KHUSHI DESAI

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EDUCATION

M. S. Computer Science, ***Columbia University*** *Sept 2023 - Dec 2024*
Graduate GPA: 3.86
Relevant Coursework: Machine Learning for Functional Genomics; Deep Learning in Computer Vision; Computer Graphics; High Performance Machine Learning; Robot Learning; Statistical Machine Learning for Genomics

B. A. Computer Science, ***University of California, Berkeley*** *Aug 2019 - May 2023*
Undergraduate GPA: 3.64
Relevant Coursework: Deep Neural Networks; Introduction to Machine Learning; Probability and Random Processes; Operating Systems & System Programming; Introduction to Artificial Intelligence; Efficient Algorithms and Intractable Problems; Computer Security; Introduction to Database Systems; Programming Languages and Compilers

TECHNICAL SKILLS

Languages: Python, Java, JavaScript, SQL, Bash, Scheme, HTML, CSS, C, RISC-v, GoLang, MongoDB, RTcmix
Platforms, Frameworks & Libraries: PyTorch, TensorFlow, SCVI, Scanpy, Anndata, Docker, DynamoDB, Jupyter Notebooks/Lab, React, Redux, AWS, Selenium, Chrome Extensions, Alexa Skill Development, Git

RESEARCH EXPERIENCE

Graduate Research Assistant, ***Azizi Lab at Columbia University*** *New York, NY | Jan 2024 - Present*

Attention Mechanism Interpretation of Cell-cell Interactions (AMICI)
Accepted to Machine Learning in Computational Biology 2024, Seattle and Single-Cell Genomics 2024, Greece

- Developed an interpretable attention-based neural network architecture to infer cell-cell interactions in single-cell spatial transcriptomics data
- Created scripts to generate semi-synthetic spatial transcriptomics data with ground truth interactions between cell populations to validate the model's performance
- Developed tools to benchmark against existing well-known methods for inferring cell-cell interactions such as Node-centric expression models (NCEM)
- Implemented methods to interpret model performance from attention weights and prediction results
- Analyzing results of applying our model to real-world single-cell Xenium data using statistical methods and libraries

Undergraduate Researcher, ***Berkeley Artificial Intelligence Research Lab*** *Berkeley, CA | Sept 2022 - Dec 2023*

Conditional Auto-encoded Radiance Field for 3D Scene Forecasting (CARFF)
Published at European Conference on Computer Vision 2024, Italy (carff.website)

- Developed an architecture and controller, CARFF, using a combination of VAE, ViTs and NeRF to predict probabilistic scenarios and take optimal actions based on occlusions in ego-centric scenes captured by autonomous vehicles
- Trained an autoencoder to determine probabilities of edge case scenarios in the case of partial or complete occlusions on the road (obstructing cars, people, etc.)
- Trained a NeRF to generate possible scenarios based on the autoencoder's probabilistic representations for obstructions around the corner of the occlusion, to ultimately enable the vehicle to make safer decisions
- Collborated with leading authors across universities and industries such as Harvard University, Toyota Research Institute, UC Berkeley, etc.

Undergraduate Researcher, ***Sky Research Lab*** *Berkeley, CA | Jun 2022 - Nov 2022*

360 Long

- Contributed to an end-to-end system that creates a 6 degrees of freedom immersive VR experience from a 360 degree video
- Used an MLP to learn the radii of multi-sphere images (MSIs), which are used to reconstruct the view in all directions
- Used K-means algorithm to learn the average radii for the MSIs and used them to retrain the model
- Ran 12 ablations to analyze the performance of model variants and found an improvement of PSNR by 10%

Undergraduate Researcher, ***Real-Time Intelligent Secure Explainable Systems Lab*** *Berkeley, CA | Jan 2022 - May 2022*

Monocular Depth

- Researched existing technical papers on approximating monocular depth of an image
- Modified an existing approximation model to improve flat-surface monocular depth estimation by averaging depth values within patches of images
- Used a learned threshold based on these approximations during the training process to improve accuracy for resulting depth approximations

WORK EXPERIENCE

Software Development Engineer Intern, ***Amazon*** *Sunnyvale, CA | May 2023 - Aug 2023*

- Designed and implemented frontend and backend for a real-time dashboard for Alexa Smart Properties to monitor the set up of devices for hotels, hospitals, etc.
- Modified on top of existing Amazon React components to build UX of the website
- Improved daily productivity for Alexa Certification team by accurately reflecting certification details

