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Overview

A member of the Department of Homeland Security, Science and Technology Directorate (DHS S&T) requested information regarding modeling and simulation (M&S) capabilities or efforts used to assess the efficacy of passive acoustic sensors in tunnel detection.

Findings

HDIAC identified several technologies and methodologies utilizing M&S capabilities for the assessment of tunnel detection sensors, discussed below.

MITRE Corporation

Researchers at MITRE (in an effort funded by DHS S&T) developed the Geophysical and Operational System Performance Tool (GOSPT), which enables assessment of technologies, mission planning, and sensor performance pertaining to clandestine tunnel detection [1]. GOSPT uses a combination of subsurface geoenvironmental data from the U.S. southern border, state-of-the-art geophysical models, and sensor physics to conduct analysis of tunnel detection equipment [1].

GOSPT's capabilities allow for 1D, 2D, and 3D high-fidelity numerical modeling and simulation of various sensor configurations in a variety of operational environments [1]. GOSPT also uses advanced spatial and temporal processing techniques and geo-statistical modeling tools to improve detector performance characterization [1]. Additionally, GOSPT incorporates a fully integrated end-to-end sensor simulation environment that enables interactive performance prediction, sensor system integration, hardware and software advancement, and further data technology development [1].

Although DHS S&T is not currently using this technology system [2], U.S. Customs and Border Protection (CBP) implements GOSPT as part of its tunnel Analysis of Alternatives (AoA) [2]. According to researchers connected with this effort, MITRE maintains interest in providing support for and further development of this program for use by the homeland security community at large [2].

Sandia National Laboratories

Sandia National Laboratories developed a sensor integration study for shallow tunnel detection technologies. This study used a systems engineering approach built on a Taguchi design of experiments to determine the efficacy of sensors used to detect a tunnel [3].

This approach used quick-paced algorithms combined with a model that simulated how various sensor platforms would respond to different environments [3]. Although this particular study only addressed four types of sensing modalities (active seismic, gravity, passive seismic, and passive electromagnetic sensors), adapting Sandia's approach for passive acoustic sensors is feasible [3]. According to Sandia researchers, the study produced a "powerful tool based on Taguchi analysis that can be used to evaluate the performance of different sensor suites for a range of scenarios of varying factors that affect detection performance [3]."

University of California (UC), Berkeley

Researchers at UC Berkeley conducted a numerical study of surface-wave-based tunnel detection at the Black Diamond Mines Regional Preserve in California. This approach used void detection analysis using surface-wave backscattering to determine the efficacy of the detection methodology before field tests [4]. The numerical simulations used the 3D elastodynamic finite-difference code (E3D) to study wave propagation through soil [4]. Lawrence Livermore National Laboratory developed E3D by using a staggered grid formulation that is fourth-order accurate in space and second-order accurate in time [4]. This particular method has been useful in studying problems ranging from earthquake simulations to seismic surveys, as well as modeling heterogeneous materials [4]. Modifications to this model to incorporate different types of sensor arrays (e.g., acoustic) are feasible.

Conclusion

HDIAC identified several systems and methods for modeling tunnel detection sensors from government and academic researchers. The systems produced by MITRE Corporation, Sandia National Laboratories, and UC Berkeley facilitate testing for different sensing modalities (seismic, gravity, acoustic, etc.) across a diverse array of environments. A comprehensive analysis of M&S for passive acoustic sensors used in tunnel detection is available through an HDIAC Core Analysis Task. Such a task could assess the state of the art in M&S across academia, industry, and government research entities.

We request your feedback on this Inquiry: https://www.hdiac.org/new-inquiry-assessment-form/

References

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