Richard Lee Hollenbach III

Essay

Through the use of smart phones, computers, and the internet, we live in an increasingly interconnected world. The common denominator between all of our devices that we use for work, pleasure, and communication is printed circuit board technology and hardware. With improved electronic design and manufacturing in the world, our devices will allow us to perform our tasks with ease. However, my vision is twofold – as we improve our electronic hardware technology, so must we improve the software, programming, and machine learning side, in order to fully implement the most successful use of electronics today.

As Gordon Moore predicted back in 1965, the number of transistors on a single silicon chip would double every two years [1]. Over fifty years later, this is nearly true, for transistors have decreased in size from millimeters to tens of nanometers. This law has allowed computers to shrink from the size of an entire room to fit within our pockets. However, the law does not stop today, for transistors are now being stacked in three dimensions. With more and more transistors in such as small proximity, the computational power of a particular device increases [2]. Suddenly, we can have high performing super computers, necessary to simulate some to today’s most complex problems.

In the past I have worked with computer chips and high-performance computer clusters. During my undergraduate years, I shadowed silicon wafer engineers at Globitech, Inc. [3]. This allowed me to see the process of creating these ultra-tiny silicon computer chips. Globitech is a major player in the global economy, for their customers range from domestic sites all the way to international locations such as China, Malaysia, and Italy. Their director of sales mentioned to me, that he does not expect sales to drop anytime soon. As a result, even as hardware decreases in size, silicon chips will not decrease in neither demand nor value. In addition, I have utilized these chips once they are implemented; in a research position at the University of Pittsburgh, I ran large scale computational fluid dynamic simulations through the use of high-performance computer clusters located in Pittsburgh, Texas, and California. The so-called High-Performance Simulation Laboratory or HiPerSimLab for short, attempted to speed up the computational time it took to simulate flow over a full-scale airplane, wind through a city, or air generating power on a wind turbine [4]. Thus, to design the next generation of aircraft, skyscraper, or renewable energy source in a timely fashion, we need to push the limits of computation, by increasing the number of transistors on a single silicon computer chip.

While hardware is important for performing complex computations, it is useless unless it can be controlled, or as it is commonly referred to, programmed. Obviously, programming has been around ever since computers have been, but the key is to improve software as fast as we do hardware. This includes creating algorithms to make computations more efficient in terms of time and storage. Over time we have developed newer computer languages to make it easier to perform complex computations, which is a trend that needs to continue as the hardware develops.

Two major areas of interest I see in the world of electronics today is parallelization and machine learning. In order to take advantage of supercomputers with large numbers of transistors, we split up computational simulations into smaller chunks that can be solved simultaneously. Thus, the pieces can be solved alone and then stitched back together to form the solution. This process saves hours of computational time without sacrificing accuracy, provided the problem is split apart correctly in the first place. Furthermore, machine learning is a relatively new area in computations. Suddenly, engineers may not have to run every single simulation or conduct every single experiment to collect necessary data; instead, running a few of each and then teaching a machine to extrapolate additional results [5]. Not only does this save time, energy, and money in conducting data, but it allows to the simulation or experimentation of systems potentially impossible to do by hand. Thus, we could solve some of the largest and most complex aerospace problems faster than ever.

In the past I have also had experience with parallelization and machine learning. While at Rolls-Royce for an internship, the complex jet engine simulations I ran were split up into smaller chunks. This took a multiple week run time and solved it in a matter of hours. This speed up is crucial when lives are on the line as our research efforts went into the design of commercial jet engines used on aircraft all around the world. Moreover, I have seen the use of machine learning in research here at Duke University, where I am studying for my Ph.D. in mechanical engineering. I plan to conduct research in our low speed wind tunnel, and then build a machine learning model to extrapolate additional data and results.

To solve the most complex problems, we need powerful and effective hardware in the form of super computers, and efficient algorithms implemented by software that utilizes parallelization and machine learning techniques. As a result, I propose a business plan for a consulting firm to provide simulation and data analysis in this field. Client companies can provide the input files and necessary conditions for simulation, and then my company can perform the computations and provide the results. This firm has the potential to be a big part of the global economy, since companies all around the world require high performance computing.

My vision for the future of electronic design, engineering, and manufacturing in the global economy consists of improving hardware and software to create ultra-high-performance supercomputing for solving some of the most complex aerospace problems out there today. Moore's Law states that more and more transistors will be printed on computer chips, allowing for more sophisticated computers in smaller sizes. Thus, supercomputers will become increasingly more efficient and powerful. Improved algorithms and software will utilize this updated hardware to maximum capacity, allowing for faster simulations. Introducing parallelization and machine learning techniques will create more data and results with less simulation time. As a result, the future is not limited strictly to electronic circuit design, but to software and algorithms as well. The future is bright, and the possibilities are endless.

References:

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[3] - http://www.globitech.com/index.htm

[4] - https://www.hipersimlab.org/

[5] - https://expertsystem.com/machine-learning-definition/