1. Course Code

2292

2. Course Title

G81e: IoT Development

3. Teacher

MARKON, Sandor

4. Term

Spring 2

5. Course Requirements (Courses / Knowledge for this course) and Important Information

Fundamentals of Computer Programming

6. Course Overview and Objectives

IoT (Internet of Things) is an important area of programming for both developed and developing countries, which belongs to the general field of embedded systems, also called dedicated computers. It can help solving a wide range of technical and social issues. Some examples include wireless sensor networks for remote data collection or disaster prevention, RFID for inventory control, human body sensors for remote medicine etc. When compared to common PCs, IoT and embedded systems use different hardware and software platforms, and to use them require understanding of special concepts like direct hardware I/O (input-output), interrupts, real-time control, cross-development environments etc.

By finishing this course, the student will be able to recognize opportunities of effectively using IoT systems to solve ICT4D issues, and to propose and initiate projects, based on concrete experience with working with such systems.

7. Course Outline

1 Orientation and Introduction
2 Motivation by Examples - existing projects solving social problems by IoT
3 Platforms (a) – ESP - introduction to hardware and software environment
4 Platforms (a) – ESP - basic usage
5 Review of embedded concepts (1)
6 Platforms (b) - Raspberry Pi - introduction to Linux and Python on this platform
7 Platforms (b) - Raspberry Pi - extension of basic capabilities
8 Review of embedded concepts (2) - discussion using experience so far
9 Mid-term project review - groups started at Lecture 2 discuss their status
10 Communication for IoT: LoRa, MQTT
11 Workshop: IoT (1) - visiting lecturers present new topics
12 Workshop: IoT (2) - visiting lecturers present new topics, group discussions
13 Workshop: IoT (3) - visiting lecturers present new topics, group discussions
14 Workshop: IoT (4) TinyML and edge computing for IoT
15 Final project review
16

8. Textbooks (Required Books for this course)

None. This course uses only material freely available on the Internet (links will be provided on Moodle).

9. Reference Books (optional books for further study)

None

10. Course Goals (Attainment Targets)

(1) Become able to recognize suitable application areas and make proper choices for embedded systems.
(2) Become able to design for reliability, maintainability, safety, and security in developing embedded systems.
(3) Can develop for an embedded platform and use its development environment.
(4) Can develop programs with embedded concepts like hardware control, sensors, actuators, timers, interrupts etc., through hands-on experience.
(5) Can combine machine learning with IoT
(6) Find and solve a development problem using embedded systems.
(7)
(8)

11. Correspondence relationship between Educational goals and Course goals

Educational goals of the school			Course Goals
High level ICT skills	Basic academic skills		(1) (2)
	Specialized knowledge and literacy		(3) (4) (5) (6)
Human skill (Tankyu skill）	Ability to continually improve own strengths		(2)
	Ability to discover and resolve the problem in society	Problem setting	(1)(6)
		Hypothesis planning	(1)(6)
		Hypothesis testing	(6)
		Practice	(3)(6)
	Fundamental Competencies for Working Persons	Ability to step forward	(5)(6)
		Ability to think through	(5)(6)
		Ability to work in a team	(6)
Professional ethics			

12. Evaluation

Goals	Evaluation method & point allocation					
	examination	Quiz	Reports	Presentation	Deliverables	Other
(1)			○			
(2)				○	○	
(3)			○	○	○	
(4)			○	○	○	
(5)				○	○	
(6)						
(7)						
(8)						
Allocation			30	30	40	

13. Evaluation Criteria

Examination	N.A.
Quiz	N.A.
Reports	Understanding of basic concepts and efforts at original ideas should be clear.
Presentation	Must include: problem statement and expected benefit to society; background; proposed solution; method; tests; validation; remaining problems; future possibilities. Participation of each group member should be stated clearly.
Deliverables	Actual operation should be demonstrated on devices (video can be used).
Other	

14. Active Learning

Hourly percentage of active learning within the whole class time		75%
1	Active learning such as problem solving assignment using the knowledge and skills acquired in class.	All the time
2	Active learning such as group works and discussions.	All the time
3	Outcome presentations and feedbacks.	Sometimes
4	Students actively make decisions on how the class should be conducted.	Not at all

15. Notes

Students not comfortable with basic electric circuit concepts (currents and voltages, Ohm's law etc.) are advised to take part in voluntary lab sessions before taking the course.

