Radiological Search – A Long-standing Streaming Application

Brian Quiter, Lawrence Berkeley National Laboratory

Radiological search has been an activity performed within the DOE complex for at least 40 years. Ambient gamma-rays and/or neutrons are measured continuously and represent the background through which radioactive signatures from real radiological threats are to be identified. The radiation detectors deployed in these missions produce streaming data types that pre-date many digital methods. As such, human analyses have historically driven the decision making that can result in various interventions. With advances in computational power, radiological search missions have implemented real-time analysis software that helps steer searches and responses, although humans remain in the loop primarily to militate against false alarms, which can be numerous when the algorithms are deployed in their most sensitive configurations. False alarms are often due to real changes in the radiological environment, possibly coupled to statistical anomalies. Better understanding of the local environment enables software to achieve dramatically improved performance, possibly improving upon human-based steering. Such claims are untested and unproven due to the fact that the diverse nature of streaming data that could be leveraged to provide context do not fit neatly within the algorithms and models that have been developed for radiological search missions. In fact, real-time analyses of the streaming data produced by many relevant 'contextual sensors' (for example high-definition video, Lidar, hyperspectral imagery, etc.) is the subject of open research in computer science and robotics. Without expecting to solve the streaming and steering challenges associated with fusing these disparate data types in real-time, research efforts have begun to at least investigate in post-processing whether algorithms that leverage these data streams can be put to use to improve the overall likelihood that radiological threats can be identified and the efficiency with which threats can be localized. In the following, two such projects are highlighted.

The Airborne Radiological Enhanced-sensor System (ARES) is a Department of Homeland Security Advanced Technology Demonstration aimed at improving the performance of radiation detector systems fielded on aircraft. The radiation detection system comprises 92 synchronized detector crystals, each with two readouts. The crystals are arranged in a manner that promotes non-uniform angular sensitivities for each individual crystal such that algorithms can probabilistically attribute each detected photon to a portion of the field of view. High definition video is also recorded, with the intention to use computer vision software to identify tracking targets such as moving vehicles that can be used to perform hypothesis tests concerning whether the measured radiological signal would be consistent with a threat moving within each tracked object. A weather sensing system is also included in the ARES sensor package to help identify weather changes that may be associated with ambient radiological shifts. Lastly, Radar and a GPS/IMU system help inform algorithms of the position of the sensor system with respect to the terrain, as proximity to objects is a primary driver of observed radiological signatures. The position and orientation information is fed to algorithms which are also provided with a 3D terrain model to further provide the understanding of the surrounding environment. The impact and potential that these data streams have with respect to improving threat detection and localization is the subject of the ongoing ARES system characterization effort.

The Radiological Mobile Analysis Platform (RadMAP) project has similar goals of identifying and highlighting the value of various streaming data sources for ground-based measurements. The RadMAP system is truck-based and contains 100 medium-resolution and 14 high-resolution gamma-ray detectors in addition to 16 neutron detectors. These detector systems all continuously and stochastically produce radiation signal data that are fed to online and offline analysis software. In addition to the radiation sensors, there are two 3π Ladybug HD video systems, a side-looking CCD video camera, two 32-beam rotating Lidar systems, two hyperspectral cameras comprising 385 spectral channels across 400-1700 nm wavelengths, a weather system, a GPS/IMU, and a vehicle speed sensor. While collecting data, the system streams the gamma-ray detector data and the CCD camera data to a user interface that operates alarming and localization algorithms in real-time. Those data products along with all other data streams are also saved to disk for further offline analyses.

The management of the data produced by RadMAP and ARES motivated the development of a fairly intensive software suite, called BDC, that comprises a web-based front-end that communicates to a backend database management system that retrieves and serves data via download or to connected software through an API. The front end provides blogging-based communication tools to facilitate descriptions of data and analyses, data visualization tools, tools to generate database queries, data filtering tools, and capabilities to manage process definitions. The API enables connection such that a user may retrieve data and potentially publish analysis results through execution of a pre-defined process. As such, the BDC system enables a growing community of research to test hypotheses and publish results pertaining to the demonstrating and improving the value of various data streams to radiological search problems and several related fields.

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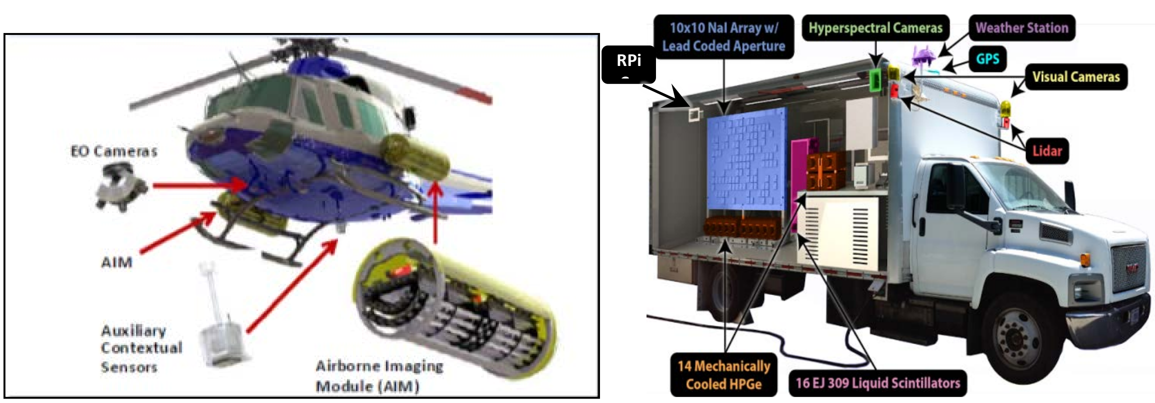

Schematics of the ARES (left) and RadMAP (right) radiological and contextual streaming sensor systems.