Part I – Contributions to research and development

Part II – Most significant contributions to research and development

Part III – Applicant's statement

Research experience

Bioinformatics: Supported by an NSERC USRA award, I joined Dr. Michael Hoffman's lab at the University of Toronto in summer of 2020. I was working on a bioinformatics project that consisted of combining several existing computational software programs into a pipeline to process data generated by the new CUT&RUN epigenetic technique [1]. Through this project, I learned a great deal about each phase in processing epigenetic data, especially a crucial step called "peak calling", which identifies regions of significant signal in the genome. By carefully examining the standard algorithms used in peak calling, I was able to understand the statistical model used and modify it to take into account a new calibration procedure that utilized spike-ins. Near the end of my summer research, I completed a flexible computation pipeline with much better centrality and significance in determining the binding location of transcription factors. The pipeline I developed for this project is further being completed a graduate student in the lab who is currently working towards a manuscript for publication.

Brain-Computer Interface (BCI): I spent six months starting January of 2022 working as a research intern at Dr. Juan Gallego's lab at Imperial College London. His lab hypothesized that to build more robust BCIs for movement restoration, we need to look beyond the motor cortex and into subcortical areas of the brain [2]. To this end, an experiment was designed where a BCI is used to decode the intended movement direction of mice from electrophysiology recordings in both the motor cortex and the striatum. In preparation for the experiment, I built the complete BCI that interfaces with electrodes (Neuropixels 1.0), processes spiking data, and provides feedback to the animal in the form of audio, all of which operate in real-time achieving a closed-loop latency of 40ms. Due to the project being in its early phase when I worked on it, other lab members are using the experimental setup I've built to collect data and have yet resulted in a publication. In a side project I worked on, I analyzed multi-dimensional neural data with statistical methods such as PCA and CCA. I trained and compared linear regression and LSTM models as neural decoders to predict hand velocity. This work has contributed to the lab publishing a paper in *Nature*. However my contributions were insufficient for authorship and thus was acknowledged in the acknowledgements section [3].

Computational Neuroscience: For my undergraduate thesis, I worked with Dr. Taufik Valiante at the University of Toronto. Neuronal network heterogeneity is hypothesized to play a crucial role in network stability, the lack of which causes epileptic seizure onset [4]. My thesis investigates the role of intrinsic plasticity in shaping neuronal heterogeneity. I incorporated a conductance-based local learning rule [5] into the Hodgkin-Hoxley model of neuron firing and constructed a network of excitatory and inhibitory neurons. By performing tests with various network inputs, I saw neurons beginning to cluster into several groups based on their ion channel conductances. Such clustering pattern resembles the connectivity of excitatory and inhibitory neurons, suggesting that the heterogeneity of neuron populations depends on the underlying connectivity patterns. My thesis provided foundation for further research using more biologically detailed neuron models, where current members of the lab are pursuing.

Software Engineering: I worked as a part-time game developer at a startup company called City From Naught from January of 2020 to October of 2021. I helped design and build a 3D cyberpunk detective game using the game engine Unity, and was responsible for gameplay, puzzles, in-game UI, and integration of 3D models and animation. In addition, I also managed and mentored a small team of software engineers, leading weekly sprint planning and distribution of tasks in a fast-paced start-up environment. My efforts ultimately helped the company release their first game on Steam and received a very positive rating, where 86% of players liked the game. Coincidentally, my proposed project also uses Unity game engine to build a driving game for participants to play. So I was able to transfer many of the coding skills I developed during this part-time job into working on my PhD thesis. I also took on a software engineering internship at Amazon in the summer of 2021, where I implemented a new item details page in Amazon Kids' online parent dashboard. This new feature provided parents with a clear description of product details, helped them make purchase decisions for their children, and impacted more than eighty thousand customers after launch. I gained professional software development and management skills which helped me tremendously in developing computational models for my proposed project.

Relevant activities

I volunteered as an English teacher at a rural elementary school in China during the summer of 2019. The school was located in an ethnic minority village in Yunnan province, with about two hundred students in six classes. There were no English teachers in the school, despite English being a required subject for elementary students. My classmate and I designed a mini-curriculum for an English course, which we prepared, taught, and evaluated. After the summer, I joined the student club that had organized this event and worked my way to vice president, responsible for organizing similar summer programs. Ultimately disrupted by COVID-19, we continued our efforts to bring an outside view of the world to students in rural Chinese schools by delivering English classes remotely and actively communicating with other rural school boards in China to expand our program into different regions.

References

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