

# CHIKA MADUABUCHI

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## Education

### Massachusetts Institute of Technology

2022 – 2024

*Master of Science in Nuclear Science and Engineering*

*Cambridge, MA*

- Awarded \$91,000 research funding from Mathworks for developing computer vision models for autonomous boiling.

### University of Nigeria Nsukka

2014 – 2019

*Bachelor of Engineering in Mechanical Engineering*

*Nsukka, EN*

## Relevant Coursework

- Advanced Machine Learning
- Modelling with Machine Learning
- Advanced Numerical Methods
- Advanced Calculus
- Computer Programming
- Complex Analysis
- Probability and Statistics
- Advanced Linear Algebra
- Computational Algorithms

## Research Interests

- Machine Learning
- Computer Vision
- Natural Language Processing
- Generative AI
- Foundation Models
- Reinforcement Learning

## Experience

### MIT Red Lab

September 2022 – Present

*Research Fellow*

*Cambridge, MA*

- Implemented transfer learning techniques using U-Net CNNs from pre-trained biological cell models to boiling videos for accurate segmentation (over 98% Dice coefficients and Jaccard index) of bubbles to enable autonomous systems control.
- Fine-tuned state-of-the-art vision transformer (ViT-H) foundation model, META SAM, on PyTorch to enhance generalization capabilities on new boiling images with complex patterns.
- Quantified uncertainty in the vision model predictions by implementing a randomized sorting algorithm which evaluated the error on the boundaries of the model predictions.
- Attended weekly group meetings and met my research advisor twice a week to share research updates and receive scholarly feedback.

### Artificial Intelligence Laboratory

October 2021 – August 2022

*Research Lead*

*Nsukka, EN*

- Led a team of data scientists to implement neural networks, support vector machines, boosting and bagging ML models in scikit-learn to forecast global weather parameters and solar power in strategic cities across the 7 continents.
- Conducted exploratory data analysis (EDA) and recursive feature elimination (RFE) on the 2 years time series data to determine the most relevant features for ML forecast of the system power and efficiency.
- Tuned the models to give the best prediction output based on numerous regression performance metrics including the relative root mean squared error (RRMSE) and Pearson correlation coefficient ( $R^2$ )
- Validated the ML forecasts with year ahead ground-truth data from NASA and submitted the developed manuscript for publication consideration in Engineering Applications of Artificial Intelligence.

## Projects

### Generative AI - Diffusion Models | *Python, PyTorch, CNNs, Einops*

October 2023

- Developed a PyTorch-based implementation of Denoising Diffusion Probabilistic Models (DDPMs) to generate high-quality samples from noise through a reverse noising process as an implementation of the paper by Ho et al.
- Designed a custom U-Net CNN architecture with sinusoidal positional embedding to condition the denoising process on the diffusion timestep for effective image denoising on MNIST and Fashion-MNIST datasets.
- Utilized a sophisticated training loop with noise application at random timesteps and hyperparameter optimization to ensure accurate noise prediction and efficient learning.
- Created dynamic visualization tools for the diffusion process and model evaluation, offering intuitive insights into the model's generative capabilities and performance.

### PoS Tagging with Layer Freezing Strategies | *Python, DistilBERT Transformers*

February 2024

- Investigated the impact of partial layer freezing on DistilBERT's performance for PoS tagging using the Universal Dependencies dataset.
- Developed and evaluated two freezing strategies: Single Layer Partial Freezing (SLPF) where individual layers were frozen, and Compound Layer Partial Freezing (CLPF) freezing consecutive layers from the model's bottom up.

- Utilized DistilBert Transformers for model implementation and fine-tuning, and Matplotlib for visual analysis of model accuracies across different configurations.
- Demonstrated through systematic experimentation and visualization that selective layer freezing can variably affect PoS tagging accuracy, with some configurations outperforming the baseline model.

## Character-Level Language Modeling - GPT Architecture | *Python, PyTorch, Transformers* December 2023

- Engineered a character-level text generation model using PyTorch, encapsulating the core principles of Transformer architectures, to autonomously generate text in the style of Shakespeare with over 0.209 million parameters.
- Implemented and optimized a simplified GPT-like architecture, including self-attention mechanisms, multi-head attention, and feedforward networks, tailored for understanding and generating Shakespearean text.
- Employed character-to-index and index-to-character mappings (*stoi* and *itos*) for efficient text encoding and decoding, facilitating the model's learning process from the Tiny Shakespeare dataset through supervised learning techniques.
- Demonstrated the model's generative capabilities by training it to predict subsequent characters, achieving coherent text generation, and showcased through a custom text generation function post-training, the model's ability to synthesize new textual content stylistically similar to the training dataset.

## Technical Skills

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**Machine Learning Libraries:** PyTorch, scikit-learn, OpenCV, TensorFlow

**Languages:** Python, C++, JavaScript, HTML/CSS, MATLAB, R, SQL

**Developer Tools:** VS Code, Jupyter Notebook, Google Colab, CUDA, ImageJ/Fiji

**Technologies/Frameworks:** Linux, GitHub, Flask, AWS EC2

## Leadership / Extracurricular

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### Enrai Summer 2022 – Present

*President* *University of Nigeria*

- Founded and lead Enrai, an organization dedicated to providing research experience in computer programming and optimization, focusing on solving societal problems and contributing to open-source projects.
- Direct and mentor a diverse team of 10+ members, fostering a collaborative environment to enhance skills in advanced computational techniques and real-world problem-solving.
- Successfully guided three members through comprehensive research projects and skill development, resulting in their acceptance into fully-funded Ph.D. programs at prestigious universities in the United States.