

# PhD Course on:

## Smart Environments

### Technologies, state of the art and research challenges

Credits: 3 CFU (20 academic hours)

Lecturers: **Ioannis Chatzigiannakis** and **Francesco Leotta** - Sapienza Università di Roma

#### Short Description

Recent advances in communication and computation technologies suggest an imminent explosion of the Internet-of-Things (IoT), i.e., a vision of billions of everyday life objects connected to offer new solutions and services to final users. Areas of application of IoT include smart spaces, i.e., private and public spaces realizing the paradigm of so called Ambient Intelligence. Smart spaces include smart houses, public spaces (e.g., airports), offices but also, in the context of the Industry 4.0 revolution, factories and manufacturing processes inside them, also including the involved supply chain. In this PhD course, students will learn fundamentals of IoT and techniques for smart environments.

#### Overview

Internet-of-Things (IoT) represents the vision of billions of computers and everyday life objects connected together to provide high-level customized services. The first part of the course will analyze how the idea of IoT evolved in the last years from the initial approaches based on wireless sensor networks, to modern approaches where connected devices are not only sensors but real computers that can contribute to the computation in the form of edge and fog computing. As communication between devices is a fundamental component of IoT, prominent protocols and communications technologies will be introduced to the students ranging from low-energy protocols (such as Zigbee, Zwave) to the imminent introduction of 5G. In addition, the student will be introduced to software platforms and framework that simplify the development of IoT applications.

Among the several applications of IoT, this course will then focus on smart spaces. The concept of smart space is the modern evolution of building automation, where intelligence (also known as **Ambient Intelligence - AmI**) allows to provide customized services to final users. Nowadays smart spaces can highly benefit of IoT as a mean to acquire information about the smart context (e.g., a house, a hospital, an airport) and to perform operations on the environment through the employment of actuators. In this sense the concept of smart space is a fundamental part of the Industry 4.0 movement, which is gathering increasing interest from industry and institutions, these latter ones promoting it through special regulations and funding channels. In the context of Industry 4.0, devices of the Internet-of-things are often called digital twins, as they provide a faithful representation of physical machinery and persons involved in the production processes and in the supply chain.

In the second part of the course, instructors will introduce the above concepts and will show techniques employed to realize the paradigm of ambient intelligence and how they relate to the techniques

introduced in the first part of the course. Additionally, available software platforms and facilities will be introduced.

## Table of Contents

1. Introduction to IoT, Sensors, Communication Technologies (small scale and broad scale) - 2 hours
2. Cloud-based Data Processing for IoT deployments, Software Architectures and Available Platforms - 4 hours
3. Edge-based Data Processing for Wearable Devices and Privacy-aware IoT deployments, Scenarios and Research Challenges - 4 hours
4. Ambient Intelligence - 4 hours
5. Smart spaces and Industry 4.0 - 2 hours
6. Digital Twins in Industry 4.0 and available platforms - 2 hours
7. Research perspectives on Industry 4.0 and Ambient Intelligence (2 hours)

## Calendar

- Wednesday April 22nd – 14:00 – 18:00 Google Meet Link <https://meet.google.com/thw-tyas-wcu>
- Friday April 24th – 14:00 – 18:00 Google Meet Link <https://meet.google.com/sqc-rwir-jae>
- Monday April 27th – 14:00 – 18:00 Google Meet Link <https://meet.google.com/vgf-nmeu-sau>
- Wednesday April 29th – 14:00 – 18:00 Google Meet Link <https://meet.google.com/cqv-skyd-wvd>
- Thursday April 30th – 14:00 – 18:00 Google Meet Link <https://meet.google.com/csa-ffrn-bzx>

## Learning Objectives, Prerequisites and Evaluation

The learning objectives of this course are:

- Mastering the technologies and techniques involved in IoT with particular focus on the applications in the fields of smart spaces and industry 4.0;
- Understanding the challenges involved in the application of proposed approaches to physical, and potentially harmful, contexts.

This course is aimed at PhD students, Master students and (potentially) professionals. A basic understanding of networks and machine learning (at the undergraduate level) is assumed.

In order to get the credits provided by the course, **a short project on the application of IoT to smart spaces or industry 4.0** from the course participants (to be held individually or in group) is required. With the project, the participants must demonstrate the ability to put into practice the notions illustrated during the course.

## References

- Alessandro Scirè, Fabrizio Tropeano, Aris Anagnostopoulos, Ioannis Chatzigiannakis: Fog-Computing-Based Heartbeat Detection and Arrhythmia Classification Using Machine Learning. Algorithms 12(2): 32 (2019)

- Orestis Akrivopoulos, Dimitrios Amaxilatis, Irene Mavrommati, Ioannis Chatzigiannakis: Utilising fog computing for developing a person-centric heart monitoring system. JAISE 11(3): 237-259 (2019)
- Ignacio Rodríguez-Rodríguez, Ioannis Chatzigiannakis, José Víctor Rodríguez, Marianna Maranghi, Michele Gentili, Miguel Angel Zamora-Izquierdo: Utility of Big Data in Predicting Short-Term Blood Glucose Levels in Type 1 Diabetes Mellitus Through Machine Learning Techniques. Sensors 19(20): 4482 (2019)
- Ignacio Rodríguez-Rodríguez, José Víctor Rodríguez, Ioannis Chatzigiannakis, Miguel Angel Zamora-Izquierdo: On the Possibility of Predicting Glycaemia 'On the Fly' with Constrained IoT Devices in Type 1 Diabetes Mellitus Patients. Sensors 19(20): 4538 (2019)
- Georgios Mylonas, Dimitrios Amaxilatis, Ioannis Chatzigiannakis, Aris Anagnostopoulos, Federica Paganelli: Enabling Sustainability and Energy Awareness in Schools Based on IoT and Real-World Data. IEEE Pervasive Computing 17(4): 53-63 (2018)
- Leotta et al. Surveying Human Habit Modeling and Mining Techniques in Smart Spaces – Future Internet (2019)
- Leotta et al. Visual process maps: a visualization tool for discovering habits in smart homes JAIHC (2019)
- Leotta et al. Applying process mining to smart spaces: Perspectives and research challenges – RW-BPMS CAiSE (2015)
- Leotta et al. IoT for BPMers. Challenges, Case Studies and Successful Applications – BPM (2019)
- Leotta et al. A Conceptual Architecture and Model for Smart Manufacturing Relying on Service-Based Digital Twins – ICWS (2019)