Statement of Purpose
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We live in an exciting age where Artificial Intelligence (AI) is radically transforming our lives. Today, we can find any information using search engines, have conversations with digital assistants, use translation services to comprehend most languages, and have email clients compose our emails. This promise of AI integrated into our daily lives, automating mundane tasks and empowering us to do much more, is what drew me to Machine Learning (ML) and Natural Language Processing (NLP). It has been exciting to see the recent breakthroughs in NLP, with large language models (LMs) like GPT-3 single-handedly writing code, composing narratives, and summarizing any text. Despite these advances, NLP techniques still struggle with factual correctness, lack common-sense reasoning abilities, often propagate societal biases, are less performant on low-resource languages, and have large carbon footprints. These problems limit the full potential of NLP, and tackling them will require new leaps in thinking. I wish to pursue a Master's in Computer Science (CS) at Stanford to gain the broad knowledge and in-depth research experience necessary to address these challenges for the wider adoption of AI. I believe that my expertise in building real-world NLP systems has given me the skill-set to excel in graduate studies and has equipped me with a novel perspective to bring to the incoming class of future technological leaders at Stanford.

Working as an Applied Scientist at Microsoft for over two years has helped me experience how the challenges faced by real-world applications of NLP limit the adoption of cutting-edge research. This became evident as I worked on the Suggested Replies dialog system, which assists users by providing short reply suggestions to their emails. To keep training and inference times tractable, this system utilized a biLSTM model trained from scratch, and thus could not reap the advantages of transfer learning from large pre-trained models. Motivated to leverage pre-trained models, I experimented with several model compression approaches to bring down their fine-tuning and inference times, and found low-cost techniques to be surprisingly effective at reducing training and inference costs while still bringing in the benefits of transfer learning. This work helped us deploy a fine-tuned pre-trained model, and it was exciting to see the resulting gains in user engagement. Through further experiments, I was then able to show that the size of the dataset affects the efficacy of compression techniques and that the large volumes of data available in the industry can make low-cost approaches very competitive. These findings were [published](#) in Microsoft's AI Journal and demonstrated that industrial settings of NLP problems could have optimal solutions that are different from those in academia. I want to take this perspective with me to grad school to bridge the gap between academic and industrial settings and explore robust solutions that can be seamlessly adopted in the industry as well.

Using user information to provide delightful, personalized experiences is crucial for the large-scale adoption of NLP. With strict user data privacy requirements and many active users with varying amounts of personal data, the industry has unique challenges and opportunities in developing novel personalization solutions. To gain exposure to this impactful area, I incorporated personalization into our GPT-2 based dialog system to tailor the reply suggestions to user writing styles. I represented users in the training data using unique user embeddings and then trained these embeddings as a prefix to condition GPT-2's reply generation – similar to the recent work on prefix-tuning. Since this personalized GPT-2 model could only work for the users seen at training time, I added a projection network and trained it to project the sparse n-gram features from users' emails to the dense user embedding space. This projection network enabled us to generate user embeddings for new users on the fly using the n-grams extracted from a single one of their emails. Together these approaches helped us suggest personalized replies to all users. However, the large number of users in the industry makes it expensive to

periodically train and update their user embeddings. Motivated by the use of prompts to guide models like GPT-3, I experimented with replacing the trained user embeddings with non-trainable user-specific prompts to induce personalized outputs and found these prompts to show superior performance. This work led to a [paper](#) submission at an upcoming NLP conference and taught me how to utilize the distinct constraints of the industry to research novel solutions. Despite these promising results, developing personalized experiences that are robust to adversarial attacks and capable of protecting user privacy remains a challenge. During my Master's, I wish to use my understanding of the industry's needs to study and advance the theoretical underpinnings of privacy-preserving techniques to enable the responsible and secure AI applications of the future. The expertise I've gained through my work in analyzing the weaknesses of cutting-edge techniques and developing innovative solutions will be invaluable in making impactful research contributions during my Master's.

While my current role as an Applied Scientist in a product team offers opportunities to innovate and gain experience with state-of-the-art technologies, the constraint of needing to fulfill an immediate business need through every innovation doesn't provide me the flexibility and environment that I need to grow as a leader in NLP. I strive to develop NLP solutions for users that significantly advance the field and are generalizable across applications. This will involve thinking beyond the immediate needs of a given product. Therefore, my long-term career objective is to be at a research lab in academia or industry, working on such visionary research investments. A Master's program will enable me to gain a broader understanding of the field in a structured way, conduct in-depth research mentored by world-class faculty, and be surrounded by brilliant, motivated peers, and is thus the best next step for me to move towards my ambitious goals.

My broad research interests lie in Deep Learning for NLP, but two areas that particularly interest me are pre-trained representations and dialog systems. Since increasing the size of pre-trained models has been unsustainable and insufficient in helping them encode world knowledge and generalize to the medical and legal domains, I wish to pursue novel approaches for addressing these issues. Dialog modeling is another crucial space with many open problems, including coreference resolution and tracking shifts in topic between turns. Addressing such issues could allow virtual assistants to serve as intelligent personal advisors capable of discussing open-ended questions and proactively making personalized suggestions. My research interests greatly align with those of Stanford's world-class faculty, and I aim to attain the Distinction in Research by working with them closely. I wish to explore innovative pre-training methods with Prof. Chris Manning, building on ELECTRA and energy-based cloze models. My experience with dialog systems also aligns well with Prof. Manning's research on user interactions with dialog agents. I aspire to build better benchmarks to evaluate tomorrow's pre-trained models with Prof. Chris Potts. My experience in personalizing dialog systems using prefix-tuning and desire to study privacy-preserving techniques aligns with Prof. Percy Liang's recent efforts as well. Prof. Liang's work in jointly using LMs and knowledge graphs for question answering also relates to my interest in improving pre-trained models with real-world knowledge.

Beyond research, Stanford's exceptional offering of courses will help me gain a comprehensive understanding of ML and NLP, with courses like *Conversational Virtual Assistants with Deep Learning* and *AI in Healthcare* providing the intellectual depth and breadth that I seek. Stanford will also bring together some of the best minds, and I am excited to collaborate with and learn from such incredible peers. I also dream of contributing to Stanford's energizing community by taking on leadership roles in associations like CS + Social Good. With its excellent CS curriculum, dynamic student body, and record of trailblazing research, Stanford will be an ideal place for me to obtain my Master's and bring the power of NLP to people worldwide.