Zack Dugue

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EDUCATION

California Institute of Technology (Caltech) Expected: **Jun. 2025**
Bachelors of Science, Major in Computer Science, Minor in Mathematics. Overall GPA: 3.9/4.3

Relevant Coursework:
Computer Science: Theory of Computation, Algorithms, Machine Learning, Computing Systems, Computer Programming

Math: Probability, Bayesian Statistics, Statistics, Discrete Math, Abstract Algebra, Differential Equations, Multivariable Calculus

Miscellaneous: Learning in Games, Game Theory, Quantum Mechanics

RESEARCH EXPERIENCE

Targeted Forgetting in Neural Networks - w/ Prof. Alexandra Brintrup (University of Cambridge) **Jun. 2024 - Present**

- Focuses on the task of ”Machine Unlearning.” This is the task of taking a pretrained Neural Network and removing the influence of certain data points from that pre training dataset, without compromising performance on the remaining data.
- Developed a novel algorithm which treats the parameters of the neural network as independent gaussians, and then uses the KL divergence between the parameters original model and the model we're training to forget in order to protect performance.
- Research is ongoing currently, but me and my mentor Jack Foster are hoping to publish our findings in DMLR.

Bayesian Neural Networks for Continual Learning - w/ Prof. Antonio Rangel (Caltech) **Jan. 2024 - Jun.**

- The goal of this research is to investigate certain hyperparameter schemes within the Bayesian Gradient Descent Algorithm (BGD). BGD is an algorithm designed for training Bayesian Neural Networks for Continual Learning.
- Derived a differential equation representation of the Bayesian Gradient Descent Algorithm in the limit of infinitely small optimization steps.
- Wrote an implementation of the Bayesian Gradient Descent Algorithm in Pytorch, including a wrapper that takes in any pytorch neural network module and converts it into a Bayesian Neural Network.
- Tested and Evaluated alternate hyperparameter configurations of the BGD Algorithm on the CIFAR10 Dataset.

Deep Neural Network Architecture Optimization - SURF w/ Prof. Georgia Gkioxari (Caltech) **Apr. - Sep. 2023**

- Designed and implemented an attention-based alternative to skip connections in transformer neural networks. Specifically, the architecture allowed ”Blocks” (collections of layers) to attend back to the outputs of prior layers through a learned query. The goal of this was to make a more expressive implementation of the naïve “sum everything up” aggregation found in skip-connection-based architectures.
- I tested this implementation on both Vision (CIFAR 10) and NLP (Wikitext 108) datasets using a training pipeline written with the pytorch library.

Neural ODEs for Streaming Perception - SURF w/ Prof. Yisong Yue's lab (Caltech) **Jun. - Sep. 2022**

- Designed a custom data loader to sample sequences from the ArgoverseHD Object detection dataset.
- Implemented a Neural ODE based feature backbone for a Fast-RCNN model. Unlike the standard implementation for the CNN backbone, this Neural ODE backbone took in a sequence of images and processed them recurrently, allowing for a lighter-weight model that could reuse redundant features from prior frames. Code was implemented using the pytorch library.
- I used performance profiling to evaluate how different ODE solvers compared in speed, (and how the ODE model itself compared against the baseline model).

Spiking Neural Network Research - SURF w/ Prof. Matt Thomson's lab (Caltech) **Jun. - Aug. 2021**

- Studied the properties of 2D Spiking Neural Networks trained with unsupervised Hebbian Learning for various vision tasks.
- Created metrics and visualizations to understand the properties of 2D Spiking Neural Networks during training.
- Programmed extensively in Matlab.

Experimental Design for Study of Lunar Regolith - w/ Dr. Osazonamen Igbinosun (JPL) **Jun. - Sep. 2020**

- Using CAD refined an experimental design for studying the properties of the thermal conductivity of Lunar Regolith under varying user-defined pressures.
- Collaborated with a fellow peer to study the heat transfer properties of this experimental design.

PROJECTS

Implemented a Pipeline for Training NLP Models on Augmented Training Objectives **Jul. - Aug. 2023**

- Adapted many Self Supervised Learning Algorithms used in Computer Vision to text based data (WikiText 103 specifically). This includes an implementation of BarlowTwins, Vector Quantized-VAEs, and an EMA encoder implementation inspired by Dino.
- The project was motivated mostly out of curiosity. The final result was that most of these methods did not transfer well at all to the language domain.
- The question of whether there is a more effective training objective than simply next token prediction for language models is still of interest to me.

Chest X-ray Diagnosis Machine Learning Project **Apr. - Jun. 2023**

- Our CS156b course, taught by Professor Abu-Mostafa, required that I and a team of 3 other students design and implement a Vision Transformer as part of a competition between other students. We were training and being evaluated on the Chexpert dataset, which contains images of chest X-rays alongside labels corresponding to radiologist-identified medical abnormalities present in the X-ray.
- Our final implementation used a DinoV2 pre-trained Transformer, with a feed-forward network fine-tuned on top of the embedding. We used many augmentation strategies and also made efforts to collect chest X-Ray data outside of Chexpert that we could use to further train our model.

Reinforcement Learning Project **Sep. - Dec. 2023**

- As part of my final project for the class ”Learning in Games”, we used Reinforcement Learning to perform trades as a simulated market-maker.
- Results showed that the policy learned was similar to an algorithm used commonly by market makers in industry.

Created a Functional Video Game **Apr. - Jun. 2022**

- Designed a game from the ground up in C as part of Caltech's Introduction to Software Design course.
- Our game was called ”Dino Defenders” and utilized a physics engine to simulate the trajectories of Asteroids, slugs, propelled rockets, and lasers. The goal of the game was to destroy the enemy asteroids before your planet was destroyed. The game contained several levels, sprite art, and music.

Programmed an App to Track User's CO2 Emissions **Jun. - Aug. 2019**

- This was part of a project for the MIT Online Science, Technology, and Engineering Community (MOSTEC) project course in Mobile App Development.
- Our group designed an app that used the make and model of your car combined with calculating your distance traveled using your phone's GPS coordinates to calculate the expected CO2 output of the user (at least with respect to their vehicle use).

TECHNICAL SKILLS

Languages: C, Java, Python, MATLAB, Maple, R, Shell Scripts, Assembly
Packages/Frameworks: Git, Pandas, NumPy, Anaconda, LaTex, SKLearn, PyTorch, Pytorch Lightning, Matplotlib
Developer Tools: VS Code, PyCharm, IntelliJ IDEA, AWS, Anaconda, SLURM