Erik M. Ferragut

Principal Data Scientist
Optum (UnitedHealth Group)
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Research Interests

My research focus is in the development and application of anomaly detection to various domains, including detection of fraud, waste, and abuse in health care, de'tection of attacks in cyber security, and detection of attacks and operating failures within cyber-physical systems. I am also interested in research in quantum computation and educational methods.

Publications

Refereed Journal Papers

[1] Ryan S Bennink, **Ferragut, Erik M**, Travis S Humble, Jason A Laska, James J Nutaro, Mark G Pleszkoch, and Raphael C Pooser. Unbiased simulation of near-clifford quantum circuits. *Physical Review A*, 95(6):062337, 2017.

[2] Robert A Bridges, John Collins, **Ferragut, Erik M**, Jason Laska, and Blair D Sullivan. A multi-level anomaly detection algorithm for time-varying graph data with interactive visualization. *Social Network Analysis and Mining*, 6(1):99, 2016.

Refereed Conference Papers

[1] **Ferragut, Erik M**, Andrew C Brady, Ethan J Brady, Jacob M Ferragut, Nathan M Ferragut, and Max C Wildgruber. Hackattack: Game-theoretic analysis of realistic cyber conflicts. In *Proceedings of the 11th Annual Cyber and Information Security Research Conference*. ACM, 2016. **Best Paper Award**.

[2] **E. M. Ferragut** and J.A. Laska. Nonparametric bayesian modeling for automated database schema matching. In *14th International Conference on Machine Learning and Applications*. IEEE, 2015.

[3] R.A. Bridges, J.P. Collins, **E.M. Ferragut**, J.A. Laska, and B.D. Sullivan. Multi-level anomaly detection on time-varying graph data. In *International Conference on Advances in Social Networks Analysis and Mining*. IEEE/ACM, 2015.

[4] S. Djouadi, A. Melin, **E. Ferragut**, J. Laska, J. Dong, and A. Drira. Finite energy and bounded actuator attacks on cyber-physical systems. In *European Control Conference (ECC)*. European Control Association, 2015.

[5] M.D. Iannacone, S. Bohn, G. Nakamura, J. Gerth, K.T. Huffer, R.A. Bridges, **E.M. Ferragut**, and J.R. Goodall. Developing an ontology for cyber security knowledge graphs. In *Cyber and Information Security Research Conference*. Oak Ridge National Laboratory, 2015.

[6] Seddik M Djouadi, Alexander M Melin, **Ferragut, Erik M**, Jason Laska, Jin Dong, et al. Finite energy and bounded attacks on control system sensor signals. In *American Control Conference (ACC), 2014*, pages 1716–1722. IEEE, 2014.

[7] Bogdan D Czejdo, Michael D Iannacone, Robert A Bridges, **Ferragut, Erik M**, and John R Goodall. Integration of external data sources with cyber security data warehouse. In *Proceedings of the 9th Annual Cyber and Information Security Research Conference*, pages 49–52. ACM, 2014.

[8] Alexander M Melin, **Ferragut, Erik M**, Jason A Laska, David L Fugate, and Roger Kisner. A mathematical framework for the analysis of cyber-resilient control systems. In *6th International Symposium on Resilient Control Systems (ISRCS), 2013*, pages 13–18. IEEE, 2013.

[9] **Ferragut, Erik M**, Jason A Laska, Bogdan D Czejdo, and Alexander M Melin. Addressing the challenges of anomaly detection for cyber physical energy grid systems. In *Proceedings of the Eighth Annual Workshop on Cyber Security and Information Intelligence Research*, 2012.

[10] **Ferragut, Erik M**, Jason Laska, and Robert A Bridges. A new, principled approach to anomaly detection. In *11th International Conference on Machine Learning and Applications (ICMLA), 2012*, volume 2, pages 210–215. IEEE, 2012.

[11] **Ferragut, Erik M** and Jason Laska. Randomized sampling for large data applications of SVM. In *11th International Conference on Machine Learning and Applications (ICMLA), 2012*, volume 1, pages 350–355. IEEE, 2012.

