

# Statement of Purpose

I am committed to pursuing ambitious, long-term, challenging research. My research focuses on wireless sensing, wireless security, computer networking and machine learning. During my PHD career, I want to explore things related to these topics. I would like to summarize my research experiences during my undergraduate studies to explain why I want to pursue a PHD and what I have done.

## 1 Machine Learning

[ICLR2019-RLGM][ICLR2019-RLGM][OpenReview] [CVIU-2018] [NeurIPS2019-MineRL]

I started doing research when I was a second-year university student. At the time, my research focused mostly on graph-represent learning. The first project I did was related to graph attention networks. That project has several contributions: (a) We proposed multiple metrics to measure the distribution of attention. (b) We found that the choice of datasets greatly impacts the distribution of attention, so we conducted experiments to assess how the choice of datasets impacts attention. (c) We analyzed attentions from different layers and heads in order to see how attention varies by layer. (d) We proposed meta graph classification to verify the relationship between attention distribution and graph semantics.[**ICLR2019-RLGM**]. As a result, we got an interesting assumption: Can we accelerate graph operation by reducing the number of edges of the graph? The result of this process is that graph neural network's performance can be kept while the edges of the graph are reduced. How can we do that? Based on our assumption, edges with large attention values should retain significant task-related information. We verified this idea by removing edges with a low attention value and applied it to some complicated graph datasets like protein. [**OpenReview**]

To promote the development of the research community, one way is to publish impactful papers, another way is to create a toolkit that people can use like Tensorflow and Pytorch. I joined the development of **Deep Graph Library**(DGL). It is a Python package built for easy implementation of graph neural network model family, on top of existing DL frameworks (currently supporting PyTorch, MXNet, and TensorFlow). It provides versatility in handling message passing, speed optimization via auto-batching and highly tuned sparse matrix kernels, and multi-GPU/CPU training to handle graphs with hundreds

of millions of nodes and edges. [ICLR2019-RLGM]. DGL gets 8000 stars in GitHub and becomes the most popular framework in this field. I'm also a contributor to **GluonCV**. It provides implementations of the state-of-the-art (SOTA) deep learning models in computer vision. It is designed for engineers, researchers, and students to fast prototype products and research ideas based on these models. It gets 4900 stars on GitHub.

In the summer of 2019, I was a visiting student at the National University of Singapore. I worked on deep reinforcement learning then. We used deep neural networks to train a meta-controller, which was combined with a multitask game agent. It achieved an average reward of 23.81 in the MineRL competition and ranked fourth place. [NeurIPS2019-MineRL]. In addition, I have also been involved in some research about the interpretability of deep neural networks. [CVIU-2018]

While I was a third-year university student, I began to consider trying some new directions. I'm a guy who likes learning new things and challenging my discomfort zone in doing research, then I begin a new one.

## 2 Wireless Sensing, Wireless Security, Computer Networking

[AAAI-2022][Semester Project][On Going Project]

In the summer of 2020, I began an internship at the Paul G. Allen School of Computer Science and Engineering at the University of Washington, where I worked with Prof. Shyam Gollakota.

Together with Prof. Shyam, my project mainly focused on acoustics sensing for wearable devices. We proposed combining beamforming with a light learning model to achieve real-time multi-channel directional speech separation. Compared to some state-of-the-art causal speech separation methods, it is faster and has comparable performance with fewer model parameters. It has low latency, causality and can generate from synthetic audio data to real-world hardware audio data and can be deployed to wearable devices like VR headsets. Interacting with a VR headset's eye-tracking function allows us to extract specific voices from mixed voices environment with angle information. [AAAI-2022].

Generally, I find this direction to be interesting, and I might explore more things in that direction. In the autumn of 2020, I went to ETH Zurich as a visiting student working with Prof. Adrian Perrig. My first project involved IoT security. Our inspiration is that: IoT networks are commonly composed of many devices with constrained computation and communication capabilities, connected to each other, and to a more capable gateway. Since these devices are usually power-constrained, the main network defenses are deployed at the gateway, which manages and filters connectivity to the Internet. We used machine learning algorithms to automate the detection of data exfiltration at the gateway in this project. We proposed a system that can simulate the defense and attacking process by using a learning algorithm based on deep neural networks.

The sub-modules of the system are an encoder, a decoder, and the attacker. The whole system uses deep neural networks to generate the adversarial encoding, as well as to perform the exfiltration detection. We find that deep neural networks can be used to reconstruct sensing data like temperature or humidity, and they can also detect data exfiltration when the sensing data is modified by attackers. **[Semester Project]**

The second project I work on with Adrian is to apply machine learning algorithm to networking systems. Basically, we want to train a flow size predictor and apply it in networking systems. As in a multi-path socket, we use the flow size predictor to observe a few communications in each path and predict the whole communication, and pick paths best suited to its performance requirements. Basically, what I need to do is collect TCP packet data from different websites, use a few packets of each flow and predict the whole flow size and apply it in networking systems. **[On Going Project]**

### 3 Summary

During my undergraduate career, it's been challenging and interesting. My experiences have given me a different perspective on the Ph.D. process. This is being patient, being passionate, being persistent, and believing in the direction you work in. My experiences in different groups and having conversations with a variety of great people have helped me to broaden my outlook on doing research, optimize my research skills, and develop a diverse mind to adapt to a variety of environments. Honestly to say, in my third year of university, I was afraid to change my direction because starting from scratch is not easy, but I managed it successfully. I deeply love what I am exploring is the reason why I want to pursue Ph.D. By doing what I really like during my Ph.D. life, I think it will certainly enrich tremendously my life journey.

Miscellaneous: I go to the gym every day. I find it really helpful, especially when I encounter problems that are hard to resolve. Fitness allows me to have a more clear mind so that I can solve problems more efficiently.