Physical Computing and Internet-of-Things

Module description

Target Audience: Second Year of the BSc Computer Science Online

Module goals and objectives

Upon successful completion of this module, you will be able to:

1. Demonstrate an understanding of electricity, electronics and transducers, including the relationship between analogue and digital devices
2. Program microcontrollers and understand the principles of microchip programming in general as well as how microcontrollers receive, interpret and send data from/to transducers
3. Develop the practical skills of building circuits with electronic components and microchips
4. Use communication protocols for inter-computer and inter-device communication
5. Understand the principles of physical interaction design, including
    i. monitoring bodily movement
    ii. making mechanical movement
    iii. the design of tactile physical interfaces
    iv. control of sound and light
6. Design and build complete physical computing systems

Textbook and Readings

Specific essential readings for each week from the following list are included in the Readings page for each week. All are available to all students from the online library.

- Electronics Projects with the ESP8266 and ESP32: Building Web Pages, Applications, and WiFi Enabled Devices (2020)
- Build Your Own IoT Platform: Develop a Fully Flexible and Scalable Internet of Things Platform in 24 Hours
- Demystifying Internet of Things Security: Successful IoT Device/Edge and Platform Security Deployment (2019, Free, Chapters 2, 4, 5, 6)
- Internet of Things (IoT): System and Applications (2019, All)

Optional

- Learning AWS IoT: Effectively Manage Connected Devices on the AWS Cloud Using Services Such as AWS Greengrass, AWS Button, Predictive Analytics and Machine Learning, (2018)
- Internet of Things: Architectures, Protocols and Standards (2018)
- Components and Services for IoT Platforms Paving the Way for IoT Standards (2016)
- Rethinking the Internet of Things (2013)
- Making things talk – (2007)

Module outline

The module consists of ten topics that focus on key areas of the fundamentals of computer science.

Topic 1. Introduction & Microcontrollers	**Key concepts:** Background of Physical computing and IoT Introduction to Microcontrollers and programming Application of IoT in Pervasive computing **Learning outcomes:** 1. Should be able to explain what is IoT, IoT Stack and IoT Architecture 2. Should be able to understand what microcontrollers are, how are they used and why 3. Should be able to install and setup Arduino IDE with drivers and relevant libraries
Topic 2. Electricity & Circuits	**Key concepts:** Electricity, electronics and Transducers Developing Digital & Analogue I/O sketches and circuits Applications of Arduino & PLC and type of nodes. **Learning outcomes:** 1. Understand the role of electricity, electronics and Transducers 2. Understand how electricity flow in the microcontroller circuit & breadboard 3. Explain the difference between Arduino and PLC and how to read schema drawings
Topic 3. Sensors	**Key concepts:** Multimodal Sensing Displays data LCD/OLED & ESP Web server (HTTP Client/Server) Wireless controller (Smart fridge and door) **Learning outcomes:** 1. Explain and critically evaluate types of sensors available, their capabilities and potential applications 2. Able to control and monitor sensor states from HTML page using HTTP protocol 3. Understand power sources requirements of different by sensors and actuators

Topic 4. Physical Interaction Design	**Key concepts:** Ambient, Embedded and Wearable interaction methods with IoT devices and sensors Creating automation and trigger events Exploring IoT platforms and application **Learning outcomes:** 1. Explain, develop and critically evaluate types of human interaction methods with IoT is available and how to apply them 2. Ability to practically create physical interactions/automations with smart home devices and sensors 3. Discuss and review existing IoT platforms, challenges and opportunities.
Topic 5. Physical Computing Projects	**Key concepts:** IoT Data Visualisation, Storage and Analytics Tools & Platforms Data exchange formats and storage/modelling standards **Learning outcomes:** 1. Able to discuss and explore various physical computing projects using IoT devices 2. Able to discuss the role of data visualization tools and data analytics when using IoT devices 3. Understand and explain IoT Data exchange formats and storage/modelling standards.
Topic 6. Motors and actuators	**Key concepts:** Motors and Actuators Security applications - smart door RFID Reader/Card **Learning outcomes:** 1. Understand the role of motors and actuators types 2. Explain and differentiate motor and actuator types, capabilities and requirements 3. Program Motors and Actuators using microcontrollers
Topic 7.	**Key concepts:** IoT Communications protocols Wireless Sensors Network Messaging protocols (Serial comm., Websocket, MQTT)

