Computer Engineering Program at Utah Valley University

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Abstract

This paper elaborates the detail content of the curriculum for the computer engineering program at Utah Valley University (UVU). A comparison is made between the curriculum of the computer engineering area of specialization and the current computer engineering program. An analysis and description of both curriculums is performed to establish similarities and differences. The major aspects taken into account in the comparison are the duration of the programs, special courses or activities of each curriculum, the differences in the student academia load and the curriculum flexibility.

Introduction

For the better part of four decades, computer engineering has arisen out of computer science and electrical engineering as its own discipline[1]. Computer Engineering assimilates computer science and electrical engineering as they relate to the design, implementation, and operation of digital computers. Several technical subjects are studied within this discipline, including electric and electronic (analog and digital) circuits, computer architecture, computer software (languages, algorithms, and data manipulations), embedded systems, digital signal processing, VLSI design, communications, and microprocessor (microcontroller) design. A computer engineer's foundation is rooted in the theories and principles of computing, engineering and mathematics[1]. He applies these principles to the design of hardware, networks, software, and computerized equipment and instruments to solve technical problems in diverse applications domains[1]. According to Computing Curricula: Computer Engineering Final Report 2004, computer engineers should satisfy the following three characteristics:

- "Possess the ability to design computer systems that include both hardware and software to solve novel engineering problems, subject to trade-offs involving a set of competing goals and constraints. In this context, "design" refers to a level of ability beyond "assembling" or "configuring" systems.
- Have a breadth of knowledge in mathematics and engineering sciences, associated with the broader scope of engineering and beyond that narrowly required for the field.
- Acquire and maintain a preparation for professional practice in engineering."[2]

Over the last few decades, computer engineering programs have been challenged with adapting their curricula to the rapid developments in technology without increasing the number of credit hours for their programs. Resulting from the demands made from students, employers, and the rapid advancement of technology has been a tendency to develop more specialized curricula that contain fewer common courses among the engineering disciplines. Specialized courses have been added to the curriculum at the expense of an incomplete foundation of mathematics, science, and engineering principles[3]. In order to have professionals that can respond successfully

to the contexts of global economy and knowledge-oriented society, some researchers [4,5,6], have argued that the development of autonomous learners is fundamental. Coto describes autonomy as:

> *… the ability to take charge of one's own learning. It means to have the responsibility for setting learning goals; identifying and developing learning strategies; developing study plans; reflecting on learning; identifying and selecting relevant resources and support; and assessing one's own progress*[7].

In a research study conducted at the National University of Costa Rica with the goal of producing a curriculum shift from a teacher-centered approach toward a student-centered approach, it was concluded that this shift is not going to be an easy one. They pointed out the importance of guiding students as well as faculty in the transition to an educational model that promotes the autonomy of the students[7]. Undoubtedly, employers worldwide value autonomous learners; they are willing to learn, are motivated to work, are effective collaborators, are good communicators, and are able to be lifelong learners. In our computer engineering program, we are trying to slowly integrate the student-centered approach to learning.

The Institution

Utah Valley University is a regional teaching university in Utah Valley with enrollment of over 31,500 (Fall 2012). Established in 1941, first as a technical college, then a community college, the institution became a state college in 1993 and a regional university in 2008. UVU retains much of the mission and philosophy of a community college in its lower division courses, offering 63 associate degree programs in addition to 67 bachelors and 3 masters programs. Unlike Utah's other universities, UVU has an open admission policy with structured enrollment support in its lower division. Charged with serving Utah's second most populous area the institution refined its vision and mission to emphasize engaged learning and community service. The main campus of UVU is located in Orem, Utah with five-satellite campuses located in its 3 county central Utah primary service area of over 4,000 square miles. The institution provides educational services to a population of just over 600,000 that includes both urban and rural communities where higher education is in high-demand.

Computer Engineering Program at UVU is the first engineering program at this institution. It is housed in the Computer Science Department. In our Computer Science Department at UVU, there are three programs which are Computer Engineering, Software Engineering, and Computer Science. Our Computer Science Program has two areas of specialization which are traditional computer science and computer networking. Our Computer Engineering program was approved by the institutional Board of Trustees on April 11, 2002 and was approved by Board of Regents on July 2012. It took us ten years to get approval for this program. Before getting the approval Computer Engineering was an area of specialization in the computer science program.

