Principles and Design of IoT Systems (PDIoT) [INFR11150]

School of Informatics, University of Edinburgh

Coursework 1 – Released on 21 Sept. '20, Deadline: 09 Oct. '20

Coursework 2 – Released on 12 Oct. '20; Deadline: 30 Oct. '20

Coursework 3 – Released on 21 Sept. '20, Demonstration on 25 Nov. '20; Final report: 15 Jan. '21

Covid-19 Update: Students taking this course will be paired and will be required to attend a weekly, 1-hour laboratory session either virtually or in person in Room AT3.07 on Wednesday mornings, at one of these times: 10am, 11am or 12noon. Each student present in Edinburgh should collect a set of sensors and development board for Coursework 3 at the first Laboratory session starting at 10am on Wednesday, 23rd September, 2020, even if they plan to attend subsequent lab sessions virtually. PDIOT students who plan to take this course remotely should contact dka@inf.ed.ac.uk once you have registered, and provide your postal address (and contact phone number) for the sensors and boards to be posted to you.

Course Overview

Welcome to the PDIoT course! You will experience the different facets of designing and implementing a complex IoT system, from specification to demonstration of a prototype implementation, over the course of 10 weeks (Coursework 3). The practical work will be complemented by knowledge gained through personal research on foundational topics in Internet of Things to be distilled in two 3000-word essays (Coursework 1 and 2).

Each student will be provided the following for Coursework 3:

- A wearable Respeck sensor for activity data collection.
- An mBed development board (NRF52-DK), and an Inertial Measurement Unit (MPU-9250) with 3-axis accelerometer and gyroscope sensors.
- The on-line ARM mBed compiler and software development environment.

Your task will be to implement a human activity recognition system for a range of common activities listed below by analysing data from a wearable sensor using machine learning techniques and displaying the results in real-time in an Android application.

- Sitting/Standing
- Lying down
- Walking
- Running/Jogging
- Ascending and descending stairs
- Desk work (working at a computer, writing, etc.)

Each pair will demonstrate their prototype to the entire class on Wednesday, 25 November, 2020. Your final report for Coursework 3 will be due by 16:00 on Friday, 15 January, 2021.

Coursework [100% of course marks]

1. Coursework 1 – Survey Paper (max. 3000 words) [15%]
   Release date: 21 Sept. '20
   Submission date: 9 Oct. '20
   Feedback return: 23 Oct. '20

   The task is to research and compose a technical Survey Paper in **one** of the following three topics:

   - Comparison of encryption algorithms for edge devices in IoT systems
   - Comparison of data fusion methods for estimating orientation in 3-D space using inertial magnetic sensors
   - Comparison of networking protocols for edge devices in IoT systems

2. Coursework 2 – Survey Paper (max. 3000 words) [15%]
   Release date: 12 Oct. '20
   Submission date: 30 Oct. '20
   Feedback return: 13 Nov. '20

   The task is to research and compose a Survey Paper on the application of IoT for social good in **one** of the following three topics:
   - IoT in healthcare of the elderly
   - IoT in the mental health
   - IoT for clean environments

3. Coursework 3 – Development of IoT system, demonstration and final report (max. 10,000 words) [70%]
   Release date: 21 Sept. '20
   Demonstration date: 25 Nov. '20 (10am – 1pm)
   Final report submission date: 15 Jan. '21 (4pm)
   Feedback return: 29 Jan. '21

   Students collaborate in pairs to develop an IoT system from concept to a working prototype in the space of 10 weeks. The human physical activity recognition system will be implemented using a wearable wireless inertial magnetic unit (IMU) sensor; the sensor data analysed using machine learning methods to classify a selection of activities, and the results displayed in real-time in an Android application.

   You will experience the different stages in the design and implementation of a complex system, from its specification to the demonstration of a working prototype and evaluation of its performance. You will be exposed to aspects of embedded systems programming, sensor data analytics using machine learning techniques, mobile application development, user interface design, and system integration and testing.

   There will be opportunity in Week 5 to demonstrate progress and receive written formative feedback. The final presentation to showcase your prototype with a live demonstration is

scheduled on Wednesday, 25 November 2020. Your final written report will be due on 15 January, 2021.

Organisation

In the first 5 weeks of the course twice-weekly tutorial meetings have been timetabled to present (2-3 slides) individual progress on your research for two Survey Papers for Coursework 1 and Coursework 2.

