CNEC | Consortium for Nonproliferation Enabling Capabilities

Dr. Yousry Azmy, Director, Interim Lead PI
Dr. John Mattingly, Technical Director
Stefani Buster, J.D., Assistant Director

CNEC Newsletter

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Our Vision

Create a preeminent research and education hub dedicated to the development of enabling technologies and technical talent for meeting the present and future grand challenges of nuclear nonproliferation.

Our Mission

Through an intimate mix of innovative research and development (R&D) and education activities, CNEC will enhance national capabilities in the detection and characterization of special nuclear material (SNM) and facilities processing SNM to enable the U.S. to meet its international nonproliferation goals, as well as to investigate the replacement of radiological sources so that they could not be misappropriated and used in dirty bombs or other deleterious uses.

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University Program Review (UPR) 2017

Stefani Buster, J.D.

Each year CNEC researchers, students and fellows participate in the US Department of Energy's (DOE) annual review meeting recently renamed University Program Review (UPR). CNEC participants join with researchers from the two other DOE National Nuclear Security Administration (NNSA) sponsored consortia for a review of our work over the past year. This year, more than 50 CNEC members attended UPR, 16 of whom made oral presentations and 25 gave poster presentations. These presentations were meant to provide an overview of CNEC's research activities and highlight the direction and progress of selected projects. CNEC's UPR 2017 presentations ranged in topic from Bayesian and Optimization Methods for Urban Radiation Source Detection Networks to Detecting Fraudulent Patterns in Digital Currency Networks.

During this event, CNEC affiliates engaged with a variety of nuclear nonproliferation specialists from sponsor representatives to fellow students thus expanding their horizon and networking with current and future experts in the field. UPR gives CNEC an opportunity to share its work, get valuable feedback from national laboratory professionals and the sponsor, observe and benefit from the work conducted by the other consortia, and develop potential future collaborations.

At this year's UPR, three CNEC Fellows won awards. Joel Kulesza, CNEC Fellow, University of Michigan, was recognized for his oral presentation, *Optimizing Monte Carlo for Computational Cost*; Joseph Cope, CNEC Fellow, NC State University, was recognized for his poster presentation, *A Rapid, Conservative Transuranic Activity Estimator for Air Filters*; and Nick Meyer, CNEC Fellow, NC State University, was recognized for his national lab project, *Cooperative Search Strategies for Pursuing Adversarial Evaders*.

Joseph Cope (left) and Dylan Hoagland (right)

Alex Clark, Jared Cook, Eva Brayfindley, and Dr. Robert Brigantic (left to right)

Jake Inman (left) and Aaron Hellinger (right)

Challenges of CNEC Thrust Areas

Dr. John Mattingly

Simulation, Analysis and Modeling (SAM)

The Simulation, Analysis, and Modeling (SAM) team's challenge problem is to develop methods that will enable the rapid localization of a radiation source in a cluttered, noisy urban environment. "Clutter" describes the heterogeneous nature of the environment: buildings attenuate radiation rapidly, while radiation tends to stream down streets with few interactions. "Noisy" describes the location- and time-dependent variations in the radiation background that results from variations in building materials and atmospheric conditions. The SAM team is developing deterministic (e.g., regression) and stochastic (e.g., Bayesian) methods to estimate the location and activity of a radiation source using a network of detectors deployed across an urban environment. They have developed a Bayesian Metropolis framework for estimating the distribution of probable source locations from the detector network, methods for propagating uncertainties in building composition and density onto the uncertainty in source location, and techniques for optimizing the configuration of the detector network. They have also developed deterministic radiation transport methods that use unstructured, tetrahedral spatial meshes and Monte Carlo radiation transport methods for estimating the sensitivity of responses to variations in the transport medium geometry. Furthermore, they are currently coupling deterministic transport calculations to Monte Carlo calculations to optimize their computational efficiency. These developments will enable efficient, high-fidelity simulations of urban source search scenarios, which will be used to develop and evaluate source localization algorithms.

