As transistors are approaching a physical limit on miniaturization, it will be necessary to use alternative computer architectures to continue to improve the processing power of machines. I believe that biologically inspired massive parallel architectures will be the key to unlocking a wide variety of tomorrow's technologies, such as radiation-tolerant deep space computers, low-power rapid image and audio processors, and advanced personalized education. Today's technology provides us with the necessary tools for building and simulating large neural networks to gain insight on the hidden layers as well as understand how to effectively encode and process information. Although it has been demonstrated with custom FPGA systems that massively parallel neural networks are superior to traditional computer architectures such as GPGPUs and CPUs, massively scalable systems have yet to been built successfully. This is because the neuroscience community focuses on building the tools for making small networks in order to bring studies through the proof-of-concept stage. Because I have gained significant experience using Altera FPGAs as an undergraduate, as well as real-world industry experience in designing, testing, and building electronic hardware and low-level software. By introducing novel innovative ways of simulating the thermodynamics of neurons on FPGAs, it may be possible to solve the scalability issue. This increase in scalability will inevitably cause simulations to run into the memory wall, as fetching data out of RAM will become the bottleneck rather than the processing speed of the network. Therefore, it would be advantageous to have a large input layer to the neural network that comes from a device such as a silicon retina, rather than RAM. The entire vector of data from this kind of sensor would be readily available to the network immediately, similar to how the brain processes sensory input, eliminating the issue of the memory wall.

"Joggling" is the sport of running and juggling simultaneously, and it has become an inseparable part of my identity. Not only has it been a way of challenging my body physically and mentally, but it has allowed me to begin tackling one of my long term goals; providing personalized education globally. Though training and setting three Guinness World Records in the sport proved to be difficult on its own, using the publicity to raise support for Rhotia Valley, Tanzania was what made the feats truly fulfilling. The primary school in this village was trying to introduce One-Laptop-Per-Child computers into the curriculum to give young students the opportunity to use technology to pursue their interests and become members of the 21st century. Furthermore, this progressive application of low-power, sophisticated electronics appealed to my background as an Electrical Engineer and inspired me to get involved.

Although studying Electrical Engineering as an undergraduate has given me a deep understanding of modern electronics at all scales, from the solid state physics of devices to the architecture of global networks, I believe that neuromorphic engineering will be a huge player in the future of computing, regardless of whether traditional CPUs are still used or not. Therefore, the digital design and software concepts I learned as an undergraduate will not necessarily translate well when developing on neuromorphic systems. My studies in the Department of Engineering will give me the most rigorous understanding of neuromorphic technology and allow me to work ahead of the trajectory of the field, rather than behind it. As stated by the computer pioneer, Alan Kay, "those who are serious about software build their own hardware," because it is only possible to build fully optimized software when the designer has a profound understanding of the underlying hardware and architecture. Ultimately, I hope to leverage neuromorphic systems to solve the two problems that are most important to me; advanced personalized education, as it is one of the Grand Engineering Challenges of the 21st century, and radiation-resistant computing in deep space, as spending time working at SpaceX has only galvanized me in my goal of making humans a multiplanetary species.

"Joggling" is the sport of running and juggling simultaneously, and it has become an inseparable part of my identity. Not only has it been a way of challenging my body physically and mentally, but it has allowed me to target a couple of specific issues. Though the extensive training for three Guinness World Records in the sport proved to be difficult, using the publicity to help improve the lives of others is what made the feats truly fulfilling. My first two records gave me the opportunity to raise support for the primary school in Rhotia Valley, Tanzania to incorporate One-Laptop-Per-Child devices into the school. From a cultural perspective, I found the way this program seeks to proliferate computers fascinating, as it brings students worldwide into the 21st century. From a technological standpoint, I was excited to see low-cost, efficient, and robust technology be applied constructively to solve social problems.

However, prior to setting my third record, I had the chance to travel to Japan and meet some of the victims of the Tohoku Earthquake in Minamisanriku.

From a cultural perspective, I found this program fascinating and inspiring, so I wanted to get involved. From a technological standpoint, I was excited to see low cost, efficient, and well-designed technology be applied constructively to solve problems, as I studied electrical engineering as an undergraduate.

