Office of Defense Nuclear Nonproliferation Research and Development

CVT – Consortium for Verification Technology

Thrust II: Fundamental physical data acquisition and analysis

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CVT Thrust II Goals

- **Goal 1: Diversion detection and localization**
  - **Objective:** To develop sensitive statistically based methods for most quickly detecting material diversions from nuclear fuel cycles
  - **Methods:** active sensing, sparse learning, anomaly detection, information fusion, nuclear fuel cycle simulation

### Table 1. Sample shipments of 1 ton with duration and average power consumption observations.

<table>
<thead>
<tr>
<th>Shipment no.</th>
<th>Duration (days)</th>
<th>Average Power Consumption (MTCWU/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17.11</td>
<td>0.2015</td>
</tr>
<tr>
<td>2</td>
<td>43.33</td>
<td>0.1018</td>
</tr>
</tbody>
</table>

Deep learning (Carin, ORNL)

Aerosol sensing (Hero, Fisher, LANL)

Sensor planning (Fisher, ONR)

Link analysis (Hero, LANL)

\[
y_t = h(x_t) + \epsilon_t, \quad x_t = f(x_{t-1}) + \omega_t
\]
CVT Thrust II Goals

- **Goal 2: Fundamental physics modeling of radiation detectors**
  - **Objective:** To simulate and experimentally validate new models for gamma and neutron detection for SNM
  - **Methods:** source/detector interaction physics, neutron correlation, nuclear unfolding, pulse discrimination

Pulse discrimination (Pozzi, LANL)

Bayesian unfolding (Pozzi, Hero)

Liquid organic and NaI(Tl) scintillator array

SNM source position

Neutron-neutron coincidence (Pozzi)
CVT Thrust II Goals

- **Goal 3: Signal and image processing for radiation detection**
  - Objective: to develop signal processing algorithms for emerging radiation detection technologies
  - Methods: Bayesian methods, frequency domain multiplexing, neutron track reconstruction, fission image reconstruction

Neutron coded aperture imager (NCAI) (Matteson – ORNL)

Single volume scatter camera using pillars of plastic scintillator (Matteson – SNL)

Bayesian unmixing of radiation portal monitor spectra (Pozzi, Hero)
Thrust II oral presentations

1. Ms. Elizabeth Hou: Sequential Detection of Unusual Documents (UM)
2. Mr. Matthew Marcath: Measured and simulated Cf-252 spontaneous fission prompt neutron-photon competition (UM)
3. Mr. Christopher Dean: An Efficient Nonlinear Dispersion Model Using Continuous-Piecewise-Affine-based Transformations (MIT)
4. Prof. Larry Carin: Deep Generative Models for Anomaly Detection (Duke)
5. Ms Sue Zheng: Robust Monte Carlo Methods for Sequential Planning and Decision Making (MIT)
Thrust II poster presentations

1. Mr. Haonan Zhu: Comparison of unfolding algorithms for monenergetic and continuous fast-neutron energy spectra methods (UM)
2. Ms Patricia Schuster: Measurements of prompt fission neutron correlations in Cf252 (UM)
3. Charles Sosa: Improvements in Energy Resolution using Conical Stilbene (UM)
4. Mr. Christopher Dean: Multimodal Multiscale Data Fusion in Spatial Processes Using the Hierarchical Beta Model (MIT)
5. Mr. Mudit Mishra: Frequency domain multiplexing of multiple organic scintillator detectors (NCSU)
6. Dr. Jonathan Mueller: Using Time-Correlated Neutron and Gamma-Ray Measurements to Distinguish Point-like Sources From Spatially Distributed Sources Without Imaging (NCSU)
7. Mr. Kyle Weinfurther: Model-based Design Evaluation of a Compact, High-Efficiency Neutron Scatter Camera (NCSU)
8. Mr. Robert Weldon: Characterization of the Anisotropic Scintillation Response of Stilbene to Neutrons (NCSU)