Curriculum for the Computer Engineering Program at UVU

The following curriculum was designed to give our students strong background in the fundamentals of computer engineering and adequate knowledge in advanced topics to prosper in this ever-changing field. A balance between theory and practice is carefully incorporated into the curriculum by the faculty. In order to graduate with a Computer Engineering degree at UVU, students must complete 126 semester hours of course work. The current curriculum consists of 36 credit hours of General Education requirements and 87 credit hours of Discipline Core requirements, and 3 credit hours of Elective requirements.

CS Requirements (30 CR)

- CS 1400   Fundamentals of Programming
- CS 1410   Object-Oriented Programming
- CS 2300   Discrete Structures I
- CS 2420   Into to Algorithms and Data Structures
- CS 2450   Software Engineering
- CS 2600   Computer Networks I
- CS 2810   Computer Organization and Architecture
- CS 305G   Global Social & Ethical Issues in Computing
- CS 3060   Operating Systems Theory
- CS 4380   Advanced/High-Performance Computer Architecture

ECE Requirements (38 CR)

- ECE 1020   Computer Engineering Problem Solving with Matlab & Labview
- ECE 2250   Circuit Theory
- ECE 2255   Circuit Theory Lab
- ECE 2700   Digital Design I
- ECE 2705   Digital Design I Lab
- ECE 3730   Embedded Systems I
- ECE 3740   Digital Design II
  ECE 3750   Engineering Analysis
- ECE 3770   Signals & Systems
- ECE 3760   Electronics Systems
- ECE 3765   Electronics Systems Lab
- ECE 4730   Embedded Systems II

- ECE 4750   Digital Signal Processing
  ECE 4760   VLSI Design
  ECE 4765   VLSI Design Lab
- ECE 4800   Computer Engineering Senior Design Project

Math Requirements (19 CR)

- MATH 1210 Calculus I
- MATH 1220 Calculus II
- EENG 3710 Engineering Probability & Statistics
- CS 2300   Discrete Structures I
- EENG 3750 Engineering Analysis

Science Requirements (18 CR)

- PHYS 2201 Physics for Scientists and Engineers I
- PHYS 2215 Physics for Scientists and Engineers I Lab
- PHYS 2220 Physics for Scientists and Engineers II
- PHYS 2225 Physics for Scientists and Engineers II Lab
- CHEM 1210 Principles of Chemistry I
- CHEM 1215 Principles of Chemistry I Lab
- BIOLOGY   GE

Electives (3 CR)

- ECE 4770   Artificial Neural Networks   or
- ECE 4780   Wireless Communication & Mobile Application

To summarize, the students in the Computer Engineering program take 36 hours of general education, 18 hours of Science, 19 hours of Math, 30 hours of Computer Science, 38 hours of engineering requirements, and 3 hours of electives.

Curriculum for the Computer Engineering Area of Specialization

Students must earn a minimum of 123 semester credits to qualify for the Bachelor of Science degree in computer science with an emphasis in computer engineering. The curriculum consists of 36 hours of General Education and 13 hours of science requirements.

Math requirements consist of 20 hours which are listed below:

- MATH 1210   Calculus I
- MATH 1220   Calculus II
- MATH 2040   Principles of Statistics
- CS 2300   Discrete Structures I
- EENG 3750   Engineering Analysis

Computer science core requirements are 27 hours. Core requirements which are taken by all the areas of specialty are given below:

- CS 1400   Fundamentals of Programming
- CS 1410   Object-Oriented Programming
- CS 2420   Into to Algorithms and Data Structures
- CS 2600   Computer Networks I
- CS 2810   Computer Organization and Architecture
- CS 305G   Global Social & Ethical Issues in Computing
- CS 3060   Operating Systems Theory
- CS 3240   Introduction to Computational Theory
- CS 3690   Advanced Topics in Data Communications

The following courses are required for the Computer Engineering area of specialization only:

- CS 4380   Adv/High-performance Computer Architecture
- ECE 1020   Computer Engineering Problem Solving with Matlab & Labview
- ECE 2250   Circuit Theory
- ECE 2255   Circuit Theory Lab
- ECE 2700   Digital Design I
- ECE 2705   Digital Design I Lab
- ECE 3740   Digital Design II
- ECE 3770   Signals & Systems I
- ECE 4800   Computer Engineering Senior Design Project