[12] Lane Harrison, Jason Laska, Riley Spahn, Mike Iannacone, Evan Downing, **Ferragut, Erik M**, and John R Goodall. situ: Situational understanding and discovery for cyber attacks. In *IEEE Conference on Visual Analytics Science and Technology (VAST), 2012*, pages 307–308. IEEE, 2012.

[13] Bogdan Czejdo and **Ferragut, Erik M**. Time analysis for probabilistic workflows. In *International Conference on Future Communication and Computer Technology (ICFCCT)*, pages 62–66, 2012.

[14] Robert K Abercrombie, **Ferragut, Erik M**, and Shane Boone. Hidden markov modeling for weigh-in-motion estimation. In *6th International Conference on Weigh-In-Motion (ICWIM6)*, 2012.

[15] Robert K Abercrombie, **Ferragut, Erik M**, Frederick T Sheldon, and Michael R Grimaila. Addressing the need for independence in the CSE model. In *IEEE Symposium on Computational Intelligence in Cyber Security (CICS), 2011*, pages 68–75. IEEE, April 2011.

[16] **Ferragut, Erik M**, David M Darmon, Craig A Shue, and Stephen Kelley. Automatic construction of anomaly detectors from graphical models. In *IEEE Symposium on Computational Intelligence in Cyber Security (CICS), 2011*, pages 9–16. IEEE, April 2011.

[17] Anita N Zakrzewska and **Ferragut, Erik M**. Modeling cyber conflicts using an extended Petri net formalism. In *IEEE Symposium on Computational Intelligence in Cyber Security (CICS), 2011*, pages 60–67. IEEE, April 2011.

[18] **Ferragut, Erik M** and E Nicole Braden. System log summarization via semi-Markov models of inter-arrival times. In *Proceedings of the Seventh Annual Workshop on Cyber Security and Information Intelligence Research*, page 44. ACM, 2011.

[19] Craig A Shue and **Ferragut, Erik M**. Dead Phish: An examination of deactivated phishing sites. In *Collaboration, Electronic Messaging, Anti-Abuse an Spam Conference (CEAS)*, July 2010.

[20] **Ferragut, Erik M**. A dynamic erasure code for multicasting live data. In *Proceedings of the 5th Annual Workshop on Cyber Security and Information Intelligence Research*. ACM, April 2009.

Presentations

[1] **E.M. Ferragut**, J.A. Laska, and R.A. Bridges. Anomaly detection and probabilistic modeling for image data (poster). In *Big, Deep, and Smart Data Analytics in Materials Imaging Conference*. Joint Nanoscale Science Research Center (NSRC), 2015.

[2] **Ferragut, Erik M**. Probabilistic schema matching. The Center for Intelligent Systems and Machine Learning (CISML), University of Tennessee, Knoxville *(Scheduled)*, January 31, 2014.

[3] **Ferragut, Erik M**. Graph-based analysis of cyber-physical system resiliency. American Mathematical Society Southeastern Sectional Meeting (AMS-SE), Louisville, Kentucky, October 4, 2013.

[4] **Ferragut, Erik M**. A principled approach to anomaly detection. The Center for Intelligent Systems and Machine Learning (CISML), University of Tennessee, Knoxville, November 14, 2012.

Patents

[1] **Ferragut, Erik M** and Jason A Laska. Cyber physical attack detection, filed September 20 2016. U.S. Provisional Pat. App. No. 62/397,095.

[2] **Ferragut, Erik M**, John R Goodall, Michael D Iannacone, Jason A Laska, and Lane T Harrison. Real-time detection and classification of anomalous events in streaming data, April 19 2016. US Patent 9,319,421.

[3] **Ferragut, Erik M**, Jason A Laska, and Robert A Bridges. Detection of anomalous events, June 7 2016. US Patent 9,361,463.

[4] Robert K Abercrombie, Frederick T Sheldon, and **Ferragut, Erik M**. Cyberspace security system, September 13 2012. US Patent 8,762,188.

