A training course on design and programming embedded systems for professionals working on Telecommunications and Mechatronics

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***Abstract*— An embedded system is a computer system with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints. Embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, and largely complex systems like hybrid vehicles, MRI, and avionics. That means that we found them in almost everyday life electronics systems. In an environment where change is continuous, success and survival itself depends critically upon the individual's ability to rapidly adapt, and upon the ability of communities to adapt quickly. Adaptation depends upon the ability to learn, and to learn quickly – and where change is continuous, adaptation must be continuous therefore learning must be continuous. The electronic and electrical engineers are among them who have to update their knowledge very often. Engineering educators interested in developing programs to meet the needs of professional engineers. In our Institutions, after a small survey among our graduates we found out that their knowledge in embedded systems is out of date and we decided to develop a training program for updating their knowledge. In this paper we present the development and the organization of the course, the modules that it contains, the lecturers and the whole materials we plan to use as also the type of exams and the ECTS units we are going to award to the participants. The whole program is funded from European Social Fund and the Greek Government under a project of reforming Lifelong Learning Education in Greece.**

Keywords—Embeeded Systems, Continuing Education, Telecomunications, Mechatronics

I. INTRODUCTION

An embedded system is a computer system with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints [1].

The recent technological advancement in electronic, electrical and informatics engineering, as long as the rapid developments in the area of electronic components miniaturization gave a boost in adapting devices which contain different types of embedded systems in everyday life.

Today's embedded systems development ranges from microprocessor-based control systems, to systems-on-chip (SoC) design, and device software development. A wide range of implementations can be found in consumer electronics (smartphones, home appliances etc.), medical devices, and commercial and military applications [2].

Based on the variety of embedded systems applications and due to the fact that the current trend in U.S and in E.U is of a growing demand for engineers, skilled in the fields of electronics, telecommunication and robotics [3], which consist some of the main areas of embedded systems integration, we have developed a continuing education program focused in educating and enhancing the skill and dexterities of working professionals that want to focus on Telecommunications and Mechatronics.

The curriculum is supported by faculty members from three departments with complementary thematic topics: Electronic Engineering, Informatics Engineering and Telecommunications. These thematic topics are heavily related to the core components of embedded systems. The approach of the proposed continuing education program is that embedded systems are a function between hardware and software device design and development.

The main benefit for the participants of the aforementioned program is that they will gain all the essential state of the art knowledge about how an embedded system is designed and programmed. This will give a competitive edge to the course graduates which will result in a better placement in the job market.

The rest of the paper is organized as follows; section II provides information about the principles based on which the curriculum was designed, while section III provides information about the modules structure, material and learning outgrowths. Section IV provides some final remarks.

II. CURRICULUM DEVELOPMENT

The program aims to enhance and keep up to date the dexterities and skills related to embedded systems of university graduates with diverse background from departments including but not limited to Computer Science, Mechanical Engineering, Electronic Engineering, Electrical Engineering etc.

The technology related background of the prospective students is essential since they must have a solid background in principal modules including but not limited to electronics, programming, electric circuits etc.

Based on this background we have developed a three level curriculum which is consisted in the first level by three core modules (Digital Design, Computer Architecture, Basic Principles of Embedded Systems), in the second level by a two application related modules (Telecommunications, Mechatronics) and at the third and final level an integration module in the form of mandatory research project. This hierarchical approach is formally presented in Fig. 1.

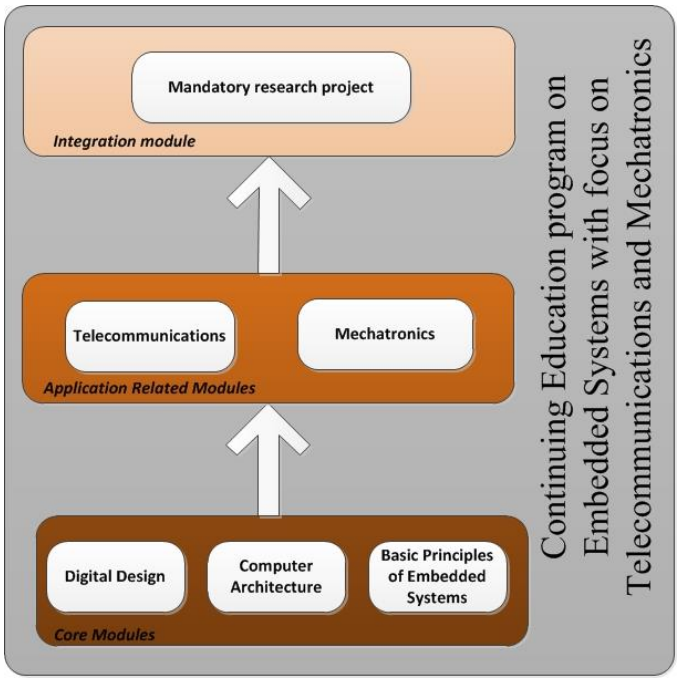

Fig. 1. The level approach of the continuing education program on embedded systems with focus on mechatronics and telecommunications

Each of the three levels aims in different type of learning outgrowth. During the core module courses the prospective student will have the opportunity to enhance and update basic knowledge related to embedded systems. Since the majority of the targeted audience will be engineers that have graduated in the last decade; the instructors will try to refresh the knowledge in digital design and computer architecture which are essential for proceeding in embedded systems design and programming.

