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- J. Tung** 560 MATLAB and Simulink in Engineering Education
- Bogdan M. Wilamowski and Ramraj Gottiparthi** 561–571 Active and Passive Filter Synthesis using MATLAB
- Analog filters play a significant role in every electronic system. There are two different ways to implement analog filters. The first one uses cascade connection of second-order circuits. These types of filters are easy to design, but they are relatively sensitive to the tolerance of elements. The second method uses passive ladder prototypes and practical VLSI implementation needs a series of integrators. This type of design is much less sensitive to the tolerance of elements, but also it is more difficult to design. The second method is rarely taught in basic analog filter courses. Both cascade as well as ladder-based filter implementation designs are complex and computationally intensive. Therefore, computer software could be very helpful to assist students and engineers in their design effort. This paper describes an educational MATLAB tool which simplifies the process of analog filter design. The software allows the use of four approximation methods: Butterworth, Chebyshev, Inverse Chebyshev and Cauer. In addition, several types of filters can be designed such as lowpass, highpass, bandpass and bandstop. In comparison to other tools this software also generates actual circuit implementation.*
- Lili Jiang, Karl Wiklund and Simon Haykin** 572–579 A Simulink Laboratory Package for Teaching Adaptive Filtering Concepts
- This paper describes a Simulink laboratory package for teaching adaptive filtering concepts. Each lab is designed to convey certain important features of a particular adaptive filter, and to provide comparisons with similar adaptive filtering algorithms. The filters covered include the LMS, nLMS, RLS, and GAL, as well as three members of the Kalman filter family and the particle filter. In addition to learning adaptive filtering concepts, these labs also help to ensure a greater familiarity with Simulink on the part of the student.*
- Fasil Muddeen and Kester Gabriel** 580–586 The Development of a MATLAB Instrumentation Tutor
- This paper describes a MATLAB/Simulink blockset called the MATLAB Instrumentation Tutor, currently being developed in the Department of Electrical and Computer Engineering at the University of the West Indies. The Tutor is being designed to support the teaching of a final year Instrumentation Systems course. The system will enable students to simulate various scenarios involving sensors, instrumentation amplifiers, filters, analog to digital and digital to analog conversions, sampling and quantizing, interference, error budget calculations, and the effect of random and coherent noise on system performance. Real parameter values taken from component data sheets will be used in this system so as to form an environment that will enable simulation of typically encountered real world instrumentation problems. The development of the necessary S-functions needed to accomplish this will also be discussed.*
- Woon S. Gan and Sen M. Kuo** 587–595 Transition from Simulink to MATLAB in Real-Time Digital Signal Processing Education
- In this paper, we propose a two-level approach for teaching digital signal processing (DSP) from basic concepts to the level of developing DSP software for real-time implementations on programmable DSP processors. In our approach, MATLAB and Simulink make the transition from theory to application easy and enjoyable. We use many interesting DSP demonstrations and examples for students to 'see' the effects of signal processing in Simulink; and then ask students to 'do' hands-on exercises in Simulink and MATLAB. The emphasis of 'seeing' and 'doing' can capture the students' attentions, cultivate their interests, and motivate their curiosities. This effective learning approach also allays fear of DSP that has been previously tagged as too theoretical and mathematically intensive.*
- Darko Hercog and Karel Jezernik** 596–605 Rapid Control Prototyping using MATLAB/Simulink and a DSP-based Motor Controller
- A rapid control prototyping (RCP) system, based on commercially available software and custom in-house developed hardware is presented. An RCP system successfully combines the well-known simulation program MATLAB/Simulink and the custom DSP-based floating point motor controller. An RCP system provides smooth and fast transition from off-line simulation in Simulink to real-time operation on the embedded motor controller. On-the-fly parameter tuning and data visualization are provided in addition to rapid code generation. The presented solution represents a powerful, versatile and portable RCP system especially suitable for educational processes as well as motor control research. This article is supplemented by an example of cascade DC motor control.*
- M. Varadarajan and Simi P. Valsan** 606–611 MatPECS—A MATLAB-based Power Electronic Circuit Simulation Package with GUI for Effective Classroom Teaching
- Power electronics devices and circuits have revolutionized the concept of power control for power conversion and electrical motor drives. Power Electronics course is essential for electrical engineers and is included in the undergraduate-level syllabus. With various circuit configurations like single-phase/three-phase circuits with R/RL/RCL/RLE loads and associated voltage and current waveforms to be dealt with, it is a tough subject to teach as well as to understand. This has led to a general disinterest in this field among the students. If all the circuit configurations and associated waveforms can be visualized for different operating conditions, the concepts become clearer and interesting. The objective of this paper is to introduce a MATLAB-based simulation package intended to make the*

