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Pedagogical Resources Reachable via Internet for Teaching Intelligent Instruments: Developments within a European Thematic Network

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***Abstract** – Built in the framework of the SOCRATES 2 European program, the THEIERE Thematic Network (2000-2003) is based on a primary idea coming from EAEEIE (European Association for Education in Electrical and Information Engineering) and follows the former INEIT-MUCON project (1996-2000). In the field of EIE (Electrical and Information Engineering), these projects formulate common Curricula and define a minimum knowledge base for an engineer (or equivalent) in a European context, both in level and content. Another aspect concerns the curricula harmonization which aims at facilitating the students and staff mobility among the European universities. The pedagogical resources in which we are working on and which are more particularly presented in the paper concerns intelligent instrumentation and digital signal processing.*

***Keywords** – intelligent instrumentation - digital signal processing - distance learning resources - SOCRATES European program - Electrical and Information Engineering - Emerging technologies*

I. INTRODUCTION

The **THEIERE** (Thematic **H**armonisation in **E**lectrical and **I**nformation **E**ngineer**R**ing in **E**urope) has been launched in September 2000.

The aims of this Thematic Network are:
- a survey concerning the available curricula in EIE (Electrical and Information Engineering) throughout Europe,
- to enable a curricula comparison that will facilitate the transfer of knowledge between higher education institutions,
- a reflection on the best practices of high engineering education in the specific field of Electrical and Information Engineering in a European perspective [1] [2],
- a development of pieces of curriculum and pedagogical tools available through the Internet as pre-requisites to help students for mobility exchange programs.

The aim is to allow the student to prepare her/himself before going in a foreign country by:
- acquiring the basic level,
- beginning to learn in the foreign language and with the foreign approach the academic content of one particular course.

The main objective is to get an harmonization of the curricula in EIE throughout Europe in order to facilitate the exchanges of knowledge, students and teachers. This harmonization will make possible the establishment of common accreditation, crediting and certification procedures [3] [4] [5]. The set of pedagogical tools developed in this project can also act as a virtual library freely usable within LLL (Life Long Learning) /ODL (Open Distance Learning) context, enabling the training and knowledge updating of a large number of students and engineering professionals in Europe.

The development of the pedagogical modules, whose content will be agreed upon by all participants, in a specific field of EIE, will contribute to lay the foundations for a virtual university with common curricula in this domain. One essential step is the definition of the core subjects that define the minimum knowledge that every engineer must possess, and be competent in.

Most of the EU partners were previously involved in a Thematic Network project entitled INEIT-MUCON "Innovations for Education in Information Technology through Multimedia and Communication Networks" [6]. This experience turned out successfully and a number of short courses, using the Internet were developed. The course on intelligent instruments is developed in the following.

The consortium responsible for this new THEIERE project is composed by:

- 79 European universities
- University of Mariupol, Ukraine,
- Bogazici University, Istanbul, Turkey,
- University of Tangiers, Morocco,
- 1 European Association EAEEIE (European Association for Education in Electrical and Information Engineering, http://www.eaeeie.org),
- an enterprise Giunti Interactive Labs S.r.l from Genoa, Italy.

II. PEDAGOGICAL AND DIDACTIC APPROACHES

In the development of the Internet-based modules the following strategies are used [7] [8]:

- Organization of curricula using new technologies
- Main course with several levels (HTML and PDF pages, dynamic slides)
- Interactive exercises with several correction levels
- Simulations to help to understand theoretical concepts
- Library of questionnaires (in several languages) for student self-evaluation,
- Distant access to some practical labs (tele-labs),
- Computer simulation of experiments (distant labs)

III. ORGANISATION AND COMMON PRESENTATION OF THE MODULES

The data concerning the project as well as various pieces of curriculum and pedagogical tools available are proposed in a web server located at:

http://www.eaeeie.org/theiere/

There are two support groups (SG). The first one is the technical working group, who is defining a common template for navigation among courses. The model is built to insert the courses and is based upon didactical aspects. Another group is working on copyright aspects.

