POLITECNICO
MILANO 1863

Computing Systems

ENGINEERING PHYSICS - INGEGNERIA FISICA - MSc Master Course
1st Semester

A.Y. 2021-2022
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COURSE DESCRIPTION

The aim of the course is to introduce skills for the contextualization, definition, requirements, and implementation -through system integration, data analysis, and algorithms- of a cyber-physical system. These systems, which are able to interact continuously with the physical environment in which they operate, combine the computational capacity, communication, and control capacity. Cyber-physical systems are typically based on microcontrollers, dedicated sensors and actuators, and communication means (wired and/or wireless). A cyber-physical system is a special-purpose system and is intended to be part of more complex systems. The context is the field of Ambient Intelligence (AmI) envisages a digital environment where humans interact with multiple smart electronic devices that are aware of the context they operate into and are capable of adapting their response to the users' requirements, anticipating their behaviour and responding to their presence. Processing power is embedded and distributed in all the devices located in the environment, in what is denoted as "ubiquitous computing" or "pervasive computing". Different application areas are currently being pursued depending on the specific environment considered: smart homes, smart buildings, smart cities, smart transportation systems, etc. Particularly interesting are the applications of AmI in such areas as people well-being (services and support, assistive technology, ...), mobility, commerce and marketing, enterprises and handicrafts, fashion, leisure and entertainment, tourism, healthcare, environmental management, arts and culture, agriculture.

The course also includes the practical use of boards for embedded systems and related development environments (e.g. Arduino and STM32 - Core / MBED).

LEARNING OUTCOMES

- *Knowledge and understanding* (DD 1)
  - Students will learn to deal with the design process of a computer system (for example, the collection definition and refinement of requirements, the analysis of previous works, the definition of the system, the identification of sensors and actuators based on the needs of the project, the data analysis and the definition of algorithms).
  - Students will learn how to design and program a computer system, with particular emphasis on interacting with the external physical environment.

- *Apply knowledge and understanding* (DD 2)
  - Students will be able to independently design a digital system;
  - Students will be able to evaluate and select the elements of the digital system;
  - Students will be able to write small embedded programs that interact with the physical environment;

- *Making Judgments (DD3)*
  - Given a specific problem and design cases, students will have the ability to analyse functional and extra-functional characteristics and to independently compare different choices in terms of HW and SW.

- *Communication Skills (DD4)*
  - Students will be able to communicate the idea behind the developed project, and to justify the design choices made, to an audience made up of specialists and non-specialists.

- *Lifelong learning skills (DD5)*
  - Students will be able to understand how to develop a real embedded system project;

- Students will be able to independently learn how to use and program state-of-the-art embedded computer systems;
- Students will be able to independently learn the new micro-architectural features of computer systems.

TEACHING METHODS

Sessions will be performed in presence according to the teaching schedule reported in this booklet.
The course is composed of a mix of lecture sessions, design support and critique sessions helping the students to directly learn, apply and test their acquired knowledge on the design problem to be solved, and to review their projects.
Learning modes consist of critique analysis of previous/existing works, lecture presentations, own design exercise (programming, integration of systems, verification and test of the prototype, data analysis, ...), own work presentations and, the demo of the prototype.

TEACHING FORM

Frontal Talks:	32 hours
Class Student Activity:	84 hours

EVALUATION CRITERIA

Students will be evaluated through working group.
Students are required to produce (note: percentage are indicative):
3 points: Innovativeness 100%
30 points: Final Paper 40% – Pitch 20 % – Video Spot 10% - Prototype 30%

- Final Paper (paper - format latex – from 6/8 pages) [.pdf – 40%]
  - Title (max 100 char - spaces included) & Authors
  - Abstract (min 800 - max 1200 chars - spaces included)
  - I. INTRODUCTION (min 3000 - max 5000 chars - Spaces included) [10%]
  - II. RELATED WORKS (min 4500 - max 6000 chars - Spaces included) [10%]
  - III. PROPOSED SOLUTION (6000 chars - Spaces included - + a picture) [10%]
    - III - a System Specifications and Requirements
    - III - b General Architecture
    - III - c Relevant Characteristics of the System (example: III-c-1. Automatic Calibration & Initialization III-c-2. Meta Algorithm)
    - III – ? (use this if you need other space or sections) - Specify the title
  - IV. EXPERIMENTAL RESULTS [10%]
    - IV-a Prototype
    - IV-b Experimental results
    - IV-? (use this if you need other space or sections) - Specify the title
  - V. CONCLUSIONS
  - VI. REFERENCES
- Pitch (10 minutes – final presentation) [.pdf from .ppt 10% - presentation 10%]
- Prototype [30%]
- Video Spot (60 seconds) [10%]

The final presentation and video will also enable students to demonstrate their communication and technical skills.
NOTE: in the document all sections are “mandatory” – any missing section will invalidate the entire document.