Dr. Alyson Wilson

Data Fusion and Analytic Techniques (DFAT)

The challenge problem for the Data Fusion and Analytic Techniques (DFAT) thrust area is to detect and characterize proliferation events and proliferation enterprise networks. DFAT focuses on the application of data science to nonproliferation problems. As examples of work on the challenge problem, consider these three projects. The first is a case study focused on the development of a principled information and sensor fusion framework using data from 2013 flooding in Boulder, CO. The multi-modal data include Landsat-8 satellite imagery, geo-tagged Twitter data, and detailed ground truth from the city. The goal is to fuse data from these initially incompatible sources. The second project, developed with LANL, focuses on event enrichment, or finding additional relevant information from social media. The first research developed a hybrid method for imputing geotags with quantified uncertainty; the extension is considering dynamic generalized linear model variable selection where features are selected from social media data with imputed geotags. The third project, developed with PNNL, is focused on new-age proliferation finance. With the advent of, and subsequent growth of, cryptocurrencies such as Bitcoin, a vast array of new money laundering and transfer avenues are available for proliferators. The project has developed a formal mathematical model for these networks and has focused on the characterization and classification of exchanges (the entrance and exit from the Bitcoin world), and attempting to identify potential laundering patterns.

Challenges of CNEC Thrust Areas

Replacement of Dangerous Radiological Sources (RDRS)

Dr. Bill Dunn

RDRS addresses the problem of replacement of dangerous radiological sources. Early in the project, we identified the first challenge problem as follows. Oil well logging tools are used around the world and, typically, contain curie-level Am-Be and Cs-137 sources. Our challenge problem is to find a suitable replacement for these radioisotope sources. The replacement of currently used radioisotope sources in oil well logging tools was chosen as a first objective because the sources are fairly long-lived, exist in thousands of tools used around the world with minimal security, and typically have multi-curie activities. These sources were identified by a National Academy of Sciences report as being "Category 1" dangerous radiological sources. Our approach has been to develop a version of the Monte Carlo Library Least Squares (MCLLS) method that can be used to invert the data from multiple neutron and photon detectors due to a single machine source of neutrons. We chose a D-T generator as the neutron source because its neutrons have high energy and can thus generate high-energy inelastic scatter gamma rays from a number of elements, providing useful information on soil composition. In order to validate the MCLLS model, it was deemed necessary to design and construct a benchmark tool and a test facility. The benchmark tool should be similar to well logging tool designs but as simple as possible, for easy simulation modeling. The test facility is a large enclosure through which an 8-in. pipe is inserted, which acts as a bore-hole. We have completed the design and construction of both the benchmarking tool and the test facility and are beginning the collection of data. As a separate source replacement task, we have identified replacing the hundreds to thousands of curies of Co-60 and Cs-137 radioisotope sources in transportable blood irradiation units with machine sources. Large X-ray tubes and LIINAC-driven sources are possible replacements.

Signatures and Observables (S&O)

Dr. Clair Sullivan

S&O addresses the location of a point source of radiation in an urban environment containing fluctuating background and nuisance sources. S&O is concerned with improving existing and future detector systems by conducting multi-disciplinary research in uncertainty quantification and by analyzing individual sensor systems. In the context of this grand challenge, a signal is defined to be data obtained from a single sensor. Traditionally, a "sensor" in nuclear nonproliferation measures an emission from a material or facility, e.g., ionizing radiation, effluent, or radio frequency. However, we are treating signals in a broader context, to not only include the aforementioned traditional sensors, but also to include data streams such as open-source big data. CNEC faculty, students, and other researchers are working to identify relevant signatures and observables and conduct basic research on quantifying signal and noise. Since the signal to noise ratio of nuclear proliferation signatures is expected to be small, it is important that clear understandings of signals, noise, and background be developed to address the challenge problem. *Continued on page 14.*

Young Investigators' Summer Program (YISP)

Lisa Marshall

Each summer NC State's Nuclear Engineering department hosts high school rising junior and senior students for a three-week residential program. This year 20 students from North Carolina, Illinois, Minnesota, New York, Virginia and Washington took part in lectures, labs, group projects and industrial field trips. It was an opportunity for high school rising junior and senior students to explore university life as well as material on nuclear science and technology. This program provides students with a multifaceted examination of what nuclear science and technology has to offer and a student pipeline into engineering education especially nuclear.

