Abhiram **Singh**

RESEARCH SCHOLAR · DEEP/MACHINE LEARNING, COMPUTER NETWORKS, BRAIN COMPUTER INTERFACE

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Research Interest

MACHINE LEARNING, DEEP LEARNING, COMPUTER NETWORKS, BRAIN COMPUTER INTERFACE

My research focuses in the development of machine learning models to improve performance of computer networks. I am currently working on the machine/deep learning based intelligent computation models for routing in IP networks and developing scalable ML based tools for the verification of computer networks. In past, I have also worked in the exciting area of brain-computer interface for decoding imagined speech.

Education

CSE	**Doctor of Philosophy (Ph.D.)**, Indian Institute of Technology Bombay (IIT Bombay)		*2016 - Present*
CSE	**Master of Technology (M.Tech)**, National Institute of Technology Hamirpur (NIT Hamirpur)		*2012 - 2014*
CSE	**Bachelor of Engineering (B.E.)**, Oriental Institute of Science and Technology Bhopal (OIST Bhopal)		*2008 - 2012*

Projects

IIT Bombay *Powai, Mumbai, India*

PH.D PROJECT 1 (PROF. ASHWIN GUMASTE) *Jan 2019 - PRESENT*

- Formulated a graph neural network based deep learning model (Grafnet) to predict the output ports directly based on the IP address contained in the packets.
- Implemented Grafnet in Tensorflow and shown that Grafnet achieves high accuracy in predicting the correct output ports on a large network of 2000 nodes with 5 million IP addresses.
- Designed a single agent based deep reinforcement learning model (Trailnet) that learns to forward IP packets depending on the cost of packet forwarding from the neighbors.
- Implemented Trailnet in Tensorflow and shown that the cost estimates provided by Trailnet are close to optimal in a network of 145 nodes with 1 million IP addresses.
- Created a machine learning model (Tapin) that takes destination IP address of a packet as its input and predicts the index of a rule in a forwarding table that provides the packet forwarding decision.
- We tested Tapin on a forwarding table containing 1 million entries. Tapin significantly reduced the search space to less than 500 entries for around 98% of table lookups.

PH.D PROJECT 2 (PROF. ASHWIN GUMASTE) *Jan. 2020 - PRESENT*

- Aim of project is to solve the network verification problem in a fast and scalable manner.
- Formulated a linear algebra based solution (LeSQnet) to find the set of reachable IP addresses between two nodes, detect loops and packet drops, model packet header transformations and check for ACL rules.
- Implemented LeSQnet in python and shown that after a rule update, LeSQnet checks for reachability within a millisecond on different networks containing millions of forwarding rules. LeSQnet is also shown to improve the complexity for checking reachability.

PH.D PROJECT 3 (PROF. ASHWIN GUMASTE) *Jan. 2017 - Jan. 2019*

- Aim of project is to generate words that user speaks in mind without moving any body parts.
- Tested various features and machine learning models to classify a group of words based on their complexity. Used Python Scikit-learn framework to develop machine learning models and shown up to 11% performance improvement in correctly identifying imagined words over state-of-the-art methods on publicly available datasets.
- Designed graphics user interface using Python Tkinter library and integrated it with trained brain thought classifier to simulate real-time detection of brain thoughts.

COURSE PROJECT (PROF. GANESH RAMAKRISHNAN) *Sept 2016 – Nov 2016*

- Researched the problem of predicting answer of a question after learning from a set of sentences or from paragraphs.
- Implemented ANN, LSTM and Memory based neural network (Memn2n) in Tensorflow.
- Utilized Facebook bAbI dataset to show that Memn2n models outperforms other models in the task with 99% success rate on test data.

COURSE PROJECT (PROF. VIRENDRA SINGH) *Oct 2016 – Nov 2016*

- Researched and implemented different branch predictors using Simple-scalar simulator written in C.
- Compared performance of implemented predictors with built in branch predictors on different benchmark programs provided with simulator.
- Shown that perceptron branch predictor outperformed other predictors with an average margin of 2-4% in miss prediction rate.

COURSE PROJECT (PROF. BHASKARAN RAMAN) *Mar 2016 – Apr 2016*

- Researched different ways to predict the data transmission rate (TX rate) of a Wi-Fi device.
- Implemented Deep Learning model (in MatLab) to predict the behaviour of Operating System implemented algorithm for TX rate estimation.
- Shown that implemented model was able to achieve same performance in 60-65% cases to which data-rate prediction algorithm will converge.

