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Part I

This paper reports on an action research project to improve teaching and learning in a computer simulation of heat conduction during welding. The research was initiated, planned and carried out by Johan Ahlström, a lecturer in materials science at the Chalmers University of Technology, Sweden, in consultation with an educational developer, Michael Christie. The exercise on which this paper focuses is part of an optional Master of Science course that is offered to both Chalmers and international students. The exercise involves the modelling of heat conduction during welding. In the past the exercise involved the use of MATLAB. The use of MATLAB has posed some problems but after the course was opened up to overseas students these problems were compounded. The Swedish students had at least some basic knowledge of MATLAB but several of the foreign students have no experience at all of using the program. As a result a lot of time was given to helping students understand and use MATLAB even though the main purpose of the exercise was to help them come to grips with the actual problem of modelling and understanding heat conduction during welding. It was clear, from discussions between the two authors, that the original aim of the exercise was being subverted and that in pedagogical terms this affected the constructive alignment of teaching and learning. This paper reports on actions taken to resolve this dilemma and an evaluation of the success of the changes that were introduced. It also proposes a simple formula for curriculum reform that can be used to initiate and evaluate changes to existing exercises and courses in engineering education.

Object oriented MATLAB software components that have been developed for and used in instruction of computational structural engineering are described. It is shown that the object orientation leads to elegant and concise implementations, which helps promote learning and understanding of the subject at the level of the algorithms.

This article describes in detail an experimental technique and an implementation of a numerical model, in MATLAB/Simulink, used in laboratory classes of the Civil Engineering course at the Faculty of Engineering of Porto University. This work aims to motivate the students to combine laboratory experiments with computer simulation. The present work also illustrates the moisture buffer capacity of building materials. The moisture buffer capacity of building materials in transient conditions was tested in small-scale laboratory tests. Alongside, was a numerical simulation tool for hygrothermal performance analyses of buildings and building materials and both results were compared. The experiment illustrates the importance of materials moisture buffer capacity in the hygrothermal behaviour of buildings; and it is important to have in mind that the majority of students do not have the opportunity to gain 'hands on' familiarity with the interplay between diffusion and sorption, nor do they have the opportunity of seeing, in practice, how it is possible to characterize porous materials in terms of their impact on indoor environment.

In this paper is presented a Distance Laboratory System (DLS), which is a distance laboratory focused in automatic control study developed in Universidad Central 'Marta Abreu' de las Villas. The main objective of this laboratory is to permit the users to learn to adjust predefined controllers and to design their own controllers for testing them later over a set of physical devices through the Internet and to analyze their performance. The targeted controllers (designed by the users) can use S-functions created using C language, permitting the creation of complex controllers in an easy and fast way. The DLS uses MATLAB-Simulink for practice processing and the Real Time Workshop Toolbox (RTW) such as real time kernel. The DLS permits integration of new processes for carrying out controller tests. At present three devices are available: a DC motor and a robot manipulator in Cuba as well as an electropneumatic cylinder in Spain. Since the last year the DLS has been used in identification and control theory undergraduate courses in Universidad 'Marta Abreu' de las Villas and Universidad de Cienfuegos in Cuba, as well as in postgraduate courses in México in the fields of advances control theory and robot manipulator control.

This paper describes the make-up of interactive computer simulations that implement virtual laboratories in the field of Control Engineering education. We introduce Easy Java Simulations (EJS), a Java-based tool designed to help control educators with a low profile in programming to create interactive scientific simulations. This tool can be used on its own, generating stand-alone Java applications or applets, or in conjunction with MATLAB/Simulink, using them as the internal engine that describes and solves the model. This tool allows users to develop complete, interactive simulations in three steps: writing the mathematical model (optionally using MATLAB/Simulink), building the graphical user interface (GUI) using off-the-shelf graphical elements, and linking the GUI elements to the variables of the model. In this way, models of control engineering can be specified either using the programming support provided by EJS or by using MATLAB/Simulink, which can then be fully controlled from EJS. In this paper we describe this particular feature in detail, and provide some examples that show the advantages that this tool offers to the world-wide engineering education community.

This paper describes a simple and cheap experimental apparatus that has been developed at Università di Roma Tor Vergata for educational purposes; this tool is currently used in the course "Laboratorio d'Automatica" (Laboratory of Automatic Control), which is offered in the first year of a three-year university programme ("Laurea" degree) in Automatic Control. The most notable feature of this experimental apparatus is that it can be controlled in real time from Simulink; the paper reports on several experimental tests for students using this tool who are only familiar with the fundamentals of calculus, geometry, physics and computer sciences.