It felt like my arms were going to fall off and my heart was going to beat out of my chest. Every time I changed my bearing to follow the first lane on the athletics track, the wind turbulence battered my 5-ball juggling pattern from a different direction. As minutes went by, it became increasingly difficult to accurately throw the balls without mid-air collisions. As sweat collected on the juggling balls and in my eyes, it became increasingly more difficult to make catches. Nevertheless, six minutes and 34 seconds after the gun went off, I became the world record holder for the fastest mile while juggling five objects.

“Joggling” has become an inseparable part of my identity. Not only has it been a way to challenge myself physically and mentally, but it has also given me a unique opportunity to help people around the world. I used the publicity from a few of my joggling world records to raise support for the primary school and children’s home in Rhotia Valley, Tanzania. The community is introducing One-Laptop-Per-Child devices into the education system to allow young kids to connect with the world, gain experience with computers, to satisfy their own curiosity, and become members of the 21st century global community. From a cultural perspective, I found this program fascinating and inspiring, so I wanted to get involved. From a technological standpoint, I was excited to see low cost, efficient, and well-designed technology be applied constructively to solve problems, as I studied electrical engineering as an undergraduate.

However, I see this project in Rhotia Valley as merely the tip of the iceberg of the much broader and intricate challenge around which I plan to build a career. It is a fact that we are approaching the physical limit on the miniaturization of transistors and it will soon be necessary to design innovative technologies in order to keep up with Moore’s Law and continue to make better computers. As stated by the influential computer pioneer, Alan Kay, “the best way to predict the future is to invent it.” I anticipate that neurosynaptic architecture will be a significant player in the future of computing, and I plan to be involved in the development of this technology.

From a reductionist point of view, my training as a joggler has been symbolic of my interest in neurosynaptic architecture. Just as my training leads to infinitesimal improvements in making accurate throws, predicting object trajectories, and minimizing physical exertion, neurosynaptic architecture inherently seeks to build shortcuts and recognize patterns to optimize efficiency in performing specific tasks. My studies as an electrical engineer have given me a deep understanding of how today’s CPUs work, from the molecular level to the global network level, but it was my personal curiosity that led me to branch out to other paradigms that force me to question every aspect about conventional electronic design. Neurosynaptic architecture has huge advantages over the modern CPU, such as low power consumption and massively parallel and redundant processing. These advantages make it a promising vehicle for enabling the two changes in the world that are most important to me; making humans an interplanetary species and advancing personalized education.

According to the National Academy of Engineering, one of the greatest engineering challenges of the future is advanced personalized learning. Although the proliferation of education through the One-Laptop-Per-Child program inspired me to use my abilities to get involved, I believe that much larger revolutions in education are on the horizon as technology advances. It is certainly important to equip children worldwide with the internet, which is essentially an encyclopedia with the entire knowledge of the human species, but personalizing each student’s education in order to maximize his/her potential is a far greater task. While a human teacher can presumably provide a student with a very powerful and customized education, it is not logistically feasible to have one teacher for every student worldwide. Machine learning and neurosynaptics will be the key to cracking this global challenge.

As far as my interest in space, it is impossible to work at SpaceX and not dream about the future of human colonization on extraterrestrial worlds. Being around the brightest engineers and cutting-edge space technology has only galvanized me in my pursuit of helping humans become an interplanetary species. One of the current challenges with deep space exploration is that radiation has the ability to flip bits and corrupt data. Modern CPUs are limited in space applications as they are highly susceptible to errors in the way data is bottlenecked through the processor without much redundancy. However, neurosynaptic architecture is an appealing candidate for deep space missions, as it processes data in massive, parallel networks, in addition to consuming a fraction of the power that modern CPUs use.

The Machine Learning Research Group in the Department of Engineering Science at Oxford University is currently researching how to design more efficient and effective machine decision-making algorithms. This research focuses on using decisions of individuals or partial systems to drive decisions of the collective group. Why is it necessary that I attend Oxford University to study machine intelligence from the computer science perspective? To quote the influential computer scientist, Alan Kay, again, “those who are serious about software should build their own hardware.” The Machine Learning Research Group studies software that is intimately related to neurosynaptic hardware architecture. Working alongside these internationally influential researchers in the field would greatly enhance my ability to grow in the area and gain the knowledge necessary to tackle complex problems at the mathematical, computational, software, and hardware levels. In order to truly use computing technology to its maximum potential, it is necessary to understand this coupling between hardware and software. Furthermore, I believe I would be an ideal fit for the interdisciplinary and diverse culture at Oxford University, as I would both immerse myself in activities that would help me grow as an individual and share my perspectives and personality with the community.

