Is Computer Engineering for You?

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Abstract

This paper gives an overview about the Computer Engineering major for students considering to major in it, and discusses how this major is different from other majors. It also discusses the qualities needed for students to succeed in this major. This paper will explore Computer Engineering from an undergraduate's perspective, examining the courses that undergraduates will take when they choose this major, and how these courses differ from other majors. This paper will also explore Computer Engineering from an expert's perspective. It will examine the research and writing done in this major, and contrast it with research done in other majors.

Keywords: computer engineering, choosing majors

Is Computer Engineering for You?

Over the last four years, the number of students enrolling for a Computer Science or Computer Engineering major has increased by more than 50% (Zweben, 2013, p. 11). As high school seniors and college freshmen are deciding their majors, many will consider Computer Science or Computer Engineering as one of their options. A decade ago, there was a sharp decline in Computer Science majors, because they were often portrayed as socially awkward people often called “nerds” (Miller, 2011). However, today, because of the increasing prevalence of computers, and because of “celebrity” entrepreneurs such as Steve Jobs and Mark Zuckerberg, the majors are now viewed as one of the best majors to take at universities (Miller, 2011). Graduates from these majors seem to have countless opportunities, from working at giant companies such as Google to starting a new billion dollar startup company.

However, in choosing majors, high school seniors or college freshmen should not base their decision only on the popularity of the major, or on the job prospects they might have if they pursue the major. They should know whether or not they will love what they will learn, and they should understand what the experts in their major actually do and value.

Thus, my aim in this report is to help students, especially high school seniors and college freshmen, to better understand the Computer Engineering major, and figure out if the major suits them. In order to do so, I will examine the courses, research and writing in this major and compare them with other majors. By examining the courses in Computer Engineering, students will be able to know what courses they are expected to take if they major in Computer Engineering, and how these courses differ from the courses they have taken. By examining the research and writing in this major, students will be able to understand the “knowledge-making” process in Computer Engineering, and understand what experts in this field do and value

(Hyland, 2011). My hypothesis is that the Computer Engineering major is suitable for students who are interested in both computer hardware and software, enjoy creating and innovating, and have adequate skills in mathematics and programming.

Research Methodology

To conduct my research and test my hypothesis, I used several research methods. First, as a junior in Computer Engineering at the University of Michigan, I have recollected the reasons I am taking Computer Engineering as my major. I also recalled my experiences from taking courses required in Computer Engineering. I remembered courses that I liked, and why I liked them, and courses that I disliked, and why I disliked them. I also recalled students who had problems with Computer Engineering courses, and why they had the problems.

Next, I interviewed a lecturer in Computer Engineering at the University of Michigan to understand more about the research and writing he does as an expert in this field. I used Klein's (2011) "hunting/gathering" heuristic, which is a heuristic for understanding research processes, to understand how research in Computer Engineering is different from other fields.

Finally, I looked through the titles of research conducted in the Computer Engineering field. I used my library's resources to find journals about Computer Engineering, and used IEEEXplore to find papers in this field. To ensure the credibility of the papers, I ranked them according to the number of citations. I then chose several research papers and skim through them, taking note of several distinct features of the papers. I used Hyland's (2011) findings about the writing in research papers in different fields to analyze the writing used in the research papers.

Admittedly, my methods are insufficient to perfectly characterize the qualities of students that should major in Computer Engineering. It is limited to my experience in the field, the papers

I skimmed through, and the interview I had with a lecturer. The experience I have may not apply in certain situations, and the number of interviews I conducted is insufficient to verify my claims. However, my methods does give an insider view of what the students in Computer Engineering learn and what the experts in Computer Engineering do.

Findings

From my experience, interview, and analysis of research papers in Computer Engineering, I found that Computer Engineering is an engineering field that integrates both knowledge from Computer Science and Electrical Engineering to make hardware and software work together. It is a Computer Engineer's work to make sure that the code that is written by developers (or Computer Science majors) can run efficiently on circuits build by Electrical Engineers.

