

Statement of Purpose

I am Abdus Salam Azad. My research interests broadly span the field of Machine Learning (ML). In my undergraduate and Master's thesis, I have worked on Memetic Algorithms. I have also attempted to explore the domain of ML further and its application in relevant fields through several courses and research collaborations. For my Ph.D, I am particularly interested to develop learning algorithms for Image and Natural Language Understanding. Hereby I express my interest to pursue my Ph.D at the Department of Computer Science at University of North Carolina at Chapel Hill (UNC-CH)—a suitable place to pursue research in this area. I would also like to mention that, I received an admission offer from your prestigious department for Fall 2017 (UNC PID: 730185246) with full funding. However, due to some unavoidable circumstances, I had to defer my admission to Fall 2018 and lost the financial guarantee. I look forward to joining UNC-CH as a PhD student. Hence, I am applying afresh.

I had my first major research experience during my undergraduate thesis. I worked on Genetic Algorithms(GA) to solve MDPVRP—a lesser studied variant of the well-known Vehicle Routing Problem (VRP), which extends VRP with multiple depots and periods. I was supervised by Prof. Md. Monirul Islam, who has been working on GAs for the past 20 years. For GAs to perform well, maintaining the population diversity is very crucial. To keep the population diverse, the existing GA approaches for VRPs incorporate a diversity measure with the solutions' fitness, which can be computationally expensive. Our proposed method aimed at maintaining the population diversity solely by the use of selection operators. We also proposed a new formulation for MDPVRP which allows interdependent operations among depots to provide cheaper solutions at the cost of a bigger search space. Our work was acknowledged as the winner in the yearly thesis poster competition organized by CSE, BUET (1st out of 57 submissions).

In my Master's thesis, I continued my work with Prof. Islam on our proposed MDPVRP formulation. This time, we developed a Memetic Algorithm (MA)—a hybrid GA with a local improvement component. The existing MA methods focus extensively on greediness, which typically leads them to a premature convergence and require additional techniques such as population restart for further progress. Our proposed method introduces a stochastic local improvement component to address this problem. The component focuses simultaneously on both greediness and randomness to maintain the balance between exploration and exploitation, which consequently helps to avoid a premature convergence. We also proposed a heuristic, partly greedy and partly stochastic, to construct the initial solutions. Extensive experiments on the benchmark problems revealed significant improvements over the state-of-the-art methods. This work has been accepted in the IEEE Transactions on Cybernetics.

I developed a decent understanding of search techniques and combinatorial optimization during my thesis. To get a greater overview and deeper understanding of the topics of AI & ML, I have taken a number of related courses during my undergrad and Master's, including AI, ML, Pattern Recognition, and Data Mining. I have also participated in MOOCs on ML (Coursera) and Deep Learning (Udacity). To strengthen my foundation in image analysis,

I also took the Advanced Image Processing course. In this course, I learned a number of useful and fundamental techniques, e.g., image enhancement, filtering, segmentation, and compression. I also implemented a paper on content-based image retrieval.

My interest towards Image and Natural Language understanding piqued during one of my Master's projects. I surveyed the literature of bidirectional image-sentence search, searching images with sentence descriptions (and vice versa), and analyzed three of the state-of-the-art methods. I also proposed a two-stage approach that unlike the previous methods decouples object detection within the images from the inference of their inherent semantic relations. In the first phase, the representation of the objects in the images are learned in a joint "Object embedding space" to have close proximities with their matching words (e.g., an image of dog will have similar "Object" representation of the word "dog"). In the next step, the "Semantic" representation of the images and sentences are learned leveraging the object representations.

I am currently working on machine/reading comprehension problem—answering questions based on passages. I have modelled the problem as a path-finding game in a passage graph, where an agent traverses the graph to locate the answer upon given a question. The graph is constructed from the passage utilizing word embeddings, parse trees, and coreference resolution. I am training the agent using reinforcement learning.

Since my undergraduate studies, I have attempted to explore AI, ML, and relevant fields through my research, courses, and different projects. In my Ph.D., I am particularly interested in designing learning algorithms which can gather knowledge from heterogeneous sources of structured and unstructured data (e.g., images, text, video, maps, and sensor data) and combine them to solve different problems. With the vast amount of human knowledge underlying in the abundant data found in the web, such algorithms have clear applications in improved web search, question answering, summarization, and many more. Among the many challenges that arise to develop such algorithms, I want to focus on Image and Natural Language Understanding for my Ph.D.

I consider the Department of Computer Science at UNC-CH a suitable place to pursue my Ph.D. UNC-CH provides an excellent environment for cutting-edge research with top-notch research facilities and many brilliant faculty members. I am particularly interested to work with Prof. Mohit Bansal. His works on machine comprehension (ACL'15), image and caption sequencing (EMNLP'16), visual question answering (EMNLP'16), and text-to-image coreference (CVPR'14) align with my research interest. I also find the works of Prof. Alexander C. Berg and Prof. Tamara L. Berg in the intersection between natural language and vision interesting. Prof. Marc Niethammer's works on biomedical image analysis are intriguing too. I am also open to working with others who have interest in developing machine learning algorithms for Natural Language Processing or, Computer Vision. I believe an opportunity to pursue my Ph.D. in the prestigious Department of Computer Science at UNC-CH will enable me to conduct impactful research and help me to advance towards a research-oriented career in academia.