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FY05 LDRD Final Report
Sensor Fusion for Regional Monitoring of Nuclear Materials with Ubiquitous Detection

S. E. Labov, W. W. Craig

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Sensor Fusion for Regional Monitoring of Nuclear Materials with Ubiquitous Detection
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Simon Labov, Principal Investigator

Abstract

The detection of the unconventional delivery of a nuclear weapon or the illicit transport of fissile materials is one of the most crucial, and difficult, challenges facing us today in national security. A wide array of radiation detectors are now being deployed domestically and internationally to address this problem. This initial deployment will be followed by radiation detection systems, composed of intelligent, networked devices intended to supplement the choke-point perimeter systems with more comprehensive broad-area, or regional coverage. Cataloging and fusing the data from these new detection systems will clearly be one of the most significant challenges in radiation-based security systems. We present here our results from our first 6 months of effort on this project. We anticipate the work will continue as part of the Predictive Knowledge System Strategic Inititive.

Introduction/Background

It is widely believed that a network of sensors can be more effective than the individual nodes acting alone. This is neither a controversial nor a particularly surprising conclusion, however the effectiveness of an integrated system will, in the end, rely on critical capabilities that do not currently exist. These capabilities include:

I. Handling and real time analysis of the data flow from both an enormous number of disparate sensors as well as other non-radiation sensor based data and information.
II. Automated decision making through the application of the cognitive sciences.
III. Fusion of these sensor data to realize the true effectiveness of these systems.
IV. Accurate evaluation of the effectiveness of this detection infrastructure both in its current state, and with the addition of various new detection technology concepts proposed for development.

Development of some of these capabilities is in progress under ongoing Strategic Initiatives at LLNL. We are developing a new Strategic Initiative proposal to address sensor fusion for the radiation detection problem and the development of the modeling capability to accurately assess, *and guide*, technology developments at the system level. A key feature of this work will be the use of overhead imagery in combination with radiation measurements. In this Exploratory Research proposal we focused on one of the first key steps, combining data from distributed radiation sensors for enhanced sensitivity.

Using the current suite of unconnected individual sensor elements, security personnel are realizing that simply looking for anomalies in the data stream due to spikes in the measured count rate is ineffective due to the high incidence of false alarms arising from normal background variations. One proposed short-term solution is to follow up each of these false alarms with additional measurements. The cost and time associated with these follow-up measurements requires that the thresholds on the detectors be set quite high. By networking the detectors, we can automate the identification of the nuisance alarms thus allowing all the instruments to operate in more sensitive modes.

Research Activities

This work began as a mid-year FY05 effort to address some basic research questions on the detection of nuclear threats with networks of radiation detections. The primary deliverable for this effort is the establishment of a firm basis for both the efficacy and the scalability of a radiation detector network approach to the problem of detecting radioactive sources in a real-world environment. Using various types of sensors, as well as geographic data as represented by a Geographic Information System (GIS), we have initiated the development of a system that combines (fuses) various sensor data to dramatically increase the probability of source detection. In addition we are studying the scalability of such an approach to the scope of problems of national interest. The work encompasses infrastructure development (database, visualization tools), new methods (algorithms, schemas), simulations and a measurement program.

Results/Technical Outcome

- Existing database restructured to allow both the curation of radiation data and straightforward access to allow producing geo-spatial radiation maps. A spatially enabled PostgreSQL database and appropriate schemas were developed and prototyped.

- Use the database approach to setup a 3 km by 3 km testbed centered on the LLNL area. Initial mapping of the radiation field in LLNL environs in both time and space. (See map and overhead image below).

- Developed algorithms to represent radiation data in a GIS layer. Two techniques are under development. To visualize relatively small numbers of measurements, one assigns each measurement to a pixel on a map, and then calculates the average intensity for that pixel. The second method uses a least-squares approach to infer the radiation emitted from each location based on nearby measurements.

- Developed, in collaboration with industrial partner Berkeley Nucleonics, a radiation sensing and geolocation device and, using their employees, collected data mapping various geographic areas. This will allow the combination, or fusing of different types of radiation data within the testbed.

- Designed, in collaboration with industrial partner wOz, a small, low-power geo-location aware radiation sensor 'tag' device that will be used in both stationary and mobile modes to collect radiation data. This tag device, which is equipped with wireless network capability, can be used as a self-contained network to blanket a

particular geographic area in a 'swarm' architecture and provides an cost-effective method to populate the testbed database.

- Developed first-order visualization tools for the GIS layers in the database.

- Began work to demonstrate detection of sources from map data to allow initial quantification of detection limits.

- Began work to demonstrate increase in source detection efficiency, over conventional approaches, using previously mapped geographic area.

Exit Plan

This work is intended to lay the groundwork for a proposed Aurora Initiative on Predictive Knowledge Systems and an emerging programmatic direction of NNSA nonproliferation research (NA-22) and the Department of Homeland Security Domestic Nuclear Detection Office (DNDO). The work described here was provided crutial for the design of the in situ sensor component of the PKS LDRD-SI proposal. The database structure, data collected and analysis team will provide a jump start as this new project ramps up. We have also submitted proposals using sensor fusion to DNDO and NA-22.