The teaching of parallel mechanisms and their controllers is a difficult task because of the complex mathematics that must be solved for the direct and indirect kinematics problems. In order to help students understand the kinematics and the dynamics of parallel manipulators and their controllers, we have designed a final-year robotics course based on MATLAB, Simulink and SimMechanics. Students are given specifications of the parallel manipulator that they must design, such as parameters of the DC motors to be used, the type of controller to be implemented, the number of degrees-of-freedom (DOF) of the developed robot, etc. Each group is then required to design a parallel manipulator of its choice in MATLAB, Simulink, SimMechanics and/or CAD. Finally, they are required to design the manipulator's controller for simulation purposes. Some mechanical components of the best robot are rapid prototyped on the Dimension 3-D printer. The mathematical analysis of the best mechanism is then studied in detail. This is compared with the simulation of the integrated manipulator in MATLAB. This paper presents the mechanical design, analysis and controller design of the parallel manipulator that was developed in MATLAB.

This paper discusses the development of a microcontroller-based control system with hardware-in-the-loop (HIL) for enhancing the teaching of control engineering. This system consists of both hardware and software. The software tools MATLAB/Simulink/xPC Target by MathWorks, Inc and a C++ compiler are used to simulate the physical system (plant) to be controlled, while the hardware include a microcontroller as a controller and interfacing circuits to allow communication between the simulated plant and the real controller. This proposed system is inexpensive and allows students to carry out extensive experimental investigations, as well as the design, implementation, performance evaluation and comparative studies of controllers. A case study of the controller design and implementation for an active suspension system is presented to illustrate the application of the proposed system.

An autonomous vehicle driving control system carries a large number of benefits, whether for the engineering industry or engineering education. The system discussed here provides the measurements obtained from vision—namely, offset from the centerline at some look-ahead distance and the angle between the road tangent and the orientation of the vehicle at some look-ahead distance—and these are directly used for control. This paper also presents simulation results regarding autonomous vehicle dynamics and control, along with methods, techniques and approaches for developing this system which can be used by engineering educators for automotive, robotics or image processing courses.

The minimization of the integral of time-weighted absolute error (ITAE) is usually referred to in literature as a good tuning criterion to obtain controller PID parameters. However this criterion is not often used because its computer implementation is not a very easy task. This paper describes how MATLAB/Simulink can be useful to apply the ITAE criterion to calculate controller parameters.

This paper presents OptimaLink, a MATLAB-based code to facilitate the teaching/learning of design of mechanisms and intelligent optimization methods. The current version of OptimaLink accommodates dimensional synthesis, analysis, and animation of four-bar (RRRR) mechanisms. Dimensional synthesis includes both precision-point and optimum synthesis methods. The paper begins by introducing the objective function for synthesis of the RRRR mechanism, followed by a summary of the intelligent search methods coded in OptimaLink, namely Simulated Annealing, Genetic Algorithm and Tabu Search. OptimaLink's structure and its use are then briefly outlined and an application example is provided to demonstrate the usefulness of the code. Finally, possible didactic uses of the code are proposed. Although dedicated to mechanism design, the user can tap into the optimization algorithms coded in OptimaLink to solve other design problems by coding the corresponding user-interface module.

An advanced engineering mechanics course teaches students to analyze and model a variety of dynamical systems using Newtonian and Lagrangian mechanics approaches. The modeling task typically produces nonlinear differential equations that are best solved numerically. In order to prepare students to competently solve these systems numerically, they must master a suitable programming environment. This mastery is achieved incrementally throughout the semester. This paper describes a successful approach to developing the necessary programming skills, culminating in a course project in which the students model a complex dynamical system and produce a graphical animation allowing visualization of dynamical behavior. The paper also describes typical course projects that have been successfully completed by advanced undergraduate and beginning graduate students.