Computer Engineering Area of Specialization takes a minimum of 15 credits from the following: (Minimum of 6 credits must be ECE)

- ECE 4750   Digital Signal Processing
- ECE 4760   Semiconductor Devices
- ECE 4765   Electronics Systems Lab
- ECE 4730   Embedded Systems
- CS 3400   Software Engineering
- CS 3520   Database Theory
- CS 3670   Network Programming

- CS 4470   Artificial Intelligence
- CS 4510   Operating Systems Design

To summarize, the students in the Computer Engineering area of specialization take 36 hours of general education, 13 hours of Science, 20 hours of Math, 39 hours of computer science, 18 hours of engineering requirements, and 15 hours of electives.

Table 1 summarizes the curriculum comparison of the Computer Engineering Program and Computer Engineering Area of Specialization in the Computer Science Department at UVU and Appendix A summarizes the prerequisite and course description for the computer engineering program at UVU.

	Computer Engineering Program	Computer Engineering Area of Specialization
Total Credit Hours	126	123
Math Requirements	19	20
Science Requirements	18	13
Computer Science	30	39
Electrical Engineering	38	18
Electives	3	15
General Education	36	36

Table 1: Curriculum Comparisons

Summary and Conclusion

There are several observations to be made regarding the comparison of the programs. One observation is that the curriculum of the computer engineering program requires 126 credit hours versus 123 for the computer engineering area of specialization. The computer engineering area of specialization is more flexible than the computer engineering program because of the variety of elective courses offered toward the end of the program. Also, science requirement increased from 13 credit hours to 18 for the computer engineering. Duration for graduation for both programs is almost the same (four years). Another observation concerning UVU's computer engineering curriculum is that it leans more toward required electrical engineering courses, whereas UVU's computer engineering area of specialization in the computer science department leans more toward computer science courses. Finally, the degree awarded for the UVU computer engineering area of specialization is a computer science degree with emphasis in computer engineering, whereas UVU's computer engineering program awards a computer engineering degree.

As can be seen from the curriculum comparisons of the UVU's computer engineering and UVU's computer engineering area of specialization, one can conclude that having an area of specialization in Computer Engineering in the Computer Science department is a viable option for schools that cannot have engineering programs. Our Computer Engineering Area of Specialization is accredited by ABET and we are working on getting ABET accreditation for our new computer engineering program.

References

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Appendix A

Computer Engineering Core Courses

1. ECE 1020   Computer Engineering Problem Solving with MATLAB and LabVIEW

   Prerequisite: MATH 1050 or higher

   Description: Introduces the field of Computer Engineering through programming in the MATLAB and LabVIEW languages. Teaches the design of various components of a prototype communication system while learning about the following aspects of MATLAB: scripts and function files, math functions,

commands for array construction and manipulation, string expressions, logic operators, control flow, and graphics. No prior knowledge of computer engineering is assumed.

2. ECE 2250   Circuit Theory

   Prerequisite: MATH 1210, PHYS 2220, ECE 1020

   Description: Develops linear circuit theory and its application in the analysis and design of RLC active circuits. Covers DC, AC, and transient analysis utilizing node and mesh analysis. Introduces the use of CAD tools. Integrates a laboratory.

3. ECE 2255   Circuit Theory Lab

   Prerequisite: MATH 1210, PHYS 2220

   Description: Laboratory for EENG 2250 develops linear circuit theory and its application in the analysis and design of RLC active circuits. Covers DC, AC, and transient analysis utilizing node and mesh analysis. Introduces the use of CAD tools.

4. ECE 2700   Digital Design I

   Prerequisite: MATH 1050 and (CS 2810 or PHYS 2220 or ECE 2250)

   Description: Studies the design and application of combinational and sequential logic circuits with discrete and programmable logic devices.

5. ECE 2705   Digital Design I Lab

   Prerequisite: MATH 1050 and (CS 2810 or PHYS 2220 or ECE 2250)

   Description: Designed to accompany ECE 2700. Covers design of digital systems with discrete and programmable logic devices. Includes the use of CAD tools for system design and verification.

6. ECE 3710   Applied Engineering Probability and Statistics

   Prerequisite: MATH 1210

   Description: Studies probability and statistical theory with an emphasis on engineering and computer science applications. Covers descriptive statistics, discrete and continuous random variables, probability distributions, hypothesis testing, expectation, estimation, ANOVA testing, and regression analysis. Includes computer analysis of data and simulation.

