Satwik **Kundu**

PhD Candidate | Penn State

satwik-kundu @ mail@satwik-kundu.me Google Scholar

Education

Present – Aug 2021 | **Pennsylvania State University** — **State College, PA**
Doctor of Philosophy (Ph.D.) in Computer Science & Engineering
Thesis (Tentative): *Enhancing the Efficiency and Security of Variational Quantum Algorithms*
Advisor: Prof. Swaroop Ghosh

June 2021 – July 2017 | **Jadavpur University** — **Kolkata, India**
Bachelor of Engineering (B.E.) in Information Technology
Thesis: *Facial Expression Recognition using Convolutional Neural Networks*
Advisor: Prof. Somenath Dhibar

Professional Experience

Present – June 2022 | **Penn State University | School of EECS** — **State College, PA**
Graduate Research Assistant | Advisor: Prof. Swaroop Ghosh
Working on evaluating and improving the security and optimization efficiency of variational quantum algorithms (VQAs) along with their applications.

Dec 2022 – May 2022 | **Semiconductor Research Corporation (SRC)** — **State College, PA**
Research Scholar | Advisors: Dr. Rasit O. Topaloglu, Prof. Suzanne Mohney, Prof. Shengxi Huang, Prof. Swaroop Ghosh
Evaluated performance gain for NbAs-based interconnects in cache memories.

May 2022 – Aug 2021 | **Penn State University | School of EECS** — **State College, PA**
Graduate Teaching Assistant | Instructors: Prof. Ishan Behoora, Prof. Griselda Conejo-Lopez
Held recitations, review sessions, office hours, and graded assignments for CMPSC 131 and CMPSC 132.

June 2021 – Nov 2019 | **Jadavpur University** — **Kolkata, India**
Undergraduate Research Assistant | Advisors: Prof. Ram Sarkar, Prof. Pawan Kumar Singh, Prof. Somenath Dhibar
Worked on language identification using MFCC features and facial expression recognition using CNNs.

Nov 2020 – May 2020 | **Indian Institute of Technology Kharagpur | SEAL** [🌐] — **Kharagpur, India**
Research Intern | Advisors: Dr. Manaar Alam, Prof. Debdeep Mukhopadhyay
Performed microarchitectural side-channel attack on Docker containers to assess security vulnerabilities.

Honors and Awards

[**2025**] **Best Paper Finalist** Selected for Best Paper & Best Student Paper Awards at HOST 2025.

[**2024**] **IBM Quantum Credits** Received $70,000 in IBM credits for my research on improving efficiency of VQAs.

[**2022**] **Graduate Research Award** One of only two students in the Department of Computer Science and Engineering at Penn State to be recognized with this award for outstanding research contributions.

[**2015**] **Gold Medal** Received a gold medal at the International Olympiad of Mathematics (iOM), organized by SilverZone.

[**2015**] **Silver and Bronze Medal** Received a silver medal in the individual contest and a bronze medal in the team contest at the International Young Mathematicians Convention (IYMC).

Publications

S=In Submission, C=Conference, W=Workshop, J=Journal, B=Book Chapter, * = Equal Contribution

[S-2] **Reverse-Engineering Quantum Circuit Compilation: A Framework for Identifying Optimization Techniques**
Satwik Kundu, Swaroop Ghosh
[Working Paper]

[B-2] **Adversarial Threats in Quantum Machine Learning: A Survey of Attacks and Defenses**
Satwik Kundu, Archisman Ghosh, Swaroop Ghosh
Quantum Robustness in Artificial Intelligence, 2025 [Working Chapter] [**Springer'25**]

[S-1] **Adversarial Poisoning Attack on Quantum Machine Learning Models**
Satwik Kundu, Swaroop Ghosh
[In Submission]

[J-2] **Towards Efficient Optimization of Variational Quantum Algorithms with Parameter Prediction**
Satwik Kundu, Debarshi Kundu, Swaroop Ghosh
IEEE Transactions on Quantum Engineering, 2025 [In Review] **[TQE'25]**