Classified Papers

Authored 16 peer-reviewed classified papers in cryptology and related fields (1994–2005, 2007–2009). Received two Crypto-Mathematics Institute and one KRYPTOS competitive paper awards.

Education

December 2003	Ph.D. in Mathematics University of Michigan, Ann Arbor Dissertation: *"Detection of Epistatic Effects in Genetic Data"* Advisor: Phil Hanlon
August 1999	M.S. in Mathematics University of Michigan, Ann Arbor
May 1997	B.S. in Mathematics, *Summa Cum Laude* Highest honors in Mathematics, Physics, and Philosophy Ursinus College, Collegeville, PA

Project Leadership and Funds Captured

PI, Cyber Physical Attack Detection (2017–2020)
Department of Homeland Security, Science and Technology
Point of Contact: Nadia Carlsten, Ph.D., Program Manager
                    Transition to Practice (TTP) program
                    Cyber Security Division (CSD)
                    Homeland Security Advanced Research Projects Agency

Task Lead, Anomaly Detection in Cyber Data (2014–2016)
Navy Cyber Defense Operations Command
Point of Contact: Rob Stappert
                    Network Forensics Technical Advisor
                    Navy Cyber Defense Operations Command

PI, Situation Awareness in Complex Networks (2013–2015)

Laboratory Directed Research and Development
Oak Ridge National Laboratory

Task Lead, Automated Data Quality Assessment (2013–2014)
Affordable Care Act Data Solutions project
Center for Medicare and Medicaid Services (CMS)

PI/Mentor, Deception Detection (2011-2012)
Intelligence Community Post-Doctoral Research Program

PI, Cyber Security Development and Training (2010-2011)
Johnson C. Smith University (HBCU)

Research Experience

12/2017 – Present
Principal Data Scientist
Optum (UnitedHealth Group)
Telecommute to Eden Prairie, MN

Principal data scientist responsible for development, testing, and monitoring of unsupervised, semi-supervised, and supervised data-driven models for detection of fraud, waste, abuse, and error within claim data for an important client. Provide technical leadership to other data scientists within the group.

6/2009 – 11/2017
Cyber Security Research Scientist
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Research scientist and principal investigator for cyber security, anomaly and intrusion detection, situation awareness, probabilistic modeling, and machine learning. Key contributor to research in visual analytics, adversarial control theory, critical infrastructure protection, quantum computing, compressive sensing, and formal methods.

8/2007 – 6/2009
Applied Research Mathematician
Institute for Defense Analyses
Princeton, New Jersey

Applied multiple areas of mathematics (group theory, representation theory, coding theory, combinatorial commutative algebra, probability theory, combinatorics, and topology) to research problems in national security.

8/2006 – 8/2007
Cyber Security Research Scientist
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Research staff contributing to distributed anomaly detection algorithms for cyber security. Supported projects in weigh-in-motion and communications.

10/2005 – 8/2006

Applied Research Mathematician
Johns Hopkins University, Applied Physics Laboratory
Laurel, Maryland

Improved methods for systematizing and validating large-scale risk assessments. Co-discovered and reported a cyber vulnerability on a high-value system together with an effective exploit.

8/1993 – 10/2005

Applied Research Mathematician
National Security Agency
Fort George G. Meade, Maryland

Participant of Stokes Fellowship Co-operative program (1993–1997), Director's Summer Program (1995), and Applied Mathematics Program (1997–2002). Research staff member in Cryptographic Research. Applied multiple areas of mathematics (group theory, representation theory, combinatorial commutative algebra, probability theory, combinatorics, and topology) to research problems for national security.

9/1997 – 12/1999

Graduate Research Assistant
University of Michigan
Ann Arbor, Michigan

Instructor for two sessions of pre-calculus.

Mentoring

- Benjamin C. Dutton, North Carolina State University, Raleigh, NC, Summer 2017.

- Emily Lindsey Grinstead, University of South Alabama, Mobile, AL, Summer 2017.

