A place of Control Engineering in Modern Education in Electronics Engineering

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Introduction

A reform in education of Electronics Engineering at universities from transition countries imposes several important issues upon which agreement must be achieved. First, it must become compatible with modern european standards. A formal mean is to start applying ECTS and to define 'diploma supplements'. Second, having in mind actual industrial potentials and needs, we must define specializations in electronics engineers curricula. Third, we must preserve certain level of diversity in our education to enable education of specialities needed in a transition period of our industry. Finally, it must be a process supported from both, inside and outside. From inside, university employees need to recognize their need for the reform and, accordingly, to start changing topics, means and approach to education of modern engineers. From outside, this process must be recognized as an imperative towards modern industrial country, thus supported by national foundations in education and research.

Here we contribute working hypotheses and a tentative list of subjects from control engineering field suitable in electronics engineering education.

Working hypotheses

A list of general hypotheses is given below:

H.1. We need a new concept with emphasis to interdisciplinarity. We can not reorganize only actual subjects to start the reform.

H.2. Bachellor of science (BSc) in EE are needed for technology transfer. Masters of Science (MSc) in EE is needed for both, technology transfer and development of new technologies. MSc studies are in some cases predoctoral studies.

H.3. Teaching in BSc should be a combination of all compatible disciplines. Teaching in MSc may be an interdisciplinary combination of electronics and other disciplines.

H.4. System 3+2 years (BSc+MSc) is probably better than 4+1 year.

H.5. All subjects should be selectable and one-semester. Subjects need to be interconnected in many ways: many of them should be prerequisite for subjects in the last years.

H.6. Not more than ten specialities should be defined as an outcome.

Control Engineering in Electronics Engineering Education

Control Engineering is the scientific and technology discpline that greatly benefits from the developments in electronics engineering. On the other side, a complex scientific and technology projects with control issues as primary goals, necessarily demand comprehensive teams of many engineering specialities, especially basics of electronics engineering. As a member of such a team, an electronics engineer needs to have understanding in many relating fields, including control engineering.

A tentative list of selectable subjects in electronics engineering education shold be devided in three major areas:

- classical control engineering,
- industrial automation, and
- modern control applications.

The following list of subjects is a proposal for further discussion among teachers, professionals, and students. The list is divided into three major areas of control engineering and applications; not according to undergraduate/graduate criteria. Subjects are selectable.

The Classical Control Engineering shold cover the following subjects:

Signals and systems

Basic signals and types of systems, linear time-invariant (LTI) systems. Fourier analysis, frequency response, and Laplace transforms for LTI systems. Fourier analysis for discrete-time signals and systems, filtering, modulation, sampling and interpolation, z-transforms, sampling/aliasing. Natural frequencies, pole-zero diagrams. Transform techniques for circuits analysis in continuous-time and in discrete-time systems.

Classical control theory

Mathematical modeling of linear systems for time and frequency domain analysis. Transfer function and state variable representations for analyzing stability, controllability, and observability; and closed-loop control design techniques by Bode, Nyquist, and root-locus methods. Controllability and observability. Pole placement. Observer design. Lyapunov stability analysis.

Digital control systems

Sampled-data systems, sampled spectra and aliasing. Z-transform. Stability analysis and criteria. Frequency domain analysis and design. Transient and steady-state response. State-space techniques. Controllability and observability. Pole placement. Observer design. Lyapunov stability analysis. Programmable logic controllers. Digital filters.

Nonlinear control systems

Nonlinear differential equations, second order nonlinear systems. Equilibrium and phase portrait, limit cycle, harmonic analysis and describing function. Lyapunov stability theory. Absolute stability. Popov and circle criterion. Input-output stability, small gain theorem, averaging methods, and feedback linearization.

Modeling and simulation in control systems

Introduction to the mathematical modeling of dynamical systems and their methods of solution. Advanced techniques and concepts for analytical modeling and study of various electrical, electronic, and electromechanical systems based upon physical laws. Emphasis on the formulation of problems via differential equations. Fuzzy and Neuro modeling. Digital computer simulation.