Studying Electrical Engineering as an undergraduate has given me a fundamental and applied understanding of modern computing technology, from the smallest level of PN junctions to the largest level of global networks and signal processing. I feel that this background may have been very advantageous for being on the frontier of a few decades ago, but is now a fact that we are approaching the physical limit on the miniaturization of transistors. It will soon be necessary to design innovative technologies that require interdisciplinary and unconventional research in order to keep up with Moore’s Law and continue to make better computers. Some of the current contenders for the future of computing include carbon nanotube transistors, quantum computing, and neurosynaptic architecture. As stated by the influential computer pioneer, Alan Kay, “the best way to predict the future is to invent it.” I anticipate that neurosynaptic architecture will be a significant player in the future of computing, and I plan to be involved in the development of this technology. Because of its low power consumption, massively parallelized data processing, and ability to use heuristics at the hardware level, neurosynaptic computing has inherent advantages that make it superior to alternative technologies in certain applications. Specifically, it will be a powerful vehicle for enabling the two changes in the world that are most important to me; making humans an interplanetary species and improving personalized education.

First, it is impossible to work at SpaceX and not dream about the future of humans in space. The joy and experience I gained from being around rocket parts every day, from small circuit boards and sensors to massive fuel tanks and Dragon capsules, is unmatched. Being around the brightest engineers and scientists has only intensified my long-term goal of helping humans become an interplanetary species. I was given the opportunity to work on various hardware and software systems on Falcon 9 and the development vehicle in Texas. I realized that one of the current challenges with deep space exploration is that radiation has the ability to flip bits and corrupt data. Modern CPUs are highly susceptible to errors in the way data is bottlenecked through the processor without much redundancy. However, neurosynaptic architecture will have an inherent advantage, as it processes data in massive, parallel networks, in addition to consuming a fraction of the power that modern CPUs use. I see the invention of this new technology as crucial to the future of space exploration.

As far as advancing personalized education goes, I have already been able to begin tackling this goal. As seemingly unrelated as it may sound, I have been a “joggler,” or runner who juggles, for many years before ultimately training and setting a few world records in the sport. During the summer after my freshman year, I decided to use the publicity from my world record attempts, the fastest 5km and 400m while juggling 5 objects, to raise support for the primary school and children’s home in Rhotia Valley, Tanzania. The community is introducing One-Laptop-Per-Child devices into the education system to allow young kids to connect with the world, gain experience with computers, to satisfy their own curiosity, and become members of the 21st century global community. From a cultural perspective, I found this program fascinating and inspiring and wanted to get involved. From a technological standpoint, I was excited to see low cost, efficient, and well-designed technology be applied constructively to solve problems, as I studied electrical engineering as an undergraduate.

This project, however, represents merely the tip of the iceberg of my goal to improve education. According to the National Academy of Engineering, one of the greatest engineering challenges of the future is advanced personalized learning. I believe that much larger revolutions in education are on the horizon as technology advances, beyond simply equipping children with an encyclopedia with the entire collective knowledge of the human species (the internet). While a human teacher can presumably provide a student with a very powerful and customized education, it is not logistically feasible to have one teacher for every student. There are countless students worldwide who are very passionate about certain subjects but have no way of truly mastering them at the moment. Personalizing each student’s education in order to maximize his/her potential will be greatly assisted by innovative advancements in machine learning and neurosynaptics. It will allow for more accurate methods of assessing a student’s abilities and knowledge, as well as more effective processes for teaching information that is designed to fit each specific student.

I was personally fortunate enough to have many eclectic research, internship, and life experiences that led me to converge on these two specific goals and dreams about the future of technology and the role of neurosynaptics. Each experience that I gained throughout my undergraduate career has been a stepping stone that helped me figure out what I am truly interested in.