[C-7] **STIQ: Safeguarding Training and Inferencing of Quantum Neural Networks from Untrusted Cloud**
Satwik Kundu, Swaroop Ghosh
17th IEEE International Symposium on Hardware Oriented Security and Trust, 2025 [Best Paper Finalist] **[HOST'25]**

[W-1] **SoK: Security Concerns in Quantum Machine Learning as a Service**
Satwik Kundu, Swaroop Ghosh
13th ACM International Workshop on Hardware and Architectural Support for Security and Privacy, 2024 **[HASP @ MICRO'24]**

[C-6] **Evaluating Efficacy of Model Stealing Attacks and Defenses on Quantum Neural Networks**
Satwik Kundu, Debarshi Kundu, Swaroop Ghosh
34th IEEE/ACM Great Lakes Symposium on VLSI, 2024 **[GLSVLSI'24]**

[C-5] **Knowledge Distillation in Quantum Neural Network using Approximate Synthesis**
Mahabubul Alam, Satwik Kundu, Swaroop Ghosh
28th IEEE/ACM Asia and South Pacific Design Automation Conference, 2023 **[ASP-DAC'23]**

[J-1] **Exploring Topological Semi-Metals for Interconnects**
Satwik Kundu*, Rupshali Roy*, M. Saifur Rahman, Suryansh Upadhyay, Rasit Onur Topaloglu, Suzanne E. Mohney, Shengxi Huang, Swaroop Ghosh
Journal of Low Power Electronics and Applications, 2023 **[JLPEA'23]**

[C-4] **Quantum Machine Learning for Material Synthesis and Hardware Security**
Satwik Kundu*, Collin Beaudoin, Rasit Onur Topaloglu, Swaroop Ghosh
41st IEEE/ACM International Conference on Computer-Aided Design, 2022 **[ICCAD'22]**

[C-3] **Security Aspects of Quantum Machine Learning: Opportunities, Threats and Defenses**
Satwik Kundu, Swaroop Ghosh
32nd IEEE/ACM Great Lakes Symposium on VLSI, 2022 **[GLSVLSI'22]**

[C-2] **On the Reliability of Conventional and Quantum Neural Network Hardware**
Mehdi Sadi, Yi He, Yanjing Li, Mahabubul Alam, Satwik Kundu, Swaroop Ghosh, Javad Bahrami, Naghmeh Karimi
40th IEEE VLSI Test Symposium, 2022 **[VTS'22]**

[C-1] **Quantum-Classical Hybrid Machine Learning for Image Classification**
Mahabubul Alam, Satwik Kundu, Swaroop Ghosh
40th IEEE/ACM International Conference On Computer Aided Design, 2021 **[ICCAD'21]**

[B-1] **Spoken Language Identification of Indian Languages using MFCC Features**
Mainak Biswas, Saif Rahaman, Satwik Kundu, Pawan Kumar Singh, Ram Sarkar
Machine Learning for Intelligent Multimedia Analytics: Techniques and Applications, 2021 **[Springer'21]**

Patents

I=Invention Under Review, P=Patent

[P-1] **Parameter Prediction to Accelerate Convergence of Hybrid Quantum-Classical Algorithms**
Satwik Kundu, Debarshi Kundu, Swaroop Ghosh
Provisional Patent Application No. 63/498,829

[I-2] **Accelerating Deep Learning Through Parameter Prediction**
Satwik Kundu, Debarshi Kundu, Swaroop Ghosh
Invention Discloser # 2023-5622 [In Review]

[I-1] **A Novel Hybrid Interconnect with Topological Semi-Metals**
Satwik Kundu, Rupshali Roy, Swaroop Ghosh
Invention Discloser # 2023-5608 [In Review]

Talks & Presentations

"STIQ: Safeguarding Training and Inferencing of Quantum Neural Networks from Untrusted Cloud"
› [Oral] International Symposium on Hardware Oriented Security and Trust (HOST) May 2025 (San Jose, CA, USA)