classroom teaching of power electronics more effective and easy. MATLAB has proved itself to be a powerful tool for simulation. It is a software package available in almost all the technical institutions. This paper presents a simple menu-driven program that students can use to explore the behavior of power electronic circuits. The paper also explains how the graphical user interface (GUI) feature of MATLAB can be effectively used for making interactive software packages.

James Z. Zhang, Robert Adams and Kenneth Burbank 612–617 Theory, Practice, and Systems—A New Approach to Teaching Electronic Communications with MatLab

Two important aspects of training future engineers are a thorough understanding of the theories behind engineering problems, and practical experience in implementing solutions to these problems. Theoretical knowledge can be best comprehended and acquired from a systems perspective. Experiential knowledge of engineering implementation and problem-solving can be best understood and obtained through practical data. Because of its strong computational and modeling capabilities, MatLab is an excellent tool to help engineering students further their theoretical and practical knowledge in the context of engineering systems. In this paper, we propose a new method of teaching the 'Introduction to Electronic Communications' course from a systems perspective using MatLab.

Heng Siong Lim and Wai Kit Wong 618–624 Interactive Teaching of Multi-user Detection for DS-CDMA Systems using MATLAB

This paper describes a direct-sequence code-division multiple access (DS-CDMA) multi-user detection course and presents an interactive teaching method utilizing computers to demonstrate multi-user detection in DS-CDMA systems. The basic concepts related to the topic are presented using PowerPoint slides and reinforced by means of a series of MATLAB simulations. The computational techniques in evaluating the performance of multi-user detectors are also demonstrated using MATLAB. In particular, a DS-CDMA multi-user detection tutorial and simulator have been developed using MATLAB for teaching and self-study. While teaching the course it has been observed that the understanding of the students could be greatly enhanced by using simulations and interactive presentation skills.

S. Singh, S. Bhatt, S. Kapoor, A. Bhavsar and B. P. Kumar 625–635 A Student-accessible Graphical User Interface-based FDTD Algorithm for Visualization of Electromagnetic Fields

The topic of Maxwell's equations and applications is always an interesting, though challenging area for faculty and students. This paper outlines a fast and user-interactive MATLAB-based graphical user interface (GUI) software for electromagnetic field calculations using a finite difference time domain (FDTD) algorithm. The significant reduction in computation time is achieved through a vector-based MATLAB algorithm, and additionally, the GUI user interface facilitates the understanding and modeling of electromagnetic field effects. This paper is primarily directed at teachers and students involved in advanced electromagnetic and RF design studies at the graduate level, for example, courses in microwave engineering, power engineering and biomedical engineering. Typical electromagnetic simulation studies are presented in this paper to illustrate the efficacy and user-friendly nature of the software.