Young Investigators at NCSU

Group projects included work in the area of light sensitive monitors for the PULSTAR research reactor, nuclear materials and air quality control. Lectures were given by faculty, professional staff and post-doctoral students on such topics as fission power systems, computational fluid dynamics,

Students at the PULSTAR research reactor

environmental assessment and applications in nuclear medicine, to name a few.

In addition to a lecture on the Waste Isolation Pilot Project (WIPP), students were able to work with Dr. Robert Hayes, Associate Professor of Nuclear Engineering on a project entitled "Exploring Principles of Air Monitoring". Hayes is a member of the Consortium on Nonproliferation Enabling Capabilities (CNEC) and holds a joint appointment with Oak Ridge National Laboratory.

Dr. Hayes giving the WIPP lecture

Ms. Lisa Marshall, Educational Director for CNEC (and the program director for the Young Investigators' Summer Program) also lectured on the US energy plan, nonproliferation initiatives and nuclear engineering education. Students were also able to attend the Health Physics Society 62nd Annual Meeting, held at the Raleigh Convention Center. The plenaries covered such topics as "Life after Linear Non-Threshold", "Adventures and Milestones in Personal Monitoring" and "Radon - Past and Now".

The Young Investigators' Summer Program (YISP) thanks faculty, staff, university students and corporate contributors (e.g. Duke Energy, AREVA, and PetNet Solutions) for their time and effort.

The closing ceremony was held on Friday, July 27 in McKimmon Center. Students presented their projects to project mentors, parents and family friends. Dr. Bourham, Alumni Distinguished Graduate Professor of Nuclear Engineering, Director of College of Engineering Master of Engineering Program & Adjunct Professor of Biomedical Engineering, served as the guest speaker.

National Lab News

Consortium for Nonproliferation Enabling Capabilities (CNEC) Validation of "Loose Rad/Nuc Source" Localization Methodology in Urban Environments

Dr. Dave Williams, ORNL

On May 8-9, 2017, ORNL hosted a team from NC State University to perform a data collection for part of the DOE-NA221 Consortium for Nonproliferation Enabling Capabilities (CNEC). Radiation measurements were performed around the 7600 complex at ORNL aimed at validating modeling performed by Jason Hite, a M.S. student at NC State. The modeling framework uses Markov Chain Monte Carlo parameter estimation applied to radiation sensor networks to locate radiation sources in urban environments. ORNL provided the radiation detection system network that enabled the team to perform many measurements over a large area of both background and a large 137Cs source. Jason's work is aimed at enabling emergency responders to design the optimal deployment of radiation sensors to locate a 'loose source' in cluttered urban environments.

ORNL participants included Dan Archer, Michael Willis, Andrew Rowe, Kayleigh Bray, Jake Carter, and James Ghawaly.

ORNL Measurement team around the measurement tent

CNEC NC State student Jason Hite with ORNL measurement systems

CNEC Fellow Nicholas Meyer Presents a Lecture

Dr. Bobbie-Jo Webb-Robertson, PNNL

On August 11, PNNL hosted CNEC fellow Nick Meyer, Ph.D. student in the statistics department at North Carolina State University, who presented a talk related to his graduate studies titled Cooperative Search Strategies for Pursuing Adversarial Evaders. Nick's research is focused on developing estimators of optimal control strategies in large-scale spatio-temporal decision problems. This presentation is the culmination of work and collaboration between Nick and scientists at PNNL which began in the summer 2015. Nick also answered questions related to the CNEC program and his plan post-graduation. A copy of the flyer that announced Nick's presentation to PNNL staff is also attached.

Summer 2017 Interns at LLNL

Dr. Stephan Friedrich

Eric Davis (center) and his LLNL collaborators with networked cell phones.

Six CNEC students are currently working as summer interns at Lawrence Livermore National Lab. Eric Davis and Simone Santos (both NCAT) are working with Dr. Simon Labov on different aspects to develop arrays of networked detectors. They characterized the response and gamma spectra of CsI detectors and improved algorithms for radionuclide identification to reduce the false alarm rate in these detectors.

