Garrett Merz
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Github Page: https://github.com/GarrettMerz
Website: https://garrettmerz.github.io/

EDUCATION:

University of Michigan, Ann Arbor MI: Ph.D. Physics 2021; M.Sc. Physics, 2017
The Ohio State University, Columbus, OH: B.S. Physics, Mathematics with Honors Research Distinction, 2016

RESEARCH INTERESTS: Use-inspired AI/ML research driven by scientific application, including but not limited to the physical sciences. Language models for symbolic mathematics and theoretical physics. Foundation models for science (self-supervised learning, representation learning, explainable/interpretable ML). Computer vision on scientific imagery (hyperspectral imagery, high-energy physics detector events, etc.).

EXPERIENCE:

University of Wisconsin-Madison Data Science Institute
Postdoctoral Researcher: March 2023-Present
Supervising PI Kyle Cranmer
- Develop small Transformer models for the calculation of high-energy physics scattering amplitudes, together with scientists from SLAC National Accelerator Laboratory and Meta AI Research
- Develop self-supervised learning methods (variants of SimCLR and VicReg) for high-energy physics jet graphs; apply to downstream quark/gluon jet identification and energy regression tasks.

Intelinair, Inc.
Machine Learning Scientist: November 2021- January 2023
- Lead development on a self-supervised Hierarchical Pretrained Vision Transformer model for monitoring the growth of corn and soybean fields using hypersectral remote-sensing imagery, pretrained on unlabeled data using DINO
- Design, build and deploy a ResNet-based classifier with Viterbi-decoder postprocessor for modeling the growth state of corn and soybean fields with 1m Airbus satellite imagery. Monitor throughout model lifecycle for domain-shift and retrain as needed. Train on synthetic data, generated using transfer functions applied to 10cm fixed-wing RGBN imagery.

ATLAS High Energy Experimental Physics Group at University of Michigan
PhD Candidate; Advisor Thomas Schwarz

Measurements of Higgs Boson Properties in the Diphoton Decay Channel at $\sqrt{s}$ = 13 TeV with the ATLAS Detector: May 2018-April 2021
- First-ever observation of rare top-associated Higgs production process (ttH)
  - (Press Release: https://atlas.cern/updates/briefing/observation-tth-production)
- Generate template signatures for key observable in background classes, perform signal shape parameterization, measure major systematic uncertainties related to signal mismodelling
  - Process real and synthetic data samples on the Worldwide LHC Computing Grid using HTCondor and CERN Grid high-throughput-computing architectures
- Develop, implement and test a novel Bayesian Gaussian Process Regression (GPR) tool to model shape of underlying continuum background process
  - Validate GPR efficacy using statistical tests across multiple regimes

CP Properties of Higgs Boson Interactions with Top Quarks in the ttH and tH Processes Using H→γγ with the ATLAS Detector: October 2018-March 2020

- Implement and compare novel top-quark-jet object classification methods (XGBoost, kinematic likelihoods) using low-level features extracted from images of proton-proton collisions taken using CERN's ATLAS Detector.
- Use synthetic data to train two complementary BDT classifiers to sort observed collision events into null-hypothesis signal, alternative-hypothesis signal, and background categories using a mixture of high-level and low-level engineered features
- Parameterize expected statistical distributions of major observables for null-signal, alternate-signal, and background events in many regions of differing classifier confidence; perform simultaneous Maximum Likelihood Estimation across these regions in order to measure total contribution of signal process to observed event counts and whether it does or does not conform to null hypothesis
- Supervise undergraduate students in introductory data analysis tasks
- Lead paper editor responsible for writing and maintaining internal analysis documentation

CMS/CDF Computational Physics Lab at The Ohio State University
Undergraduate Researcher; Advisor Richard Hughes

Using Convolutional Neural Networks to Identify ttH Events at the LHC: August 2014-June 2016

- Build a simple VGG/AlexNet style Deep Convolutional Neural Network model in Lua/Torch7 to distinguish between signal process (*ttH*) and background (*tt+jets*) using raw physics detector signals rather than high-level engineered features
- Compare CNN against traditional MLP-based methods for classification of synthetic event images generated from a simulated high-energy physics detector using the Monte Carlo method

Georg-August Universität Göttingen, Second Institute of Physics: June 2014- August 2014
DAAD RISE Intern; Group Leader: Arnulf Quadt

- Assist in development of KLFitter kinematic likelihood fitter for top quark jet reconstruction.
- Attend HASCO 2014 Hadron Collider Summer School

SELECTED PUBLICATIONS AND CONFERENCE PROCEEDINGS:

