Erik A. Bensen

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Education

Ph.D. Student in Statistics, *Carnegie Mellon University* ..... **August 2023 – Present**

M.S. Applied Math & Statistics, *Colorado School of Mines* ..... **May 2022**

– Honors: Full Tuition Harvey Scholarship

B.S. Engineering Physics, *summa cum laude*, *Colorado School of Mines* ..... **May 2021**

– Minor: Computational & Applied Mathematics
– Honors: Full Tuition Harvey Scholarship, Physics Faculty Commended Graduating Senior Award

Research

National Renewable Energy Laboratory (NREL) **Golden, CO**

Researcher I: Complex Systems Simulation & Optimization Group ..... **June 2022 – August 2023**

– Empirical Analysis of Energy Efficient Supercomputing
  * Investigate predictive power of analytical energy consumption methods for dense neural networks and apply them to the *Better Understanding of Topologies Through Empirical Results* dataset.
  * Develop empirical models of validation loss isolines as a function of training epochs and free parameters.
  * Investigate the most energy efficient dense neural network architectures and training durations.
  * Collect and evaluate a convolutional neural network empirical dataset, comprising epoch-wise loss information and energy measurements over extensive sweeps of network architecture & hyperparameters.
  * Impact: The energetic cost of computing is quickly reaching a non-zero asymptote and predicted to surpass 20% of energy consumption by 2030. This project aims to refocus ML research to improve the energy efficiency of state-of-the-art models and prevent an energy crisis.
– Wireless Communication Modeling for Cooperative Driving Automation
  * Develop comprehensive wireless communications models for messages exchanged between vehicles, or vehicles and road-side units, using Aimsun and NS-3 simulation platforms.
  * Impact: These comprehensive analyses optimize the propagation of safety-critical messages in mixed traffic environments consisting of both connected and unconnected vehicles.
– AI Bias in Transportation Systems
  * Analyze and develop mitigation strategies for demographic bias in ML predictions, such as socioeconomic bias in traffic volume estimations and predicting optimal EV charging locations.
  * Impact: This project aims to evaluate and improve demographic equity in transportation development by addressing biases present in data and ML algorithms.
– Machine Learning for Traffic State Estimation
  * Develop deep learning models based on sparse vehicle traces, to predict traffic density and signal timing, in order to optimize signal control algorithms.
  * Impact: This signal control optimization can directly improve the safety and energy efficiency of actors in the traffic network.
– Explainable, Interpretable and Verifiable AI
  * Helped organize seminar series on Explainable, Interpretable and Verifiable AI
  * Helped develop whitepaper on current state-of-the-art techniques, current NREL use cases using XAI and potential future funding sources.
  * Impact: expand NRELs research capabilities into the XAI space and potentially pave the way to use XAI techniques to allow ML/ AI to be used in safety-critical NREL applications.

Graduate Intern: Computational Sciences Center ..... **December 2020 – June 2022**

– Vehicular Ad-hoc Network (VANET) Communications
  * Conducted extensive literature review of state-of-the art communications models in VANET networks, and presented findings to the US Departments of Energy and Transportation.
  * Impact: Investigated the ability to use VANET communication to allow future control systems to optimize vehicle energy efficiency and safety.
– Sensor Fusion and Simulation for Infrastructure Perception and Control
  * Created a Monte Carlo Particle filter framework to track vehicles moving through a simulated intersection.
  * Developed measurement error models for noisy LiDAR/Radar data and applied these models in simulation using

the CARLA and SUMO traffic simulation platforms.
  * Impact: These error models allow for high-confidence object detection and tracking, which can be used by intersection level control algorithms to improve the safety and energy efficiency of vehicles and pedestrians.

SULI Intern: Computational Sciences Center ..... **August – December 2020**
- LiDAR Object Detection for Infrastructure Perception and Control
  * Analyzed object detection algorithms for LiDAR data.
  * Simulated traffic scenarios with LiDAR sensors and recorded data for analysis, using a supercomputer.
  * Impact: Evaluated the feasibility of using LiDAR sensors for safety-critical applications.

Colorado School of Mines — Golden, CO

Undergraduate Researcher: Toberer Thermoelectric Lab Group ..... **June 2018 – May 2021**
- Numerical Methods for Analyzing Semiconductor Materials
  * Explored the relationship between the Nernst coefficient and fundamental materials parameters.
  * Developed an algorithm to computationally solve the method of four coefficients. Analyzed the propagation of experimental error using this method.
  * Created a numerical solver to determine fundamental material parameters, based on their measured properties as determined by Boltzmann Transport Theory integral equations.
  * Impact: This algorithm extends the capability of data-driven, renewable energy materials design into areas that were previously intractable.
  * Mentored an intern in numerical modeling techniques during the Summer of 2019.
- Analysis of ZnVSb
  * Synthesized ZnVSb samples using a high-energy ball milling technique
  * Determined the crystal structure using x-ray refinement from synchrotron data.
  * Collaborated with several other universities to characterize and measure properties of the material.
  * Constructed a machine learning model to predict structural deviations for an aggregate of compounds similar to ZnVSb.
  * Built a vacuum chamber for a heat capacity measurement device.
  * Impact: Investigated the feasibility of using structural deviations to design renewable energy materials.
- Materials Discovery
  * Worked with the Mg-V-Sb and Mg-V-Te ternary systems to look for undiscovered, crystalline materials.
  * Synthesized semiconductor materials samples in an oxygen-free glovebox and performed x-ray diffractometry analysis using the TOPAS software to determine the compounds present.
  * Analyzed samples with an ESEM electron microscope to determine the grain structure.
  * Impact: Expanded the search space for high-efficiency renewable energy materials.
- Energy Storage in Phase Transitions
  * Assisted with the field testing of the STEALS system to store energy in the phase changes of an aluminum-silicon alloy. Assisted with the write-up of experimental results.
  * Impact: Improved the knowledge base of novel energy storage methods for solar energy production.

