied to data collected at sites with relatively benign topologies. To address these problems, SERDP and ESTCP funded a research effort to develop new generation of UXO sensors that will produce data streams of multi-axis vector or gradiometric measurements. The focus of this research is to present here is on development of new physics-based signal processing algorithms applicable to the problem in high variance data available from such sensors.

Specifically, we will present modeling and processing results obtained using site of the art multi-axis sensors developed by LBL and USGS. Here, we demonstrate that estimation of the phenomenological model parameters of this new model for data inversion results in improved discrimination performance over inversion strategies that use simplified models. We also consider the impact of releasing the assumption of a symmetric object in the inversion process, and demonstrate improved classification results. We carefully consider options for the inversion process, and demonstrate that multi-axis data reduction can impact performance significantly. In addition, we show some success on new classifier work. Results are presented for two test stands from the ALLTEM system and Camp Sibert data for the BUD system.

3 MULTI-AXIS EMI SYSTEM MODELING

GENERALIZED TIME-DOMAIN MAGNETIZATION TENSOR MODEL

LRL BUD AEM Multi-Axis System

USGS ALLTEM Multi-Axis System

PHENOMENOLOGICALLY INSPIRED DECAYING EXPONENTIAL SIGNAL MODEL

Single Receiver Model for M Modes:

Multiple Receiver Model for R and M Receivers and M Modes:

LRL BUD AEM Multi-Axis System

Example Inversion for Test Stand Hom (9P inclination)

Example Inversion for Camp Sibert UXO Target SE2-48

4 FEATURE SELECTION SENSITIVITY

Feature Selection Using the Entire Data Set

Feature Selection Sensitivity to Changes in the Data Set

INTERVENTION: EXPERIMENTAL DATA

M(t) = [a(t) 0 0] [0 f(t) 0] [0 0 f(t)]

Example Inversion for Test Stand Hom (9P inclination)

Example Inversion for Camp Sibert UXO Target SE2-48

1 UXO: CHALLENGES

- Using current technologies, the cost of identifying and disposing of UXO is estimated to range up to $50 billion
- 1900 Formerly Used Defense Sites (FUDS) and 130 Base Realignment and Closure (BRAC) installations that need to be cleared
- False alarms. Over the last several years, modern geophysical techniques have been developed that merge more sophisticated sensors, underlying physical models, and statistical signal processing algorithms. These new approaches have dramatically reduced false alarms, although for the most part they have been applied to data collected at sites with relatively benign topologies.

2 APPROACH

- Utilize statistical approaches and theory of optimal experiments to design the best sensors and sensing modalities
- Use modern geophysical techniques that merge more sophisticated sensors, underlying physical models, and statistical signal processing algorithms to develop a new generation of UXO sensors that will produce data streams of multi-axis vector or gradiometric measurements. The focus of this research is to present here is on development of new physics-based signal processing algorithms applicable to the problem in high variance data available from such sensors.

Specifically, we will present modeling and processing results obtained using site of the art multi-axis sensors developed by LBL and USGS. Here, we demonstrate that estimation of the phenomenological model parameters of this new model for data inversion results in improved discrimination performance over inversion strategies that use simplified models. We also consider the impact of releasing the assumption of a symmetric object in the inversion process, and demonstrate improved classification results. We carefully consider options for the inversion process, and demonstrate that multi-axis data reduction can impact performance significantly. In addition, we show some success on new classifier work. Results are presented for two test stands from the ALLTEM system and Camp Sibert data for the BUD system.