1. Merz, Garrett W., et al. Transformers for Scattering Amplitudes. NeurIPS 2023 Workshop on Machine Learning in the Physical Sciences. New Orleans, LA. 15 December 2023. https://ml4physicalsciences.github.io/2023/files/NeurIPS_ML4PS_2023_72.pdf

2. ATLAS Collaboration. CP Properties of Higgs Boson Interactions with Top Quarks in the tt̄H and tH Processes Using H→γγ with the ATLAS Detector. Phys. Rev. Lett. 125. 9 April 2020. 10.1103/PhysRevLett.125.061802

3. ATLAS Collaboration. Measurement of the properties of Higgs boson production at $s\sqrt{}$=13 TeV in the H→γγ channel using 139 fb−1 of pp collision data with the ATLAS experiment. Journal of High Energy Physics 07. JHEP 07 (2023) 088

4. ATLAS Collaboration. Searches for third-generation scalar leptoquarks in $s\sqrt{}$= 13 TeV pp collisions with the ATLAS detector. Journal of High Energy Physics 06. 28 June 2019. 10.1007/JHEP06(2019)

5. ATLAS Collaboration. Observation of Higgs boson production in association with a top quark pair at the LHC with the ATLAS detector. Phys. Lett. B 784 (2018) 173.

6. Merz, Garrett W. Precision Measurements of Higgs Boson Couplings in the Diphoton Decay Channel with Run-2 of the ATLAS Detector. 2020. University of Michigan, Ph.D. Thesis.

7. ATLAS Collaboration. Measurement of the properties of Higgs boson production at $s\sqrt{}$=13 TeV in the H→γγ channel using 139 fb−1 of pp collision data with the ATLAS experiment. ATLAS Conference Note (40th International Conference on High Energy Physics, Prague, Czech Republic). 3 Aug 2020.

8. ATLAS Collaboration. Measurements of Higgs boson properties in the diphoton decay channel with 36 fb−1 of pp collision data at $s\sqrt{}$=13 TeV with the ATLAS detector. Phys. Rev. D 98 (2018) 052005.

9. ATLAS Collaboration. Search for pair production of heavy vectorlike quarks decaying into hadronic final states in pp collisions at $\sqrt{s}$= 13 TeV with the ATLAS detector. Phys. Rev. D 98 (2018) 092005.

10. ATLAS Collaboration. Combination of the searches for pair-produced vector-like partners of the third-generation quarks at $s\sqrt{}$= 13 TeV with the ATLAS detector. Phys. Rev. Lett. 121, 211801 (2018).

11. Merz, Garrett W. Novel Applications of Image-Processing Techniques to Particle Physics. 2016. The Ohio State University, undergraduate thesis. https://kb.osu.edu/handle/1811/76804.

12. Kevin Jablonka et al. 14 Examples of How LLMs Can Transform Materials Science and Chemistry: A Reflection on a Large Language Model Hackathon. *Digital Discovery*, **2023.** 8 August 2023

PRESENTATIONS, WORKSHOPS, AND INVITED TALKS:

1. Transforming the Bootstrap: Transformers for Scattering Amplitudes. ORIGINS Data Science Lab Seminar. 19 April 2024. Munich, Germany (Virtual).
2. Rieck, Patrick; Dreyer, Etienne; Kakati, Nilotpal; Kobylianskii, Dmitrii; **Merz, Garrett**; Soybelman, Nathalie; Cranmer, Kyle; Gross, Eilam. Generic Representations of Jets at Detector-Level with Self-Supervised Learning. European AI for Fundamental Physics Conference 2024. Amsterdam, NL. 30 April to 3 May 2024. Presented by Collaborator.
3. Rieck, Patrick; Dreyer, Etienne; Kakati, Nilotpal; Kobylianskii, Dmitrii; **Merz, Garrett;** Soybelman, Nathalie; Cranmer, Kyle; Gross, Eilam. Generic Representations of Jets at Detector-Level with Self-Supervised Learning. 22nd International Workshop on Advanced Computing and Analysis Techniques in Physics Research. 11 March-15 March 2024. Presented by Collaborator.
4. Transformers for Scattering Amplitudes. SLAC AI Seminar. 1 February 2024
5. Transformers for Scattering Amplitudes. Hammers and Nails, Ascona, Switzerland. https://indico.cern.ch/event/1202995/. 1 November 2023.
6. Transformers for Scattering Amplitudes. University of Wisconsin-Madison Postdoctoral Research Symposium. 20 September 2023.
7. Full Run-2 H$\to\gamma\gamma$ Couplings Measurement. 2020 Higgs Workshop Plenary Meeting. 19 November 2020. CERN (Virtual).
8. Measuring the CP Properties of a Neutral Higgs with ttH$\to\gamma\gamma$ in $\gamma\gamma$ in pp Collisions at $\sqrt{s}=$ 13 TeV with the ATLAS Detector. ATLAS HTOP 2020 Workshop. 25 March 2020. CERN (Virtual).
9. Measuring the CP Properties of a Neutral Higgs with ttH$\to\gamma\gamma$ in $\gamma\gamma$ in pp Collisions at $\sqrt{s}=$ 13 TeV with the ATLAS Detector. 2019 USATLAS Collaboration Meeting. Aug 6, 2019- Aug 11, 2019. Amherst, MA.
10. Saturday Morning Physics: Update on Physics from the LHC. University of Michigan Department of Physics, 30 March 2019.
11. Third Yandex Machine Learning in High Energy Physics Summer School. Reading, UK. 17 to 23 July 2017.
12. 2016 Denman Undergraduate Research Forum, First Prize in Mathematical and Physical Sciences Division. The Ohio State University. March 30, 2016.
13. 2015 Natural and Mathematical Sciences Poster Forum. The Ohio State University. Jan. 8th 2015.
14. 2014 Hadron Collider Physics Summer School. University of Goettingen. July 20, 2014-August 1, 2014.

