

Hai Duong

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EDUCATION

George Mason University , Ph.D., Computer Science	2022 - now
<ul style="list-style-type: none">• Advisor: Prof. ThanhVu Nguyen• Topic: Formal Verification of Deep Neural Networks	
Hanoi University of Science and Technology (HUST) , M.S., Electrical Engineering	2019 - 2021
<ul style="list-style-type: none">• Advisor: Prof. Quoc Cuong Nguyen• Topic: Deep Learning-based Speech Processing	
Hanoi University of Science and Technology , B.E., Electrical Engineering	2014 - 2019

AWARDS

- NeuralSAT ranked 2-nd at [VNN-COMP'24](#).
- NeuralSAT ranked 4-th and received New Participant Award at [VNN-COMP'23](#).
- HUST Outstanding Undergraduate Award 2015, 2016, 2017, 2018 (top 5% of School of Electrical Engineering).

PUBLICATIONS

- **Bold conference or journal names:** full technical papers at top conferences or journals.

Published

1. Hai Duong; ThanhVu Nguyen; Matthew B. Dwyer. [NeuralSAT: A High-Performance Verification Tool for Deep Neural Networks \(to appear\)](#)., In: **Computer Aided Verification (CAV)**, to appear, 2025.
2. Hai Duong; Dong Xu; ThanhVu Nguyen; Matthew B. Dwyer. [Harnessing Neuron Stability to Improve DNN Verification.](#), In: **Foundations of Software Engineering (FSE)**, Article 39, pp. 859-881, 2024.
3. Dong Xu; Nusrat Jahan Mozumder; Hai Duong; Matthew B. Dwyer. [Training for Verification: Increasing Neuron Stability to Scale DNN Verification.](#), In: **Tools and Algorithms for the Construction and Analysis of Systems (TACAS)**, pp. 24-44, 2024.
4. ThanhVu Nguyen; KimHao Nguyen; Hai Duong. [SymInfer: Inferring Numerical Invariants using Symbolic States.](#), In: International Conference on Software Engineering - Tool Demo (ICSE-Demo), pp. 197–201, 2022.
5. Thanh Dat Nguyen, Thanh Le Cong, Duc Minh Luong, Hai Duong, Xuan Bach D. Le, David Lo and Quyet Thang Huynh. [FFL: Fine grained Fault Localization for Student Programs via Syntactic and Semantic Reasoning.](#), In: International Conference on Software Maintenance and Evolution (ICSME), pp. 151-162, 2022.
6. Huu Binh Nguyen; Hai Duong; Tien Dat Bui; Ngoc Chau Hoang; Quoc Cuong Nguyen. [Multi-Channel Speech Enhancement using a Minimum Variance Distortionless Response Beamformer based on Graph Convolutional Network.](#), In: International Journal of Advanced Computer Science and Applications (IJACSA), Volume 13 Issue 10, pp. 739-747, 2022.
7. Huu Binh Nguyen, Hai Duong, Anh Xuan Tran Thi, and Quoc Cuong Nguyen. [Efficient Keyword Spotting System using Deformable Convolutional Network.](#), In: IETE Journal of Research, pp. 4196-4204, 2021.

EXPERIENCE

Research Assistant	2022 - now
DynaROARS Lab , George Mason University, USA	Fairfax, VA
<ul style="list-style-type: none">• Deep Neural Network Verification: Developed a verification tool aiming to formally verify safety and robustness properties of DNNs, NeuralSAT, by adapting Boolean Constraint Propagation, Conflict Clause Learning, etc., from SAT solving, with the Abstraction Interpretation. Participated in the annual competition VNN-COMPs, ranked 4-th at VNN-COMP'23, 2-nd at VNN-COMP'24 and published papers at FSE'24, CAV'25.	

- **DNN Proofs Generation and Checking:** Identified commonalities in the algorithmic approaches taken by DNN verifiers to define a verifier-independent proof format - APTP. Designed a tool for checking those proofs that is proven correct and optimized to enable scalable checking, which significantly outperforms prior work on a benchmark of 16 neural networks and 400 DNNV problems, and that it is robust to variation in APTP proof structure arising from different DNN verification tools. Tool can formulate an optimization problem to achieve concrete bugs in DNN verifiers when detecting unsound results.
- **Compositional Verification of DNNs:** Proposed an assume-guarantee compositional framework, CoVeNN, that is parameterized by an underlying verifier to generate a sequence of verification sub-problems to address this challenge. CoVeNN presents an iterative refinement-based strategy for computing assumptions that allow sub-problems to retain sufficient accuracy to prove the original problem. An evaluation using 6 neural networks and 120 specifications demonstrates that CoVeNN can verify 6.5 times more problems than SoTA verifiers.
- **Decision Heuristic for DNN Verification:** Developed a decision strategy based on Deep Reinforcement Learning without significantly increasing branching costs. DRL has capability of learning long-term rewards that allows proposed heuristic to avoid myopic selections during the search. We trained our models on small and simple FNN networks and made them generalized for different types of networks, such as CNNs, ResNets, etc.
- Contribute to tool building for the SymInfer paper, published at ICSE'22 demo track.

Research Assistant

2021 - 2022

BachLe's Lab, University of Melbourne, Australia

Remote

- Worked on Graph-based source code modeling, explanation techniques on graph, and conduct experiments for a published paper at ICSME'22.

Research Assistant

2019 - 2021

Sensor Lab, Hanoi University of Science and Technology, Vietnam

Hanoi, VN

- Adopted Deformable Convolution in the small foot-print Keyword Spotting task, resulting in a published article at IETE'21 journal. Improved inferencing speed 5 times by implementing DNN executor in FPGA.
- Developed multi-channel speech enhancement system using graph-based neural beamforming, published an article at IJACSA'22 journal.

TECHNICAL SKILLS

- **Languages:** Python, Java, C/C++.
- **Frameworks and tools:** PyTorch, Tensorflow, HuggingFace, Pytorch Lightning, Scikit-learn, Numpy, Git, Docker

MISCS

- Contributed to proposal: *NSF CAREER: NeuralSAT: A Constraint-Solving Framework for Verifying Deep Neural Networks*. NSF 2238133. 8/1/2023–7/31/2028, \$510,509. NSF (funded).
- Contributed to proposals: *Amazon Research Award (Automated Reasoning): Scalable and Precise DNN Constraint Solving with Abstraction and Conflict Clause Learning*. 2023, \$50,000 unrestricted gift. Amazon (funded).
- Helped review papers at conferences: ISSTA'23, PLDI'24, OOPSLA'24.