Jacob Inman (GA Tech) is working with Dr. Natalia Zaitseva on developing plastic scintillators with efficient pulse shape discrimination (PSD) to distinguish gamma and neutron signals. The goal is to produce plastic scintillators with PSD efficiency and light output similar to that of commercial (and toxic) liquid scintillators. As part of this project, Jacob has characterized signal shapes and intrinsic neutron detection efficiencies of several plastic and liquid scintillators. He also improved simulations (using Geant4), analysis methods (using ROOT) and automation techniques (in C++ and Python).

Aaron Hellinger (KSU) is trying to determine the unknown (n,2n) cross section in Pu-241 in Dr. Jason Burke's group using the surrogate technique. Since Pu-241 targets are difficult to manufacture, they studied the (α,α'2n) reaction in a surrogate Pu-242 target whose compound nucleus is similar. Aaron worked on the analysis of data taken at the Texas A&M cyclotron.

In computer vision, Ken Tran (NCSU) is working with Dr. Wesam Sakla to improve object detection in satellite imagery, for example to detect nuclear activities. He is adapting convolutional neutral nets (CNNs) to fit satellite data, using images from U.S. regions as training sets.

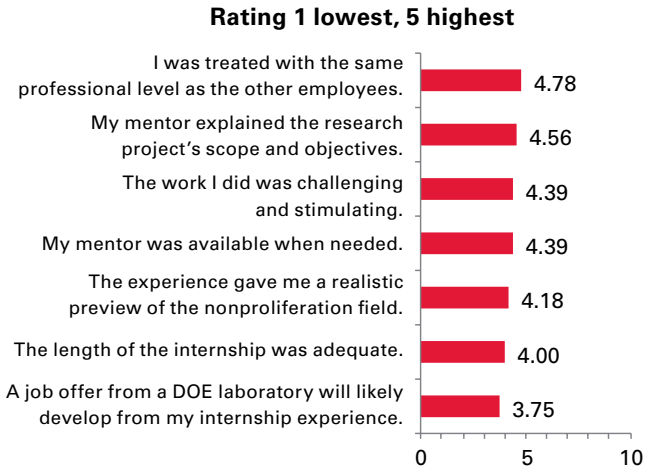
On the policy side, Julie Beeston is examining Chinese nuclear strategy with Dr. Wes Spain and Prof. Michael Nacht (UCB). The goal is to develop a comprehensive strategy for U.S. policy in the context of Chinese military modernization and an expansionist foreign policy. Julie's familiarity with Chinese policy and language allows her to work with original Chinese sources on military strategy and state policies, and her research will be included in a report by the LLNL Center for Global Security Research (CGSR)

CNEC Summer 2017 Interns

Bernie Kirk, CNEC Consultant

Twenty seven of the 90 educational participants in CNEC spent their summer performing research in nuclear non proliferation areas at the national laboratories.

National Laboratory		Number of Interns
Argonne National Laboratory	ANL	1
Idaho National Laboratory	INL	1
Naval Nuclear Laboratory	NNL	1
Lawrence Berkeley National Laboratory	LBNL	1
Lawrence Livermore National Laboratory	LLNL	6
Los Alamos National Laboratory	LANL	11
Oak Ridge National Laboratory	ORNL	4
Pacific Northwest National Laboratory	PNNL	2



Towards the end of the internship, the participants were asked to evaluate their experiences. The ratings below indicate the response, with 1 being least favorable or relevant and 5 being most favorable or relevant. The response is based on 18 individuals out of a total of 27 interns. Of the 18 respondents, 15 were graduate students and 3 were undergraduate students.

ANS Annual Meeting 2017 Panel

"Establishing and Advancing Nonproliferation and Nuclear Policy Education at US Nuclear Science and Engineering Programs"

Stefani Buster, J.D.