Rohit Dua, Steve E. Watkins, Samuel A. Mulder and Donald C. Wunsch 636–648 MATLAB-based Introduction to Neural Networks for Sensors Curriculum

Specialists and non-specialists in artificial neural networks (ANN) must closely interact in many applications, including structural sensing. The non-specialists must be aware of ANN-specific terminology, capabilities, and connecting concepts for effective collaboration. An instructional approach for ANNs is described that progresses from practical concepts to guided MatLab-based experimentation. Back propagation-trained multilayer perceptron neural networks are presented with an emphasis on parallel processing and training characteristics. The one-week instructional module has a lecture to convey terminology and structure, detailed examples to illustrate the training process, and guided application-based exercises. The MatLab neural-networks toolbox provides a transparent learning environment in which the students focus on network design and training concepts rather than the tool itself. Learning effectiveness was evaluated in an applications-oriented sensors curriculum. Instructional resources including realistic problems are web-accessible. These resources may be adjusted for different degrees of challenge and for simpler or more realistic problem solving.

Elif Derya Übeyli and Inan Güler 649–667 Teaching Automated Diagnostic Systems for Doppler Ultrasound Blood Flow Signals to Biomedical Engineering Students using MATLAB

This paper presents an initiative to teach the concept of automated diagnostic systems for Doppler ultrasound blood flow signals to biomedical engineering students. The approach was based on illustrative applications that highlight the performance of multilayer perceptron neural networks (MLPNN) and adaptive neuro-fuzzy inference system (ANFIS). Following a brief description of the artificial neural networks (ANNs) and ANFIS, applications of the models to the Doppler signals obtained from ophthalmic artery and internal carotid artery were done by means of a series of MATLAB functions. The functions involved in the neural network and fuzzy logic toolboxes of MATLAB can be used to develop automated diagnostic systems for the signal under study. The authors suggest that the use of MATLAB exercises will assist the students in gaining a better understanding of the various automated diagnostic systems in blood flow signals.

C. Riverol, S. Andrade and J. Cooney 668–675 A Laboratory Course on Real-Time Control for Food Engineers

In this paper, we describe a control laboratory course as a teaching aid during the training of undergraduate food engineering students. This approach facilitates the understanding of the subject matter (Application of Artificial Intelligent (AI) in food processing) introducing a first-hand experience at implementing real-time intelligent control. Students execute a series of laboratory exercises, for a variety of processes, implementing fuzzy control and neural networks.

Juan García, Rebeca García, Eduardo García, Alvaro Aparicio and María J. Cocero 676–682 MATLAB: A Powerful Tool for Experimental Design in Chemical Engineering

Laboratory experiments in chemical engineering can be modelled by defining heat and material balances and considering transport phenomena in non-stationary conditions. Usually, these equations have no analytical solution and students cannot solve the problem easily to compare experimental results with theory. In this paper the use of MATLAB is presented as a powerful tool in order to solve chemical engineering problems numerically. A new laboratory experiment for third-year students in chemical engineering has been developed combining a laboratory rig with a computer-aided solution using MATLAB and Simulink. The experiment consists of three gas–solid fluidised beds, one of them prepared with two heaters and temperature transmitters to obtain non-stationary data. A fluidised bed is considered a globalised system owing to perfect mixing, so temperature gradients are negligible. The other two beds have different diameters and work at ambient temperature to give steady-state results for hydrodynamic conditions. This experiment is a partner-to-partner design between university teachers, a control engineer, a technical staff member and the students; contribution of each was crucial. A new laboratory plant for university students has been developed with a MATLAB-aided solution. The combination of theory, experimental results and simulation improves learning and safety in operation.

Lars Öhrström, Göran Svensson, Stig Larsson, Michael Christie and Claes Niklasson 683–691 The Pedagogical Implications of Using MATLAB in Integrated Chemistry and Mathematics Courses

The last years the undergraduate chemistry and mathematics courses at Chalmers Tekniska Högskola (Chalmers University of Technology, Sweden) has undergone a major curriculum reform. One of the driving motives behind the reform was that students should

learn to use mathematics as a real tool for solving chemical problems. Mathematicians and chemists, with pedagogical help from an educational expert, changed the traditional course structure in terms of organization, content, and teaching and learning methods. This paper concentrates on the use of MATLAB in laboratory work and in individual and group assignments. It deals, in particular, with the pedagogical benefits that the designers of the new course saw in presenting real chemical problems that could be solved using applied mathematics and the MATLAB software. Student experience was evaluated both by the teachers and the educational consultant and responses are largely positive. Increased student learning can be seen through higher motivation and synergy effects of treating chemical problems in the MATLAB tutorials. The most serious problem is to give all students the necessary MATLAB skills and a risk is an overestimation of the MATLAB proficiency in subsequent courses leading to disproportional workloads on projects and little time for reading and study.