Computer Engineering from an Undergraduate Student Perspective

Why I major in Computer Engineering. I major in Computer Engineering because I love computers, I love programming, and I love creating something that can improve people's lives. Because of this, I initially wanted to major in Computer Science. But I feel that I do not want my inventions to be stuck as software--something intangible that just exist inside the computer. I want my inventions to be something tangible, something that can be put in people's hands, hung on walls, and used in any way. Besides that, I do not want my knowledge of computers to be limited to software and algorithms. I want to understand the hardware I am working with--how it is constructed, how it works, and how it understands the code I write.

Courses in Computer Engineering. Initially, the courses taken to major in Computer Engineering are similar to other engineering courses. Students are required to take Physics, Chemistry, and Programming introductory courses. They are also required to take four

Mathematics courses. We can observe from here that engineering is generally a Mathematics heavy field. At this time, most engineering students are still choosing which part of engineering they want to specialize in. The introductory courses gives a broad overview about the branch of knowledge they will apply once they choose a specialization.

After the introductory courses are taken, Computer Engineering majors will take more specialized courses, usually with either Electrical Engineering or Computer Science majors. These courses includes an intermediate programming course, a course in analyzing circuits, a course in designing logic circuits, and a course in computer organization. These courses are closer to what Computer Engineers actually do. In my opinion, these courses are a lot more interesting than the introductory courses. During this time, students will learn the basic building blocks of computers and how code is translated into ones and zeroes for a computer to understand. They will also have the opportunity to design simple logic devices such as calculators and traffic lights.

Although these intermediate courses may sound interesting, students usually decide not to major in Computer Engineering while taking these courses. These courses are a lot harder than the introductory courses, and the workload is also much heavier. Besides that, most of the courses uses a lot of Math, and some students are not comfortable with it. Some courses, such as programming and logic design, require a different "algorithmic" way of thinking that some students find hard to comprehend.

After taking intermediate courses, Computer Engineering students will take upper-level courses. There are around twenty of these courses, and students are only required to choose three. These courses are mostly specializations to the intermediate courses.

Comparison between Computer Engineering Courses and non-engineering courses. Comparing Computer Engineering courses to non-engineering course I had taken, I noticed that most non-engineering courses are about theories in specific fields, and most engineering courses are more about applying these theories. For example, in my Physics course, I learned how magnetic field and electric field react to produce capacitances. In my logic design course, I learned how these capacitances are used to store temporary data and make computer memory.

Research in Computer Engineering

From my correspondence with Dr. Mark Brehob, I was able to understand the research process in Computer Engineering and how it differs from other fields. I discovered that Computer Engineering is considered an empirical field, similar to most engineering fields (M. Brehob, personal communication, March 28, 2014). This means that unlike Mathematics or Physics, research in Computer Engineering has no definite “true” or “false” answer. The results of research in Computer Engineering is usually something measurable, such as an increase of write speed to hard drive, or an increase in processor speed. Moreover, research in this field depends a lot on the current situation (M. Brehob, personal communication, March 28, 2014). For example, today, people are interested in utilizing multi-core processors, which are computers that have more than one processor. Thus, currently, most Computer Engineering research are done to accommodate this.

Computer Engineering Research Topics. By looking through paper titles in the IEEEXplore online database, I observed that Computer Engineering research is mainly concerned about computer performance and hardware designs. For example, some of the papers are titled: “The MIPS R10000 Superscalar Microprocessor” (Yeager, 1996), “Selective Cache

Ways: On-Demand Cache Resource Allocation" (Albonesi, 1999), and "Effective Hardware-based Data Prefetching for High-Performance Processors" (Chen & Baer, 1995).

Computer Engineering Research Process. Similar to other fields, research in Computer Engineering starts with a research question. These research questions can be formed by looking at other research, helping out other researchers with their research, or making certain general observations (M. Brehob, personal communication, March 28, 2014). The process of forming a research question is similar to Kleine's (2011) "gathering" heuristic where researchers gather information and "discover what might be of use" (p. 25).

With a research question in hand, researchers will then formulate a hypothesis, or an initial conjecture on what the outcome of the research will be. This is one of the most important part of research (M. Brehob, personal communication, March 28, 2014). Then, researchers will test the hypothesis by making simulations and measuring empirical data. The hypothesis is confirmed by observing the empirical data. The process of confirming the hypothesis is similar to Kleine's (2011) "hunting" heuristic, where researchers look for certain information to confirm their hypothesis.