In an effort to showcase education in nuclear nonproliferation science, the American Nuclear Society (ANS) 2017 Annual Meeting included a panel on nuclear science and engineering programs in the US that include nonproliferation in their curriculum. The Establishing and Advancing Nonproliferation and Nuclear Policy Education at US Nuclear Science and Engineering Programs panel session was sponsored by the Nuclear Nonproliferation Policy Division and co-sponsored by the Young Members Group and the Education Training Workforce Development Division. Session Organizer, Dr. Charles D. Ferguson, President, Federation of American Scientists, and Chair Dr. Gilbert J. Brown, Emeritus Professor, UMass, Lowell, brought together professionals who are engaged in various aspects of nuclear nonproliferation science education. The panel included Dr. John Mattingly from CNEC/NC State University; Dr. Rian Bahran from Los Alamos National Laboratory; Dr. Charles Ferguson; Dr. Bethany Goldblum from the Nuclear Science and Security Consortium NSSC/University of California, Berkeley; Dr. Sunil Chiriyath from the Nuclear Security Science and Policy Institute at Texas A&M University; and Dr. Sara Pozzi from the Consortium for Verification Technologies CVT/University of Michigan.

Continued on page 10.

Left to Right: Drs. John Mattingly, Charles Ferguson, Gilbert Brown, Sara Pozzi, Rian Bahran, Bethany Goldblum, Sunil Chirayath

ANS Annual Meeting 2017 Panel *Continued from page 9.*

With a focus on training the next generation of nuclear nonproliferation specialists, the discussion examined existing opportunities for undergraduate and graduate students to learn about the science of nuclear nonproliferation. The panelists also addressed the need and possibilities for advancing nuclear policy within science and engineering programs in the US especially as it pertains to nuclear nonproliferation. CNEC's work,which includes science as well as policy education in nonproliferation was highlighted by Dr. John Mattingly's overview presentation.

Dr. John Mattingly presented for CNEC

IRRMA X

Stefani Buster, J.D.

From July 9th to 13th, over 100 specialists in the field of radiation and radioisotope measurement technologies traveled to Chicago, Illinois to attend the tenth triennial International Topical Meeting on Industrial Radiation and Radioisotope Measurement Applications (IRRMA X). The event was organized by Professor Clair Sullivan of the Department of Nuclear, Plasma, and Radiological Engineering and her team from the University of Illinois at Urbana-Champaign (UIUC).

IRRMA, which was founded by Professor Robin Gardner of NC State University, is dedicated to exploring trends and advancements in radiation and radioisotope research and providing a forum for scientists from across the globe to exchange relevant ideas. This year's conference solicited presentations in research areas ranging from radiation data science and analytics to applications for radiation in environmental sciences. Along with 100+ abstracts and registrations from five continents, the conference included several sponsors and exhibitors.

Upon participant request, research submissions were eligible for peer-reviewed publication in a special issue of the journal Radiation Physics and Chemistry.

This year, IRRMA X's organizers engaged a committee of senior researchers to identify the best student oral and poster presentations. During the conference banquet, which was held at Chicago's Museum of Science and Industry, the awards were presented to two CNEC students, both of whom hail from NC State University's Department of Nuclear Engineering. Jason Hite won best oral presentation, Bayesian Metropolis Methods for Source Localization in an Urban Environment Characterization of the Anisotropic Scintillation Response of Stilbene Using Monoenergetic Neutron and Aaron Feinberg won best poster, Detector Resolution Effects on Spectral Uncertainty in Gamma-Ray Elemental Analysis.

Dr. Clair Sullivan presents at IRRMA X

IRRMA X also offered participants the opportunity to tour UIUC's research facilities, campus, and its environs. Rivaling past conference venues such as the Czech Republic and Italy, Chicago, IL offered an interesting backdrop for the event.

Guests at the IRRMA X reception

Featured Research

Modeling intelligent but imperfect adversaries with application to pursuit evasion problems in non-proliferation

Nicholas Meyer, CNEC Fellow, North Carolina State University

Nicholas Meyer

Pursuit-evasion is a multi-agent sequential decision problem wherein a group of coordinating agents, called the pursuers, seeks to locate an intelligent adversary, called the evader, as efficiently as possible. The pursuers are allowed to adapt their search behavior in real-time using accruing information which may come from mobile sensors, informants, or projections based on models of adversary behavior. Similarly, the evader can adapt their behavior in real-time to information they receive. Pursuit-evasion problems arise in a wide range of contexts including artificial intelligence, wildlife management, border security, law enforcement, and defense. In the context of non-proliferation, a primary application is the rapid location of nuclear material.