Publications and Presentations

In Review

[1] **E. A. Bensen**, J. Severino, J. Ugirumurera, Q. Wang, J. Sanyal, and W. Jones, "A machine learning method for real-time traffic state estimation from probe vehicle data", in *International Conference on Intelligent Transportation Systems 2023 (In Review)*, 2023.

[2] J. Ugirumurera, J. Severino, **E. A. Bensen**, Q. Wang, J. Gonder, and J. Macfarlane, "A machine learning method for estimating traffic signal timing from probe vehicle data", in *International Conference on Intelligent Transportation Systems 2023 (In Review)*, 2023.

Publications

[1] S. E. Young, **E. A. Bensen**, L. Zhu, C. Day, J. S. Lott, R. Sandhu, C. Tripp, and P. Graf, "Concept of operations of next-generation traffic control utilizing infrastructure-based cooperative perception", in *International Conference on Transportation and Development 2022*, 2022, pp. 93–104.

[2] K. Ciesielski, L. C. Gomes, G. A. Rome, **E. A. Bensen**, J. M. Adamczyk, D. Kaczorowski, E. Ertekin, and E. S. Toberer, "Structural defects in compounds Zn X Sb (X= Cr, Mn, Fe): Origin of disorder and its relationship with electronic properties", *Physical Review Materials*, vol. 6, no. 6, p. 063 602, 2022.

[3] C. M. Crawford, **E. A. Bensen**, H. A. Vinton, and E. S. Toberer, "Efficacy of the method of four coefficients to determine charge carrier scattering", *Phys. Rev. Applied*, vol. 16, p. 024 004, 2 Oct. 2021.

[4] **E. A. Bensen**, K. Ciesielski, ..., D. Kaczorowski, E. Ertekin, and E. S. Toberer, "Anomalous electronic properties in layered, disordered ZnVSb", *Phys. Rev. Materials*, vol. 5, p. 015 002, 1 Jan. 2021.

[5] B. R. Ortiz, P. Gorai, T. Braden, **E. A. Bensen**, S. D. Wilson, V. Stevanović, and E. S. Toberer, "Discovery of n-type zintl phases RbAlSb4, RbGaSb4, CsAlSb4, and CsGaSb4", *ACS Applied Energy Materials*, vol. 3, no. 3, pp. 2182–2191, 2020.

[6] J. E. Rea, C. J. Oshman, ..., **E. Bensen**, R. T. Bell, N. P. Siegel, D. S. Ginley, and E. S. Toberer, "Prototype latent heat storage system with aluminum-silicon as a phase change material and a stirling engine for electricity generation", *Energy Conversion and Management*, vol. 199, p. 111 992, 2019.

Presentations

[1] C. Tripp, **E. Bensen**, L. Hayne, J. Perr-Sauer, and M. Lunacek, "Green AI: Insights into deep learning's looming energy efficiency crisis", Presented at EPRI AI and Electric Power Summit, 2022.

In Preparation

[1] **E. A. Bensen**, C. E. Tripp, J. Perr-Sauer, and L. Hayne, "Empirical investigation of energy consumption during neural network training", *(In preparation)*, 2023.

[2] **E. A. Bensen**, C. E. Tripp, J. Perr-Sauer, and L. Hayne, "Understanding convolutional neural network energy trade-offs through empirical results", *(In preparation)*, 2023.

Skills

Programming Languages: Python, C^{++}, *R*, Matlab, Mathematica, LabView, LaTeX, Linux, Bash, Git
Machine Learning: Tensorflow/ Keras, PyTorch, XGBoost, SciKit Learn
High Performance Computing: MPI, OpenMP, slurm scheduler
Simulation Platforms: CARLA, SUMO, Aimsun, NS-3
Software: Solidworks Certified, ArcGIS, TOPAS, Vector Graphics, Microsoft Office Suite, QTI Plot
Leadership: Strong team building, team management and community outreach skills
Communication: Excellent public speaking, teaching and technical writing skills

Leadership

Leadership Board, Harvey Scholars Program ..... **May 2018 – May 2022**
- Served as President (2021-2022), Applications Technical Coordinator (2020-2021) and Service Coordinator (2018-2019). All positions promoted philanthropy & community service amongst the scholarship community. Accomplishments include implementing biannual, in-person community-building retreats, reorganizing the leadership board to emphasize collaboration, developing computational resources for and overseeing the Harvey Scholarship applications process, raising $2,000 for Sewall Child Development Center, starting an annual Harvey Habitat for Humanity build.

Vice President of Campus Engagement, Mines Philanthropy Council ..... **May 2018 – May 2019**
- Developed a meal swipe donation program to support students on campus with limited food security and organized a Shark Tank style event where students pitched their ideas to a panel of judges and were eligible to win up to $10,000 in funding to support initiatives to improve campus.

Teaching Assistant ..... **January 2019 – May 2020**
- TA for upper division *Electromagnetism* (PHGN 361), Spring 2020 at Colorado School of Mines.
- Taught 2nd and 6th grade English, Fall 2019 at La Salle School, Seville, Spain
- TA for the cross-disciplinary course *AMPED: Algebra I in the Engineering Context*, Spring 2019 at Green Mountain High School

References Available Upon Request