"Enhancing Efficiency and Security of Variational Quantum Algorithms"
› Department of Computer Science, Colorado School of Mines Feb 2025 (Golden, CO, USA)

"Security of Quantum Machine Learning Models"
› 2nd Quantum Computer Cybersecurity Symposium (QCCS), Yale University Oct 2024 (New Haven, CT, USA)

"Security Concerns in Quantum Machine Learning as a Service"
› [Oral] Workshop on Hardware and Architectural Support for Security and Privacy Nov 2024 (Austin, TX, USA)

"Knowledge Distillation in Quantum Neural Network Using Approximate Synthesis"

› [Oral] Asia and South Pacific Design Automation Conference (ASP-DAC) Jan 2023 (Tokyo, Japan)

"Security Aspects of Quantum Machine Learning: Opportunities, Threats and Defenses"

› [Oral] Great Lakes Symposium on VLSI (GLSVLSI) June 2022 (Irvine, CA, USA)

"A Shuttle-Efficient Qubit Mapper for Trapped-Ion Quantum Computers"

› [Poster] Great Lakes Symposium on VLSI (GLSVLSI) June 2022 (Irvine, CA, USA)

Academic Services

Reviewer

2025	Elsevier Neurocomputing
2025	IEEE Computer Architecture Letters (CAL)
2023-2024	International Conference on Quantum Computing and Engineering (QCE)
2022-24	International Symposium on Microarchitecture (MICRO)
2023-24	Design Automation and Test in Europe (DATE)
2023-24	Asia and South Pacific Design Automation Conference (ASP-DAC)
2023-24	International Symposium on Hardware Oriented Security and Trust (HOST)
2024	International Symposium on Computer Architecture (ISCA)
2024	International Conference on Computer-Aided Design (ICCAD)
2023	International Conference on Computer Design (ICCD)

Research Experience

Pennsylvania State University Aug'21 - Present

Graduate Research Assistant

› Implemented a novel indiscriminate data poisoning attack on QNNs, resulting in over 90% accuracy degradation.
› Developed a novel framework to safeguard QNNs against cloud-based adversaries; enhanced model security by ≈70%.
› Evaluated efficacy of model stealing attacks on QNNs. Proposed novel perturbation based defense techniques.
› Implemented a prediction technique to accelerate optimization of VQAs by upto 3.3× while requiring 2.5× fewer shots.
› Evaluated performance gain for NbAs-based interconnects in caches and observed IPC improvement of up to 23.8%.
› Built QML models to explore applications in addressing hardware security challenges, such as classifying PCB defects.
› Explored the QNN design space, like encoding and PQC architectures, to optimize image classification accuracy.
› Proposed knowledge distillation with approximate synthesis to compress pre-trained QNNs, minimizing retraining.

Jadavpur University Nov'19 - June'21

Undergraduate Research Assistant

› **Language Identification:** Developed a spoken language identification framework using MFCC features for the recognition of the six most widely used spoken languages in India.
› Trained a SVM Classifier with static and delta features. Discovered that the best results are obtained using only 13 static features and adding delta and delta-delta features reduces performance.
› **Emotion Recognition:** Developed a Keras-based facial expression recognition system for identifying facial expressions. Trained the model on the FER2013 database and achieved an accuracy of 72.34%.

Indian Institute of Technology Kharagpur June'20 - Nov'20

Research Intern

› Built a Docker-containerized client-server framework featuring the AES-128 encryption server (T-table version).
› Conducted a microarchitectural side-channel attack (Flush+Reload) on the framework, demonstrating the challenges of key extraction via cache attacks in containerized environments.