The pursuit-evasion problem is naturally formulated in the language of game theory. Thus, one dominant approach to estimating an optimal strategy for the pursuers is to postulate a mathematical model for the system dynamics and subsequently solve for an equilibrium. However, for this approach to be analytically tractable, one may be forced to impose gross simplifications in terms of system dynamics or require the evader to be perfectly rational, calculated, and stationary. My work in this space has focused on relaxing these assumptions to develop optimal search strategies for the pursuers when:

(i) the system dynamics are unknown;

(ii) pursuers and evaders observe asymmetric, noisy, incomplete, and possibly corrupted information;

(iii) the evader is imperfect in that they might not calculate infinitely far into the future, make incorrect assumptions about the pursuer behavior, or change strategies over time.

My vision is to develop efficient algorithms for optimal real-time decision making in complex adversarial environments that faithfully reflect the salient features of pursuit-evasion in application.

As part of my CNEC Fellowship, I developed a novel variant of a reinforcement learning algorithm known as Thompson sampling that can be applied to general multi-agent adversarial decision problems including pursuit-evasion. The basic idea of Thompson

sampling is to maintain a (possibly infinite dimensional) Bayesian model that specifies a probability distribution for the system dynamics given the observed data. At each time point draw a random model from this distribution and optimize agent behavior assuming the drawn model is correct. This approach balances selecting decisions that provide improvements in estimated model dynamics and those that are close to optimal under current estimated model dynamics. The tension between decisions that provide information to improve a model and those that are optimal under the current estimated model is known as the exploration-exploitation trade-off. To apply Thompson sampling in the pursuit evasion problem requires specification of an initial distribution over evader behavior. Specifying a distribution that captures a wide range of plausible behaviors and yet is computationally tractable for complex environments is an open problem. Our approach uses an infinite dimensional distribution that includes a range of potential behaviors ranging from a random walk to a Nash equilibrium; consequently, we termed this process a *Nash process prior*. The distribution is constructed (conceptually) through a potentially uncountable infinite sequence of optimizations alternating between improving pursuer and evader behaviors.

We have tested our methodology on a series of examples including pursuit-evasion on a network and a special variant of the video game Pacman wherein the pursuers are ghosts with a very limited range of vision.

Radiation Sensor Network within a Virtual Environment

Christian Zircher, University of Illinois at Urbana Champaign

Christian Zircher

Radiation sensor networks consist of a number of radiation detectors that collect and report radiation data. The two main uses for radiation sensor networks are detecting nuclear threats (i.e. dirty bomb), and studying background radiation levels along with their fluctuations. For radiation sensor networks large enough, they can create such enormous amounts of data that processing, analyzing, and understanding the information can be quite difficult. These networks can be classified as Big Data systems. There are many studies on how to collect and analyze the data from Big Data systems such as this, but the importance of presenting and visualizing the analyzed results is often overlooked. Solely looking at the analyzed results can be of little use for those whom are not experts in the field. The Radiation Sensor Network within a Virtual Environment's (RaiSoN VEnom) goal is to visualize the data collected from a radiation sensor network in real-time and in such a way that experts as well as non-experts can fully utilize the information.

The Virtual Environment

The 3D environments are created with various software programs such as Unity 3D, Google Earth, and SketchUp. The virtual environment within Unity can be seen

Fig. 1. Virtual Environment within Unity 3D

Fig. 2. Designated Area to be Modeled

in Figure 1. The area of interest that is modeled for this project is comprised of the Bardeen Quad at the University of Illinois at Urbana–Champaign along with a few surrounding blocks. This can be seen in Figure 2.

Radiation Sensor Network

The detectors used for the radiation sensor network are D3S detectors. These mobile detectors collect radiation data utilizing a 2x1x½ in CsI(Tl) Crystal for gamma detection and a Helium 3 Gas detector for neutron detection. These detectors are paired to Samsung Galaxy S6 phones via Bluetooth. The network is comprised of 18 of these detectors, each assigned to a volunteer. The data collected includes gross counts per second (gamma and neutron), latitude and longitude coordinates, detector name, time, and spectral information.

Data Streaming

Every second, each phone uploads its measurements to an AWS S3 bucket where it is stored indefinitely. Next, a script consolidates all of the data into Redshift (a SQL based data warehouse). Redshift allows for easier data cleaning, additional analytics, and centralization of as well as ease of access to all of the data collected. After storage, a python script formats and saves the data as a csv file to the host computer where the virtual environment is located. At this point a C# script reads in the csv file using a special class called WWW, which is designed for streaming information into Unity.