MATLAB software package has been assisting engineers to design and test system models for different fields of engineering. It provides a deep understanding of system parameters and how they affect its performance. Since it is a programming package, it can interact with other programming languages to provide engineers who use those languages the flexibility to run their codes within a MATLAB environment. Engineering students can build their model and test it before implementing it in the real process. This paper presents and describes some dynamic models and control systems for mechatronics engineering students using MATLAB and Simulink. Those models will be used as laboratory experiments to expose students to different topics and techniques in control engineering. This will enhance students' knowledge and make them familiar with the MATLAB environment

The methodology of integrating MATLAB/Simulink into mechanical engineering curricula to improve the quality of engineering education is presented and discussed. The integration is implemented, wherever appropriate, via MATLAB and Simulink. The four key elements in course design for deep learning approach, which include high motivation, active learning, peer interaction and well-structured knowledge base, are enhanced by using MATLAB and Simulink facilities. Among the benefits of integrating MATLAB and Simulink facilities are the emphasis on basic concepts, deep understanding, student's interactive learning, addressing real-world problems, graphical visualization, and the use of mathematical libraries. The methodology is illustrated through examples covering some mechanical engineering undergraduate courses which demonstrate significant improvement of the mechanical engineering deep learning approach.

Our undergraduate/graduate course Computer Methods in Engineering Design targets students who want to do mechanical design. Although we treat basic numerical methods that support design (solution of simultaneous equations, integration, interpolation), we emphasize curve fitting and constructions generated by splines, B- splines and Bézier curves, then transformations of point groups (objects), and computer graphics to manipulate objects, and culminate with solid modeling and simulation when students are in a position to appreciate such sophistication. In this paper we share our approach to teaching splines: some theory, some concepts important to learning it, key references, and a time frame for doing it; and touch upon transformations in computer graphics. We then show off results from student projects. MATLAB is the engine used to render the graphics.

Part II

With institutional programs in engineering education in their infancy, there is as yet little scientific proof that teaching prospective engineering faculty how to teach impacts their careers positively, but there is abundant anecdotal evidence. A survey of graduates of a Purdue course 'Educational Methods in Engineering' was conducted. Graduates who chose academic careers reported a very significant impact on their careers, while graduates who chose industrial careers reported a positive but less significant impact. A survey of 17 courses at other institutions showed that the educational topics in how-to-teach courses are similar to the topics in the Purdue course; thus, the results should generalize to other institutions for graduates who choose academic careers.

Portfolios and other assessments of student achievement are proving to be important topics of concern in engineering education. While portfolios have a long history in other disciplines, their use in engineering is fairly new. This paper provides a case study on the development and implementation of electronic portfolios in engineering education through our Polaris system built specifically for undergraduate engineering students. The end goal of Polaris is to provide students with a presentation of their academic accomplishments in a variety of multimedia formats on a professional looking website. While there are many web-development tools for creating a portfolio, the distinguishing characteristic of Polaris is that it specifically engages engineering students in developmental exercises to help them understand their budding professional skills. This case study provides background history and reveals issues that are germane to creating a developmentally appropriate resource to enhance engineering students' scholastic experiences.

Core physics courses are prescribed in engineering curricula by professional and accrediting bodies. However, factors such as curriculum crowding and time constraints frequently bring into question the content and the extent of coverage of these courses. A survey was undertaken to assess the attitudes of engineering faculty to physics, mathematics and chemistry courses. The results for physics confirm that, while many of the classical topics in physics are perceived as relevant in engineering curricula by all faculty, topics in modern physics are not. Furthermore, variations in attitudes towards modern physics exist on a departmental and regional basis. This paper presents the results of the physics survey, with an analysis of attitudes towards physics in general in engineering curricula and to individual topics in particular, and tries to suggest reasons for the variations in departmental and regional attitudes.

The European Global Product Realization (E-GPR) project represents the main practical part of the E-GPR course organized by 3 European universities: the Swiss Federal Institute of Technology of Lausanne, the Technical University of Delft and the University of Ljubljana. It is defined in collaboration with the industrial partner(s) of the E-GPR course and consists of developing a global product that can be sold in Europe and other markets. The project provides the teams of participating students with an opportunity to put into practice the knowledge learned throughout the E-GPR course and during other related courses undertaken at their universities. In this paper we investigate how the collaborative design aspects are incorporated in the E-GPR project. There are two main activities in collaborative design to focus on: (i) concepts generation and (ii) concept selection. We noted that in the E-GPR project the concepts generation activity is well structured and organized to some extent whereas the concept selection activity is dealt with in an informal way. We show that in the concepts generation activity of the E-GPR project the students experiment with almost all the collaborative design aspects they have learnt during the E-GPR lectures. The concept selection activity is dealt with in an informal way whereas it is known that inefficient decisions during the concept selection activity can seriously affect the next stages of the product development. That is why we describe a group decision-making framework that allows structuring and formalizing the concept selection activity in order to improve its efficiency.

