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Optimal Imaging for Treaty Verification

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Abstract

This report provides a short overview of the DNN R&D funded project SL12-OptImg-PD2Nc, Optimal Imaging for Treaty Verification. The project began in FY12 and in FY15 is merging with a PNNL project to form the PL14-V-InfoBarrierimg-PD2Nc venture. The Project Description below provides the overall motivation and objectives for the project as well as a summary of programmatic direction. The most recent comprehensive technical report is referenced.

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INTRODUCTION

This report provides a brief overview of the DNN R&D funded project SL12-OptImg-PD2Nc, Optimal Imaging for Treaty Verification. The project began in FY12 and in FY15 is merging with a PNNL project to form the PL14-V-InfoBarrierimg-PD2Nc venture. The Project Description below provides the overall motivation and objectives for the project as well as a summary of programmatic direction. The most recent comprehensive technical report is referenced.

PROJECT DESCRIPTION

This project leveraged advanced inference methods developed for medical and adaptive imaging to address arms-control applications. We investigated methods to acquire and analyze imaging data of declared treaty-accountable items (TAI) without creating an image of those objects or otherwise storing or revealing any classified information. Such a method would avoid the use of classified-information barriers (IB).

In a typical model of future arms-control monitoring regimes, one or more TAIs are presented for inspection using an agreed-on system of inspection tools. At a minimum, the inspection system must measure and report whether the inspected object is a TAI as declared. This system must be insensitive to any normal variability in the measurement configuration or environment, including background radiation.

Based on our experience with related radiation imaging systems for medical applications, we expect to achieve superior performance and avoid classified-information barriers by use of raw image data instead of reconstructed images. The medical tasks of detecting, locating, and classifying the radiation signatures from a medical patient as indicators of either threatening or benign conditions are adaptable to similar treaty-verification tasks. Aspects of task-based methods in nuclear medicine that are key to achieving our arms-control research objectives are: (1) data from individual radiation-detection events can be processed as they are measured, which removes the need to store those data for future analysis, (2) the resultant processed information cannot be analyzed to recreate those original event data, and (3) the resultant processed information cannot be analyzed to extract classified spectroscopic or geometric information about the object being measured. In a treaty scenario, the combination of these properties would enable the use of spectroscopic imaging hardware without an information barrier to prevent the collection or disclosure of classified information.

Additionally, the reconstruction and analysis of images is not optimal for the task of detecting, locating, and classifying sources of radiation present in a cluttered background-radiation environment. Techniques based on image reconstruction are suboptimal primarily because they do not fully utilize the statistical information available in the raw detection data. Further, in most cases a human is used to analyze the images produced, which is costly and inefficient. Even in those cases where automated algorithms are employed, their performance is inherently hindered both by the information lost and ignored during image reconstruction and by the artifacts present when complex scenes are reconstructed from sparse data. Thus, even automated image-processing methods have limited ability to detect, locate, and classify weak radiation sources and yield high false-positive detection rates. Most importantly, in arms control, no images of the object can be generated for an automated analysis without the use of an IB, which is not a desired solution.

Our task-based imaging methods are intended to enable and enhance automated collection and analysis of raw detection data in a manner that avoids the need for a classified-information barrier. These methods are automated, simple to calibrate and use, and known to optimally utilize collected radiation-detection data (i.e., the raw data) to yield the best-available source detection, localization, and classification performance.

TECHNICAL PROGRESS TO DATE

The technical progress to date has been recently described in the "Optimal Imaging for Treaty Verification FY2014 Technical Report", SAND2014-18497 (October 2014).

FUTURE WORK

Although this document serves as a final report for the SL12-OptImg-PD2Nc project, the goals and tasks of this effort will be pursued by the SNL team as one component of the PL14-V-InfoBarrierimg-PD2Nc venture project. Results of ongoing and future work will be documented under that venture.

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