Research Statement

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https://scholar.google.com/citations?hl=en&user=unXtH3IAAAAJ

Most of our collective knowledge is written down in texts, including, books, newspapers, etc. I develop algorithms that can understand language, and I empirically evaluate them. My goals are to solve challenging technical problems in the field of Natural Language Processing (NLP) and apply the solutions to real-world scenarios that can benefit society. Recently, I showed how to build systems that read online reports about software vulnerabilities to help security analysts track and prioritize these threats. This was covered by WIRED[1] and is also used by the major security firm, FireEye.[2] I am also building semantic parsers for wet-lab protocols[3] to support reproducible experiments in chemistry and biology (Kulkarni et al. NAACL 2018). To extend this effort, I recently started working with chemists who are building autonomous laboratories for drug discovery, as part of DARPA's Accelerating Molecular Design program.

Significant improvements in accuracy have recently been achieved on various Natural Language Understanding (NLU) benchmarks, largely due to the application of Deep Learning methods. However, these methods rely on huge amounts of supervised training data, and thus have yet to translate into major breakthroughs beyond a few select applications. To address this supervised data bottleneck, I develop methods that learn representations using structured inference to effectively make use of *indirect* supervision. For example, I showed how a Latent Structured SVM with end-to-end learned representations achieves state-of-the-art results on a minimally supervised relation extraction task (Bai and Ritter, NAACL 2019). By incorporating side-information through a missing data model, and performing inference during learning, the approach can learn effectively without human supervision. This reduction in labeling effort enables rapid exploration of new language understanding applications, using data that is locked away in unstructured text.

I was also the first to propose data-driven methods for open-domain dialogue generation (Ritter et al. EMNLP 2011). My approach can produce plausible responses to almost any utterance by borrowing methods from machine translation (MT) to learn from millions of online conversations. This has led to significant follow-on work by other research groups. One practical application is Gmail's smart reply feature that uses neural MT to suggest a set of short responses to an email. A significant challenge, however, is that when applied to dialogue, neural generation tends to produce plausible but dull replies (for example: "I don't know" or "Sounds good"). In collaboration with researchers from Stanford and Microsoft Research, I have explored methods that address various aspects of this problem: First, my work has used reinforcement learning to generate responses that maximize the long-term success of a conversation (Li et al. EMNLP 2016). Secondly, I showed that an adversarial learning objective can help generate more human-like conversations (Li et al. EMNLP 2017). Lastly, I demonstrated how distributional decoding constraints can effectively be used to encourage generation models to produce responses that add more content to a conversation (Baheti et al. EMNLP 2018). My future research in this area will build new algorithms to learn open-domain conversational agents directly from data. These will include question answering agents that can carry on a dialogue or conversational recommender systems that act as a virtual concierge.

Moving forward, I plan to extend and improve the minimally supervised learning methods described above, to tackle a diverse set of language understanding tasks, without human supervision. Instead of using toy problems to evaluate progress on language understanding, I will apply minimally supervised learning to rapidly explore new applications of practical importance, in collaboration with domain experts in areas such as chemistry, biology, cybersecurity and more. I argue this approach will provide a better measure of our progress on language understanding, and will also have the positive side-effect of leading to many new applications along the way. Finally, I will build on top of these efforts to develop data-driven dialogue systems that can understand us better and sound less artificial.

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[1] https://www.wired.com/story/machine-learning-tweets-critical-security-flaws/

[2] https://www.fireeye.com/blog/threat-research/2019/08/automated-prioritization-of-software-vulnerabilities.html

[3] http://bionlp.osu.edu:5000/protocols