Eight working groups exist in some sub-parts of Electrical and Information Engineering, working on eight packages:

- Computer and Information systems
- Communication
- Electronics
- Power systems
- Instrumentation and control
- Internet services and applications
- Fundamental
- Virtual labs

IV. THE INSTRUMENTATION AND SENSORS THEMATIC SUB-PACKAGE

This sub-package is a part of the package on "Instrumentation and Control". Presently, the package developed in instrumentation and sensors is composed of the following chapters [9].

A. Objectives

The aim is to teach some aspects relative to sensors, physical and methodological aspects, as well as sampling and digital signal processing. The course is designed in order to emphasize the role of measurement in all technical activities. Measurement is at the basis of a lot of technical activities because a main part of actions is done after an observation of the environment; so in the technical world sensors are considered as "weak links" since a lot of decisions are based on measurement information provided by these.

B. Metrology

The chapter on Metrology could be considered as a milestone; it is going to be designed in order to emphasize the role of measurement in all EIE processes. Terminology and standards definitions such as accuracy, rangeability, measurement errors, … dedicated to the measurement area are at first introduced. Generic structures of sensors are proposed in order to show that sensors could be considered as energy converter process.

The learning objectives of this module could be considered as reached when the learner has understood:

- that one measurement is only an image or an estimation of the measurand ; this image could be more or less far from the "True Value",
- the choice of the "best sensor" for a particular application must be done by taking into account environment criteria in order to minimize sources of errors.

Various tools for the illustration of these aspects are proposed. One of the main interest to use these new technologies is to enrich the "classical" course by Java applets as simulation helping the students to understand some concepts. These Java applets can be used as a dynamic slide by the teacher when she/he explains the concept to the students, then the students can use it during some practical works at school, and finally the student can also use it distantly through the internet.

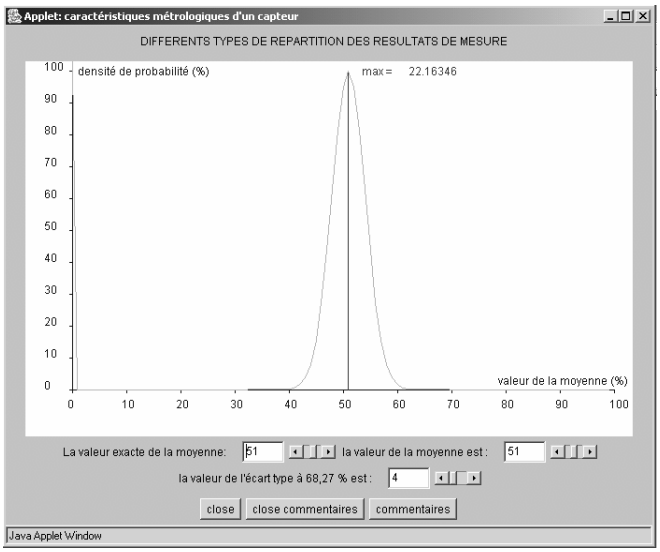

Fig. 1: Characterization of measurement errors

The applet shown on figure 1 aims at helping to understand the properties of justness and accuracy of a sensor.

The applet figure 2 is an animation to illustrate the possible utilization domains of a sensor.

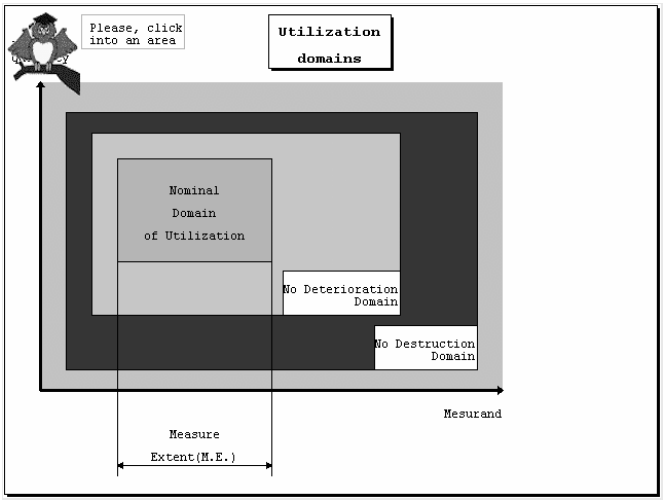

Fig. 2: Utilization domains of a sensor

C. *Types of sensors*

In this part, several kinds of sensor are proposed for a study:
- Thermal sensors
- Mechanical sensors
- Temperature Measurement