The data warehouse specifically used for this project imports data from the S3 buckets every five minutes, meaning that there is a minimum of a five-minute lag between the detectors and virtual environment. In order to have a stable and continuous stream into the virtual environment, an artificial lag is induced. This artificial lag is designed so that every five minutes a python script queries the data warehouse for the previous ten minutes of data. Then every second, the data from the current time minus ten minutes is formatted and saved as a csv file. This effectively creates a ten-minute lag that allows for a continuous data stream. Different settings for redshift can be explored along with potentially other data warehouses entirely for the purpose of reducing this lag down to the scale of seconds.

Data VISUALIZATION

Once the data is read into the virtual environment, it can be visualized using various techniques. Each detector is represented by a 3D character which continuously runs towards a waypoint that represents the real-world location of the detector-phone pair. This effectively acts as interpolation for the data which allows for a smoother and more fluid visualization of the detector's location.

The radiation data is visualized primarily in the form of various radiation heat maps. Heat maps are an intuitive way to visualize the import information from the collected data. One can quickly and easily determine if the radiation levels present are above average and require further investigation. A 2D heat map is located at the base of each character as seen in Figure 3. Additionally, the radiation can be visualized by spawning a 3D object with a particular color and height for each measurement (as seen in Figure 4). Similar to the color, the height of the object also correlates with the gamma count rate. This additional feature not only assisted with the understanding of the radiological data, but also increased visibility of high count rates that may indicate a source.

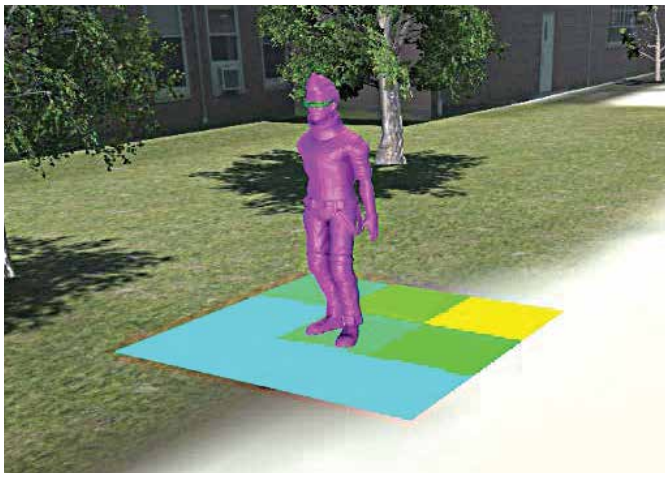


Fig. 3. Radiation Heat Map

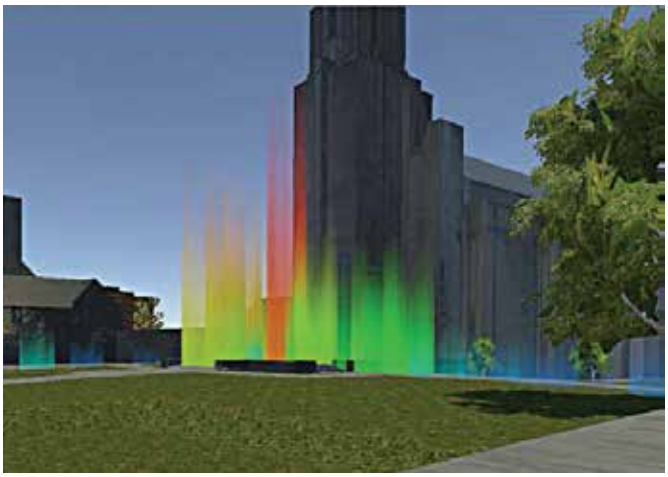


Fig. 4. 3D Data Visualization

Challenges of CNEC Thrust Areas

Signatures and Observables (S&O)

Continued from page 5.