Over the 10 weeks starting on 23rd September, 2020, weekly laboratory sessions have been organised in AT3.07 or accessed via Blackboard/MSTeams. Student pairs should sign up for one of the 1-hour slots at 10am, 11am or 12noon. Attendance at these sessions is compulsory.

Timetable

Phase DISCOVER

Week 1

- Students registered for this course or wishing to take this course should attend the first meeting at 10am on Tuesday, 22nd September 2020 via Blackboard/MSTeams for a short presentation on the PDIOT course and discuss Coursework 1.
- Students based in Edinburgh should attend first Lab session at 10am on Wednesday, 23rd September 2020 in AT3.09 to collect their sensors and development board.
  Students outside Edinburgh should connect via Blackboard/Teams. When you registered for the course you should have sent dka@inf.ed.ac.uk your full postal address and contact number so that your sensors and boards can be posted to reach you in time for start of the course.
- After the first week student pairs can sign up for one of the three 1-hour laboratory slots at 10am, 11am or 12 noon on Wednesdays during Week 1 – 10.
- The following will be covered in the first laboratory session in AT 3.09:
  - Explanation of the Coursework 3 assignment
  - Demonstration of an end-to-end IoT system as an exemplar
  - Formation of student pairs and collection of sensors and development board, one set for each student.
  - Students will start collecting human activity data using an Android Application provided, and store the data in a shared repository.

Phase DEFINE

Week 2

- Capture the requirements and use cases for the target application
- Presentation of sensor data collected in Week 1
- Discussion on approaches to data analysis for physical activity recognition
- Start development of the Human Activity Recognition algorithms
- Continue data collection of physical activity

Phase DEVELOP

Week 3

- Introduction to Android development
- Development of the mobile application displaying real-time recognition of physical activity using TFLite from TensorFlow.
- Submission of Coursework 1 Survey Paper

Week 4

- Introduction to mBed platform and development environment
    - Start programming on the NRF board
    - Establish connection between NRF board and the Android App using BLE
- Continue development of the mobile application displaying real-time recognition of physical activity using TFLite from TensorFlow.
- Start Coursework 2 Survey Paper

Week 5

- Demonstrate mobile application displaying real-time recognition of physical activity and receive written formative feedback
- Choose between continuing with the Respeck sensor (accelerometer only) with emphasis on machine learning based analysis of the accelerometer data,

  OR

  embedded system development of the application in the Cube sensor using accelerometer and gyroscope
- Receive feedback on Coursework 1 Survey Paper

Week 6

- Submit Coursework 2 Survey Paper
- Embedded route
    - Algorithm migration to the Cube platform
- ML algorithm route
    - Algorithm tuning
    - Live prediction on the Android App
    - Focus on usability and interface

      OR
    - Create a backend server where you upload the ML model for generating predictions

Week 7

- Continue activity in Week 6
- Test the algorithms:
- validate against off-the shelf models
    - Discuss other methods for validation, e.g. cross-testing the existing models
- User interface testing for the teams that chose to concentrate on the Android app

Week 8

- Second demonstration and feedback
- Receive feedback on Coursework 2 Survey Paper in Week 8

Week 9

- Prepare for the final demonstration in Week 10

Phase DEMONSTRATE

Week 10

- 10-minute presentation and demonstration by each pair to the class followed by 5-minute Q&A session
- Remote students broadcast your phone screen using Vysor

Final Report

The final report (in 11pt font) should not exceed 10,000 words (excluding Bibliography and Appendices) and should be organized along the following chapters:

- Title Page
  - o PDIoT Coursework 3 (2020-21)
  - o Project title
  - o Name
  - o Matriculation Number
  - o Abstract
- Introduction
  - o Project aims
  - o Brief description of the method adopted
  - o List the physical activities used in the classification
  - o Summary of results
- Literature survey
  - o A review of the state-of-the-art for human activity recognition algorithms
- Methodology
  - o A description of the system and its implementation
  - o Hardware and firmware
  - o Wireless communication
  - o Algorithm for human activity recognition
  - o Mobile application
  - o Software organisation
  - o Testing
- Results
  - o Critical analysis of the implementation using quantitative methods
  - o Benchmarks
- Conclusions
  - o Reflection on the project
  - o How might you wish to extend the project and improve the implementation