This chapter comprises not only a presentation of the temperature measurement but is also a synthesis of the part concerned with metrology. By using Temperature Measurement, one of the most common application in industry, the learner will acquire practical knowledge about:

- Some physical laws such as Seebeck effect in thermocouple applications, for instance Java simulations are used in order to help partners to understand the cold junction compensation procedure,
- Compensation of influence quantities,
- Correction of errors due to the way of measurement in RTD applications, in order to take into account self-heating effect.

The applet shown on figure 3 aims at helping the students in understanding functioning of sensors. It is based on the various energetic transformations which are used to supply a (electric) signal representing the measurand value.

You must choose the diferent changes of energy in the selected instrument.

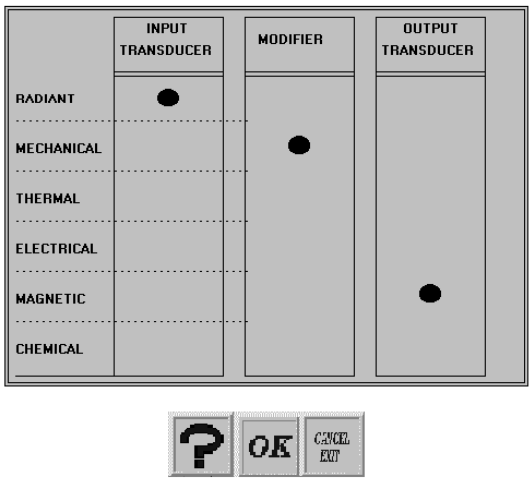

Fig. 3: Dynamic grid proposed by the server and filled by the student

D. *Sensor power*

This part developed by the Universität Darmstadt (Germany) deals with the problems of power linked to a sensor, what is the possible solution to bring an energy supply to a sensor as a function of the required application?

In principle, any type of sensor requires a power supply for the generation of output. The supply has a direct influence on the quality of the sensor system: Noise, Voltage variations, transients, drift etc. can decrease the accuracy. For many applications, it is also quite difficult to make wire connections.

V. SIGNAL PROCESSING

This part considers the interface of a sensor with a digital environment, typically a fieldbus network or another communication network. This part considered within the frame of a general curriculum as a common pre-requisite for several courses in Electrical and Information Engineering has been

developed in collaboration with the Universität Ulm (Germany). The main parts are the following:

A. Fourier Series

After a short introduction, two chapters of courses are proposed, one on the Dirichlet conditions and the other one dealing with the Gibbs phenomenon. These aspects emphasize on the mathematical aspects which are an important pre-requisite in the field of signal processing. Some problems are proposed, with an automatic correction, and a questionnaire for self-assessment of students is also available.

B. Fourier Transform

One chapter of course explain what is and how to calculate the Fourier transform of a signal. The mathematical aspects are here also emphasized. Some problems are proposed, with an automatic correction, and a questionnaire for self-assessment of students is also available.

C. Digital signals spectra

In this part, it is emphasized more specifically on the practical use of signal processing, or on the graphical way to determine the spectrum of a signal. Some graphics, as well as some Java applets are available to achieve simulations in order to well understand the problem of samplings, both in temporal and frequency domains. This aspect of using Java applets to help students in understanding theoretical concepts is a real added value in the pedagogy of some academic fields such as signal processing, in which the concept lays on theoretical mathematical aspects not so easy to make the students aware of, but for which it is far easier to render the concepts understandable with a graphical display.

