

An Interdisciplinary Graduate Program at WVUTech

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Abstract

This paper describes the development and implementation of a graduate program in Control Systems Engineering at the Leonard C. Nelson College of Engineering in West Virginia University Institute of Technology (WVUTech). This unique interdisciplinary program is directed towards professional engineering practice and includes internships for those who can be placed with industries in the Upper Kanawha Valley region. With the current enrollment of 21 students, this graduate program is still considered to be small compared to the much larger graduate programs at other institutions across the country. But what makes this unique is the fact that the program has produced excellent graduates who are self-starters and good problem solvers and they all seem to enter the workforce with a penchant for, rather than a fear of, interdisciplinary activities.

1. Introduction

With a rapid move towards global economy and the resulting competition, almost all industries in the country are required to increase their productivity using fewer employees. This requires, for the most part, use of automatic control systems in order to maintain and regulate product output creating a demand for more engineers with control systems skills. There are only a few universities in this country that offer the type of interdisciplinary graduate program that can address this particular need. In January 1990, the Board of Regents authorized WVUTech to offer the Control Systems Engineering Program and to accept students for the fall semester of 1990-91. Although it started out as a joint program with the West Virginia University in Morgantown, it is no longer operated as such. The Program over the last ten years at WVUTech has grown in quality, enrollment and strength.

There are a large number graduate programs offered by many institutions across the country in several engineering disciplines. Keeping in mind that the global marketplace is becoming very competitive and the resulting need for engineers to quickly access, and utilize technical information and knowledge from multiple sources, engineers nowadays rely on computers heavily. As a result, electronic communication via internet has become very popular in recent years. Institutions of higher learning offer internet-based courses ^{1,2,3} at the undergraduate as well as graduate levels partly to meet the needs of industries. Also, the continuing education and retraining of engineering professionals using distance education has received much attention ^{4,5} and these aspects are currently being considered by WVUIT in the delivery of graduate education in the control systems area.

Control Systems Engineering is a unique interdisciplinary program directed toward professional engineering practice with the intention of serving the industrial needs and includes internships for those who can be placed with industry. Over the years the program has had interns with Ashland Petroleum, Elkem Metals Company, Rhone Poulenc and Union Carbide which are companies operating in the Upper Kanawha Valley and surrounding regions. This program is unique in that it accepts BS graduates in Chemical, Mechanical, and Electrical Engineering. Others such as chemists, civil engineers, etc., may be accepted on an ad hoc basis by taking a series of undergraduate preparatory courses.

The program is operated by the Dean of Engineering who also serves as the Director of the Graduate Program and he is advised by the Graduate Committee. This committee reviews and gives recommendations to the Director on all graduate applications for admission. In addition, this committee serves as a curriculum review committee and proposes any changes to the program, as well as, oversees the course content. This committee has representatives from those departments involved in teaching the control courses. All faculty members in the Graduate Committee have the terminal degrees, i.e., Ph.D., in their prescribed fields.

2. Program Description

Curriculum:

All students in the program are required to complete 33 credits hours in order to receive a degree. Students may select one of three options. The Course work Option requires 33 credit hours of course work, which includes 9 credit hours of electives. The Project Option requires 30 credit hours of course work and the 3 credit hour COSE 690 Project. The Thesis Option requires 27 credit hours of course work and 6 credit hours of thesis work (COSE 699 Thesis). Table 1 provides the standard pattern sheet and specific course titles and numbers.

Faculty:

The faculty members involved in the Graduate Committee, administering the program and

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teaching in this program all belong to the College of Engineering and the departments of English and Mathematics. The program currently, or at least in the last five years, has not utilized any part-time faculty. All of these faculty members have terminal degrees in different disciplines of engineering and mathematics and all but two are currently tenured. Members of the Graduate Committee are drawn from this group of faculty to help evaluate graduate applicants for admission and to provide advice and support on curriculum matters.

Students:

Each prospective student will hold a Bachelor of Science Degree in Engineering with an undergraduate GPA of at least 3.0 in an engineering discipline. Students with degrees not in engineering, such as, chemistry, physics, etc., are considered on a case by case basis by the Control Systems Engineering Graduate Committee. Eligible students are admitted into the program under the condition that they successfully complete core engineering prerequisite courses before they are allowed to take graduate classes. Students not completing undergraduate work at West Virginia University Institute of Technology (WVUIT) are required to have a GRE verbal and quantitative scores totaling at least 1100. This requirement may be waived for applicants who have passed the Engineering Fundamentals (FE) or one of the Professional Engineering Exams or who have graduated from an ABET accredited program. International students are expected to obtain a TOEFL score of 550 or better in the paper-based test.

Exit Abilities:

Students that successfully complete degree requirements will possess the following abilities: They will meet normal requirements to pursue a Ph.D. in Control Systems or related areas elsewhere. They can serve as industrial design and analyst engineers in the control systems area. Table 2 provides a list of known recent employers over the past five year period. Specific starting salaries are not available. Current salaries range approximately \$2000 to \$5000 above those with BS Engineering degrees. This places the current range at \$44,000 to \$53,000 per year. The wide span is due to a student's previous work history as a BS Engineer and whether the student has worked as an intern with the employer. Students graduating from the Control Systems program are required to maintain at least a 3.0 GPA for graduation. Over the past five years, at least three students are known to have continued on for Ph.D. degrees at other institutions.