H. P. Wallin, Ulf Carlsson, Urmas Ross and Khalid El Gaidi 692–701 Learning MATLAB: Evaluation of Methods and Materials for First-Year Engineering Students

The paper describes the development of a MATLAB course as part of a first-year introductory engineering course 'Perspectives of Vehicle Engineering' in the MSc programme in Vehicle Engineering at the Royal Institute of Technology (KTH) in Stockholm, Sweden. This course is intended to give core engineering knowledge and experience, and to prepare the students for their studies in engineering mechanics and vehicle engineering. The expectation is that the students, upon completion of the MATLAB course, will have acquired the ability to use MATLAB in later courses in the curriculum where MATLAB is chosen to be the primary computational and visualisation tool. The development work was divided into three parts. The first part contained a preparatory phase in which the work was planned, the purpose and objectives formulated, the course content and implementation planned, and suitable instructional materials identified. The next step was to select a student test group to go through a trial run of the course, using the different options available for instructional materials. The experiences obtained from the test group's efforts, and their results, were the basis for carrying out the first year of regular instruction of the MATLAB course. In the third and final phase of the course development, it was given for the first time as an ordinary part of the curriculum for first-year students in the KTH vehicle engineering program. The results and experiences obtained from that 1st year will serve as a basis for modifications to the MATLAB course to be given in later years.

Part II

Samuli Kolari, Eeva-Liisa Viskari and Carina Savander-Ranne 702–711 Improving Student Learning in an Environmental Engineering Program with a Research Study Project

The suitability of constructivist teaching strategies was studied in the context of environmental engineering education. The object of this study was a course called Water and Soil Analyses, which is taught to third- and fourth-year environmental engineering students. Using pre-lecture assignments, focusing on peer interaction, having the students take responsibility for making their own research plans, taking advantage of the PDEODE method, doing fieldwork and laboratory analysis, and producing a report and presenting the results in a seminar, were all tools for motivating and engaging students to take responsibility for their learning. In addition, assessment of the course was spread throughout the course, without a traditional exam. When assessing the students' learning it was clear that the learning results were excellent. This includes both subject matter and other skills, such as social, teamwork and communication skills. The students' feedback was also mainly positive. The students found the course laborious and sometimes also difficult, but very rewarding. Taking responsibility for their own learning motivated them to work hard and thus gave excellent learning results. Also, seeing their work in a real-world context improved their engagement and learning. From the lecturer's point of view there is no turning back, even though some work modes need adjustment and focusing.

Autar K. Kaw, Glen H. Besterfield and James Eison 712–722 Assessment of a Web-Enhanced Course in Numerical Methods

Effectiveness of web-based modules developed for a course in numerical methods was measured via three mixed assessment instruments—student satisfaction survey, student performance on a multiple-choice examination based on Bloom's taxonomy, and summative rating of the modules based on content, learning, usability and technology. The web-based modules are holistic and are customized based on a student's engineering major and choice of computational system. Statistical analysis of the assessment data indicates that web-based modules improved both student satisfaction and performance.

Paul S. Steif and Anna Dollár 723–729 Reinventing the Teaching of Statics

A substantial revamping of teaching engineering statics is proposed. Several common features of traditional instruction in statics are critiqued, including a general failure to focus students on the key concepts of the subject. The ultimate goal of instruction, empowering students to apply the methods and ideas of statics to real artifacts, is emphasized. This goal requires students to make clear connections between the symbols of the subject (primarily forces) and what they represent (the interactions between bodies). We also point out a major stumbling block to making such connections: the considerable difficulty many students have in envisioning forces between inanimate objects, a difficulty which is well documented in the physics education literature. This forms the backdrop to our proposed approach to statics instruction. We have reorganized statics to allow students to confront the major concepts one at a time, initially within the context of forces that students experience first hand – through the senses of touch and of sight. The proposed progression of topics and concepts, and how they are elucidated through artifacts that students manipulate in class, are presented. In addition, we describe highly interactive classroom methods that allow students to confront these concepts, test their understanding of them, and refine that understanding through spirited discussions with peers.