B. Digital filters design

This part is the more practical one, because it deals with the design of digital filters. A course is available explaining the method; then a Java applet for the design of infinite impulse response digital filter is available. The pedagogical aim of this applet is to render the students aware of the problems of placing in the best way poles and zeros, discovering the problems of stability, and also to design and get the transfer function of such filters in an easy and recreational manner.

VI. LABORATORIES

In the proposed approach, we consider the courses may be interesting both for distant learners also as a complement to present learners. It's the reason why it is important to have also access to distant physical processes.

For the moment, a laboratory is available as a pilot thermal process. It's so possible to send distantly some orders to the heater, to the valves, and to collect back some measurements (mainly flows and temperature) taken in various points of the primary and secondary circuits.

The sensors used on the process are the following:

- As temperature sensors, The temperature measurements are made through PT100 platinum resistors. This kind of RDT is calibrated in order to provide an electrical signal (4-20 mA) for a temperature variation of 0 to 100°C. The resistance variation is a function of the temperature in accordance with:

Rsonde=Rc0(1+AcT+BcT^2) where
T : temperature in °C
Rc0=100
Ac=0.0039/°C
Bc=-0.00000058/°C

- The flow measurements are made with the help of variable-pressure-drop flowmeters, associated with differential pressure sensors: The flow Q is given by the relationship:
Q = K sqrt(DP/r) with
K = calibration coefficient
DP = Differential pressure
r = fluid mass density

The differential drop is converted into an electrical-signal of 4 to 20 mA. Then, it is necessary to extract the square root in order to obtain a proportional signal in flow. This task is made by an external treatment.

The principle of this tool allows students to design an automation system completely or partially. To do that, functional blocks are used and represent functions of sensors, actuators, controllers… or mathematical treatments (ex.: PID, delay, comparison…). The student connects these blocks and chooses their parameters. When this step is achieved, his/her automation system can be executed on a real process, the pilot thermal process. The data are transmitted via Internet and some treatments such as an identification of physical parameters or a control loop can be realized. The fieldbus Worldfip is used to connect the Internet server and the process and permit a local real-time control.

This system of distant control offers several advantages. With predefined control system, students can realize identification or can test different parameters for control loops. Or, in an advanced level, they can build themselves their own automation system and test it on a real process.

VII. COMMENTS ON THE PROJECT

This project presents the main interest to have been developed within a specific context: that is, the EAEEIE association, together with the thematic network, give the opportunity to a big amount of partners to work together in several aspects dealing with compatibility of curricula and compatibil-

ity of diploma. We may mention that several thematic networks exists in several academic fields (http://cranmmx.esstin.u-nancy.fr/tnpn/tnpnt).

Concerning electrical and information engineering, which is the core of the project, we may say the interest deals with the use of new technologies for teaching. The interest of this approach aims at several targets :

- improvement of the pedagogy by the possibility to supply students with attractive simulation, reachable through internet or intranet. This kind of simulation does not aim at replacing a more formal and deepen formalization, but could be useful for beginners in a field to understand some concepts more easily,
- possibility for students, once in the professional life, to keep a contact with the university,
- tools very useful as pre-requisites to prepare students either in their own country or before going abroad (possibility to get pre-requisites in a field in the language and with the approach normally used in the destination country). This point is for us very important and may emphasize the student and staff mobility.
- development of tools for Open Distance Learning. This purpose is a long-term purpose we are following, the experience acquired in the thematic networks helps us in emphasizing the best practices in this activity.

Another interesting point is the participation of students in the project development. Various kinds of students have participated in the development of the thematic packages. Two students from the Universidade de Vigo in Spain came in our laboratory for a three-month training within an ERASMUS exchange. The project they were responsible for was to develop two applets, one for design of a sensor possibly using several transducers, and the other one for digital signal processing teaching.

Some other projects have been proposed to several students, at various levels: technician level, bachelor level, or master level. It is interesting to notice it is not trivial to develop some applets or other tools for simulation. The time necessary for the students to apprehend the technology for the developments and then to develop cannot be neglected. The following table shows some examples of the implication of students.