NOTABLE SCHOLARSHIPS AND LEADERSHIP ROLES:

2023 American Physical Society Group on Data Science: Executive Committee, Junior Member at Large
2018 National Science Foundation Graduate Research Fellowship
2018 UM Science Communication Fellowship Program
2017 Norman Barnett Award
2016 National Science Foundation Graduate Research Fellowship, Honorable Mention
2015 Staninovski Mathematics Scholarship
Undergraduate High Energy Physics Journal Club, OSU Chapter: *Secretary/Founding Member,* 2014-2016
2013 Hellen Cowan Book Award
2012 Valentino Physics Scholarship
2012 Honors Medalist Scholarship
Society of Physics Students, OSU Chapter: *Vice President* 2013-2015

SERVICE:
Reviewer for: Journal of High-Energy Physics, Machine Learning: Science and Technology, Journal of Open Source Software, NeurIPS Machine Learning for the Physical Sciences Workshop (2022), CVPR Agriculture-Vision Workshop (2022, 2023)
Organizing Team Member, NeurIPS 2023 Workshop on Machine Learning in the Physical Sciences
Discussion Panel Moderator, CVPR 2022 Agriculture-Vision Workshop

TOOLS AND PACKAGES:
Proficiency with: Python, (scikit-learn, pandas, numpy/scipy, matplotlib/seaborn, rasterio, PIL, beautifulsoup, networkX, nltk, etc.), Pytorch/Lightning, TensorFlow/Keras, C++, UNIX/Linux, git, bash/csh, postgresSQL, AWS, Docker, ML lifecycle tools such as ClearML/ Weights and Biases/ Tensorboard, various agile workflow tools such as JIRA/Confluence, ROOT, pyROOT
Some Familiarity With: MatLab, Lua, Torch7, Jax

TEACHING AND SCIENCE COMMUNICATION:

UMATLAS Virtual and Augmented Reality Outreach Program: June 2016-April 2021
- Present ATLASRift virtual reality software (showcasing the ATLAS detector in virtual reality using HTC Vive and Oculus Rift software) to the general public at museums and showcases
- Develop novel pedagogical experiences integrating virtual and augmented reality demonstrations into introductory physics laboratory classes (ongoing effort through UMich Center for Academic Innovation XR Grant)

ComSciCon 2019
- Attend seminars on science journalism, data visualization, podcast development
- Produce and workshop a piece of science communication writing

University of Michigan Dept. of Physics. Graduate Student Intructor: September 2016-December 2017
- Instructor for a total of seven sections of introductory physics lab work
- Design and administer weekly quizzes and facilitate the completion of weekly lab reports
  - Participate in general physics tutoring through the Physics Help Room

STUDENTS SUPERVISED:

Chris (Haotian) Cao: Graduate student at University of Wisconsin-Madison.
- Together with Kyle Cranmer and Gary Shiu, explore symbolic regression methods for calculating high-energy limiting behavior of conformal field theories (CFTs)

Noah Zipper: Undergraduate student. Currently a PhD student at CU boulder in the CMS group.
- Implemented and modified the Kinematic Likelihood Fitter (KLFitter) for use in Higgs to diphoton based analyses.

Sabrina Corsetti: Undergraduate student. Currently a PhD student at MIT in the Notaros Group.
- Developed gradient boosted decision trees for ttH CP analysis.

Thomas Sandell: Undergraduate student. Currently a Software Engineer at Patreon.
- Supervised development of ATLASRift VR software