List of subjects in Industrial Automation that belong to control engineering topics:

Process control theory and practice

Basics on industrial controls and automation. Industrial information theory and practice. Sensors and actuators in industry application. Process systems. Process control theory. Large scale systems. Understanding of wiring diagram creation, hardware selection and programmable logic controller design and operation.

Applied control systems and Instrumentation

Analog signal transducers, conditioning and processing; motors and other actuation devices; AD and DA converters; data acquisition systems; microcomputer interfaces to commonly used sensors and actuators. Design principles for electronic instruments, real time process control and instrumentation. Computer controlled instrumentation to collect data for modeling of physical systems using statistical analysis.

Industrial machine control

Application of the principles of electromechanical energy conversion to the analysis of various devices, which configure power and control systems. Basic power electronic components are introduced and applied to circuits used in power generation and in control of energy conversion devices.

Industrial robotics

Basic robot components from encoders to microprocessors. Kinematic and dynamic analysis of manipulators. Jacobians. Open-and closed-loop control strategies, task planning, contact and noncontact sensors, robotic image understanding, and robotic programming languages. Robot control theory and practice.

List of subjects in Modern Control Applications, that requires input from control engineering, covers mostly intelligent machines like robots, home appliances, and various gadgets.

Advanced Control Systems

Introduction to feedback control theory. Classical control system design. LQ, LQG, H2 control system design. Multivariable control system design. Uncertainty models and robustness. H_∞-optimization and μ-synthesis. Matrices and norms.

Man-Machine interaction

Basic principles of information and energy transfer between man and machine. Identification and modeling of human performance. Mechanical and congnitive user modeling. Prototyping and designing of user interfaces. Learning systems. Guidelines for building applications for: PDA, cellphones, industrial devices, computers, smart home appliances. Guidelines for applications in different environments: stand alone, client/server, web.

Intelligent systems and machines

Definition of intelligent machines and systems. Definition of mechanical intelligence. Intelligence in assessment. Differences between natural and artificial solutions. Motion and manipulation as basis of intelligence development. Natural ways of movements and interaction. Mechanism design by functional imitation of natural solutions. Biomimetics. Functional robustness of mechanical design for control problem simplification. Intelligent actuation as functional copy of natural ways of movements. Actuators with integrated sensors and controllers at primitive control level. Methods and techniques of interaction modeling. Design of controllers with integrated models. Examples of intelligent machines..

Intelligent control

Theory, design and application of feedback control systems containing elements of artificial intelligence (AI). Feedback control theory: deterministic, stochastic, optimal, adaptive. Limits of conventional control. Neoromorphic control systems: connectionist approach to Al, closed-loop control architectures containing neural nets. Learning control strategies. Knowledge-based control systems: symbol-processing approach to AI, representing and manipulating knowledge bases, rule-based expert systems, closed-loop architectures. Fuzzy and hybrid systems. Implementation and applications. Bayesian probability theory as tool to handle uncertainties.

Introduction to robotics

Characteristics of modern industrial manufacturing. Coordination of movements in machines. Mechanical joints. Robot as an universal machine. Basic subsystems of robot. Modern solutions in mechanical design of robots. Actuators and systems for force and torque transmission. Sensors in robotics. Structure of control subsystem. Hierarchical approach in control. Motion planning in workspace. Robot programming. Examples of robot applications in manufacturing. Robots in production and machine loading. Robotized assembly. Autonomous guided vehicles.

Service robotics

Environment entropy as motive for robot application. Robots in non industrial halls, offices, hospitals, houses, and outdoors. Specifics of robot construction of interaction with unstructured environment. Autonomous drive and control. Vision, sound, distance and touch sensors. Flexibility and robustness of control system. Underwater, land and air robots. Ordnance robots. Automation of work and living space. Robots in medicine. Robots as universal asistants in surgeries and robots in diagnostics.

Systems Engineering Design

Introduction to the macro-techniques of engineering design including performance, reliability, management control, redundancy, man-machine systems and testing techniques. Design, construction, test and evaluation of the approved projects.