7. ECE 3730   Embedded Systems I

   Prerequisite: ECE 2700

   Description: Presents an introduction to the basic building-blocks and the underlying scientific principles of embedded systems. Covers both the hardware and software aspects of embedded processor architectures and assembly language programming. Develops the theory and technology necessary for the interconnection of devices and systems to microcontrollers by using hardware and software examples and students' projects.

8. ECE 3740   Digital Design II

Prerequisite: ECE 2700

Description: Covers the design and verification of digital systems. Emphasizes hierarchal design principles and the use of programmable logic devices (PLDs). Utilizes modern CAD tools and design languages (VERILOG).

9. ECE 3750   Engineering Analysis

Prerequisite: MATH 1220, ECE 1020

Description: Studies Linear systems, abstract vector spaces, matrices through eigenvalues and eigenvectors, solution of ordinary differential equations, Laplace transforms, first order systems, and complex numbers.

10. ECE 3760   Electronic Systems

Prerequisite: ECE 2250

Description: Introduces semiconductor theory and the fundamentals of diode and transistor operation. Covers the use of discrete and integrated active devices in linear amplifier and switching applications.

11. ECE 3765   Electronic Systems Lab

Prerequisite: ECE 2255

Description: Designed to accompany ECE 3760. Covers electronic analog circuit design, simulation, construction, debugging and measurement of circuit performance quantities using advanced instrumentation techniques.

12. ECE 3770   Signals and Systems

Prerequisite: ECE 3750

Description: Studies the time and frequency domain analysis of continuous time systems subjected to periodic and nonperiodic input signals. Introduces signal and transform theory and the application of Laplace and Fourier transforms.

13. ECE 4730   Embedded Systems II

Prerequisite: ECE 3730

Description: Presents the design of hardware and software required for embedded, real-time systems. Covers types of real-time systems, fuzzy logic, sensors, real-time operating systems, C programming skills, and wireless sensor networks.

14. ECE 4750   Digital Signal Processing

Prerequisite: ECE 3770 and ECE 3710

Description: Introduces the theory of digital signal processing and its application to practical problems. Covers z-transforms, discrete-time Fourier transforms, FIR (Finite Impulse Response) and IIR (Infinite Impulse Response) digital filter design.

15. ECE 4760   VLSI Design

Prerequisite: ECE 3760

Description: Focuses on theories and techniques of VLSI design on CMOS technology. Studies the fundamental concepts and structures of designing digital VLSI systems, including CMOS devices and circuits, standard CMOS fabrication processes, CMOS design rules, static and dynamic logic structures, interconnect analysis, CMOS chip layout, simulation and testing, low power techniques, design tools and methodologies, VLSI architecture.

16. ECE 4765   VLSI Design Lab

Prerequisite: ECE 3765

Description: Designed to accompany ECE 4760. Teaches students the complete process of building a ready-to-fabricate CMOS integrated circuit using a commercial design software. Lab experiments include the layout design of CMOS transistors, gate level design, design using VHDL, CHIP design and pin configuration, and simulation of the circuit for slack time and power consumption.

17. ECE 4770   Artificial Neural Networks

Prerequisite: MATH 1210

Description: Introduces a range of topics in the field of artificial neural networks: modeling of brains, applicable algorithms, and related applications. Develops the theory of a number of neural network models such as Perceptron, Multilayer Perceptron, and Hopefield networks. Emphasizes algorithms for implementing simple artificial neural networks and their applications.

18. ECE 4780   Wireless and Mobile Communications

Prerequisite: MATH 1210

Description: Covers the fundamentals of analog and digital wireless communications. Includes baseband and bandpass, analog and digital signaling techniques along with appropriate mathematical background in Fourier transforms, probability and random variables. Introduces both software and hardware designs.

19. ECE 4800   Computer Engineering Senior Design Project

Prerequisite: ECE 3740

Description: Serves as a project-oriented capstone course for computer engineering majors. Emphasizes major hardware and software design. Includes identification and completion of a suitable design project to be mutually selected by the faculty supervisor and student. Requires weekly written and oral presentations as well as a final written project report and an oral presentation. Requires completion of a program level assessment test.