Data fusion with distributed mobile detectors in a highly variable background

Simon Labov[1], Larry Hiller[1], Karl Nelson[1], Yiming Yao[1], K. Mani Chandy[2], Annie Liu[2], Matt Wu[2], Robert Sherbert[3]

[1]*Lawrence Livermore National Laboratory, Livermore, CA 94550 USA*
[2]*California Institute of Technology, Pasadena, CA 91125 USA*
[3]*Drexel University, Philadelphia, PA 19104 USA*

Abstract

We have developed a broad-area radiation detection system to evaluate data fusion algorithms for distributed radiation detectors. Our system is designed to work with a variety of network architectures, different distributed detector array configurations and a range of data fusion algorithms. Our measurements show many features that can have a large impact on distributed detector data fusion algorithms including non-statistical background variations and non-uniform detector coverage and motion. The spatial, spectral and temporal variations in the radiation measurements are extremely complex and strongly dependent on the type of region, detector deployment and operation. These are the characteristics that make radiation detection with high sensitivity so challenging, and any distributed radiation detector analysis system must be designed to take this into account. We have therefore developed a technique that can simulate any number of detectors operating under conditions that include the variations found in the real measurements. We present an overview of our system along with the algorithms we are developing and evaluating. Results include performance comparisons with and without data fusion for a network of detectors operating serendipitously in vehicles and carried by personnel who's primary duty brings them to areas of interest but who are mostly engaged in non-radiation related activities. We find that the performance of the data fusion algorithms changes dramatically as the realism of the simulation is increased. Analysis with coverage and background variations consistent with real measurements shows that prior measurement of the background can greatly improve performance

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Supporting Material

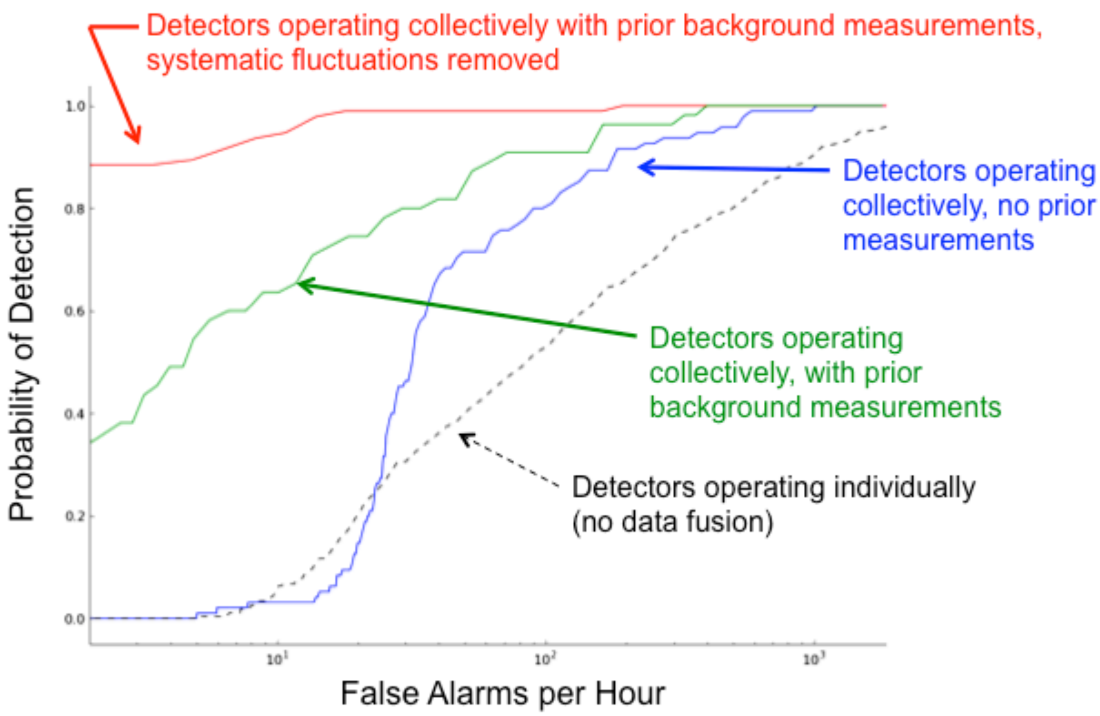
Radiation detection systems, including radiation portal monitors and nonintrusive inspection systems, are currently deployed at ports of entry (POE) to scan incoming vehicles and cargo for radiological or nuclear threats. These systems can be effective for traffic coming through the port, but a different architecture is required to protect against threats that do not pass through these ports, are missed by the port systems, or are created within the country.

We are developing a Distributed Nuclear Detection Array (DNDA), a broad-area radiation detection system designed to evaluate network architectures and data fusion algorithms for distributed radiation detectors. Our system is designed to work with a variety of network architectures, different distributed detector array configurations and a range of data fusion algorithms. We are developing a series of threat scenarios under which such a system would have to operate. For each scenario, we are defining specific detector array configurations and network architectures appropriate for the scenario. We are developing a series of data fusion algorithms that the system can use to collectively process the data. We are also using our system to evaluate the sensitivity and selectivity of the system for the detection, classification and tracking of radioactive sources.

Radiation measurements have many features that can have a large impact on distributed detector data fusion algorithms including non-statistical background variations and non-uniform detector coverage and motion. The spatial, spectral and temporal variations in the radiation measurements are extremely complex and strongly dependent on the type of region, detector deployment and operation. These are the characteristics that make radiation detection with high sensitivity so challenging, and any distributed radiation detector analysis system must be designed to take this into account. Purely synthetic simulations are therefore of limited use for developing and testing distributed detector algorithms such as those needed for our DNDA.

To address this problem we have developed a technique we call “measurement-based simulations.” We have developed tools to create measurement-based simulations that can simulate measurements with any number of detectors that include the variations found in the real measurements. We can also produce many realizations of the measurement-based simulations with similar deployment and operating parameters. This allows us to run statistical evaluations of our algorithms. We have also developed a radiation sensor network system and have accumulated data covering a variety of different radiation environments including urban, commercial, residential and industrial regions. This data set includes continual spectroscopic measurements throughout each region with repeated measurements over the same locations. Our data archives include some measurements of sources, both standard test sources and nuisance sources that were encountered during the measurements. While these sources can provide some benchmarks, we require a more thorough evaluation of source sensitivity and selectivity. We have therefore developed a source injection tool that can modify real measurements directly to include the effect a source would have had on the data. For this injection, we have modeled sources ranging from radiological dispersal devices and improvised nuclear devices that a terrorist may build to the sophisticated nuclear weapons in the U.S. and foreign stockpiles. We inject these sources into our measurement-based simulations allowing us to create receiver operation characteristic (ROC) curves.

We report here on the development and testing of fusion algorithms that enhance the performance of networks of detectors operating collectively. Detecting, locating and identifying threat sources in an environment of highly variable background and nuisance sources is a challenging mission. To be effective, the system must be able to discriminate threats with high sensitivity and low false alarm rates. We show here that this sensitivity can be greatly enhanced using data fusion algorithms that analyze the data collectively. Results include performance comparisons with and without data fusion for a network of detectors operating serendipitously in vehicles and carried by personnel who's primary duty brings them to areas of interest but who are mostly engaged in non-radiation related activities. We find that the performance of the data fusion algorithms changes dramatically as the realism of the simulation is increased. Analysis with coverage and background variations consistent with real measurements shows that prior measurement of the background can greatly improve performance



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