Gobinda Saha

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Objective

I am actively pursuing a full-time engineering or research position focused on AI/ML algorithm and system design. I have 6 years of research experience and solid background in deep learning algorithm design with coding proficiency in Python and PyTorch. I am interested in research and development of scalable and efficient AI technologies for computer vision, natural language processing, autonomous AI and generative AI applications.

Education

Purdue University, West Lafayette, Indiana, USA
PhD in Electrical and Computer Engineering (Deep Learning) **Aug. 2017 – Oct. 2023 (expected)**

Bangladesh University of Engineering and Technology (BUET), Bangladesh
Master of Science (M.Sc.) in Electrical and Electronic Engineering **May 2013 – Aug. 2015**

Bangladesh University of Engineering and Technology (BUET), Bangladesh
Bachelor of Science (B.Sc.) in Electrical and Electronic Engineering **Jan. 2008 – Feb. 2013**

Domain Skills

Deep Learning (DL) Algorithms: Continual & Online Learning, Meta/Few-shot Learning, Transfer & Multi-task Learning, Decentralized & Federated Learning, Supervised/Self-supervised Learning, Out-of-Distribution Detection, Adversarial Training
DL Optimization: Orthogonal, Scaled & Natural Gradient Descent, Second-order & Bi-level Optimization
DL Techniques: Model Compression/Pruning, Distillation, Quantization, Regularization, Hardware-aware Training
Text Analytics: Natural Language Processing (Language Models, Transformers), Vision-Language (Multimodal) Models
Visualization Tools: Saliency Maps (Grad-CAM, Smooth-Grad), Loss-landscapes and Input/Embedding Space Visualization
Applications: Computer Vision (Object Localization, Detection, Image Synthesis), Reinforcement Learning (Model-free RL)
Data Analytics: Principal Component Analysis (PCA), Singular Value Decomposition (SVD)
Programming Languages: Python (Expert), C (Intermediate), C++ (Basic), Julia (Basic)
DL Frameworks/Technologies: PyTorch (Expert), TensorFlow (Basic), AWS (Amazon Elastic Compute Cloud)

Research Experience

Nanoelectronics Research Laboratory & Center for Brain-Inspired Computing, Purdue University
Graduate Research Assistant | Advisor : Professor Kaushik Roy **Aug. 2017 – Present**
Skills: Python, PyTorch, torchvision, torchmeta, opencv, numpy, panda, scikit-learn, matplotlib, gym, CUDA, Anaconda

- **Overcoming Catastrophic Forgetting during Continual Learning (CL) in Neural Networks**
  - Invented Gradient Projection Memory (GPM)[4] to store important gradient spaces of each task during CL
  - Obtained near zero forgetting on continual object classification tasks through orthogonal gradient descent to GPM
  - Proposed Scaled Gradient Projection (SGP)[1] algorithm relaxing strict orthogonal gradient constraints in GPM
  - Attained up to 2% higher accuracy in continual image classification and 12% more reward in reinforcement learning (Atari games) tasks than SOTA with minimal forgetting in SGP
  - Introduced SPACE[5] algorithm to optimally allocate resources for each CL task by network pruning and growth
  - Achieved zero forgetting with SPACE and up to 5x energy efficiency during inference due to emerging sparsity
- **Explainable Learning and Meta-Learning for Fast Online Continual Learning (OCL)**
  - Invented an experience replay method (EPR)[2] with episodic memory utilizing explainable AI (XAI) tools - saliency maps for memory selection
  - Attained up to 5% accuracy improvement over SOTA on OCL object classification benchmarks with tiny memories
  - Proposed a meta-optimization algorithm - Amphibian[9] for episodic memory-free online fast continual learning
  - Obtained up to 4% higher accuracy on computer vision tasks with meta-learned gradient scaling in Amphibian
- **Communication Efficient and Data Private Decentralized Continual Learning (DCL)**
  - Collaborated in a team of 4 to design CoDeC[10] - a DCL algorithm - combining orthogonal gradient projections with gossip-averaging among distributed agents ensuring inter-agent data privacy
  - Achieved SOTA accuracy on 3 DCL image classification benchmarks with up to 4.8x reduced communication cost

Internship Experience

GlobalFoundries, Santa Clara, CA, USA

Research Intern, Memory Solution Team | Mentor : M. Ahosan Ul Karim **Jun. 2019 – Aug. 2019**

Skills: Python, PyTorch, CUDA, HSPICE, Cadence, AWS (Amazon Elastic Compute Cloud)

