

## Statement of Purpose

### of Mrigank Raman (CS PhD applicant for Fall—2021)

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My objective in writing this application is to pursue a PhD in Computer Science with a focus on Natural Language Processing and Graph Representation Learning. My past research in this field has investigated the reliability of existing Knowledge Graph based models. I have experience in working on Commonsense Question Answering using external knowledge as well. I am also interested in applications of Generative models like VAE's and GAN's. I have previously worked on using a generative model to solve the problem of Domain Generalization in the field of Computer Vision. I am currently working on using GNN's to calculate different graph distance functions for range and top-k queries. My eventual goal is to be a Professor at a research institute in the near future.

My motivation for research stems from the various research based projects and activities that I have been a part of as an undergraduate research assistant. My first research project was based on Energy Efficient Active Remote Sensing under the guidance of Prof. Arpan Chattopadhyay of IIT Delhi. This project was instrumental in providing me with an introduction to research. In this particular study, we designed an algorithm for active tracking of a Markov Chain with unknown dynamics. I proposed the idea of treating the model as a Hidden Markov Model and apply the online version of the Expectation Maximization algorithm to estimate the parameters of the Markov Chain. I also suggested the use of asynchronous updates to tackle vector parameters which were proving to be a difficulty otherwise. The proposed algorithm also uses Gibbs Sampling to constrain the mean number of active sensors which makes our algorithm energy efficient. My paper on this topic has been published at the IEEE MASS 2020 Conference. This experience piqued my interest in research related to Machine Learning that further motivated me to survey the field related to this very aspect and continue my search for more research opportunities henceforth.

My goals being primarily directed towards finding out research opportunities, had finally led me to applying to the IUSSTF Viterbi-India scholarship as a research intern. I was selected as a research intern in the INK Lab under the guidance of Prof Xiang Ren to research in the field of NLP during Summer 2020. To gain experience in Graph Representation Learning and its applications in NLP, I enrolled for a graduate course on Graph Neural Networks (Special Topics in Database Systems in the transcript) and its applications. This course helped me get familiar with the current advances in the field. I also read a plethora of research papers and presented quite a few of them which helped me gain a lot of interest in this field and get ready for my research internship. During my internship, I worked on the reliability and robustness of Knowledge Graph (KG) based Question Answering and Recommendation models. My work was aimed towards investigating which parts of a KG actually contribute to the performance of the model. By showcasing different types of perturbations on the KG we try to reveal how current models fail to capture the semantic knowledge

in the graph but instead focus more on the structure of the graph. This was actually a very interesting study as it indicates that there is a scope of improvement on how KGs are leveraged in models. We also try to show that explanations generated using a KG for a prediction may be corrupted which further raises a question over the reliability of such models. This work motivated me to join another project in the INK Lab which was based on Commonsense Question Answering. In this work, I, along with my partners of study tried to make better use of the KG and attempted to incorporate external generated features from a Knowledge Generator such as GPT-2 along with the Conceptnet extracted features. We used these generated features and the Conceptnet extracted features on a general Graph Network based model that allows edge based message passing along with node based message passing to predict the answer of a given question. Working in INK Lab has been a great learning curve for me as a researcher in this field.

During a group meeting of INK Lab we had a discussion on Domain Adaptation and Generalization and how it could be used in domains with limited labelled data available. This discussion spurred my interest and I started reading more on domain adaptation and domain generalization in the field of Computer Vision and Natural Language Processing. It fascinated me to the extent that I started working on devising a novel method for Domain Generalization under the guidance of Prof Prathosh AP. In this work we tried to learn a domain agnostic feature space that retains class information and hence converts the multi source domain generalization (DG) problem to a single source DG problem. We then made use of a VAE (Variational Auto Encoder) to sample the nearest neighbour from the source domains to a given target and use this nearest neighbour for prediction. My contributions to the work were aimed at proving the interpretable bounds on the risk of the classifier and also suggesting the idea of working in the above-mentioned domain agnostic feature space. We have also demonstrated the effectiveness of our work via state-of-the-art numbers on the PACS, VLCS, Office-Home and Digits dataset using both Alexnet and ResNet18. The paper is currently under review at the AAAI 2021 Conference. This experience has helped me gain key insights into Generative Models and has played a very big role in enhancing my problem solving skills.

Being exposed to the opportunity to work in a competitive research environment with some of the brilliant minds at Stanford would be the boost I need to take my academic trajectory forward. I find **Dr Jure Leskovec's** work on Commonsense Reasoning and Graph Representation Learning exciting and relevant to my research interests. I also find **Dr. Percy Liang's** work on NLP exciting and interesting. In my view, areas such as zero-shot learning, domain generalization and adaptation, adversarial attacks and defenses may be very interesting to explore in graphs and NLP using graph representation learning. These two groups are pioneering research in these fields with Dr Percy Liang's group recently publishing a paper on "Selective Question Answering under Domain Shift". I keenly look forward to being a part of the Stanford PhD program. A continuous advancement of knowledge and science through proper learning and training with dedication, remains my lifetime goal.