Software Development Engineer Intern, ***Amazon*** *Sunnyvale, CA | May 2022 - Aug 2022*

- Designed and implemented frontend and Java APIs for a personalized dashboard for Alexa Voice Services Console, used by Amazon Alexa Certification team to manage third-party client certifications for integrating Alexa into their products
- Created React Redux components from scratch to build UX of the website
- Developed Java APIs to pull and transform data from internal (DynamoDB) and external databases for accurate certification details
- Improved daily productivity for Alexa Certification team by accurately reflecting accurate certification details

Solutions Architect Intern, ***NVIDIA*** *Santa Clara, CA | May 2021 - Aug 2021*

- Developed a Python perception application within a Docker container using a PyTorch semantic segmentation library and trained the neural network using Cityscapes dataset and RTX A6000 GPUs
- Modified the semantic segmentation library by building a new data loader to allow the application to evaluate custom images on the trained neural network
- Using the application, trained and evaluated the model on different levels of compute power including DGX A100 GPUs
- Using application performance analysis, created a pitch to market NVIDIA's supercomputer unit, NVIDIA SuperPOD

TEACHING

Instructor, ***InspiritAI*** *Cupertino, CA | June 2023 - Aug 2024*

- Held summer sessions for high school and middle school students to learn basic concepts of AI and ML
- Taught students to build, train and evaluate AI models using Python libraries using Jupyter Notebooks
- Guided students to incorporate their learnings into a final project, applying AI to various fields ranging from biomedical to autonomous driving applications

Research Mentor, ***Polygence*** *Cupertino, CA | June 2023 - Sept 2023*

- Held 10 session courses to mentor high school students to write a research paper on the applications of AI for software to prevent distracted driving
- Mentored students to read and analyze existing literature, identify gaps in existing methods, train existing models and software, and build conclusions for their paper

Teaching Assistant, ***Cubstart DeCal*** *Berkeley, CA | Aug 2020 - May 2022*

- Developed curriculum, homework materials and lecture content for student-run Cubstart DeCal course (full-stack development for beginners)
- Held weekly labs and taught students to combine JavaScript, HTML, CSS, React, MongoDB and authentication APIs to build their own web application from scratch

Instructor and Mentor, ***Computer Science Mentors*** *Berkeley, CA | Jan 2021 - May 2021*

- Conducted weekly meetings and teaching sessions for undergraduate students taking the Data Structures and Algorithms course at UC Berkeley

LEADERSHIP

Sponsorship Director, ***Cal Hacks*** *Berkeley, CA | Feb 2020 - Dec 2021*

- Organized sponsorship and raised over $200,000 for one of the largest collegiate hackathons at UC Berkeley, by collaborating with over 120 companies including Microsoft, Google, and Uniswap
- Hosted hack:now virtually in April 2020 (in response to COVID-19) with 2500+ participants from around the world and Steve Wozniak as keynote speaker

Hackathon & Events Lead, ***FemTech*** *Berkeley, CA | Sept 2019 - May 2021*

- Co-hosted UC Berkeley's first hackathon, FemHacks, with Cal Hacks, for underrepresented and minority undergraduate students

My research interests lie in the development and application of machine learning and computer vision methods with the aim of providing insights into treatments for conditions that impact women's health. Living with endometriosis and having watched four family members struggle with breast cancer, I am driven to learn more about the underlying biology behind these diseases and to work towards effective treatments with my research. Leveraging my strong background in computer vision research and recent experience developing methods for single-cell data, I aim to build machine learning methods for high-throughput biological data in my PhD.

I first got involved in research at RISELab in my third year of undergraduate college at UC Berkeley. I joined a team of students supervised by Professor Joseph Gonzalez to improve existing depth approximation models. While training and evaluating a state-of-the-art model called Boosting Monocular Depth Estimation to High Resolution (BMD) on complex datasets, I found it performed poorly on images with finer details. For example, a bike stand was classified as the road. Specifically, model-generated patches during training lacked the resolution needed to distinguish minute features within each patch. Using the intuition that distinct objects within a patch would have significant depth variations, we introduced a learned threshold based on the average differences in pixel depth values within each patch to aid the model training. The model improved on the original reconstruction metric, peak signal-to-noise ratio (PSNR), by 1.7.

