P.J.Antsaklis, "New Directions in Control Engineering Education: A North American Perspective," Abstract of Plenary Lecture, in Proceedings of the IFAC/IEEE Symposium on Advances in Control Education (ACE), Sea World Nara Resort, Gold Coast, Australia, December 17-19, 2000.

NEW DIRECTIONS IN CONTROL ENGINEERING EDUCATION: A NORTH AMERICAN PERSPECTIVE

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Abstract: In this plenary talk several educational issues in control engineering will be discussed with emphasis placed primarily on issues faced by North American educational institutions. This talk is based on issues discussed and recommendations made at a NSF/CSS workshop on New Directions in Control Engineering Education, and reported in the IEEE Control Systems magazine [Report on New Directions, 1999].

SUMMARY

The field of control systems science and engineering is entering a golden age of unprecedented growth and opportunity. These opportunities for growth are being spurred by enormous advances in computer technology, material science, sensor and actuator technology, as well as in the theoretical foundations of dynamical systems and control. Many of the opportunities for future growth are at the boundaries of traditional disciplines, particularly at the boundary of computer science with other engineering disciplines. Control systems technology is the cornerstone of the new automation revolution occurring in such diverse areas as household appliances, consumer electronics, automotive and aerospace systems, manufacturing systems, chemical processes, civil and environmental systems, transportation systems, and even biological, economic, and medical systems. The needs of industry for well trained control systems scientists and engineers are changing, due to marketplace pressures and advances in technology. Future generations of engineering students will have to be broadly educated to cope with cross-disciplinary applications and rapidly changing technology. At the same time, the backgrounds of students are changing. Many come from nontraditional backgrounds; they often are less well prepared in mathematics and the sciences while being better prepared to work with modern computing technologies. The time is thus ripe for major renovations in control and systems engineering education [Report on New Directions, 1999].

Control systems education takes place in many different academic departments and disciplines, and control systems applications occur in a wide variety of technologies. Viewed from the broadest perspective, control systems science and engineering is concerned with automation. It involves a variety of tasks such as modeling, identification, simulation, planning, decision making and optimization, combating uncertainty through feedback, and performance evaluation. In addition, successful application of control principles involves the integration of various tools from related disciplines, such as signal processing, electronics, communications, software, algorithms, real-time computing, sensors and actuators, as well as application specific knowledge. Application areas of control automation include transportation, manufacturing, communications, aerospace, process industries, and commercial products. The basic control systems principles influence and impact all of these application areas, as well as diverse fields of study such as biology, economics, and medicine.

In [Report on New Directions, 1999] several recommendations concerning undergraduate and graduate curriculum issues and laboratory issues were made. Also recommendations concerning computing and World Wide Web (WWW)

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technologies, as well as continuing education and industry/university relations.

These recommendations were:

General Recommendation

1. Enhance cooperation among various control organizations and control disciplines throughout the world to give attention to control systems education issues and to increase the general awareness of the importance of control systems technology in society.

Mechanisms to accomplish this include joint sponsorship of conferences, workshops, conference sessions, and publications devoted to control systems education as well as the development of books, websites, videotapes, and so on, devoted to the promotion of control systems technology.

Additional Recommendations

2.Provide practical experience in control systems engineering to freshmen to stimulate future interest and to introduce fundamental notions like feedback and the systems approach to engineering.

This can be accomplished by incorporating modules and/or projects that involve principles of control systems into freshmen courses that already exist in many engineering schools and colleges.

3. Encourage the development of new courses and course materials that will significantly broaden the standard first introductory control systems course at the undergraduate level.

Such new courses would be accessible to all third year engineering students and would deal with fundamental principles of system modeling, planning, design, optimization, hardware and software implementation, computer aided control systems design and simulation, and systems performance evaluation. Equally important, such courses would stress the fundamental applications and importance of feedback control as well as the limits of feedback, and would provide a bridge between control systems engineering and other branches of engineering that benefit from systems engineering concepts such as networks and communications, biomedical engineering, computer science, economics. etc.

4. Develop follow on courses at the undergraduate level that provide the necessary breadth and depth to prepare students both for industrial careers and for graduate studies in systems and control.

Advanced courses in both traditional control methodologies, like digital control, and courses treating innovative control applications should be available to undergraduate students in order to convey the excitement of control systems engineering while still providing the fundamentals needed in practice.

5. Promote control systems laboratory development, especially the concept of shared laboratories, and make experimental projects an integral part of control education for all students, including graduate students.

Mechanisms to accomplish this include increased support for the development of hands-on control systems laboratories, as well as the development of benchmark control systems examples that are accessible via the Internet. Shared laboratories within individual colleges or universities as well as shared laboratories among different universities makes more efficient use of resources, increases exposure of students to the multi-disciplinary nature of control, and promotes the interaction of faculty and students across disciplines. The promotion of laboratory development also includes mechanisms for continued support. Too often, laboratories are developed and then abandoned after a few years because faculty do not have time or funds for continued support. It is equally important, therefore, to provide continuity of support for periodic hardware and software upgrades, maintenance, and the development of new experiments. The National Science Foundation and IEEE Control Systems Society can also help realize this goal by developing workshops and short courses for laboratory development and instruction to promote interaction and sharing of laboratory development experiences among faculty from different universities.

6. Emphasize the integration of control systems education and research at all levels of instruction.

The National Science Foundation program, Research Experiences for Undergraduates, exemplifies an excellent mechanism to accomplish this at the undergraduate level and should be continued. Sponsorship of student competitions in control is another such mechanism that should be encouraged. At the graduate level control educators should take advantage of National Science Foundation programs such as the Integrative Graduate Education and Research Training Program (IGERT) and the Course, Curriculum, and Laboratory Improvement Program (CCLI).

7. Improve information exchange by developing a centralized Internet repository for educational materials. These materials should include tutorials,

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exercises, case studies, examples, and histories, as well as laboratory exercises, software, manuals, etc.

The IEEE Control Systems Society can play a leadership role in the development of such a repository by coordinating the efforts among various public and private agencies.

8. Promote the development of a set of standards for Internet based control systems materials and identify pricing mechanisms to provide financial compensation to Internet laboratory providers and educational materials providers.

A mechanism to accomplish this could be a National Science Foundation sponsored workshop devoted to Internet standards for control education materials and pricing.

9. Develop WWW-based peer reviewed electronic journal on control education and laboratory development.

Control systems professional organizations can play leadership roles, perhaps working with the American Society of Engineering Education (ASEE) to accomplish this goal.

10. Encourage the development of initiatives for technical information dissemination to industrial users of control systems and encourage the transfer of practical industrial experience to the classroom.

Mechanisms to accomplish this include special issues of journals and magazines devoted to industrial applications of control, programs to bring speakers from industry to the classroom, and programs that allow university faculty to spend extended periods of time in industry.

In this talk, these recommendations will be discussed, and a progress report on the implementation and impact of these recommendations will be given.

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