Abdelrahman S. Abdelrahman

Curriculum Vitae

PhD candidate in Electrical and Computer Engineering specializing in machine learning, stochastic optimization, and scalable probabilistic algorithms.

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Publications	Google Scholar
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EDUCATION

PhD Electrical and Computer Engineering Jan 2026–Present
University of California, Santa Barbara
Thesis: Probabilistic Approximate Optimization
GPA: 4.0/4.0

MSc Electrical and Computer Engineering Sep 2023–Dec 2025
University of California, Santa Barbara
GPA: 4.0/4.0

BSc Electrical and Electronics Engineering Sep 2017–May 2022
King Fahd University of Petroleum and Minerals
Ranked 1st with GPA: 3.99/4.0

RESEARCH

My research focuses on developing scalable machine learning and optimization algorithms based on probabilistic modeling and stochastic processes. I study how controlled randomness can be used to efficiently explore high-dimensional, non-convex objective functions arising in optimization and learning.

I develop learning-based optimization methods where sampling dynamics are treated as adaptive, parameterized processes rather than fixed procedures. My work spans variational Monte Carlo, probabilistic approximate optimization algorithms (PAOA), and sampling strategies, with applications to combinatorial optimization and inference.

More broadly, my research lies at the **intersection of machine learning, optimization, and statistical modeling**, with an emphasis on designing algorithms that are both theoretically grounded and scalable to large systems.

SELECTED JOURNAL PUBLICATIONS

J4. **A. S. Abdelrahman**, S. Chowdhury, F. Morone, K. Y. Camsari, Generalized Probabilistic Approximate Optimization, Nature Communications, 17, 498 (2026).

JOURNAL PUBLICATIONS

J7. S. Bunaiyan, C. Delacour, S. Chowdhury, K. Lee, **A. S. Abdelrahman**, K. Y. Camsari, Isingformer: Augmenting parallel tempering with learned proposals, In review, (2026).

J6. C. Delacour, X. Zhang, **A. S. Abdelrahman**, S. Bunaiyan, K. Lee, S. Chowdhury, K. Y. Camsari, Probabilistic Algorithms for Ising Machines: From Optimization to Generative AI, Nature Reviews Electrical Engineering, (2026).

J5. Z. Alsawidan*, **A. S. Abdelrahman***, Md S. Sajal*, S. Chowdhury, K. Lin, H. Guthrie, S. Seshan, S. Blanton, F. Morone, M. Dandin, K. Y. Camsari, T. Srimani, npj Unconventional Computing, In press, (2026).* Equal contribution.

J3. F. Al-Dirini, **A. S. Abdelrahman**, H. ElSawy, Y. Yuan, S. Cheema, D. Akinwande, and M. Lanza, Defect-Aware Extreme Device Scaling Limits of 2D Memristive Technologies, Under review (2025).

J2. O. Khalifa, A. S. Mohammed, A. Alhejab, **A. S. Abdelrahman**, A. Al-Radhwan, R. Zhagypar, H. ElSawy, N. Kouzayha, N. Al-Harthi, J. Elmirghani, Z. Aksoy, and T. Y. Al-Naffouri, Energy-Efficient Aerial Data Aggregation for IoT: From Prototyping to Large-Scale Implementation, IEEE Transactions on Instrumentation and Measurement, vol. 74, pp. 1-18 (2024).

J1. F. H. Alharbi, **A. S. Abdelrahman**, A. M. Alkathiry, and H. M. Al-Qahtani, Energy Transfer and Coherence in Coupled Oscillators with Delayed Coupling: A Classical Picture of Two-Level Systems, Physica Scripta, 97(8), (2022).

CONFERENCE PUBLICATIONS

C5. S. Bunaiyan*, M. Alsharif*, **A. S. Abdelrahman**, H. ElSawy, S. S. Cheema, S. A. Fahmy, K. Y. Camsari, and F. Al-Dirini, Configurable p-Neurons Using Modular p-Bits, ISCAS-IEEE International Symposium on Circuits and Systems, (2026).* Equal contribution.

C4. A. S. Mohammed, O. Khalifa, A. Alhejab, **A. S. Abdelrahman**, A. Al-Radhwan, H. ElSawy, N. Kouzayha, N. Al-Harthi, J. Elmirghani, M. Hanif, and T. Y. Al-Naffouri, Demo Abstract: Energy-Efficient Aerial Data Aggregation in IoT Networks with WuR, IEEE International Black Sea Conference on Communications and Networking, pp. 147-149 (2023).

C3. **A. S. Abdelrahman**, H. ElSawy, M. Lanza, D. Akinwande, and F. Al-Dirini, Scalability of h-BN Based Memristors: Yield and Variability Considerations, Silicon Nanoelectronics Workshop (2023).

C2. T Ballal, **A. S. Abdelrahman**, A. H. Muqaibel, and T. Y. Al-Naffouri, An Adaptive Regularization Approach to Portfolio Optimization, ICASSP - IEEE International Conference on Acoustics, Speech and Signal Processing, pp. 5175-5179 (2021).

C1. **A. S. Abdelrahman**, H. M. Al-Qahtani, and F. H. Alharbi, A Comparison of Numerical Solvers for the Delay Eigenvalue Problem of Coupled Oscillators, Journal of Physics: Conference Series, 1730(1) (2021).

