Penghao (Basil) RAO

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EDUCATION

The Chinese University of Hong Kong (CUHK) Hong Kong

-Bachelor of Science Degree in Mathematics | GPA: 3.52/4.0 (First Honor Class, Top 10%) Sept 2022 - Present

-Minor in Computer Science

-Core Courses: Advanced Calculus (A), Introductory Probability (A), Ordinary Differential Equation (A), Complex Variables with Applications (A), Linear Algebra (A-), Data Structures and Applications (A-)

-Award and Scholarship: Shaw College Academic Merit Scholarship (2022 – 23, 2023 - 24)

Carnegie Mellon University (CMU) Pittsburgh

-Research Internship advised by Prof. Min XU (One Year) Sep 2025 – Present

-Core Task: Efficient online computation of the influence function during model training by leveraging algorithmic uniform stability to replace explicit Hessian inversion and mitigate transformation in differentiable optimization under SGD.

Peking University (PKU) Beijing

-Summer School (Academic Sessions) July 2023 – Aug 2023 & July 2024 – Aug 2024

-Core Courses: The Laws of Economic Cycles, The Development of Modern Artificial Intelligence

PUBLICATIONS

Online Influence Function Calculation Framework Based on Algorithm Stability. *Penghao Rao, Xingjian Li, Min Xu. (In Preparation, Planned Submission: ICML)*

Edge Attention Mechanism Guided Super-Resolution Generative Adversarial Network. *Penghao Rao, Tieyong Zeng. (In Preparation, Planned Submission: CVPR)*

RESEARCH EXPERIENCE

Perform Efficient Online Calculation of Influence Function During Model Training May 2025 – Present

Model Algorithm Research Internship advised by Prof. Min XU, Dept of Computational Biology, CMU Pittsburgh

-Established a theoretical linkage between algorithmic uniform stability, a bounding generalization via small β-error, and influence function, a function predicting output perturbations under dataset modifications.

-Designed an online influence function approximation method, with an error below 1%, that exploits stability-based global smoothing to control perturbation propagation and circumvent costly, unstable Hessian inversion in non-convex and non-smooth regimes.

Improve Image Recovery Efficiency by Using SRGAN Combined with Edge Information Sep 2024 – June 2025

Computer Vision Research Assistant advised by Prof. Tieyong ZENG, Dept of Mathematics, CUHK Hong Kong

-Proposed a new composite loss function, which is the sum of pixel loss, edge loss, and VGG loss based on their respective weights in different proportions, in the backpropagation process

-Developed an Edge-SRGAN architecture incorporating Canny-extracted edge maps from low-resolution inputs into the generator pathway and a novel edge attention mechanism with an edge-guided residual block to enhance structural fidelity, resulting in a 5db resolution improvement on average.

Analysis of Output Error for a Network Using Super-Expressive Activation Function Dec 2024 – Mar 2025

Model Interpretability Research Assistant advised by Prof. Fenglei FAN, Dept of Mathematics, CUHK Hong Kong

-Analyzed output error behavior when using super-expressive activation functions, such as $x - \text{floor}(x)$, trigonometric classes, and so on.

-Derived explicit relationships between input perturbations and output error, theoretically supporting an average 22% error reduction via such activation choices.

Real-Time Scenery Recovery with Physical Light Scattering Method and CUDA C Program Jan 2024 - May 2024
Computer Vision Research Assistant advised by Prof. Tieyong ZENG, Dept of Mathematics, CUHK Hong Kong
-Implemented a CUDA-accelerated real-time super-resolution pipeline integrating rank-one approximation, physical light scattering models, and linear projection for transmission estimation in low-visibility conditions, such as fog and sandstorms.
-Compared with traditional deep learning methods, the CUDA-accelerated physical light refraction restoration method I designed shortens the program running time by 3.7 seconds and achieves real-time restoration well.

INTERNSHIP EXPERIENCE

Python Serial Port for Robotic Signal Process May 2024 – Aug 2024
Sony (China) Co. LTD, advised by Dr. Xusheng DU (Ph.D. Houston University) Shenzhen
-Developed a concise Python-based serial communication control module for a 300+ kg demonstration robot used at the Greater Bay Area Exhibition.
-Conducted 100+ structured experiments over varied terrains to profile velocity, acceleration, and stride metrics, validating precision and responsiveness of the control interface.

PROJECTS

Numerical Algorithms for Path-Dependent Partial Differential Equations (PPDEs) July 2025 – Present
Math Major Final Year Project advised by Prof. Xiaolu TAN, Dept of Mathematics, CUHK Hong Kong
-Investigated machine learning–based approximation strategies for PPDE solutions.
-Designed discretization schemes adapted to path dependence, and employed dimensionality reduction and sparse representation techniques for high-dimensional path spaces.
-Provided rigorous stability and error bounds for proposed numerical methods.

Web App for Checking Locations with HTML, CSS, Java and MongoDB Nov 2024 – Dec 2024
Computer Science Course Project advised by Dr. Colin TSANG, Dept of Computer Science, CUHK Hong Kong
-Implemented secure login with hashed credential storage supporting default and newly registered accounts.
-Built integrated user and admin dashboards enabling CRUD operations on events, location filtering, favorites, and booking workflows.

SKILLS

Programming Skills: Proficient in Python, C programming, MATLAB, HTML, JavaScript
LLM Skills: Expert in using the diffusion Model and PyTorch package, familiar with the Linux OS environment
Language Skills: Native Mandarin, Fluent English (26 in TOEFL Speaking part)

EXTRACURRICULAR ACTIVITIES

Stage Manager of The Chinese University of Hong Kong Mandarin Drama Club Sep 2022 - Nov 2022
-Led a 15-participant team in CUHK to hold a drama collaboration with The Mandarin Drama Clubs of HKU and HKUST.

Organizer of The Chinese University of Hong Kong Mainland Students' Sports Festival Oct 2022 – Nov 2022
-Led a 30-volunteer team to organize multiple events like the Sports Festival and Student E-Sports Competition.