- Andrew C. Brady, Jefferson Middle School, Oak Ridge, TN, Summer 2015.

- Ethan J. Brady, Oak Ridge High School, Oak Ridge, TN, Summer 2015.

- Jacob M. Ferragut, Oak Ridge High School, Oak Ridge, TN Summer 2015.

- Nathan M. Ferragut, Oak Ridge High School, Oak Ridge, TN Summer 2015.

- Max C. Wildgruber, Oak Ridge High School, Oak Ridge, TN, Summer 2015.

- George E. Gallarno, Christian Brothers University, Memphis, Undergraduate Student Researcher, Summer 2014.

- Timothy D. Goodrich, North Carolina State University, Raleigh, Graduate Student Researcher, Summer 2014.

- Ronald D. Hagan, University of Tennessee, Knoxville (UTK) Graduate Student Researcher, Summer 2014.

- Samantha N. Petti, Williams College, Science Undergraduate Laboratory Internships (SULI), Summer 2014.

- Jessica L. Robins, University of Tennessee, Knoxville (UTK) Science Undergraduate Laboratory Internships (SULI), Summer 2014.

- John P. Collins, Post-Masters Researcher, 2013–2014.

- Robert Bridges, Post-Doctoral Researcher, 2012–2013.

- Riley Spahn, Post-Baccalaureate Researcher, Fall 2012 to Spring 2013, and Auburn University Undergraduate Student, Summer 2011

- Jason Laska, Intelligence Community Post-Doctoral Researcher, 2011–2012.

- E. Nicole Braden, University of the Cumberlands Undergraduate Student, Summer 2011.

- Scott Mancuso, Brigham Young University Undergraduate Student, Summer 2011.

- Stephen Kelley, Intelligence Community Post-Doctoral Researcher, Summer 2010 to Spring 2012.

- Alicia Marino, Quinnipiac University Undergraduate Student, Spring 2011.

- David Darmon, Ursinus College Undergraduate Student, Summer 2010.

- Anita Zakrzewska, Brandeis University Undergraduate Student, Summer 2010.

- Aimee Cothran, High School Mathematics Teacher in the Greater Memphis Area, Summer 2010.

Teaching Experience

Spring 2011 – Fall 2012   *Online Adjunct Instructor (4 Classes Taught)*
University of Maryland University College
Adelphi, Maryland

Instructor (online) for core courses leading to a Master's Degree in Cybersecurity. CSEC 610 Cyberspace and Cybersecurity (2 sessions). CSEC 630 Prevention and Protection Strategies in Cybersecurity (2 sessions).

Spring 1998 – Fall 1999   *Graduate Teaching Assistant*
University of Michigan
Ann Arbor, Michigan

Instructor for precalculus mathematics course (2 sessions).

Professional Membership and Service

Memberships

- Member, American Mathematical Society (AMS)

- Member, Society for Industrial and Applied Mathematics (SIAM)

- Member, Latinos in Science and Engineering (MAES)

Service

- Reviewer in 2017 for IEEE Conference on Visual Analytics Science and Technology (IEEE VAST 2017)

- Reviewer in 2015 for:
    - SSCI CICS 2015
    - IEEE Transactions on Automatic Control, July 2015,
    - Hawaii International Conference on System Sciences (HICSS) 49

- Organizer in 2013, Machine Learning Challenges in Cyber Security Applications, Special Session for the International Conference on Machine Learning Applications (ICMLA) 2013.

- Reviewer in 2012 for IEEE Networks Magazine.

- Reviewer in 2010 for:

  - ACM Transactions on Modeling and Computer Simulation Journal (ACM TOMACS) 2010
  - Hawaii International Conference on System Sciences (HICSS) 2010.

- Reviewer, Cyber and Information Research (CISR) Workshop 2010–2015.

Other Information

- Fluent in English and Spanish

- Programming preferences: Python, C/C++, Matlab/Octave, Sage

- Preferred machine learning tools: Python, numpy, scipy, scikit-learn, TensorFlow, Keras, pandas

- Citizenship: USA