Graduate and Employer Satisfaction:

Three different graduate surveys are conducted on a regular basis: WVUIT Graduate Survey, the ACT Student Satisfaction Survey and the Alumni Survey. These surveys are conducted with all available graduates from WVUIT. The graduate program has also relied on direct student-advisor contact for accurate student satisfaction information.

In addition, the College of Engineering conducts a employer satisfaction survey of all engineering majors approximately every two years. Known employers are contacted about the current number of WVUIT alumni employees and are requested to supply specific information on graduates. Here are some sample quotes from industrial sponsors concerning the internship program and the graduates they hired from WVUIT.

On internship from R. E. Wymer, Manager of Elkem Metals Company: *"Based on several letters and calls from Mr. Insley since his graduation, I believe that he left with a full appreciation and understanding of the real world of industry, with the experience, self esteem and attitude to step into full time employment better prepared than those without such a program"*

About our graduates from Clark W. Thurston, UCC Corporate Fellow of Union Carbide: *"We have several West Virginia Tech graduates on our process automation technical staff (I can count four in our work area), and we value the contribution that these associates make to the Engineering Department. I am aware of the course work required in the Control Systems Engineering Program, and I am sure that graduates from this program are able to contribute in a significant way to the rapid growth of industrial automation in the basic US industries"*

On internship from Todd M. Hess, Manager, Process Automation of Ashland Petroleum Company: *"I have had the privilege of working with two of your students from the Control Systems Engineering program at West Virginia Tech-Lowell Elkins and Jeff Drabesh. Both students provided quality expertise in support of control systems engineering development work for Ashland Petroleum Company...Certainly, without the assistance of these two gentlemen, our approach to automated solutions in these areas would likely not have been shaped into what it is today"*

Resources:

The Control Systems program is operated by the Dean of Engineering who also serves as the Director of the Graduate Program and he is advised by a Graduate Committee. Total expenditures for the Fall 2000 were approximately \$125,000 which included the tuition and fee waivers for 15 students, purchases of equipments, seminar and other expenses. Every student admitted to the graduate program is given tuition and fee waiver. Several students are supported with additional stipends from external sources for the research that they do on sponsored research projects.

Facilities:

The Department of Electrical Engineering has one laboratory devoted to control systems graduate and undergraduate courses. This laboratory has been utilized by the graduate Control Systems program since inception. The laboratory is equipped with four robotic arms, Feedback Limited control work station, and 10 PC's for modeling, simulation and real time control. Six PCs were replaced with networked Pentium class machines during the Fall 1998 semester and four existing

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Pentium machines were transferred to the lab. Additional equipment and laboratory space is available on a need basis in the microprocessor lab, power lab, electronics lab, and the project room. Graduate students use a designated student study area and all of them are given office space either in the laboratories or other locations in the engineering building.

Enrollment data and projections:

Table 3 gives enrollments over the last five years. This program is designed as an 18-month program, but for various reasons students end up taking two years to complete the program. The enrollment over the next five years is expected to increase to the level in 1996 (28). It is to be noted that the enrollment this year is 40% more compared to last year's enrollment of 15. The enrollment is limited by the number of internships we can provide, as well as other graduate assistantships we may be able to offer to our students.

3. Assessment Information (Student and Programmatic)

The Controls Systems program utilizes multiple means to assess program quality and student performance. A summarized list of assessment items and instruments include:

Program Quality is assessed through:

1. School-wide assessment of facilities and administration
2. Satisfaction at time of graduation
3. Student program satisfaction
4. GPA requirements
5. Entrance requirements

Student Performance is assessed by:

1. Program entry standards
 - GRE, TOEFL,
 - BS Engineering Degree
 - Department evaluation of course work from BS degree
2. Course performance (testing and assignments)
3. Program performance (Project/thesis presentation)
4. Employment

Measurement Instruments used in collecting assessment data include:

1. Student GRE scores
2. Student TOEFL (international students only)
3. College Transcripts (student should have a BS degree to enter graduate program)
4. The ACT Student Opinion Survey
5. Graduate Exit Survey (Registrar's office)
6. Master's Project Presentation (Control Systems Program)
7. Graduate Student Semester Meetings (Control Systems Program)

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8. Faculty Evaluations (WVUIT)
9. Graduate follow-up (Faculty Advisor)

Goals and success in achieving goals:

The goals of the program are to provide a quality graduate education oriented towards professional engineering practice in the control systems area and to prepare students for higher education leading to Ph.D in control systems or related areas. These goals have been achieved as they are supported by the data collected over the years in terms of employments of graduates from this program and feedbacks from various industries and the number of students pursuing Ph.D in control systems and related areas at other institutions.

