

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 Genetic Algorithms. I have also explored other branches of ML and their application in relevant fields through several courses and research collaborations. In my Ph.D I am interested in working on ML techniques to solve problems in different domains with an emphasis on Computer Vision.

I got my first taste of research in my junior year. We 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. In contrast, there have been no significant changes in rainfall. The results also indicate that in terms of temperature the eastern part of the country has faced more climatic changes 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 crossover operator by generalizing the Edge Recombination Operator—a widely used crossover operator for the Travelling Salesman Problem. Finally, we 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 have taken a number of courses related to ML 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). Most of these courses involved projects. In one such project, 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, first learns the representation of the objects within the images in a joint object embedding space to align them with their matching word embeddings (e.g., an image of a dog will have an object representation similar to the word ‘dog’). In the next step, these object representations are utilized to learn the semantic representation of the full images and sentences hierarchically. In another project, I studied and implemented a content based image retrieval method.

Currently, I am working on citation recommendation problem, where, given a paper abstract as a query, the task is to recommend the most relevant works from the literature. A paper may cite another paper for a number of different orthogonal reasons, such as having similarity in the applied methodology, problem definition, and/or venue. To incorporate such multidimensional similarity we are developing a multi-objective optimization based Learning to Rank algorithm. This research is jointly collaborated by BUET and the University of Illinois Urbana-Champaign.

I have been working as a Lecturer in the Department of CSE at Bangladesh University of Engineering and Technology (BUET), my alma mater, since 2014. I have conducted a number of lab courses including Artificial Intelligence and Machine Learning. I have also conducted the Microprocessor and Microcontrollers lab course a number of times. As part of this course, students build small projects using ATmega 32 microcontroller. In most of the offerings, I had the opportunity to supervise a number of exciting projects, which enabled me to work with a wide variety of sensors and actuators. During my undergraduate studies, I also built an automatic door using ATmega32 and PIR sensor that implements a color-pattern based dynamic password protection. I have also worked with Arduino Uno on a few projects.

Finally, I consider the Department of Computer Science and Engineering at the University of Minnesota, Twin Cities a suitable place to pursue my Ph.D., as there are a number of exciting research projects where I believe I will be able to contribute. I am particularly interested in Prof. Junaed Sattar’s work in his Minnesota Interactive Robotics and Vision Laboratory. A number of his projects, including Underwater Image Restoration and Adversarial Image Colorization, employ ML techniques to solve computer vision problems. I believe the experience I obtained from my research and projects along with my familiarity with microcontroller based systems make me a good fit for his lab. I am also motivated by the works of Prof. Hyun Soo Park and Prof. Arindam Banerjee, which also align with my interest and experience. I believe an opportunity to pursue my Ph.D. in this prestigious department will enable me to conduct impactful research and help me to advance towards a research-oriented career in academia.