In the core module which is related to basic principles of embedded systems we will initially emphasize the growing importance of the field of embedded systems by formally analyzing its techniques, applications, concepts and practical implementations [4].

Upon the ending of these three core modules the participants will have a strong background to proceed in application oriented modules. Based on the theme of the continuing education program, the application modules will be related to mechatronics and telecommunications. An emphasis will be given so that the participant will acquire hands on experience on the aforementioned subjects.

The final module will be related with a mandatory research project. The term research is not referred in a traditional research thesis, but in developing a final project in small teams which will integrate all the learning elements that the participants have acquired in the previous modules. Emphasis will be given in projects related with real problems that are met in the industry.

Upon the completion of the program the participants will have gained all the essential knowledge of embedded systems design and programming. They will have learned how to program an embedded device, become proficient in programmable logic design and analysis and they will have increased their understanding of real-time operating systems.

The learning process will be conducted using all the essential facilities and equipment which are provided by the participating departments. All state-of-the-art synchronous and asynchronous learning methodologies will be used to assist the participants who are mainly going to be working professionals. The program will not work in the traditional day to day lecture in classes approach, but it will combine scheduled lectures and laboratory training in parallel with web based learning methodologies (i.e. learning material in eClass, podcasts etc.). The participants will work on different kind of projects in regular basis.

III. MODULES DESRIPTION

The continuing learning program is consisted by six complementary modules aiming to provide the participants with all the appropriate knowledge to excel in embedded systems related positions.

The three core modules: Digital Design, Computer Architecture and the Basic Principles of Embedded Systems will be having 25 hours of teaching per module. The evaluation methodology in all three modules will be based on combination of laboratory coursework, essays prepared by the participants and tests which will be conducted during the teaching period.

The Digital Design module aims in updating and enhancing all knowledge related to digital systems. It will cover introductory issues in digital computing, digital systems and binary numbers. A detailed overview of Boolean algebra and issues related with logic gates and gate-level minimization will be given as long as issues related to combinatorial logic. We will also address issues related to Synchronous sequential logic design and fault detection coding. We will also study

asynchronous sequential logic system. The module is accompanied by laboratory experiments and exercises using FPGA development boards.

The Computer Architecture module aims in updating and enhancing all knowledge related to computer organization. We will emphasize in the lower levels of computer organization and design of CPUs. We will present all the basic aspects of computer organization and present in detail the IEEE Standard for Floating-Point Arithmetic (IEEE 754), the programming and internal structure of MIPS processor and other related subjects. The module is accompanied by laboratory experiments and exercises using VHDL in ISE environment by Xilinx and programming in MIPS' symbolic language.

The third core module entitled Basic Principles of Embedded Systems, aims in providing the participants with all the basic information related to embedded systems. This module is the essential link so that the students may move a step further and start developing their own embedded systems applications. We will describe the System on Chip (SoC) technique which emphasize the coexistence of hardware and software in the system design. Upon the completion of this module the participant will have an update related to operating systems of embedded systems, hardware and protocols for input/output in embedded systems, microprocessors and microcontrollers related to embedded systems, design and integration of digital systems using VHDL and FPGA, analyzing the performance of embedded systems and optimization of their performance, reliability and energy consumption. The module is accompanied by laboratory experiments and technical training.

In the second level we have two modules both with 30 hours of teaching. Each module aims in emphasizing the relation of embedded systems with modern devices in two distinct fields: telecommunications and mechatronics. The participants of the continuing education program will get hand on experience in applying the principles of embedded systems design by combining theoretical knowledge and practical training in the aforementioned fields.

The application of embedded systems in telecommunications module aims in emphasizing the use and integration of embedded devices in all kind of modern telecommunication systems/ devices like smartphones, smart antennas, digital TV and radio etc. Upon the completion of this module the participants will have an in-depth knowledge and hands on experience of all the related aspects. The module is accompanied by laboratory experiments and technical training.

The application of embedded systems in mechatronics module aims in emphasizing the use and integration of embedded devices in all kind of modern systems related with "intelligent" systems that combine mechanical, electronic and electrical components able to operate as an independent device. Upon the completion of the module the participants will have hands on experience on design and integrating an embedded system able to control a complicated device (i.e. a robot, house automation etc.).

The performance of the participants in both application modules will be evaluated based on combination of laboratory coursework, essays prepared by the participants and tests which will be conducted during the teaching period.

After the completion of all the aforementioned modules, the participants will have the opportunity to combine all the acquired skills and dexterities and work in an advanced project simulating a real project that they might face in their working environment. This project will be carried on by teams of students.

The total work load of the program is equivalent to 12 ECTS units. Upon the completion of the program the participants will be awarded with a certificate of attendance.

IV. CONCLUSION

We have briefly presented the continuing education program entitled "A training course on design and programming embedded systems for professionals working on Telecommunications and Mechatronics". This program aims in enhancing the skills and dexterities of engineering or technology related fields' graduates in the design, integration and use of embedded systems in the fields of telecommunications and mechatronics. The curriculum was developed to meet the rapid development of the related technological fields and help the participants to maintain a competitive edge in the job market. The structure of the program assures that the participants will gain all the appropriate knowledge to be actively involved in all aspects of embedded systems application in diverse environments.

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