Inspired by how depth approximation models captured meaningful 3D information from just a 2D image, I joined the Berkeley Artificial Intelligence Research (BAIR) lab to work on 3D reconstruction models. In my final year at UC Berkeley, I undertook another project with a peer under Professor Joseph Gonzalez. State-of-the-art methods, like NeRF-VAE, model beliefs of an environment's state in 3D based on visual perception. However, when I trained NeRF-VAE on complex datasets, like a car turning at obstructed intersections, reconstructions collapsed to black due to interdependent optimizations of the NeRF and variational autoencoder (VAE). I first built a new VAE architecture, a pose-conditioned VAE (PC-VAE), with the decoder conditioned on different camera angles of a scene. To avoid unstable training, I independently trained the PC-VAE and a latent-conditioned NeRF decoder, resulting in complex 3D scene reconstruction from 2D images with a PSNR of 28. To enable 3D scene forecasting, I created an inference pipeline from our model to a probabilistic mixture density model to predict possible future 3D scenes given the current occluded view. Our model generated optimal actions over 30 trials across diverse simulated driving scenarios, outperforming existing baselines. From this work, I co-authored a paper called Conditional Auto-encoded Neural Radiance Field for 3D Scene Forecasting (CARFF) that was published at ***European Conference on Computer Vision 2024***.

Subsequently, I pursued my Master's at Columbia University to expand my research experience and explore socially impactful applications of my interests. At the start of my program, I was fascinated by diverse applications in computer vision and machine learning through **Professor Peter Belheumer's** Deep Learning for Computer Vision course, **Professor David Knowles's** Machine Learning for Functional Genomics course, and collaboration with students in **Professor Carl Vondrick's** lab utilizing computer vision for climate change.

Around this time I learned that I likely had endometriosis. I was prescribed medication to reduce side-effects like excruciating pain, fainting spells, extreme nausea, and body incapacitation that had previously impacted me for years. Months later, four close family members were diagnosed with different stages of breast cancer and went through grueling treatments that derailed their lifestyles and careers. Breast cancer and endometriosis are among many health issues that impact millions of women across the world, yet they are still under-researched and challenging to diagnose and cure.

Watching and experiencing daily struggles from these conditions underscored the urgency of precise technological treatments, compelling me to pursue computational biology over other applications. I joined the Azizi Lab under **Professor Elham Azizi** to develop more accurate and interpretable models for inferring cell-cell interactions. We built a multi-head-attention-based model designed such that learned attention values would reflect interaction strengths between cells. The initial model accurately recovered ground truth interactions in simple semi-synthetic datasets, but struggled to distinguish closely interspersed cell types and predicted false positive interactions for complex cell populations. To address this, I implemented a new positional embedding for the model that resolved cell populations by combining cell type labels and relative positional information of surrounding cells. To expand downstream interpretability of the model, I wrote functions to determine significant attention heads for predicting interactions between different cell populations and important genes involved in those interactions. I used this analysis to show our model outperformed state-of-the-art models such as Node-centric expression models (NCEM). Applied to breast cancer data from high-resolution spatial profiling technology, the model recapitulated known interactions, such as between CD8 T cells and tumor cells. Our preliminary yet promising results led to a poster called Attention Mechanism Interpretation of Cell-cell Interactions (AMICI), which I presented at ***Machine Learning in Computational Biology 2024*** and ***Single Cell Genomics 2024***.

Working on AMICI exposed me to new computational methods, challenged me to view them through a biological lens, and dive deep into a new field to better guide my research. Columbia's Computer Science PhD program will provide me with the necessary set of resources and academic community to extend and grow the cumulative knowledge I have gained from research experiences at RISELab, BAIR, and the Azizi Lab. I am keen to continue work with **Professor Elham Azizi** on AMICI and computational methods to uncover the biology behind tumor progression and the formation of complex cellular structures. I hope to collaborate with **Professor David Knowles** on adapting large language models for interpreting patterns in DNA sequence data, to understand and improve treatment responses in breast cancer data.

My ambition is to pursue a research career in academia or industry and collaborate with leading machine learning scientists and pioneers in immunotherapy. I want to develop computational methods that accurately reflect nuances in real biological data, and collect high-quality patient data for improved statistical analyses. Ultimately, I hope to see my research and career contribute to enriching the lives of women like me and those in my family, by shedding a brighter light on the diseases and conditions that they deal with every day.