Paramount to the solution of any type of signal-to-noise ratio (SNR) problem is developing an accurate estimation of the background. CNEC is working on two major components of feature extraction to address this: 1) nonlinear, feature-based anomaly detection; and 2) knowledge-based background estimation. With these approaches, research focused on developing a sound theoretical framework for S&O emphasizing machine learning approaches is being conducted, including, but not limited to, anomaly detection and its application to high-fidelity feature recovery.

Announcements and Special Recognition

CNEC proudly hosted it's inaugural Distinguished Technical Lecture Series with Dr. Avneet Sood of Los Alamos National Laboratory where he gave his presentation titled "Nuclear Safeguards, Monte Carlo Method, and MCNP - A Review of Our 70 Year History".

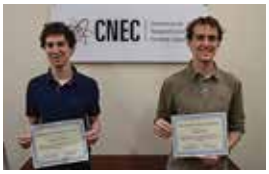
Dr. Rizwan Uddin has been named Department Head of Nuclear, Plasma, and Radiological Engineering at the University of Illinois Urbana-Champaign.

Through the efforts of Dr. Yousry Azmy and Dr. Rob Hayes, CNEC s now formally an affiliate member of the European Safeguards Research and Development Association. A seat at the table during discussions on research recommendations, policy, or protocols within ESARDA will allow CNEC to leverage U.S. research in E.U. efforts to optimize collective designs and capabilities in nonproliferation work.

Dr. Nolan Hertel of Georgia Tech started his year as President Elect of the Health Physics Society (HPS). The picture shows the ceremonial "Passing of the Astro-Chicken", a tradition that the HPS has held over the years.

Dr. Rob Hayes has been invited as a keynote speaker at the 2nd International Conference on Nuclear Chemistry in Las Vegas, NV to give his presentation "Nuclear Cameras, Isotopic Identifiers and Retrospective Thermometers Currently in Your Bathroom, Kitchen, and Office".

Dr. Miltos Alamaniotis was the recipient of the Purdue University BRAVO Award during Spring 2017. The BRAVO Award serves to recognize the excellence that exists among Purdue University employees and is intended to recognize faculty and staff who work in the College of Engineering and have made significant contributions in one or more of these four areas: moving the University forward, operational excellence, innovation and creativity, and fiscal stewardship.



Congratulations to Aaron Feinberg (left) and Jason Hite (right) for winning awards at IRRMA X in Chicago, IL. Aaron won the award for the best Poster Paper Presentation and Jason Hite won the award for best Oral Presentation.

Lisa Marshall of NCSU and Educational Director for CNEC was one of five new at-large ANS Board members elected from a pool of ten candidates.

The American Nuclear Society (ANS) student membership elected Kathryn A.Mummah, a CNEC student who graduated this spring from the University of Illinois at Urbana-Champaign, to a two-year term as the Board's student director. Katie is a first year graduate student in nuclear engineering at the University of Wisconsin-Madison. Her research interests include the nuclear fuel cycle, nonproliferation, and computational science and engineering.

Tim Burke, CNEC post-doctoral fellow at the University of Michigan, won the ANS Mathematics and Computation Division's "Best Summary and Presentation Award" for his summary, "Monte Carlo Estimates of Eigenvalue Sensitivity to System Dimensions using Kernel Density Estimators", presented at the 2017 ANS Annual Meeting.

Eva Brayfindley participated in the Nuclear Engineering Student Delegation this summer in Washington, D.C. The NESD is a chance for students in nuclear and related fields to bring issues seen as highly important in the field to the forefront of policy, with members of Congress in attendance.

Congratulations to Joel Kulesza (left), Joseph Cope (center), and Nicholas Meyer (right) for winning awards at the 2017 UPR in Walnut Creek, CA. Joel won the award for Best Oral Presentation, Joseph won the award for Best Poster, and Nicholas won the award for Best National Laboratory Project.

Upcoming Events

Event	Date	Location
ANS Winter Meeting and Nuclear Technology Expo	October 29 - November 2, 2017	Washington, D.C.
NNSA Sponsor Visit	November 2 - 3, 2017	Raleigh, North Carolina
CNEC Annual Workshop and Advisory Board Meeting	February 8 - 9, 2018	Raleigh, North Carolina
Distinguished Lecture Series Dr. Manoj Prasad	March 22, 2018	Raleigh, North Carolina

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