Statement of Purpose

I am Siddhartha Shankar Das, currently working as a Lecturer in the department of CSE at BUET (Bangladesh University of Engineering and Technology). My research interests lie broadly in the domain of Artificial Intelligence (AI) with a specialization in Machine Learning (ML). I am interested in Evolutionary Computation where bio-inspired meta-heuristics are used for solving complex optimization problems and on distributed system for large scale optimization. I am also interested with the development of effective learning algorithms for Deep Neural Network and with the problems of Computer Vision, Natural Language Processing (NLP).

Research Background : Inspired by the interesting algorithms and the applications of AI, I did my undergraduate thesis under the supervision of Professor Dr. Md. Monirul Islam who has significant contributions in the field of Neural Networks and Evolutionary Computation. We worked on the development of *Multi-Objective Evolutionary Algorithm* (MOEA) framework for *Many-Objective Optimization Problems* (MaOPs). MaOPs frequently appear in real-world problems and with increasing objective number traditional multi-objective algorithms have been found to be ineffective to maintain *Convergence* (closeness of solutions to the Pareto optimal front) and *Diversity* (even distribution of solutions in Pareto optimal front) in the objective space.

During background studies, I found fuzzy logic based MOEA approaches have issues with parameter settings, require problem domain knowledge and can not maintain diversity among solutions, rendering its true strength of comparability underutilized. With that motivation, I proposed a new fuzzy based procedure to rank the candidate solutions. Here I used a statistical model to adaptively define the parameters of fuzzy functions which requires no prior domain knowledge. Then I developed a compatible grid based clustering procedure to maintain diversity. The procedure achieved outstanding performance compared to existing fuzzy based works but the increasing computational complexity for diversity maintenance in higher dimensions (more than ten) led me to do more research in the beginning of my M.Sc. studies. This time, I improved the fuzzy definition further and proposed a novel active diversity promotion technique. The proposed diversity method uses supplied or generated preference points to cluster the candidate solutions. The algorithm has a suitable control over diversity and convergence and can effectively solve very complex, multimodal, deceptive, degenerate optimization problems. The proposed algorithm outperforms existing fuzzy based works and is highly competitive compared to state-of-the-art modern optimizers. The work is under review at the *ELSEVIER Journal on Swarm and Evolutionary Computation* and the extension of the algorithm can be implemented in cellular distributed systems which is currently under preparation.

In the meantime, I have been working on utilizing Google's famous PageRank algorithm for characterization of Knee Points (solutions that are usually preferred by decision maker in absence of any preference information) for *Many-Objective Optimization Problems* (MaOPs). In this work, we defined a new utility metric and proposed a fast algorithm that scales well for large problem size. Our metric is also scalable to any number of objectives. This work has been done with the collaboration of Michigan State University and currently under preparation for submission in a top journal. During this study, we have also formulated procedure for approximating the computationally expensive Hypervolume value using fast PageRank approach and the work is under preparation for submission.

These research works gave me a foundation in the domain of Evolutionary Computation which helped me to contribute in the algorithmic part for solving real world optimization problems. Recently we worked on "Many-Objective Performance Enhancement in Computing Clusters" with a goal to select a right combination of machines within a cluster to enhance the overall performance. This selection

depends on some conflicting cluster objectives which have been formulated using year long empirical data. We formulated it as a Many-Objective problem and proposed custom algorithm for solving it. This work has been accepted as a poster paper in the IPCCC 2017 (*IEEE International Performance Computing and Communications Conference*) and a more detailed version is currently under review at ICC 2018 (*IEEE International Conference on Communications*). I am also collaborating in the field of Software Engineering for finding best software architectures (e.g. class diagram) in terms of quantified many-objective metrics. Here, we have developed new metrics and compatible algorithms to solve this problem effectively.

Research Vision : Beside working on Evolutionary Computation, I wanted to explore more on Machine Learning techniques and I did some interesting research projects like near duplicate video detection, handwritten document segmentation, advertisement fraudulent activities detection, etc. Also being a Lecturer, I conduct courses like Machine Learning, Pattern Recognition, Artificial Intelligence, which keeps me updated with the latest advent of AI techniques. My current research works and academic experiences motivated me to pursue higher studies in the domain of Machine Learning where I will be able to do more in depth research. In my higher studies, I would like to work with the challenging problems on Evolutionary Computation and large-scale nonlinear optimization. I am also keen to properly utilize my experiences on evolutionary approaches and Multi-objective optimization techniques on real world problems and in other subareas of Machine Learning. In Multi-task Learning (MTL), we focus on predictions for multiple tasks at once through optimizing multiple loss functions. This makes Multi-Objective optimization techniques to be a potential fit for making learning system effective. Recent works on evolutionary Deep Neural Network (DNN) shows a significant comeback of neuroevolution for building robust learning algorithm. The applications of such techniques have shown promising results in automatic image captioning, activity recognition, scene understanding and many other problems of Computer Vision which I intend to work on. I would also like to work on developing algorithms for the problems in intersection domain of Computer Vision and Natural Language Processing (NLP) specially on problems like images/videos to knowledge representation, automatic generation of a picture book from textual description. My long term goal is to work with Artificial General Intelligence and continue research after my Ph.D., as an academician.

When I was looking for prospective graduate programs, the Department of Computer Science at the Purdue University has stood out with its amazing collection of research opportunities. I am motivated by the works of Professor Dan Goldwasser on Natural Language Understanding which match my research interest. I am also interested with the work of Professor Jennifer Neville on development and application of Machine Learning techniques which match my research interest as well. I am familiar with works of Professor Ming Yan on Machine Learning and Human Computer Interaction. I am also open to working with other faculties who have interest in Machine Learning and Optimization. The recent research projects of the faculties of the university are quite enthralling and seem to pave the way of many sub-areas of research that I would eventually love to explore. For these reasons, I have applied to the Ph.D. program in the Department of Computer Science at the prestigious Purdue University.