Communications protocols	**Learning outcomes:** 1. Able to explain communication protocols and standards for IoT devices and applications 2. Able to understand and explain Wireless Frequency Spectrum (Wifi, ZigBee, Z-wave, RF) and their strengths and capabilities 3. Able to critical select appropriate communication protocols for varied IoT applications and build wired/wireless connectivity
Topic 8. Networked Devices	**Key concepts:** Network topology, WAN, LAN, Smart Home/Smart Cities Mesh Networking Over-the-air (OTA) programming **Learning outcomes:** 1. Able to explain, identify and understand challenges when selecting Network topology and IoT architecture for suitable applications (i.e. in Smart Homes & Smart Cities) 2. To understand the need for Mesh network technology and how to practical implement it (i.e. with WIFI Mesh) 3. Understand the over-the-air programming concept to maintainability/push updates to IoT devices overtime
Topic 9. Bodily Monitoring	**Key concepts:** Body Area Sensor Network Wearable Computing (Smart Textiles, HCI, Health monitoring) Social Internet of Things, Crowdsensing. **Learning outcomes:** 1. Able to understand and explain the building blocks of monitoring body vital signs and movements 2. Applications and discussion on varied Body Area Sensor Network (BASN) and sensing modalities 3. To understand the concept of Social IoT (SIoT) and Social Web of Things (SWOT)
Topic 10. Robots.	**Key concepts:** Internet-of-robots (IoR)/ Internet-of-Robotics-Things (IoRT) Robots Ecosystem/Framework Distributed Data Analysis and Intelligence for Robots **Learning outcomes:** 1. Ability to understand and explain types of robots, hardware & software building blocks 2. To identify the relationship between robotics and IoT infrastructures.

Activities of this module

The module is comprised of the following elements *(please explain in detail the activities included in the module, for example:*

- *Lecture videos.*
  - *Lectures broadly divided into ten topics that evolve from theoretical foundation to practical development of physical and Internet-of-Things (IoT) systems.*
- *Practice Quizzes.*
  - *Each video has a practice quiz after it, and some longer videos have in-video questions.*
- *Peer Reviewed Assignments.*
  - *There one mandatory peer reviewed assignments for final submission. Not graded but need to pass providing constructive feedback to peers and discuss what you can learn from their work.*
- *Graded Assignments.*
  - *There are two graded assignments – a individual IoT Project proposal report document for the mid-way assessment, and an individual IoT project developed from proposal for the final submission (which comprises of a system prototype, the report, and a video demonstration (maximum length 3 minute).*
- *Discussion Prompt.*
  - *Many videos have discussion prompts in addition to practice quizzes. It is strongly recommended that students engage in these debates with their colleagues.*
- Team check points
  - There are regular activities where you can comment on how well you think your team is working together and to quickly identify and remedy any problems that might occur.

How to pass this module

This module is 100% coursework, and there is no exam.

The module has two major assessments:

- Coursework:

- Mid-term assessment: A solo project proposal document. This will be a detailed account on how your real-world IoT project will be developed, rational and development design documents that will be developed for your final assessment.
  You will submit a single .pdf document.

- Final assessment: An individual to develop the system, report and a maximum 3 minutes video length to demonstrate the system. This will be the product of several weeks' worth of development time, using the design document and the peer feedback. As part of final assessment, you will be required to provide peer review on another student's proposal after mid-term assessment. Although, peer-review of the proposal is not marked, but you are required to complete it this component and this is **strongly encouraged**. This will be the opportunity for you to give constructive feedback to peer and also learn from each other.
  *You will submit the source code for your project and the video as a **link** to the repository **in your final report**.*
  *You will need to **submit one report as .pdf** document that documents and encapsulates the whole project including rational, implementations (include screenshots/pictures), evaluation and conclusion as an **individual**.*

- The coursework consists of several activities. This is a detailed breakdown of all of the marks (see an example below and please provide the table relevant to your module)

Activity	Required?	Deadline week	Estimated time per module	% of final grade
Mid-term assessment	Yes	9	10 hours	30
Peer assessment: Solo concept document	Yes	10	2 hours	0
Final assessment	Yes	22	30 hours	70