My first research experience was at Pennsylvania State University through an NSF-sponsored REU, designing and building MRI microcoils for imaging individual cells. Here I learned about circuit resonance and design, as well as standard laboratory procedures and methods. I had the chance to use 7T and 14T MRI coils and design my now Helmholtz resonators with remotely tuneable resonant frequencies via varactor diodes. I found this project academically interesting, but it often left me wondering what research at the more basic and molecular level is like. For this reason, I scoped out nanomaterials work that would give me this experience.

The next summer, I was accepted into the NanoJapan program through Rice University, another NSF-sponsored REU. Not only did this program give me the chance to pursue my interest in materials science, but it also let practice my Japanese skills that I had been practicing for years inside and outside of the classroom at the University of Florida. However, because of the Fukushima incident, I conducted my actual research in the Ajayan Lab at Rice University. Although I did not get a chance to immerse myself for as long as I had hoped in, I gained a lot of experience working with graphene and nanomaterials for energy storage applications. Furthermore, being at Rice University gave me the opportunity to pursue a bit of inspiration I gained while in Japan and train for and set my third world record in the sport of joggling.

One of the weekends I spent in Japan was in Minamisanriku, a small village that was devastated by the Tohoku earthquake and tsunami. One of the most memorable parts of the trip was when one of the elder men in the town told us (in Japanese), “when you return to the big cities in America, do not forget about us. The media forgot about us but we are still struggling.” This moment galvanized me into taking action the same way that I did for helping out Rhotia Valley the year before. I was ultimately successful in running the fastest mile while juggling five objects and helping raise awareness and support for the community in Minamisanriku. It also infused me with some invaluable experiences, such as waking up to a phone call at 6AM with a voice telling me that the next voice I hear will mean that I am live on BBC radio. Another character-building moment was when I did a live radio interview with a show in Minnesota whose premise is humiliating their guests. They did not give me the slightest indication of this style when they invited me on the show, but being forced to respond to their malicious banter with composure and eloquence on the spot was very challenging.

Shortly after I learned of my acceptance into the NanoJapan program that year, I also learned that I was accepted as an intern at SpaceX for the first time. I was unable to do both programs during summer, so I decided to take time off of school to follow my dream of working on rockets. This juxtaposition of fundamental scientific research and results-based industry within the same year had a profound affect on my academic trajectory. While research at Rice was exciting and cutting-edge, seeing my work launch to space at SpaceX was enthralling. While research at Rice was occasionally frustrating and confusing, work at SpaceX moved at such a dizzying rate that it was sometimes difficult to catch my breath. That year, I decided that nanomaterials research was not a field that I would enjoy spending the rest of my life in, nor was Avionics Integration.

One of my SpaceX projects, however, threw me a bone. I worked on the thermal imaging systems that monitors temperatures of the vacuum nozzle on the second stage of the F9R rocket. This sparked a heavy interest in photonics and led me to take a specialized Photonics class at my university and join another NSF-sponsored program, the Optics in the City of Light REU through University of Michigan. My project was designing and characterizing a full-field optical coherence tomography setup that could be coupled with optical tweezers for cell-level biological studies. Although I found this to be the most interesting and exciting work up to that point, and thoroughly enjoyed the international atmosphere, I was still not satisfied settling on photonics as a career. I was developing a deep interest in computer and information science at the time.

I returned to SpaceX the next summer in the Hardware Development department to see if I would enjoy the hardware-software interface in industry. Although I found ultimately decided that SpaceX is not where I want to establish my career, one of the projects I worked on employed a small amount of machine learning in order to automate certain parts of the rocket design process. I loved programming the various algorithms and continued to learn more about the subject. This led me to join the Machine Intelligence Laboratory at the University of Florida for the end of my undergraduate career to gain more experience with unsupervised learning and robotic vision. I am currently developing SLAM algorithms for the university’s robot in the IEEE autonomous robot competition. I hope to be able to use this work as a Segway into my graduate studies in machine learning and neuromorphics.

Overall, I am very fortunate to have had been able to follow such a wide variety of interests as an undergraduate. My personality and character have undergone severe battering that left me feeling stronger every time. I cannot imagine what I would want to study more than electrical engineering, as I feel that it is gearing me to be able to tackle the goals that I truly and passionately care about. If the past century has been any indication of how science changes the world beyond imagination, then the next century will be full of exciting new technologies that I want to be part of.