KCP-613-5563
Distribution Category UC-706

Approved for public release; distribution is unlimited.

A VEHICLE MOUNTED MULTI-SENSOR ARRAY FOR WASTE SITE CHARACTERIZATION

Chris W. Baumgart
AlliedSignal Inc., Kansas City Division

Christopher A. Ciarcia and
Tom W. Tunnell
EG&G Energy Measurements, Inc.

Published February 1995

Paper submitted to Field Screening Methods for Hazardous Wastes and Toxic Chemicals
February 22-24, 1995
Las Vegas, Nevada

AlliedSignal
AEROSPACE

MASTER

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

A Vehicle Mounted Multi-Sensor Array For Waste Site Characterization

Chris W. Baumgart
AlliedSignal Inc., Kansas City Division, Kirtland Operations*
(Formerly with EG&G Energy Measurements, Inc.)
P.O. Box 4339, Station A
Albuquerque, New Mexico 87196

Christopher A. Ciarcia and Tom W. Tunnell
EG&G Energy Measurements, Inc.
P.O. Box 809
Los Alamos, New Mexico, 87544

ABSTRACT

Personnel at AlliedSignal Aerospace, Kirtland Operations (formerly EG&G Energy Measurements, Kirtland Operations) and EG&G Energy Measurements, Los Alamos Operations, have successfully developed and demonstrated a number of technologies which can be applied to the environmental remediation and waste management problem. These applications have included the development of self-contained and towed remote sensing platforms and advanced signal analysis techniques for the detection and characterization of subsurface features.

This presentation will provide a brief overview of applications that have been and are currently being fielded by both AlliedSignal and EG&G Energy Measurements personnel and will describe some of the ways that such technologies can and are being used for the detection and characterization of hazardous waste sites.

INTRODUCTION

In order to accurately characterize a known or potential waste site in an accurate and timely fashion, several capabilities are required. First, and most obviously, an appropriate array of sensors, along with a general purpose platform capable of supporting multiple sensors for in-situ acquisition and processing of data, is required. Such platforms either currently exist or are in the construction phase at the present time. Processors for data analysis can either be integrated directly onto the platform, or can be housed in a separate vehicle which is linked to the remote platform. Second, an ability to correlate many pieces of diverse data acquired with the sensor array must be provided. The process of correlating many pieces of information, often from multiple sensors, and providing a reduced set of data for interpretation is called data fusion. Finally, rapid assessment and interpretation of the acquired data is required for a most efficient survey. Therefore, near real-time processing of data would certainly be a goal of any site characterization philosophy.

In recent years, a number of technologies that can meet these requirements have been developed and demonstrated. These include feature extraction and pattern recognition algorithms for processing ground penetrating radar and metal detector data, data fusion, artificial intelligence, high speed data processing, and self-contained multi-sensor platforms. This paper will discuss some of these technologies and describe how they have been and are currently being used in waste site

*Operated for the United States Department of Energy under Contract No. DE-ACO4-76-DP00613.
©Copyright AlliedSignal Inc., 1995.

characterization applications.

DEMONSTRATED TECHNOLOGIES

The Minefield Reconnaissance and Detector Platform

The Minefield Reconnaissance and Detector Platform (MIRADOR)[1] was developed for the U.S. Army's Ft. Belvoir Countermine technology group. MIRADOR's original purpose was the detection of anti-tank land mines. However, it has also been used recently to characterize a toxic waste site at Los Alamos National Laboratory and to survey an unexploded ordnance site. Specifically, in June of 1990, the ground penetrating radar and metal detector sensors were used to detect a number of subsurface features at the TA-21 site at Los Alamos National Laboratory[2]. The TA-21 site has been used to contain various radioactive waste materials since its establishment in 1945 and has recently served as a test site to appraise and compare the effectiveness of various non-intrusive survey techniques. Central to the success of the MIRADOR platform is the data fusion algorithm used to correlate metal detector and radar data to detect and characterize subsurface objects.

Another application of the MIRADOR technology was performed in Summer of 1994. In this instance, the MIRADOR vehicle was used to survey a portion of the Jefferson Proving Ground (Madison, Indiana) and locate surface and buried unexploded ordnance[3]. Performance results of that deployment will be available in the near future.

Throughout the course of the development and use of the MIRADOR (and other related) technology, significant technology advancements in the areas of image processing and data fusion have been attained. These include:

- The development of image processing algorithms for image segmentation, feature extraction, and pattern recognition in the optical and dual infrared bands[4] (patent pending).
- The development of multi-band correlation algorithms for object recognition.
- The development of neural network algorithms to provide high accuracy cross track location of objects utilizing ground penetrating radar.
- The development of PC-based data correlation algorithms utilizing neural networks and fuzzy logic for the fusion and interpretation of multi-sensor data[5].

One patent on the MIRADOR technology has already been awarded. Another patent is pending based on image processing techniques developed in conjunction with the MIRADOR technology.