PROFESSIONAL EXPERIENCE

Graduate Student Researcher—OPUS Lab, UCSB Sep 2023–Present

- **Quantum-inspired Algorithm**. Developed the Generalized Probabilistic Approximate Optimization Algorithm (PAOA): a variational Monte Carlo algorithm inspired by QAOA. (manuscript, <code>)
- **Hardware Implementation**. Implemented a probabilistic algorithm on 64×64 perimeter-gated single-photon avalanche diode (pgSPAD) array fabricated in 0.35 µm CMOS. (manuscript, <code>)
- **On-Chip Deployment**. Implemented variational annealing on FPGA hardware, recovering conventional simulated annealing and achieving an $800\times$ speedup in flips/ns. (manuscript, <code>)

Handshake AI Fellow—Trainer and Reviewer, Handshake AI May 2026–Present

- **Project Peacock.** Selected for PhD-level STEM expertise to create and review graduate-level benchmarks for large language models; completed +20 problems, each receiving 5/5 quality ratings across three review stages.
- **Project Ozone (Anthropic).** Developed long-form AI evaluations for electrical engineering and computer engineering workflows.

Data Scientist—Computer Vision, Wakeb Aug 2022–Sep 2023

Led end-to-end implementation of 4+ large-scale computer vision projects (∼0.5M each) for major clients, including Saudi Water Authority, Alfanar Electric, and the Islamic Development Bank.

- **Dataset Engineering**. Curated and processed (∼100,000) images for fine-tuning large object-detection models. (report, <code>)
- **Detection** & **Tracking**. Built pipelines combining YOLOv5 and ByteTracker for real-time monitoring with high (99%) accuracy. (report, <code>)
- **Hardware Acceleration**. Deployed optimized vision models on NVIDIA edge device, enabling (10x) faster inference. (report, <code>)

Researcher—Neurotronics Lab, KFUPM Aug 2020–Sep 2022

- **Device Characterization**. Characterized the yield and variability of (0.33 nm) two-dimensional memristive technology. (manuscript)
- **Predictive Modeling**. Developed a defect-aware statistical model via stochastic geometry to predict operational voltage. (manuscript)
- **Scaling Extrapolation**. Evaluated the physical requirements and defect-based constraints for nanoscale miniaturization. (manuscript)

Research Intern—Information Science Lab, KAUST June 2020–Sep 2020

Led a research project in the field of regularization and covariance matrix approximation. (manuscript)

TEACHING

Research Mentor—Research Mentorship Program (RMP), UCSB — Summer 2026

Mentored a four-week research project, **Protein Folding Using Variational Annealing**, guiding a student through problem formulation, a tested HP lattice-folding environment, REINFORCE baselines and benchmarks, and a final report/presentation. (project description)

Instructor—Introduction to Research in STEM, UCSB — Summer 2026

Designed and delivered **INT 93LS–001: Probabilistic Computing**, an intensive summer course introducing students to Monte Carlo sampling, Metropolis-Hastings, Gibbs sampling, Ising and Potts models, simulated annealing, discrete optimization, probabilistic machine learning, and stochastic neural networks.

(lecture slides, lecture notes)

Teaching Assistant—ECE Department, UCSB

Led discussion sections and labs for 100+ students, translating complex concepts into accessible material, designing assessments, and mentoring student progress.

- Digital Design Principles (**ECE 152A**): timing diagrams, propagation delay, latches and flip-flops, shift registers and counters, Mealy/Moore finite state machines, Verilog, 2-phase clocking, timing analysis (Winter 2026). (material, feedback)
- Signal Analysis and Processing (**ECE130A**): analysis of continuous-time linear systems in time and frequency domains, including convolution, Laplace and Fourier transforms (Winter 2024, Winter 2025). (material, feedback)
- Introduction to Applied Linear Algebra (**ECE130C**): matrix arithmetic, vector spaces, orthogonality, matrix factorizations, determinants, eigenvalues and eigenvectors, difference and differential equations (Spring 2024). (material, feedback)

SELECTED PROJECTS

Probabilistic Approximate Optimization—UC Santa Barbara · New York University · Carnegie Mellon University

Led the full implementation of a new variational MCMC algorithm called PAOA (see [J5, J4] in the Publications section). **Skills used**: FPGA/MATLAB/C++/HPC.

Smart Alerting System—Alfanar Electric

Delivered a computer vision system (99% accuracy) for personnel detection in high-voltage testing, enabling automated safety shutdowns. **Skills used:** PyTorch, YOLO, ByteTrack, C++, NVIDIA Jetson. (video demo)

Aware: Data-driven-based Deep Learning System—Saudi Water Authority

Developed and deployed a real-time computer vision system across 100+ security cameras for crowd management, operating autonomously with a secure offline dashboard. **Skills used:** PyTorch/YOLO. (video demo)

TECHNICAL SKILLS

Programming: Python, C++, MATLAB
Machine Learning: Optimization, probabilistic modeling, stochastic processes, Monte Carlo methods
Tools: PyTorch, NumPy, HPC, parallel computing
Systems: FPGA, hardware-accelerated computing

SELECTED AWARDS AND HONORS

- International Doctoral Recruitment Fellowship, UCSB.
- Ranked 3rd in a poster competition at the Future of Semiconductor Forum (KAUST, 2026).
- Best Senior Design Project (2022), KFUPM. (manuscript, <code>)

PROFESSIONAL ACTIVITIES

Invited Talks

- Is Quantum Advantage Overhyped? A Probabilistic Analogue to QAOA, UCSB, Sep. 1, 2026.
- Accelerated Convergence in Glassy Energy Landscapes via Variational Learning, UCSB, June 15, 2026. (recording)
- Learning the Sampler: The Probabilistic Approximate Optimization Algorithm, UCSB, Nov. 21, 2025. (video, slides)
- Bypassing Non-differentiability Straight-Through and Applications, UCSB, Oct. 31, 2025. (slides)
- ADAM Optimizer: History, Convergence, and Practical Insights, UCSB, Dec. 3, 2024. (video, slides)

Referee Activities

- Science Advances (AAAS).
- IEEE Journal on Exploratory Solid-State Computational Devices and Circuits.