- **Software Framework for Hardware-Algorithm Co-design for Deep Learning Applications**
  - Proposed a 10T bit-cell based IMC primitive for accelerating binary neural network inference as part of a team of 6
  - Developed a Python-HSPICE based software framework for hardware-algorithm co-design and measured performance of in-memory computing (IMC) arrays on DL workloads under nonidealities and process variations [6]

Teaching Experience

Bangladesh University of Engineering and Technology (BUET), Bangladesh

Faculty Member, Dept. of Electrical and Electronic Engineering **Aug. 2014 – Aug. 2017**

- Taught electrical circuits and digital electronics theory courses to undergraduate classes of 65 students each
- Supervised over 200 students in VLSI laboratory courses and projects with step-by-step instructions, guiding them to learn good circuit/hardware design practices with Cadence and HSPICE tools
- Complied coding assignments and guided 100 students to solve problems with numerical techniques in MATLAB

Projects

Interior Point Linear Program (IPLP) Solver | Skill: *Julia* **May 2020**

- Implemented IPLP solver in Julia based on Mehrotra's Predictor-Corrector algorithm with modified Cholesky factorization

Hardware Accelerator Design for Neural Network Inference on FPGA | Skills: *Verilog, Quartus* **Dec. 2018**

- Built a hardware accelerator for MLP on Altera DE2-115 FPGA board to reduce inference time for MNIST classification

Photonic IMC Primitives Design for Spiking Neural Networks (SNNs) | Skills: *COMSOL, MATLAB* **Jan. 2018**

- Designed spiking neuron and synaptic arrays based on GST (phase change material) embedded optical micro-ring resonators to realize energy-efficient and fast photonic computing primitives [7,8]
- Developed a device-circuit-algorithm co-design framework to evaluate their performance as SNN inference engine

Relevant Coursework

- Machine Learning (Python, TensorFlow)
- Computational Methods in Optimization (Julia, Python)
- Natural Language Processing (Online Courses)
- Data Structures and Algorithms (Python)
- MOS VLSI Design (Cadence, HSPICE)
- Advanced VLSI Design
- System On Chip Design (Verilog, Quartus)
- Solid State Devices

Selected Publications

1. G. Saha, K.Roy, "Continual Learning with Scaled Gradient Projection", AAAI, vol. 37, no. 8, pp. 9677-9685, Jun. 2023.
2. G. Saha, K.Roy, "Saliency Guided Experience Packing for Replay in Continual Learning", Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision (WACV), 5273-5283, 2023. (**Award Finalist - Top 1% paper**)
3. G. Saha, C Wang, A Raghunathan, K Roy, "A cross-layer approach to cognitive computing", Proceedings of the 59th ACM/IEEE Design Automation Conference (DAC), 1327-1330, 2022.
4. G. Saha, I.Garg, K.Roy, "Gradient Projection Memory for Continual Learning", International Conference on Learning Representations (ICLR), 2021. (**Oral Presentation - Top 1% Papers**)
5. G. Saha, I.Garg, A.Ankit, K.Roy, "SPACE: Structured Compression and Sharing of Representation Space for Continual Learning", IEEE Access, 9, 150480-15094, 2021.
6. G. Saha, Z.Jiang, S.Parihar, C.Xi, J.Higman and M.Ahosan Ul Karim, "An Energy-Efficient and High Throughput in-Memory Computing Bit-Cell With Excellent Robustness Under Process Variations for Binary Neural Network", IEEE Access, 8, 91405-91414, 2020.
7. I. Chakraborty, G. Saha, K.Roy, "Photonic In-Memory Computing Primitive for Spiking Neural Networks Using Phase-Change Materials", Phys. Rev. Applied, 11, 014063, Jan 2019.
8. I. Chakraborty, G. Saha, A. Sengupta, K.Roy, "Toward fast neural computing using all-photonic phase change spiking neurons", Scientific Reports, 8, 12980, Aug 2018.
9. G. Saha, K.Roy, "Amphibian: A Meta-Learner for Rehearsal-Free Fast Online Continual Learning", 2023. (Under review)
10. S. Choudhary, S. Aparna Aketi, G. Saha, K.Roy, "CoDeC: Communication-Efficient Decentralized Continual Learning", arXiv:2303.15378, 2023. (Under review)
11. G. Saha, K.Roy, "Online continual learning with saliency-guided experience replay using tiny episodic memory", Machine Vision and Applications 34, 65 (2023).