

## STATEMENT OF PURPOSE

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**Program:** M.S. in Computer Science

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Technology is at its 5th epoch, according to Raymond Kurzweil's book *The Singularity is Near*, undergoing its merger with human cognition. In the current digital age, with computing applications generating and processing billions of GBs of data every day, it is now most important to teach machines to do tasks humans themselves cannot. Complex real-world scenarios are often represented as abstract graphical or probabilistic models, modeled to take decisions with the same efficacy as of a human. My broad interests primarily lie in building such graphical models, often using Approximate Inference. I am also exceedingly interested in Deep Learning, Bayesian Optimization, Generative Modeling, and Statistical Learning Theory.

I have always been fascinated by the convoluted machine, that is the personal computer. I started programming when I was 14 years old and have been hooked since. During high school, I learned to code in the Visual Basic environment and dabbled in web development. I had decided at that time to get a degree in computer science and started preparing for the Joint Entrance Examination (JEE), an admit to the top technological institutes in India, the IITs. After two years of arduous preparation and competing with more than a million aspirants, I qualified in the top 0.12% of those who took the JEE Advanced test.

I was conflicted between two choices I had at the time, pursuing a major in Electrical Engineering in IIT Bombay, or Computer Science in IIT Kanpur (IITK). I had lived in Kanpur my whole life and wanted to experience life in a new city, however owing to my love for computers, I chose IITK. Presently, I am a senior in the Department of Computer Science and Engineering at IITK. I regularly took part in online programming contests on Codeforces. With two of my friends, I participated in a popular programming contest, ICPC during my junior year. We were able to clear the online round, however, due to our lack of practice at the time we were not able to move past the onsite round.

It wasn't until the sophomore year that I discovered Machine Learning, through Prof. Andrew Ng's Course on Coursera. Fascinated by the concepts discussed in the course and in order to probe deeper into machine learning, I decided to go for an internship in a leading unicorn startup in the field of mobile advertising, Inmobi. During this internship, I looked at ways of feature extraction for ad creative images and built interpretable regression models to predict the click rate of an ad based on actionable features. The internship allowed me to look into some theoretical aspects of machine learning, particularly regression, and gain practical knowledge on building simple interpretable models.

Summer of 2018 saw me working at Goldman Sachs (GS) where I worked in the Corporate Treasury Strats team on augmenting features to existing models for Asset Liability Gap management. In another project at GS, I developed a greedy strategy for customer margin allocation to maximize internalization in the firm, taking various parameters into consideration. Through these internships, I was exposed to the working of the industrial world, and they helped me connect with many people. These experiences made me realize how widely Machine Learning is used in the day to day operations of industries in the financial and marketing sectors.

During my junior and senior years, I have undertaken multiple courses in machine learning, including "Introduction to Machine Learning", "Natural Language Processing" and "Data Mining". I have also completed a course on "Probabilistic Modelling and Inference" under Prof. Piyush Rai, which particularly piqued my interest. It was this course that introduced me to formal methods in probabilistic machine learning and laid the foundations of my interest in Approximate Inference and Bayesian Optimization. Another riveting course I have done at IITK is "Statistical and Algorithmic Learning Theory" under Prof. Purushottam Kar, which introduced me to concepts in learning theory, particularly statistical convergence analysis of algorithms.

Apart from the coursework, I have done a number of projects during my undergraduate study up till now. I worked on a reading comprehension task on the SQuAD dataset under the supervision of Prof. Harish Karnick, in the “Natural Language Processing” course. In another course project under Prof. Purushottam Kar, I worked on an incremental method to train two-layer neural networks (single hidden layer) by presenting a (two-layer) network as an ensemble and incrementally training each node in the hidden layer using boosting, particularly Gradient Boosting. Using this incremental training as a pre-training step prior to applying backpropagation afforded interesting results on some simple datasets. In the same course, I did a survey on the convergence of different techniques for convex optimization such as Vanilla Gradient Descent (Vanilla GD), Stochastic GD, NAG, etc., and also studied the non-convergence of Adam.

During my junior year, I did a project as part of the course “Probabilistic Modelling and Inference” under Prof. Piyush Rai on clustering in arbitrary shapes. We surveyed several models based on clustering in the latent space. Moreover, we proposed a novel Mixture of Experts model using the clustering embeddings discovered in Variational Deep Embeddings (VaDE) model as a gating function. I extended this work in another course project during my senior year, under the supervision of Prof. Arnab Bhattacharya. In order to overcome the slowed inference in VaDE, we proposed another model based on approximating the posterior of the cluster assignments using a deep neural network. The model built was shown to work better than VaDE at clustering tasks, with much faster inference. We further extended the model to be used as a gating function for ME models, and it was shown to be superior to some baseline gating functions.

Presently, I am working with Prof. Piyush Rai on models for link prediction in graphs. So far in the project, I have extended an unpublished work to build a model combining the predictive properties of Graph Variational Autoencoders with the interpretability of variants of Stochastic Block Models (SBMs), more particularly Mixed Membership SBMs. In addition, I surveyed some of the state of the art smoothing and reparametrization tricks in Black Box Variational Inference for Discrete Latent Variable Models, particularly VAE styled models with RBM priors. Using the GumBolt trick, I was able to build a model which afforded superior results to most existing baselines on some graph datasets.

The various projects I have pursued in my undergraduate study are evidence of my interest in research, however, my motivation for pursuing masters comes not only from this interest in research but also in exploring the ways machine learning can help the general cause. Machine Learning and Artificial Intelligence are the cornerstones to the advancement in technology in many fields, including healthcare, education, and transport. My ultimate research goal is to build such learning models which can be applied to help the society and give meaning to the work I do.

The primary reason I decided to apply for masters is to get a broader exposure to the field of Statistical Learning. With the excellent research facilities and stupendous connection to industry, I believe Columbia University presents the perfect ground for exploration. I envisage myself as a researcher, either in academia or industry, and graduate studies at Columbia University will help me connect with brilliant minds from across the globe and motivate me to achieve my full potential as a researcher.

Amongst the wide range of research being done at Columbia University, I feel particularly fascinated by the works of Prof. David M. Blei, Prof. Tony Jebara, and Prof. Daniel Hsu. Prof. Blei’s and Prof. Jebara’s forays into probabilistic machine learning constitute the kind of research I would like to pursue. I am deeply inspired by Prof. Blei as one of my first encounters with research started with perusing one of his papers, *Variational Inference for Dirichlet Process Mixtures*. Prof. I also feel my interests match closely with Prof. Jebara on topics of Deep Probabilistic Models and Statistical Learning Theory, and I earnestly hope to work with him. Prof. Hsu’s work on statistical learning theory also kindled my interest and I would be glad to be one of his students. The transcendence of technological evolution from 5th epoch to 6th epoch is a journey, and I wish to be a part of this journey. I am confident that pursuing an M.Sc. in a reputed university such as Columbia University will open the gates to this odyssey for me.