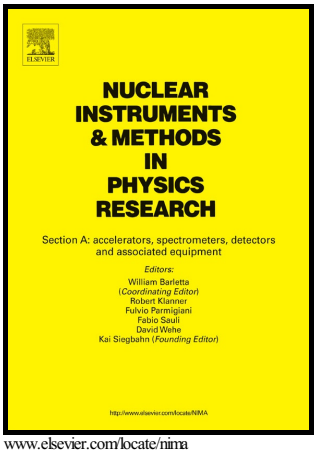
Linear Models to Perform Treaty Verification Tasks for Enhanced Information Security

Christopher J. MacGahan, Matthew A. Kupinski, Erik M. Brubaker, Nathan R. Hilton, Peter A. Marleau



www.elsevier.com/locate/nima

PII: S0168-9002(16)31136-6
DOI: http://dx.doi.org/10.1016/j.nima.2016.11.010
Reference: NIMA59429

To appear in: *Nuclear Inst. and Methods in Physics Research, A*

Received date: 6 July 2016
Revised date: 31 October 2016
Accepted date: 7 November 2016

Cite this article as: Christopher J. MacGahan, Matthew A. Kupinski, Erik M Brubaker, Nathan R. Hilton and Peter A. Marleau, Linear Models to Perforn Treaty Verification Tasks for Enhanced Information Security, *Nuclear Inst. an Methods in Physics Research, A,* http://dx.doi.org/10.1016/j.nima.2016.11.010

Linear Models to Perform Treaty Verification Tasks for Enhanced Information Security

Christopher J. MacGahan[a,b,*], Matthew A. Kupinski[a], Erik M. Brubaker[b], Nathan R. Hilton[b], Peter A. Marleau[b]

[a] *College of Optical Sciences, The University of Arizona, 1630 E. University Blvd, Tucson, AZ, 85721, USA*
[b] *Sandia National Laboratories, Livermore, CA 94551*

Abstract

Linear mathematical models were applied to binary-discrimination tasks relevant to arms control verification measurements in which a host party wishes to convince a monitoring party that an item is or is not treaty accountable. These models process data in list-mode format and can compensate for the presence of variability in the source, such as uncertain object orientation and location. The Hotelling observer applies an optimal set of weights to binned detector data, yielding a test statistic that is thresholded to make a decision. The channelized Hotelling observer applies a channelizing matrix to the vectorized data, resulting in a lower dimensional vector available to the monitor to make decisions. We demonstrate how incorporating additional terms in this channelizing-matrix optimization offers benefits for treaty verification. We present two methods to increase shared information and trust between the host and monitor. The first method penalizes individual channel performance in order to maximize the information available to the monitor while maintaining optimal performance. Second, we present a method that penalizes predefined sensitive information while maintaining the capability to discriminate between binary choices. Data used in this study was generated using Monte Carlo simulations for fission neutrons, accomplished with the GEANT4 toolkit. Custom models for plutonium inspection objects were measured in simulation by a radiation imaging system. Model performance was evaluated and presented using the area under the receiver operating characteristic curve.

Preprint submitted to Nuclear Instrumentation and Methods A *November 10, 2016*

**Corresponding author*
Email address: cmacgahan@optic.arizona.edu (Christopher J. MacGahan)