Mentoring

[**2023 - Present**] **Archisman Ghosh** PhD in CSE, Penn State

[**2022 - Present**] **Debarshi Kundu** PhD in CSE, Penn State

[**2022 - Present**] **Rupshali Roy** PhD in EE, Penn State

[**2021**] **Kevin Lin** BS in CS, Penn State

Teaching Experience

Object-Oriented Programming and Data Structures (CMPSC 132) *Graduate Teaching Assistant* Spring 2022

- Managed two recitation sections with over 140 undergraduate students, facilitating weekly quizzes and office hours.
- Organized review sessions and graded assignments and exams, providing detailed feedback to support student learning.

Fundamentals of Programming and Algorithm Design (CMPSC 131) *Graduate Teaching Assistant* Fall 2021

- Led three recitations with over 200 undergraduate students from various departments, delivering weekly lectures.
- Conducted weekly office hours, graded assignments, and developed course materials, including quizzes & assignments.

Media Coverage

[2023] **Interconnects: Exploring Semi-Metals, Semiconductor Engineering** Semiconductor Engineering

[2022] **Quantum Machine Learning: Security Threats & Lines Of Defense** Semiconductor Engineering

Technical Skills

Languages	Python, C/C++, HTML/CSS, JavaScript, SQL, LaTeX, Flask.
Tools	GDB, VS Code, Docker, Eclipse, GitHub, MATLAB, gem5, MySQL, SQLite.
Libraries	Qiskit, PennyLane, PyTorch, TensorFlow, Jax, NumPy, Pandas, Scikit, OpenCV, Keras, OpenMP, MPI, CUDA.

Academic Projects

Analyzing BLIP for Image-Text Retrieval Dec'23

Pennsylvania State University

- Finetuned BLIP model on Flickr30K dataset achieving near SOTA results despite hardware constraints (batch size: 8).
- Leveraged CapFilt mechanism to mitigate noisy data, synthesizing captions and filtering mismatched image-text pairs.
- Conducted hyperparameter tuning (lr: $10^{-4}, 10^{-5}, 10^{-6}$) and achieved a 2.7% average R@1 improvement over baseline.

Visual Question Answering with Multi-Modal Fusion Nov'23

Pennsylvania State University

- Developed an end-to-end VQA model that integrates a VGG16-based CNN for image feature extraction with an LSTM-based encoder for natural language processing, enabling efficient multi-modal information fusion.
- Designed a custom fusion module employing multiple transformation layers, dropout regularization, and multiplicative interactions to seamlessly combine image and question embeddings, followed by an MLP for answer classification.

Visual Grounding with DETR and BERT Oct'23

Pennsylvania State University

- Developed a visual grounding model by integrating a DETR-based visual backbone with a BERT text encoder, enabling effective fusion of image and language modalities for precise object detection.
- Implemented a novel visual-linguistic fusion module utilizing a learnable token, transformer architecture, and custom projection layers, optimized with GIoU and Smooth L1 loss functions for bounding box regression.

Image Captioning with Encoder-Decoder Architecture Sep'23

Pennsylvania State University

- Developed an captioning model by integrating a CLIP-based vision encoder with a transformer mapping module and a GPT-2 text decoder, enabling robust and coherent caption generation.
- Engineered key components including image-to-text embedding transformation, custom positional embedding integration, and dynamic token decoding using pre-trained transformer APIs to enhance model performance.

CUDA-based Blocked All-Pair Shortest Path April'23

Pennsylvania State University

- Developed a CUDA-based blocked APSP algorithm, achieving a $56\times$ speedup by leveraging advanced blocking, shared memory optimizations, and loop unrolling.
- Explored various block sizes; found 16×16 optimal for performance, minimizing cache misses and balancing ILP.

MPI + OpenMP Distributed Algorithm March'23

Pennsylvania State University

- Implemented a distributed version of the Floyd-Warshall algorithm, achieving $1.94\times$ speedup for $1,000$-vertex graph.
- Handled uneven graph partitions with MPI Scatterv/Gatherv, ensuring correctness even when vertices were not divisible by the number of processes and threads.

References

Prof. Swaroop Ghosh (Advisor)
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