16. Course plan

(Notice) This plan is tentative and might be changed at the time of delivery

Lesson 1: Orientation and Introduction (lecture and demonstration, 90min)

Review through examples the basic concepts of IoT and other embedded systems, from TV remote controls and rice cookers to airplane controls and power plants; the reasons for using them, principles, problems, evolution, and current status. Explain the course plan: discussions, practice, work group forming, projects, evaluation, and further studies.
Students are shown some of the devices used in the course.

Lesson 2: Motivation by Examples (lecture and group discussion, 90min)

Introduce examples of IoT and embedded systems in products and services through case studies. Student groups are formed, and based on understanding some typical applications, discuss other uses in fields familiar to them, listing up possible project topics, analyzing their merits and difficulties, their novelty, feasibility, profitability and sustainability.
Student groups start their discussions on their project topic.

Lesson 3: Platforms (a) – ESP (practice, presentations, 90min)

Students learn to develop a simple application using the open source / open hardware ESP32/ESP8266 platform as an example of working with a simple stand-alone embedded environment. Groups receive sets of ESP boards, sensor and actuator devices, and after installing the development environment on their PCs, design, program, and test a simple embedded application according to the provided requirement specifications.
Student groups present their project proposals with Tankyu charts and overall plans.

Lesson 4: Platforms (a) - ESP (continued, 90min)

Student groups review the possibilities available with the provided hardware and software tools, and compete to design the most surprising IoT application with their resources on ESP.

Lesson 5: Review of embedded concepts (1) (lecture and group discussion, 90min)

Starting from their experience with the ESP board, student groups discuss basic embedded system concepts, reviewing and analyzing the handling of I/O devices, timings, process flow etc. Motivation is given for searching for more advanced capabilities like interrupts, multi-threading, guaranteed real-time response etc.

Lesson 6: Platforms (b) - Raspberry Pi (practice, 90min)

Student groups receive Raspberry Pi boards and install Linux on them. By connecting them to the network, they learn how to use such a self-development environment on a small embedded platform. Students also discuss common features and differences between the Raspberry Pi and the ESP environment, and try to find out advantages and limitations through reading the documentation and performing experiments.

Lesson 7: Platforms (b) - Raspberry Pi (continued, 90min)

Student groups re-build their Raspberry Pi Linux OS from source, and add a new device driver, file system, or other extra capability of their choice that was not present in the original distribution. Discuss the experience from the point of view of open source vs. proprietary systems.

Lesson 8: Review of embedded concepts (2) (lecture and group discussion, 90min)

Starting from their experience with the Raspberry Pi board, student groups discuss using an operating system like Linux for embedded systems, reviewing the advantages and drawbacks of isolating the hardware from the application, and of providing basic development capabilities on the deployed embedded system itself. Soft- and hard real-time OS concepts will be introduced here.

Lesson 9: Mid-term project review (presentations, mid-term exam, 90min)

Student groups present the progress of their embedded application projects, reviewing their current status and roadmap. Different groups share their experiences and exchange advices.

Lesson 10: Communication for IoT (lecture and group discussion, 90min)

Review and compare communication infrastructure and protocols, including WiFi, LoRa, and MQTT. Gain experience with publishing and subscribing to MQTT brokers.

Lesson 11: Workshop: IoT (1) (lecture and group discussion, 90min)

Visiting lecturers from ICTP introduce concrete examples of Internet of Things (IoT) and its role in developing countries, through examples from their practice.

Lesson 12: Workshop: IoT (2) (lecture and group discussion, 90min)

Visiting lecturers demonstrate and explain IoT with AI (machine learning) using the new embedded platform "TinyML" for IoT. Student groups explore creating and operating WSN using the provided equipment, and review their project topic in light of what they have learnt about IoT.

Lesson 13: Workshop: IoT (3) (lecture and group discussion, 90min)

Student groups discuss their ideas and application areas for IoT and AI with visiting lecturers, and review their experience with experiments on Arduino and various sensors.

Lesson 14: Workshop: TinyML (lecture and group discussion, 90min)

Visiting lecturers present a popular edge computing platform "TinyML", and review the application of machine learning in the context of IoT.

Lesson 15: Final project review (presentations, 90min)

Each group presents its project results, demonstrating the device and system they have built, explaining how it will solve an actual problem of development, how it can be put into practice, and how can its effects be evaluated and verified. Each team member takes part in the presentations in turn.