BIBLIOGRAPHY

1. Igoe, T. - Making things talk. Third Edition (2017).
2. Margolis, M. Arduino Cookbook: Recipes to Begin, Expand, and Enhance Your Projects (2020)
3. Gulliksson, H. Pervasive Design, fourth edition (English Edition) (kindle Edition)
4. Hendr, I. ESP32 Development using the Arduino IDE (English Edition) (Kindle Edition)
5. Osterwalder A., Value Proposition Design: How to Create Products and Services Customers Want (Kindle Format)
6. Monk, S. Programming Arduino Getting Started with Sketches. (McGraw-Hill Education TAB, 2011).
7. Schwartz, M. Internet of things with Arduino cookbook. (Packt, 2016).
8. Cameron, N. Electronics Projects With the ESP8266 and ESP32: Building Web Pages, Applications, and Wifi Enabled Devices (Apress)

TEACHING SCHEDULE Computing Systems 2021-22

	PHASE	DATE	TOPIC
SEPTEMBER	INTRO	thu 16 sep Frontal	Introduction, 2020/21 projects (examples), Projects ideas (types), Description of the project flow and objectives, Description of the structure of the project outcomes: paper, presentation, video spot
SEPTEMBER	INTRO	fri 17 sep Frontal	Ambient Intelligence
SEPTEMBER	BACKGROUND	thu 23 sep Frontal	Binary representation of numbers (integer, 2's Complements, FxP and FP), C (review) and, introduction to PYTHON
SEPTEMBER	BACKGROUND	fri 24 sep Frontal	Arduino e STM 32: architecture, programming, IDE, Simulator (Tinkercad), examples
SEPTEMBER	BACKGROUND	thu 30 sep	Arduino Projects (STUDENT ACTIVITY)
OCTOBER	BACKGROUND	fri 01 oct Frontal	ESP32 (WiFi), LORA, Raspberry (Introduction), GIT (Introduction)
OCTOBER	BACKGROUND	thu 07 oct	**SOSPENTION – LAUREE**
OCTOBER	BACKGROUND	fri 08 oct Frontal	Arduino and ESP32 Projects (STUDENT ACTIVITY)
OCTOBER	DEFINITION	thu 14 oct	**PHASE 1 project**: definition of the idea (GROUP ACTIVITY)
OCTOBER	DEFINITION	fri 15 oct Frontal	From idea to prototype - Industrial Example of a Project: Chain Elongation Measurement System (problem of defining both functional and non-functional requirements, identification of the architecture, data collection and processing, etc.)
OCTOBER	DEFINITION	thu 21 oct Frontal	Sensors (introduction)
OCTOBER	PROJE CT EVOL	fri 22 oct	**PHASE 2 project**: analysis of previous works (GROUP ACTIVITY)

		thu 28 oct	**PHASE 2 project**: analysis of previous works (GROUP ACTIVITY)
		fri 29 oct	**PHASE 3 project**: definition of the architecture (GROUP ACTIVITY)
NOVEMBER		thu 04 nov	**PHASE 4 project**: description architecture, component selection (e.g. sensors and actuators) (GROUP ACTIVITY)
		fri 05 nov	**PHASE 4 project**: description architecture, component selection (e.g. sensors and actuators) (GROUP ACTIVITY)
		thu 11 nov	**PHASE 5 project**: implementation - group work (GROUP ACTIVITY)
		fri 12 nov	**PHASE 5 project**: implementation - group work (GROUP ACTIVITY)
		thu 18 nov	**PHASE 5 project**: implementation - group work (GROUP ACTIVITY)
		fri 19 nov	**PHASE 5 project**: implementation - group work (GROUP ACTIVITY)
		thu 25 nov	**PHASE 5 project**: implementation - group work (GROUP ACTIVITY)
		fri 26 nov	**PHASE 5 project**: implementation - group work (GROUP ACTIVITY)
DECEMBER		thu 02 dic	**PHASE 6 project**: experimental analysis and results (definition of the test bench, definition of the stop criteria, etc.) (GROUP ACTIVITY)
		fri 03 dic	**PHASE 6 project**: experimental analysis and results (definition of the test bench, definition of the stop criteria, etc.) (GROUP ACTIVITY)
		thu 09 dic	**PHASE 6 project**: experimental analysis and results (definition of the test bench, definition of the stop criteria, etc.) (GROUP ACTIVITY)
		fri 10 dic	**PHASE 7 project**: finalization of the document and presentation (Elevator PITCH) (GROUP ACTIVITY)
		thu 16 dic	**PHASE 8 project**: Video spot (form story telling to video) (GROUP ACTIVITY)
	DELIVER	fri 17 dic	**FINAL PRESENTATION**
		thu 23 dic	**FINAL PRESENTATION**