Spatial-Information Approach for Analyzing and Planning Distributed Nuclear Material Detection Systems

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Abstract

The existing domestic nuclear material detection system in the United States often experiences high false alarm rates, which contribute to increased time and effort costs. Using a multi-layered or distributed security system may offer improvements by combining information from multiple sensors or detection systems to increase the available information about transported materials, thus helping to make better-informed interdiction decisions. Implementing such a system would require a strong platform for sensor network analysis and design to provide a system-wide perspective on performance, operations, and management. Our work aims to serve this role by developing methods for sensor network design, management, and analysis in distributed detection environments.

Our information-theoretic framework focuses primarily on sensor network design and sensor location optimization and management, relying on the value of information quantified by Kalman Filtering to develop these network analysis tools. Applied at a software level, the user could simulate sensor network operation conditions, and algorithms attempt to maximize information gain from the sensors’ locations (subject to budget and error rate constraints) while attempting to find a detection system design with adequate information gain to reduce existing uncertainty. Similarly, minor changes to an existing system could be analyzed by limiting sensor network modification in the simulation, allowing users to perform cost-benefit analyses to evaluate sensor networks upgrades and examine mobile sensor location management. Currently in the research phase, detection network uncertainty propagation may potentially offer useful performance metrics related to false alarm and miss rates, further adding to the decision maker’s understanding of the overall system operation and performance.
Bio

Dr. Xuesong Zhou is currently Assistant Professor in the Department of Civil and Environmental Engineering at the University of Utah. Prior to joining the University of Utah, he served as a Traffic Data Architect and Senior Software Engineer at Dash Navigation, Inc, designing and developing the first commercialized internet-connected GPS navigation system in the U.S. He is also the co-inventor of Key2SafeDriving technologies, which has been reported by more than 300 media outlets including New York Times, Wall Street Journal and National Public Radio. Dr. Zhou’s research interests include dynamic traffic assignment, traffic estimation and prediction, large-scale routing and rail scheduling. He has been assisting the Federal Highway Administration (FHWA) to develop and provide technical support for large-scale simulation-based dynamic traffic assignment systems, for the past 10 years. Dr. Zhou’s research work has been published in highly cited scholarly journals such as Transportation Research Part B, Transportation Science, IEEE Transactions in Intelligent Transportation Systems. He is the Co-Chair of the IEEE ITS Society Technical Committee on Traffic and Travel Management and serves as a Committee Member for TRB Committee on Transportation Network Modeling (ADB30).