Lastly, researchers will present their research at conferences. As Brehob (personal communication, March 28, 2014) puts it, "if you don't communicate [your results, research] does not matter much." Research is commonly presented at Computer Architecture conferences such as International Symposium of Computer Architecture (ISCA), High Performance Computer Architecture (HPCA), and International Symposium on Microarchitecture (MICRO). Interestingly, researchers in this field do not commonly publish in journals (M. Brehob, personal communication, March 28, 2014).

Comparison between the research process in Computer Engineering and the research process in other fields. The research process in Computer Engineering is mostly similar to the research process in most fields. It starts with finding a research question, formulating and confirming a hypothesis, and presenting the research. This research process also closely follows Klein's (2011) "hunting/gathering" heuristic. The major difference between the research processes is the method used to confirm the hypothesis. While research in some fields uses experiments, surveys, outside research, or proofs to confirm the hypothesis, research in Computer Engineering mostly uses empirical data to confirm it.

Writing in Computer Engineering Research. Writing is an integral part of research in Computer Engineering, and it forces researchers to be more formal in their thought process. It serves as a medium to communicate a research outcome to other researchers (M. Brehob, personal communication, March 28, 2014). Compared to researchers in other fields, who may do their writing during research, or may consider writing part of their research (Kleine, 2011), in Computer Engineering, researchers often write after the research is done, and their hypothesis is verified (M. Brehob, personal communication, March 28, 2014, Kleine, 2011).

Distinct features in Computer Engineering papers. The distinct features I noticed in Computer Engineering papers are pseudocodes and state diagrams. Pseudocodes are informal code written to describe an algorithm used in the paper. State diagrams are diagrams used to describe each state a "machine" can be in, and how the "machine" would transition from one state to another (See Figure 1). The machine can be anything the researcher is working on, whether it is a calculator, a computer processor, or even a traffic light. Both of these features are used to succinctly describe the logic used in the paper, and has close ties to programming. From this, we can see the extensive use of logic and programming in Computer Engineering.

