IEEE Hamilton Section

Seminar on Computational Thinking

McMaster Innovation Park, 2014-10-25 08:00/12:00

Aim and Scope

By nature, engineers are problem solvers. Moreover, almost any engineering problem contains one or more computational problems. Most of the latter involve a set of known variables and a set of unknowns, linked by a mathematical model. Model-based problem solving has become a current buzzword. Since their years at elementary and secondary schools, and later at college or university, engineers are solving computational problems, but hardly ever a syllabus included problem solving as a study object. Experience has shown that learning problem solving by doing, without a guiding theory is not an efficient nor a far-reaching strategy. A new trend in computing, known as Computational Thinking (CT), strives to a systematic education on problem solving. World authorities in computing are calling for CT, although its structure and contents as a subject matter are still under wide discussion. This seminar presents a rational approach to CT, developed and tested in engineering education and practice by the author along two decades.

Intended Audience

The seminar is aimed at electrical and mechanical engineers, as well as professionals from other branches of engineering, seeking to improve their skills to pose and solve efficiently practical problems of technical computing, by hand or assisted by any known means.

Instructor

Jose Martinez Escanaverino, BSc, PhD (Eng)

- Full Professor, 1985/2008, Higher Polytechnic Institute *J.A. Echeverría*, Havana, Cuba.
- Full Member, 1996/2010, Engineering Sciences Section, Academy of Sciences of Cuba.
- Engineering Advisor, 1994/2005, CVG Basic Industries, Puerto Ordaz, Venezuela.

Seminar Fee

IEEE Member	$50
IEEE Life Member	$40
Non IEEE Member	$100
IEEE Student	$40
Non IEEE Student	$80

Learning Outcomes

Attendants to the Seminar will become aware of the following key concepts and processes regarding model-based engineering computational problems:

- Informal problem and problem.
- Choosing mathematical models.
- Posing problems on given models.
- Probing solubility of given problems.
- Solving simulation problems.
- Solving optimization problems.
- Solving, when possible, inconsistent problems.

Thematic Program

0. Introduction

What is a problem? Problems as questions. Problems as knowledge gaps. Problems as contradictions. Problem solution. Algorithm. Model-based problems. Informal problem. Data. Query. Problem. At school. At campus. Traditional approach. Proposed approach. Synopsys of seminar.

1. Mathematical models

Physical systems. Model of a system. Physical model. Mathematical model. Hybrid model. Variables. Relations (constraints). Properties. Equations. Unequations. Relation symmetry. Model reduction. Slack variables. Model graph. Model components.

2. Situations and problems

Data. Situation. Situation graph. Situation components. Unknowns of a situation.. Problem. Problem graph. Problem components. Unknowns in a problem. Problems in a mathematical model.

3. Problem characterization

Matching. Resolvent. Canonical problem. Problem solubility. Problem freedoms. Determination of a problem. Problem deficiencies. Consistency of a problem. Simulation problem. Optimization problem.

4. Simulation problems

Algorithm. Algorithm graph. Algorithm components. Closed and open algorithms. Arboreal and cyclic algorithms. Sequential and parallel algorithms. Direct and Variational simulation. Criterion of choice.

5. Optimization problems

Optimization criterion. Objective function. Operation problems. Design problems. Associate simulation problem. Scalar optimization. Methods for scalar optimization. Vectorial optimization.

6. Inconsistent problems

Reducible inconsistency. Natural relation. Criterial relation. Error variables. Reduction to an optimization problem. Method of least squares. Method of minimax.

Structure of the Seminar

The parts of the Seminar, as well as their times and hours are given in Table 1.

Table 1. Structure of the Seminar

Theme		***Time***	***Hours***
Number	***Name***		
Coffee break		08:00/08:15	00:15
0	Introduction	08:15/08:40	00:25
1	Mathematical models	08:40/09:05	00:25
2	Situations and problems	09:05/09:30	00:25
3	Problem characterization	09:30/10:00	00:30
Coffee break		10:00/10:15	00:15
4	Simulation problems	10:15/11:00	00:45
5	Optimization problems	11:00/11:40	00:40
6	Inconsistent problems	11:40/12:00	00:20
TOTAL		—	04:00

Seminar Synopsis

In four hours, the seminar introduces to an original method for computational problem posing and solving developed by Professor Jose Martinez Escanaverino along more than 20 years. Such method has been published in international engineering events in Canada, Cuba, the United States, and the Netherlands, as well as taught in full courses—typically of 36 hours—developed in universities and enterprises of Brazil, Cuba, and Venezuela. The method helps develop professional *computational thinking* in engineering, an area currently under discussion, but still in process of constitution as a subject matter in university syllabi. The seminar exposes briefly key ideas and procedures useful to get a first level of understanding of the process of problem resolution. Such process begins enunciating an informal problem, going further into the making of a mathematical model and precise problem formulation, and arriving to the algorithmic solution of the same. Although the concepts and processes involved are treated with rigor, the method becomes intuitive, thanks to the use of bipartite graphs. The method may be applied in any computational context, from manual—pencil and paper—to computer-aided calculations, using any software tool. It is not presupposed in the attendants any knowledge beyond the level of a typical sophomore year in engineering.

Seminar Presentation

The seminar will be presented in Microsoft *Power Point*, by means of a video projector with computer input and a projection screen. The contents of the seminar cover more than 200 full-color *Power Point* slides. Each attendant is going to receive a printed handout containing all the slides covered by the activity.

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