4. Improving program quality using assessment data

Specific examples of how the curriculum, program administration, and program policies have changed as a result of the assessment process over the past five years include:

1. The Oral Examination Option was dropped based on student and faculty dissatisfaction.
2. The program of study dropped some required courses (such as Modeling and Simulation) and added electives (such as Intelligent Control).
3. Separate student advisory and project presentation committees were consolidated.
4. College Graduate Committee to get involved in curriculum development.
5. Restructuring program administration by placing entire program under the control of Dean of Engineering.
6. Allocation of program budget.
7. Moved student admissions decision to Graduate Committee.

As indicated above, one of the Graduate Committee functions is to assess and improve the quality of the program. This committee has frequent meetings in which curriculum and course content, as well as content of prerequisite courses are discussed, and modifications are made as needed. In addition, contact with intern industrial preceptors is also helpful in getting feedback on the educational ability of our students. This is an informal process in which faculty advisors for the interns have direct association with the interns' preceptors. In addition, these preceptors or industrial advisors are normally present at the students' oral examination which also gives formal contact between the faculty members and industrial representatives. This feedback is shared by members of the Graduate Committee to ascertain if any changes in curriculum are necessary.

5. Strengths of the program

Highly trained, full time faculty with specializations specifically in control systems are involved

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not only in teaching but in advising, curriculum development, assessment and admission aspects of the program. Many of the faculty members are actively involved in research and consulting in the area of control systems. Control systems laboratory facilities are state-of-the-art on the WVUIT campus. In 1996, WVUIT was designated as a regional campus of West Virginia University. Immediately following this action, Engineering Enterprise was formed to foster cooperation between the colleges of engineering at these two institutions. WVUIT/WVU partnership (Engineering Enterprise) has received renewed attention with emphasis on possible mutual cooperation in offering additional graduate programs in other areas of engineering.

WVUIT is involved in regional economic development activities and is working with industries in the region to serve their higher education and applied research needs. Control Systems Engineering program changes that are under consideration include the entire program being converted over to a late afternoon/early evening program in order to serve traditional/industrial as well as increasing number of nontraditional/part-time students. This change will allow existing engineering workforce based in Charleston/Huntington areas desiring a graduate level degree to pursue advanced engineering education.

6. Conclusions

This paper describes a unique and a popular interdisciplinary graduate program in control systems engineering at WVUTech. Over the last several years the program has grown and has attracted students from several disciplines of engineering. In addition to the normal course work and thesis requirements, the program vigorously encourages participation of many local industries through co-op programs offered to students in the program. Over the years the program has produced excellent graduates who are self-starters and good problem solvers and they all seem to enter the workforce with a penchant for, rather than a fear of, interdisciplinary activities.

The following is a quote from West Virginia University Institute of Technology's mission statement, "As West Virginia's only public institute of technology and a regional campus of West Virginia University, has the responsibility to address the engineering, scientific, and technical education needs of business, industry, and government." This program and its mission compliments the institution's mission extremely well.

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TABLE 1
CONTROL SYSTEMS ENGINEERING PATTERN SHEET

Term	Number	Title	Credit Hrs
Fall	COSE 601	Advanced Differential Equations	3
	COSE 603	Control Systems I	3
	COSE 611	Modern Control Theory	3
	COSE 626	Non-Deterministic Systems I	3
Spring	COSE 620	Digital Control	3
	COSE 622	Control Systems II	3
	COSE 629	Nonlinear Control	3
	COSE Elective		3
Fall	COSE Elective		3
	COSE Elective		3
	COSE Elective		3

PRE-APPROVED ELECTIVES

COSE 627	Non-Deterministic Systems II	3
COSE 628	Robotics	3
COSE 630	Optimal Control Theory	3
COSE 631	Adaptive Control Theory	3
COSE 632	Intelligent Control	3
COSE 640	Project I	3
COSE 641	Project II	3
COSE 642	Project III	3
COSE 660	Individual Studies (limit 1)	3
COSE 680	Special Topics	3
COSE 690	Project	3

NOTE:1. Electives not on approved list must be approved by the Graduate Committee

2. This represents the pattern sheet used by currently enrolled students.

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TABLE 2
PARTIAL LIST OF EMPLOYERS OF RECENT GRADUATES (Past 5 years)

EMPLOYER	LOCATION
Diversified Engineering	Richmond, VA
CNG Communications	Dallas, TX
CNG Communications	Los Angeles, CA
Transglobal Communications	Durham, NC
Digirad, LLC	Brookfield, CN
Coleman Instruments	Cincinnati, OH
Robert Mason Company	Charlotte, NC
Union Carbide	South Charleston, WV
Omeda Corp	Denver, CO
Egan, McCallister Consultants	Lexington Park, MD
Special Metals	Huntington, WV
American Electric Power	Beckley, WV
Control System Contracting and Consulting, LLC	Houston, TX
Control System Contracting and Consulting, LLC	Cleveland, OH

TABLE 3
ENROLLMENT DATA

Fall	Applied	Accepted	Enrolled
2001	88	39	21
2000	37	33	15
1999	30	27	6
1998	42	31	12
1997	66	42	20
1996	80	58	28