

Statement of Purpose

I am Abdus Salam Azad, currently employed as a Lecturer in the Department of CSE at Bangladesh University of Engineering and Technology (BUET). 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. In my Ph.D, I am interested to work on developing ML algorithms for solving real-world learning problems arising in different domains including natural language understanding and image understanding.

I got my first taste of research in my junior year. I along with two of my classmates, developed an online portal providing an interactive interface for climate researchers to run different analysis on climate data. Out of our motivation, we also analyzed 40 years of historical weather data from different regions of Bangladesh to identify the trends in temperature and rainfall. We used a wide range of data analysis techniques, including clustering such as K-means, non-parametric trend tests such as Mann-Kendall and Sen's slope estimator, etc. We found a number of interesting insights, such as, over the years the maximum temperature of our country has significantly increased during June to November. We also discovered that the temperature of eastern part of our country has increased much more than its western part. The findings of the study were published as a book chapter by Springer.

For 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 acquainted with other topics of AI & ML, I have taken a number of related courses during my undergrad and masters, including Artificial Intelligence, Machine Learning, Pattern Recognition, Advanced Image Processing, and Data Mining. I have also participated in MOOCs on Machine Learning (Coursera) and Deep Learning (Udacity). As a lecturer in CSE, BUET, I have conducted Artificial Intelligence and Machine Learning lab courses. Besides, I am also instructing an applied machine learning course for a group of 20 graduates from five different institutions. Such experiences have allowed me to study machine learning techniques in depth.

In 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. My inclination towards the field of natural language and image understanding started during this project.

I am currently working on two research projects: citation recommendation and machine/reading comprehension. In citation recommendation, the task is to recommend the most relevant works from the literature given a research idea or, abstract as a query. A paper may cite another paper for a number of different reasons, such as having similarity in the applied methodology, problem definition, and/or datasets. To incorporate such multidimensional similarity we are developing a multi-objective Learning to Rank algorithm. In my other project, we have modeled the machine comprehension problem (answering questions based on passages) 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. We are training the agent using reinforcement learning.

Finally, I consider the Department of Computer Science at the University of Toronto (UofT) a suitable place to pursue my Ph.D. UofT 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. Sanja Fidler. Her works in the intersection of language and vision align with my interest and brief experience. I also find Prof. Marzyeh Ghassemi's works on Machine Learning to predict human risk intriguing. Prof. Sheila McIlraith's work on automated programming is equally exciting to me. I am also open to working with others who have interest in developing machine learning algorithms to solve interesting and significant problems arising in different domains. I believe an opportunity to pursue my Ph.D. in the prestigious Department of Computer Science at UofT will enable me to conduct impactful research and help me to advance towards a research-oriented career in academia. I look forward to joining UofT as a PhD student.