The Automated Subsurface Characterization System

The Automated Subsurface Characterization System (ASCS) is an internal R&D project started in 1994 under EG&G Energy Measurements with continuing development into 1995 provided by internal R&D funds from AlliedSignal. The ASCS combines two non-intrusive sensor technologies - electromagnetic/conductivity sensing (EM) and ground penetrating radar (GPR) - with an ultrasonic position tracking and logging system to demonstrate a cost effective, readily transportable system to perform non-intrusive characterization of sub-surface injected barriers[6]. Results of the surveys will consist of contour maps of the sites which identify the location (within +/- 6"), size, and general properties (depth, thickness, approximate size and orientation, distribution, and extent) of the injected grout barriers.

In 1994, a survey of the Sandia injection site was performed. The Sandia site contains several sub-surface injection experiments that were performed in July of 1994. Lessons learned on that effort lead to a number of equipment and data processing modifications. An additional survey of the Sandia site is to be performed in February, 1995. Yet an additional survey at Hanford will be performed this coming summer. This will allow us to compare sensor performance characteristics under two very different geologic conditions. The nature of the Hanford site is not yet known, although we anticipate that the experiment may involve the encasement of a grouping of buried objects (drums) utilizing the same sub-surface injection technology that was prototyped at the Sandia site.

Data from each of the sensors used will be registered using the USRADS® (CHEMRAD Tennessee Corporation) positioning system. Features in the sensor data outputs related to detected sub-surface objects will be extracted. The extracted features will then be "fused" to correlate detected features in one sensor with those features (if any) detected by the other sensors at that same location. This "data fusion" makes use of the outputs from the multiple sensors to form a consensus between the sensors and to confirm the detection or improve the confidence with which a detection is made. Contour maps for each sensor output as well as for fused feature sets, will be generated as the final output.

Remediation Efforts

Data fusion and artificial intelligence techniques will be used this coming year in two waste remediation efforts. The first is a cooperative research and development agreement with FemtoScan (Salt Lake City, UT) to develop algorithms for the analysis of gas chromatograph and mass spectrometry data collected with man-portable sensors developed by FemtoScan. The goal of this development will be to produce algorithms which can accept large quantities of the gas chromatograph and mass spectrometry data, correlate it two-dimensionally, and then provide the operator with a reduced set of information to aid in performing the site survey.

The second effort is being performed under the Department of Energy's Technology Assistance Program to develop signal analysis and mechanical gate control algorithms for a soil sorter currently under development. The soil sorter makes use of gamma detectors to monitor potentially contaminated soil as it is passed along a conveyor belt. When a contaminated portion of the soil is identified with the signal analysis algorithms, that portion is physically gated out of the soil stream. Uncontaminated soil is then returned to the site.

CONCLUSIONS

This paper has highlighted some of the technologies developed and currently being deployed by AlliedSignal and EG&G Energy Measurements. Special emphasis was placed on describing how such technologies could be of specific utility in a hazardous waste site characterization task. These technologies included:

- Multi-sensor integration and platform design
- Ground penetrating radar
- EM detection
- Image processing
- Data fusion and pattern recognition
- High speed data acquisition and analysis

These available technologies, and their application to the waste site characterization problem, provide us with the means for the detection and in-situ characterization of known and potential waste sites.

References

1. Baumgart, C.W., Cave, S., Ciarcia, C.A., Creager, J., and Hall, H.; *Minefield Reconnaissance and Detector (MIRADOR) Design Study, Final Report*, KO-064-90; EG&G Energy Measurements, Inc., 1990.

2. Cave, S.; *Los Alamos DOE Waste Site Survey*; EG&G Energy Measurements, Inc., 1990.

3. Johnson, M., Cave S., Creager, J., and Mathes, J., "UXO Detection at the Jefferson Proving Ground, Madison, Indiana", in *Proceedings of the Fourth International Symposium on Field Screening Methods for Hazardous Wastes and Toxic Chemicals*; Air and Waste Management Association: Las Vegas, 1995; poster presentation, Non-Invasive Technologies session.

4. Baumgart, C.W. and Ciarcia, C.A., "An Automated Target Recognition Technique For Image Segmentation and Scene Analysis", in *Proceedings of the SPIE - Applications of Artificial Neural Networks V* , Volume 2243; The International Society for Optical Engineering: Orlando, 1994; pp 194-199.

5. Menlove, H.O., Howell, J.A., Rodriguez, C.A., Eccleston, G.W., Beddingfield, D., Smith, J.E., and Baumgart, C.W., "Integration Of Video and Radiation Analysis Data", in *Proceedings of the 35th Annual Meeting of the Institute of Nuclear Materials Management*, Volume 23; The Institute Of Nuclear Materials Management: Naples, Florida, 1994; pp 834-841.

6. Baumgart, C.W., Cave S., and Creager, J., "Preliminary Results From a Field Survey Conducted With the Automated Subsurface Characterization System", in *Proceedings of the Fourth International Symposium on Field Screening Methods for Hazardous Wastes and Toxic Chemicals*; Air and Waste Management Association: Las Vegas, 1995; poster presentation, Non-Invasive Technologies session.