Takoi K. Hamrita, Walter D. Potter and Benjamin Bishop 730–738 Robotics, Microcontroller and Embedded Systems Education Initiatives: An Interdisciplinary Approach

This paper reports on four microcontroller-based courses developed at the University of Georgia for a broad multidisciplinary undergraduate and graduate student body. The courses are Introduction to Robotics, Embedded Systems, Introduction to Microcontrollers, and Advanced Microcontrollers. These courses, which are taught in a hands-on manner, equip students with the necessary tools and know-how to make use of the powerful technology of microcontrollers within their own disciplines. This paper addresses some of the challenges encountered due to the diverse student backgrounds and how these challenges are met through various pedagogical methods such as teamwork, achieving the right balance between theory and practice, and giving students from various disciplines an 'industry-like' experience.

Ahmad Smaili and Saleh Chehade 739–744 Effective Integration of Mechatronics into the Mechanical Engineering Curriculum: A Cooperative, Project-Based Learning Model with Seamless Lab/Lecture Implementation

In today's competitive markets, engineers face ongoing challenges to produce complex engineering systems with a high level of performance, reliability, value and price. This requires the integration of a number of technologies, which may be accomplished through mechatronics. This paper presents a model for integrating mechatronics education into the Mechanical Engineering curriculum at the American University of Beirut (AUB). A strong component of the model is collaborative, project-based, learning-by-doing experience in which students realize mechatronics devices, possibly of their own choosing, using various laboratory tools including microcontroller technologies. The implementation strategy involves minimal lecturing, a seamless lab/lecture interface, and just-in-time learning. An example of a typical student's project is presented and course assessment is briefly discussed.

Michael Rex Maixner

745–749 Design of a Waterjet-Propelled Barge: A First Computer Modeling Project

A computer project for an introductory design course is presented which entails preliminary calculations associated with a rectangular, waterjet-propelled barge. It combines ideas of computer modeling, tradeoffs, iteration, and optimization into a problem that can be solved without requiring an extensive technical science background. This quasi-steady problem requires recalculation of various parameters at each time step, thereby necessitating looping. Variations on the design are suggested as possible modifications for different design groups within a class or from one term to the next. With suitable documentation and assistance to students, the project could also be used in an introductory computer course.

Willem J. M. A. Hochstenbach

750–757 Quantitative Modelling of an Air Conditioning Problem

To solve a saturation problem involving the moisturizing effect of an air conditioning unit, a practical model has been developed. In particular, this model demonstrates that the humidity feedback control in a printing office was not effective under certain ambient disturbances. Rather than measuring the relative humidity within the building, the air conditioning's redesigned control system uses the absolute humidity of the ambient atmosphere for a corrective feedforward action. This paper is based on a related case study for students in the Technical Business Studies programme.

Xuefeng Yu and Bala Ram

758–766 Teaching Intelligent Agents to Industrial Engineering Majors

Since the applications of intelligent agents are continuously growing in many industries, it is imperative for future industrial engineers to develop their knowledge base of intelligent agents. The paper first reviews the intelligent agent courses taught around the world, teaching resources that are available for such a course, and agent construction tools. The paper next presents the authors' experience teaching an intelligent agents course to industrial engineering students. The course was designed to ensure that students learned the skills to apply intelligent agents to analyze and design decentralized, changeable and complex industrial systems. The course format that was used is introduced with recommendations on the content, pedagogy and software. Demonstrations and course projects, used in the course to give students the opportunity to experiment with agent technology, are also described.