AC 2007-622: TEACHING CLASSICAL CONTROL IN ET PROGRAMS; TIME FOR REASSESSMENT?

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Abstract

This paper is based on the recommendations made by the National Science Foundation and Control Systems Society of IEEE. In light of those recommendations and issues discussed at a NSF/CSS workshop, the author raises the question of appropriate contents for a control system course as taught in a typical first course ET program. Presently, the majority of electrical, some mechanical and almost all electromechanical engineering technology programs have a course in their curriculum called control systems. Even though they carry the same name, most often their contents are drastically different. In many programs the focus of the course is on the application of typical classical control. There are some programs where the whole course is about application and programming of micro-controllers. There are also programs where the emphasis of the course is entirely on the study of instrumentation and programmable logic controllers. In this paper an attempt will be made to find an answer to the question of what is the appropriate content for a typical first course in control systems to be taught in a typical ET program. The argument will be made that the recommendations made by NSF and Control System Society of IEEE can easily be implemented and therefore should be considered.

Introduction

The control area has been structured in the recent years in a process that includes, for instance, foundation of IFAC (International Federation of Automatic Control). In this maturing process, different works, as Blondell[6] and Antsaklis[1] have addressed general questions, such as control challenges in the new millennium. Those works are based on discussions performed by control communities, arising as relevant consolidated opinions based on individual experiences. At the same time, other works, as Kheir[7] and Heck[2], approach control education, with many scenarios based on technological learning process. The main purpose of this paper is to broaden the scope of the discussion and get the ET educators involved in it. Therefore, in the next sections, an attempt is made to analyze the role of a classic control course in an ET curriculum. The question that needs to be addressed is whether or not a control course is an essential part of an ET curriculum and if yes what are the appropriate course contents.

Need for reassessment

The field of control systems science and engineering has entered 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. Control system 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, engineers, technologists and technicians are changing, due to marketplace pressure 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 background of students entering regular engineering and engineering technology is changing. They often are less well prepared in mathematics and the sciences while being well prepared to work with modern computing technologies. The time is thus ripe for major renovations in control systems education. 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.

Control systems taught under the umbrella of different disciplines (electrical, mechanical, industrial and manufacturing) is differentiated by the applications, which support its introduction. In electrical engineering technology, control is characterized by its relationship to circuits and systems, to signal processing and instrumentation.

A useful structure for analysis of control education is provided by the National Science Foundation / IEEE Control System Society workshop.

NSF/ CSS of IEEE Recommendations

1. Provide Practical experience in control systems engineering to first-year students to stimulate future interest and introduce fundamental notion like feedback and the system approach to engineering.

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

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

4. Make experimental projects an integral part of control education for undergraduate and graduate students.

5. Introductory control courses should place greater emphasis on digital control.

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

7. Improve information exchange by creating a centralized Internet repository for educational materials. These materials should include tutorials, exercises, case studies, examples and histories, as well as laboratory exercises, software, manuals etc.

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

Only two of these recommendations (1 and 6) may be difficult to satisfy in ET programs. The rest can be easily implemented in any ET program. One of the fundamental strengths of ET undergraduate program is the emphasis placed on laboratory work. Recommendation # 4 calls for " experimental projects", suggesting a problem-based learning approach to experimental work. This may be difficult to achieve, particularly at undergraduate level with large classes.

Laboratory extensive classical control in ET programs

Teaching the first course on control systems today faces many dilemmas not only about the syllabus, i.e., what to teach but the methods, i.e., how to teach. The course syllabus at electrical and computer engineering technology department of Southern Polytechnic State University covers the traditional collection of topics starting with the 'first principle' model building, Laplace transform, feedback notion, both time and frequency response, steady-state performance, stability and concluding with controller design using root locus and frequency methods. The indispensable part of this syllabus is a set of laboratory experiments using MATLAB, SIMULINK and FEEDBACK CONTROL. As a basis for a curriculum design or reform, it is helpful to understand what is it that practicing engineers and technologists working in the area of control do. For that information we have relied on the list provided by Skogestad[3] and Postlethwaite[4] given in table 1.

1	Study the system (plant) to be controlled and obtain initial information about the control objectives
2	Model the system and simplify the model, if necessary
3	Analyze the resulting model; determine its properties.
4	Decide which variables are to be controlled
5	Select the control configuration.
6	Decide on the type of controller to be used
7	Decide on performance specifications, based on the overall control objectives.
8	Design a controller
9	Analyze the resulting controlled system to see if the specifications are satisfied; if not modify the specification or the type of controller.
10	Simulate the resulting controlled system
11	Choose hardware and software and implement the controller
12	Test and validate the control system and tune it on-line if necessary.

Table 1, Steps involved in the design of a control system[4]

In order to reduce the gap between the theory and practice one can use simulation based experiments to emulate the performance of the control system. Another approach (even more novel and quite contemporary) would be using the www, developing and running the virtual control laboratories. Both approaches are aimed at overcoming the problems in developing real life experimental equipment.
However there is an old truth that nothing can replace the real, hands-on experience of laboratory work and there is a definite need for learning control subjects by doing. At the same time the class sizes keep increasing and resources of time and money keep decreasing at most ET programs.

Conclusions

An attempt has been made to draw attention to the need to reassess the contents and methods of teaching of control systems in ET programs. It was shown that with control systems technology being the cornerstone of new automation revolution, control system must be included in the curriculum of ET programs. Although a laboratory extensive classical control is presented, a definite recommendation has not been made. The recommendations of NSF/ IEEE, with regard to control system education, were discussed. It was concluded that some of the recommendations are well suited to be implemented in ET programs.

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