- Researched problem to find average packet latency in a switch and measure switch throughput as a function of packet size.
- Simulated a switch of 16 ports (10Gbps) in Simpy and found that on increasing packet size, switch throughput increased and on the other hand average packet latency decreased.
- Did observed a considerable difference in average port to port latency of 0.6ms for packet size of 2000 Bytes and 250 Bytes.

NIT Hamirpur (Prof. T. P. Sharma)   *Hamirpur, Himachal Pradesh, India*

M.Tech Project   *Jul 2013 - Jul 2014*

- Formulated an area coverage scheme in Wireless Sensor Network (WSN) to obtain full coverage of target area by providing 3 way connectivity of sensor nodes and simultaneously minimizing number of active sensor nodes.
- Showed that the proposed approach can also provide network routing of data packets by providing tree structure among active sensor nodes.
- Implemented all the functionalities in Omnet++ simulator and obtained state-of-the-art performance in the field.

Publications

Patent

- Abhiram Singh, Sidharth Sharma and Ashwin Gumaste, *Grafnet: Using Graph Neural Networks to Create Table-Less Routers*, Patent Granted by United States Patent and Trademark Office (USPTO), Patent Number: 11310119.

Machine Learning

- Abhiram Singh, Sidharth Sharma and Ashwin Gumaste, *Grafnet: Using Graph Neural Networks to Create Table-Less Routers*, Published in IEEE Transactions on Network Science and Engineering (TNSE 2021).
- Abhiram Singh, Sidharth Sharma and Ashwin Gumaste, *Using Deep Reinforcement Learning for Routing in IP Networks*, Published in International Conference on Computer Communications and Networks (ICCCN 2021).
- Abhiram Singh, Aniruddha Kushwaha and Ashwin Gumaste, *TAP-IN: Table Address Prediction using Intelligent Learning for SDN Networks*, to be submitted in IEEE Transactions on Emerging Topics in Computing.
- Abhiram Singh and Ashwin Gumaste, *Decoding Imagined Speech and Computer Control using Brain Waves*, arXiv preprint arXiv:1911.04255, Published in Elsevier Journal of Neuroscience Methods (JNM 2021).
- Abhiram Singh and Ashwin Gumaste, *Interpreting Imagined Speech Waves with Machine Learning techniques*, arXiv preprint arXiv:2010.03360.

Computer Networks

- Abhiram Singh, Sidharth Sharma and Ashwin Gumaste, *LeSQnet: Least Squares for Holistic and Expressive Verification of Networks*, Under review in ACM SIGCOMM 2022.
- Abhiram Singh and T. P. Sharma, *Position and Hop-count Assisted Full Coverage Control in Dense Sensor Networks*, Published in Springer Journal of Wireless Networks, 2015.
- Abhiram Singh and T. P. Sharma, *A survey on area coverage in wireless sensor networks*, Published in International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT 2014).

Experience

Teaching Assistant	IIT Bombay, Mumbai, Jan 2016 – Present
Software Engineer	Aricent, Gurgaon, Oct 2014 – Aug 2015
Teaching Assistant	NIT Hamirpur, Himachal Pradesh, July 2012 – Aug 2014
Reviewer	IEEE Transactions on Cognitive Communications and Networking (TCCN), Wireless Networks (Springer Journal), IEEE Networking Letters
Talks	Using Deep Reinforcement Learning for Routing in IP Networks (ICCCN 2021), A survey on area coverage in wireless sensor networks (ICCICCT 2014)

Skills

Programming	Python, C/C++, MatLab, LaTeX
ML Framework	Tensorflow, Scikit-learn, Numpy, Pandas
Simulators	Simpy, Omnet++, Simple-scalar

National Examinations Cleared

2012	**All India Rank: 1115,** The Graduate Aptitude Test in Engineering (GATE)-Computer Science	*India*
2013	**All India Rank: 528,** The Graduate Aptitude Test in Engineering (GATE)-Computer Science	*India*
Jun 2013	**Assistant Professorship,** National Eligibility Test (NET)-Computer Science and Applications	*India*
Dec 2013	**Assistant Professorship,** National Eligibility Test (NET)-Computer Science and Applications	*India*
Dec 2013	**Junior Research Fellowship (JRF),** National Eligibility Test (NET)-Computer Science and Applications	*India*