Java applet for temporal problems in sampling	2 students	app. 100 hours	IUT
pre-requesite: Java applet for sensor	3 students	app. 100 hours	IUP
Java applets for teacher assessment	2 students	3 months	ERASMUS (engineer level)
FFT Java applet	1 student	Equ. 1 month	engineer school
Applet for thermocouple modeling	1 student	Equ. 1 month	engineer school
Tools for helping teachers in developing quest.	2 students	3 months	ERASMUS (engineer level)

Table: Some example of level of students and time used for their projects

VIII. EVALUATION BY STUDENTS

Finally, we may mention some evaluations have been achieved showing that the students are interested in the development of these new technologies for teaching [10]. In order to achieve this evaluation, the pedagogical tools have been tested on some sets of students, preferably from another university within the network.

Some experimentation were done relative to the use of the pedagogical resources on signal processing with a group of 80 undergraduate French student. Another test has been done by 15 students in a master degree in "Networks" at the Institut Supérieur du Génie Appliqué (IGA) in Casablanca (Morocco). All these students were asked to give their impressions on the use of these pedagogical tools:

- facility to use (ergonomics),
- problems of connection (the students in Nancy had direct access to a metropolitan network and so, to the internet, the students in Casablanca had access via a unique modem),
- interests and difficulties of the courses in HTML, simulations (Java applets),
- difficulties in using the English language,
- suggestions of improvements.

The first remark is that the students in Casablanca are obviously more mature than the younger under-graduate students in Nancy.

They had also a very positive reaction to the use of these kinds of tools but they think it will not replace a present teacher. They had noted some interesting particular points, in addition to what was said concerning the previous group, are the following:

- the possibility to keep the contact with the university, once in the professional life,
- the possibility to reduce the gap between developing countries and richest countries due to the free access to the site
- they encourage us to work on the possibility for a potential user to test his level before beginning to get the more adapted tool to his needs.

Their remarks concerning the use of the English language are quite the same as the French students, that is there are no important difficulties concerning the English language as long as the text is relatively short but an on-line help on specialized and/or difficult words could be useful.

IX. REFLECTION ON THE HARMONIZATION OF CURRICULA IN EUROPE

This co-operation, sponsorized by the European Union, between more than 80 European universities, aims globally at reflecting on the organization of the University for the future in Europe. This reflection needs to be achieved under the frame of the White paper [1] within the idea of an access to the "Knowledge" for each citizen of the European Union.

The first aspect we are working on, globally on Electrical and Information engineering, and for our team, on aspects dealing with intelligent instruments and digital signal processing, is the implementation and use of new technologies in order both to allow the use for distant students and also, as it is explained formerly, to have some tools to facilitate the understanding of some concepts, for physically present students also.

The second aspect we are now reflecting on, is linked with the European proposal to try to find some transparencies and convergence in the presentation and organization of curricula throughout Europe, in order to facilitate the exchanges of students during their studies and also the recognition of their diploma, once in the professional life.

X. CONCLUSIONS AND PROSPECTS

It is envisaged that this project will act as a catalyst for co-operation with a European, or even broader, dimension, and for the introduction of the latest innovations to education and learning in the framework of such a Virtual University in EIE. Some tools are already available.

The purpose is now to go further in the finalization of these modules. Another aspect in which we are presently working on is the use of a database to help us in the structuration of pieces of curriculum and pedagogical tools. The future works will have to include these aspects dealing with navigation aspects, related to the students pre-requisites and learning approach.

At the present time, we have worked in a European context (+ a Moroccan experimentation), with problems of multi-lingualism and multi-educational systems, so we have from that acquired a certain experience in working in such an environment. We are interested in any collaboration and co-operation with potential partners who would like to go in this direction, for example in America...

The set of tools developed in the project can act as a virtual library freely usable within LLL (Life Long Learning) /ODL (Open Distance Learning) context enabling the training and knowledge updating of students, and also disadvantaged people. Either those with a physical handicap, or suffering from lack of mobility for a given period of time, as well as people living in remote areas or under-developed countries can take advantage of the possibility of studying at home at their own pace.

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