

# 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

**Edge-Aware Normalized Attention for Efficient and Detail-Preserving Single Image Super-Resolution.** Penghao Rao, Tiejiong Zeng. (Pre-print: <http://arxiv.org/abs/2509.14550>. Planned Submission: CVPR)

**SG-OIF: A Stability-Guided Online Influence Framework for Reliable Vision Data.** Penghao Rao, Runming Jiang, Min Xu. (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 an algorithm stability-guided real-time reliability controller, and a confidence calibration for online calculation of the influence function.

-Designed a Stability-Guided Online Influence Framework (SG-OIF) for predicting the influence of a training data point on the outputs, achieving 78.6% accuracy in the top 1% prediction sample for noise label detection and 5 % accuracy improvement in the distribution shift monitoring task.

### Improve Image Recovery Efficiency by Using SRGAN Combined with Edge Information

Sep 2024 – June 2025

Computer Vision Research Assistant advised by Prof. Tiejiong ZENG, Dept of Mathematics, CUHK

Hong Kong

-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

-Designed 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.

-Conducted more than 50 experiments, demonstrating that this model results in a 1.5dB 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. Tiejong 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.