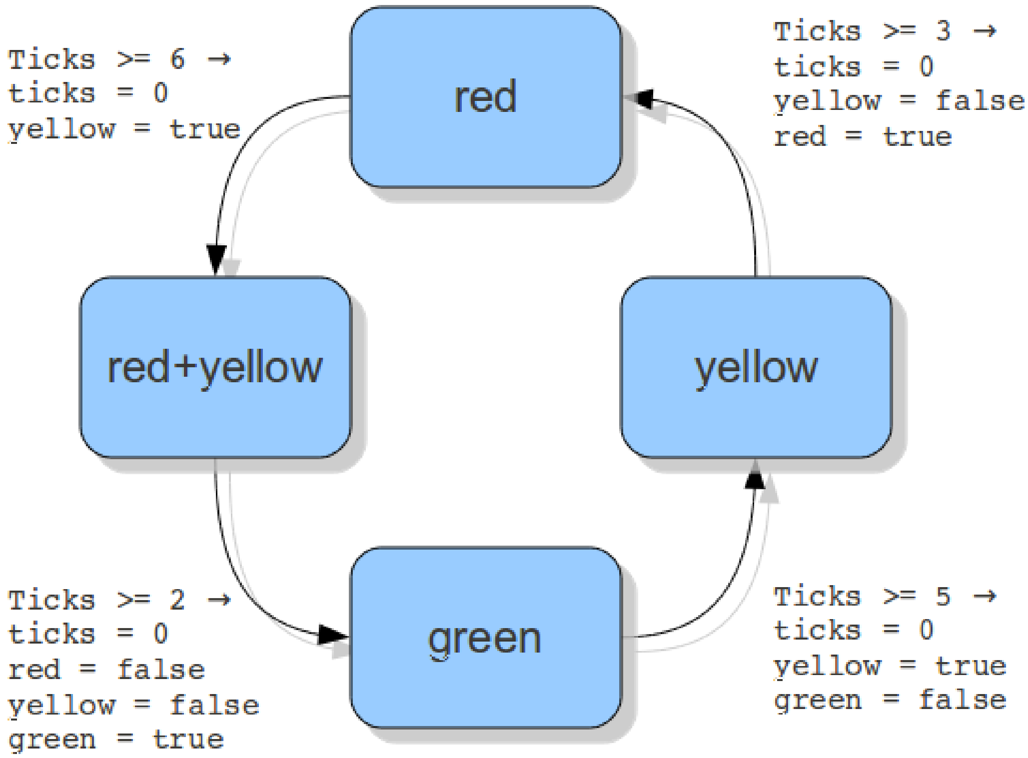

Figure 1: A traffic light state machine. (sw2, 2010)

Usage of stance and engagement in research papers. In light of Hyland's research, I observed the usage of stance engagement in several papers in my field. Stance is some markers that conveys a writer's personal feeling towards a particular information (Hyland, 2011). Engagement is a way for writers to connect with readers (Hyland, 2011). I observed that researchers in Computer Engineering uses stance and engagement sparingly. A search for stance and engagement features such as questions, or words such as "think" or "suspect," yields almost zero results in most papers. This feature is similar to the papers in hard sciences field (Hyland, 2011).

From these observations, I can conclude that Computer Engineering researchers tend to value data and objectivity rather than personal opinion. By minimizing the use of stance, researchers in Computer Engineering minimizes their role in the paper and allows the conclusions of their paper to be tied more closely to the results rather than their personal opinions (Hyland, 2011). The minimal usage of engagement, on the other hand, allow readers to concentrate more on the results of the research. Computer Engineering researchers often view engagement features such as questions as a distraction because it makes it harder for readers to find the results (Hyland, 2011).

Computer Engineering research analysis. Connecting my findings from the research topics, research process, and writing in Computer Engineering, I can conclude that research in Computer Engineering is about applying existing knowledge in new ways to make computers better and more efficient. The research is not concerned about explaining natural phenomenon or explaining human behavior. Therefore, there is no need for researchers to thoroughly explain their perspectives and argue their points. They only need to show whether their methods make computers more efficient or not (M. Brehob, personal communication, March 28, 2014). To show this, researchers only need to show their empirical data, the actual results of the research. This is why researchers value empirical data far more than the personal opinion of the researcher. As the results of the research require no explanation or argument, researchers can immediately look at the results of the research and understand it.

Discussions

By observing the courses and research in Computer Engineering, I can conclude that Computer Engineering is mainly about understanding computers, designing it, and optimizing it. In order to do so, Computer Engineers must be someone who enjoys solving problems and working with computers. They must also have capable mathematics, programming, as well as problem solving skills. Students who are planning to major in Computer Engineering must ask themselves if they have these necessary skills and interests.

Next, by observing the research and writing in Computer Engineering, and the empirical nature of it, I am able to discern the difference between research in Computer Engineering and other non-empirical fields. While most research in non-empirical fields such as Economics, Mathematics, and Physics seek to discover new knowledge, Computer Engineering research is more about optimizations of the current technology. Students must keep this point in mind while choosing between Computer Engineering and another major. Students who prefer to do research and discover new theories should major in a non-empirical field. Students who prefer to do research about computer optimizations should major in Computer Engineering.

Conclusions

Computer Engineering is a major for those who are interested in both computer hardware and software, who love innovation, and who love solving problems. By majoring in Computer Engineering, not only will students gain knowledge on how computers work internally, they will also have the knowledge to design and optimize their own processor, and create their own computer. Computer Engineering graduates will work on the forefront of technology, creating new devices, high performance computers, and whatever the future of computing holds.

However, Computer Engineering is not suitable for every student. In fact, Computer Engineering is not suitable for the majority of students. Students who enjoy learning scientific theories, and wish to discover their own theories, should choose to major in pure sciences. Students who loves to observe people and understand how people work, should major in social sciences. Students who loves painting, or arranging things, should major in art and design. There are hundreds of different majors, and hundreds of different interests. Students should major in what they love, not in what they think is popular, because in the end, each major is important in its own way.

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