As stated by the computer pioneer, Alan Kay, “the best way to predict the future is to invent it.” My ultimate goal is to use my experience in the Marshall program to stay ahead of the trajectory of Electrical Engineering, rather than work with the technology of yesterday that I have already mastered as a result my undergraduate career. I am certain that neuromorphic engineering and bio-inspired architectures will have an irreplaceable role in the future of computing, and I intend to be involved in this next generation of technology. Working on the SpiNNaker project at the University of Manchester would be an irreplaceable opportunity to learn from top engineers in the field while simultaneously helping to advance it.

Currently, research projects around the world in neuroscience, engineering, and materials science have been aimed at taking creative approaches to modeling and simulating the brain with computers and electronics, from using memristor devices as synapses (University of Michigan’s Nanoelectronics Research Group) to connecting a large amount of FPGAs to achieve enough processing power to simulate the flow of data over neural networks (University of Cambridge’s Blue Brain). However, all of these approaches have yet to lead to a highly scalable and inexpensive neural supercomputer due to limitations in our understanding of how information is processed and encoded in the brain, so we have only been able to make guesses at how to design systems. Theoretically, the brain is a very noisy analog and digital hybrid system, so achieving a breakthrough in the field should be a matter of discovering an optimal architecture rather than using the best (and most expensive) components.

I would like to use the SpiNNaker project at the University of Manchester as a foundation for studying more complex and comprehensive electronic neuron models. The architecture is currently optimized to work with a point-neuron model, which assumes that neurons have negligible spatial characteristics. However, it could improve the system’s performance and open new opportunities if the propagation delay and spatial characteristics of neurons were native to the device’s operating system. Besides revamping the software, one way to explore alternative models would be to introduce customized CMOS architecture chips to build the thermodynamics of a neuron in silicon. One biological source of inspiration for this technique is the Hodgkin-Huxley model, where the chemical reactions and flow of ions in the neuron are modeled as a set of complex equations. Though simulating these equations is too computationally intensive to simulate on FPGAs and microprocessors, discovering a valid model with transistors and passive circuit components could unlock techniques to embedding this model in the circuitry.

In the most direct sense, this work is important because it would give neuroscientists the tools to glimpse into the inner layers of the mammalian brain. From a broader perspective, this technology would enable a copious amount of advancements, including artificial intelligence, more accurate visual and auditory pattern recognition, radiation-tolerant electronics, and super computers that consume a fraction of the power that they do today.