Industrial communication networks are a difficult subject to teach due to the wide range of standards found in industry for communicating systems and processes. In this article, a new approach is proposed; the methodology allows the student to deal with all the different steps involved in automation systems when the creation of a whole automation pyramid is pursued. This task is achieved in ten 3-hour lab sessions, following a rotating strategy in certain sessions. The course is developed around an almost real application: a simplified 'cookie factory'. Every session is part of the complete automation system, thus, the student builds the whole system step by step, from the sensor/actuator level to the management level including Ethernet connection, Supervisory Control And Data Acquisition (SCADA), and Human-Machine Interfaces (HMI).

Sabah A. Abdul-Wahab   973–980   Contribution of International Environmental Design Competitions in Raising the Profile of Environmental Education in Engineering Students

Every two years since 2000, the College of Engineering at the United Arab Emirates University (UAEU), has held a Student Environmental Design Competition, where engineering students from all over the world converge to put their best designs to the test. It is a cooperative effort between industry, government agencies, and academia to tackle real environmental problems facing industry in the region. The teams must prepare four different assignments: written, oral, poster and bench scale design. The concept of the competition is interesting because the engineering students are to approach the task as though a company has asked them to solve an environmental problem. Each team design is compared and judged with other competing designs to decide the winners. And more importantly, the competition is a unique event that brings together industry, government, and academia in the search for improved environmental solutions. It also provides the engineering design content required by the Accreditation Board for Engineering and Technology (ABET). Hence, it is one solution to the missing bridge between fundamentals of engineering and appropriate design training that is a basic issue in engineering education. In the Third International Design Competition (EDC 2004) which was held on May 2–5, 2004, at the UAEU, 20 competing teams comprising 60 students participated. The competition gathered students from regional and international universities to tackle real environmental challenges while addressing issues including technical, legal, health, community relations and economics. The goal of the competition was to design, develop, and test actual environmental processes for real-world problems. Typically, the environmental tasks presented had no known solution, or the available solutions did not meet the desired performance criteria. In this competition, 6 students from Sultan Qaboos University (SQU), College of Engineering (Mechanical & Industrial Engineering Department) participated. The SQU team received first place in two tasks. This paper presents the experience and highlights the need for such competitions to raise environmental awareness of engineering students. All competing teams agreed that this competition was the best part of their engineering education.

Frank C. Walsh, Pedro Trinidad and **Dan Gilroy**   981–992   Conversion Expressions for Electrochemical Reactors which Operate under Mass Transport Controlled Reaction Conditions—Part II: Batch Recycle, Cascade and Recycle Loop Reactors

In a previous paper, graphical plots were used to calculate the fractional conversion of reactant to product in batch and single pass electrochemical reactors under mass transport controlled conditions. This paper extends the approach to treat batch recycle, cascade and recycle loop reactors. These cases are common both in industry and in pilot laboratory scale in universities. The working curves developed provide a rapid route to the calculation of reactor performance. These simulated curves, produced via standard spreadsheet/plotting software, help to illustrate a chemical engineering approach to science and technology students and short course delegates. The use of a family of working curves avoids the tedious calculation of fractional conversion over a range of process conditions and helps students to appreciate the use of graphical displays to describe the fractional conversion over electrochemical reactors.

S. Sadek and **M. El-Khoury**   993–1002   The ABCs of Soil Nailing: an Integrated Tutorial and Knowledge-based Approach to Teaching Design

Soil nailing is an earth stabilization method that combines in-situ reinforcements and a flexible facing to support existing natural slopes and hillside cuts or excavations. Since its inception in the early 1970's soil nailing has proven to be a successful and reliable shoring approach when proper design guidelines and construction methods are applied. Given the highly empirical nature of available design approaches, a fundamental understanding of the behavior of soil-nailed walls is critical to a safe and satisfactory outcome. In this respect case studies of successes and failures and established codes of practice are very important teaching and training resources. This paper describes an integrated approach for teaching engineering design. The approach was developed for the case of soil-nailed walls but could be applied in other similar engineering design contexts. The approach comprises a computer-based tutorial combined with an automated knowledge base developed to assist in formulating design decisions. The students are introduced to the basic principles through an interactive tutorial module and guided through the design process by the automated tool which is based on the CLOUTERRE and FHWA Guidelines.