CS3237: Introduction to Internet of Things Project

CS3237 Group Project will contribute towards 60% of your final grade.

Timeline of the Project:

- Project Release: **29th September**
- Preliminary 2-Page Project Proposal Due: **11th October** [Upload to LumiNUS]
- Feedback on Project Proposal: **17th October**
- Preliminary Project Assessment (including demo): **Week of 1st November**
- Final Project Presentation and Demo: **Week of 15th November**
- Final Project Report Submission: **22nd November** [Upload to LumiNUS]

Grading of the Project (Total 70%):

- Project Proposal: **10%**
- Preliminary Project Assessment: **10%**
- Project Assessment: **20%**
- Final Project Demo + Presentation: **25%**
- Final Report: **5%**

Please note that the Final Project marks will include **peer-review** to assess your individual contributions towards the project.

The project will be assessed based on (a) novelty of the application, (b) difficulty and complexity of the target problem, (c) technical achievements (both in sensing and machine learning), (d) quality of the final solution, and (e) quality of the presentation, demo, and report.

Project Objective:

The objective of the project is to build a complete IoT system consisting of the IoT device (TI SensorTag kit), optional gateway (smartphone), and the cloud (laptop or AWS).

A) The focus should be on real-time processing of critical data that requires instant action in the edge device (for example, fall detection, heat ailments detection, or motion sensors based security) along with long-term analytics in the cloud (for example, the patient's activity trends). Judicious partitioning of the application among the IoT device, gateway and the cloud is expected.

B) You will use a RESTful API and MQTT for communication between the sensors and the gateway/cloud.

C) You HAVE to use more than one sensor in the project and use the information from all the sensors in a collective fashion.

D) You may only use the sensors available on the Sensor Tags, and the sensors/cameras available on your smartphone and laptop. **You should not buy any additional sensors/hardware for your project.**

E) You are expected to use some form of machine learning algorithm for the analytics part in the cloud. As there is limited opportunity for communication among the team members, each of you can first collect data using your own sensor and build the model. But eventually, it would be good to combine the data from all the team members for training.

F) Some machine learning methods that have been covered in the lectures include the following. You may need a fair bit of creativity to combine these diverse techniques to solve your problem.

   a. Clustering algorithms like K-means and Kohonen Self-Organizing Maps. These are useful for seeing which datapoints are very close together, and are thus likely to be related.

   b. Statistical methods like regression, which is good for predicting values based on past values, and support vector machines, good for doing classification.

   c. Simple backpropagation neural networks, which work well for classifying patterns, and for predicting values, and autoencoders, which map data points to vectors that represent relationships between these points.

   d. Recurrent neural networks like LSTMs, very useful for learning patterns over a period of time.

   e. Convolutional neural networks, which infer structure from unstructured data.

G) You can use your mobile phone as a gateway device.

H) You can use cloud service providers for collaboration among the team members in the analytics part. You may also use your laptop to emulate the cloud so as avoid complications in connecting the gateway device to commercial cloud services when you are working on your own.

I) The gateway (mobile phone) should be connected to the cloud over WiFi. Be careful to avoid extensive cellular usage charges if you do not have good WiFi coverage.

Setting Up Your Cloud Accounts:

There are numerous providers like Amazon Web Services, Microsoft Azure, Google Cloud and Digital Ocean that you can set use to set up your cloud server. Here are some resources that you can use.

Github Student Pack: https://education.github.com/pack#offers

AWS Free Tier: https://aws.amazon.com/free/

Unless you are very familiar with other flavors of Linux, you should always set up an Ubuntu instance as Ubuntu has the widest range of precompiled tools available (installed through apt-get).

This is a tutorial to set up an AWS Elastic Cloud instance (please use a micro-instance as the rest may not be free):

https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EC2_GetStarted.html

Though not recommended, you may also choose to set up your own server at home. In this case you will need knowledge of how to reserve IP addresses on your home router, how to set up a DMZ, or how to remap ports. Please consult the manual for your home router on how to do these. You will also need to enable the SSH server and appropriately set up any firewall settings on your server.

Bonus Points:

You will receive bonus points for introducing real-time operating systems features (e.g., threading, synchronization, timing), power management, or Bluetooth Low Energy Software Stack. These are available through TI-RTOS (Real-Time Operating Systems) on TI Sensor Tag CC2650 using Code Composer Studio (CCS) that comes with SensorTag Debug Devpack. See "References" section at the end of this document.

Deliverables:

1. 2-pages preliminary project proposal detailing the application you have in mind and explanation of the feasibility of the project within the constraints of the infrastructure you have access to. In other words, we are looking for creativity within the broad parameters mentioned earlier; but it cannot be just a dream that is not realizable. Deadline: 11th October 23:59
2. A preliminary project demo in the week of 1st of November. You should complete a baseline working version of the project at this point. The advanced options can be implemented later on. You will be given detailed feedback about the project during this demo session.
3. The final completely working project demo and presentation in the week of 15th of November.
4. Final project report (at most 20 pages) detailing the high-level idea of project, the techniques employed, the implementation details, the experimental evaluation, and the challenges faced during the project and how you solved those challenges. Deadline: 22nd November 23:59
5. A peer review process.

Example Projects from Past Years (for Inspiration):

- IoT for Heat Injury Prevention
- Elderly Health Monitor
- Monitoring Dementia Patients
- Fall Detection and Prediction
- Heat Stroke Detection
- Weather Prediction
- Monitoring Food Stock Levels in Fridge
- Fish Tank Monitoring

Published Example IOT Projects:

1. Pierleoni, Paola, Alberto Belli, Lorenzo Palma, Marco Pellegrini, Luca Pernini, and Simone Valenti. "A high reliability wearable device for elderly fall detection." IEEE Sensors Journal 15, no. 8 (2015): 4544-4553.
2. Cheng, Yuejiao, Chenglong Jiang, and Jiong Shi. "A Fall detection system based on SensorTag and Windows 10 IoT core." 2015 International Conference on Mechanical Science and Engineering. Atlantis Press, 2016. https://download.atlantis-press.com/article/25851343.pdf

3. McCarthy, Madison, and Petros Spachos. "Using mobile environment sensors for wellness monitoring." 2016 IEEE 21st International Workshop on Computer Aided Modelling and Design of Communication Links and Networks (CAMAD). IEEE, 2016. https://www.researchgate.net/profile/P_Spachos/publication/311897840_Using_mobile_environment_sensors_for_wellness_monitoring/links/5ae3f625a6fdcc3bea93d714/Using-mobile-environment-sensors-for-wellness-monitoring.pdf

4. Vamos, Daniel, Stefan Oniga, and Anca Alexan. "Personal data acquisition IOT gateway." Carpathian Journal of Electronic and Computer Engineering 11.1 (2018): 44-47.

   https://content.sciendo.com/downloadpdf/journals/cjece/11/1/article-p44.pdf

5. Monitoring Refrigerator with TI SensorTag
   https://techblog.calvinboey.com/monitoring-refrigerator-with-ti-sensortag/

6. Venkatesan, Chaitra. "Testing Environmental Sensors to Reduce Heat Ailments among First Responders." (2018).
   https://digitalcommons.unomaha.edu/cgi/viewcontent.cgi?article=2370&context=srcaf

7. Motion Security System http://www.blesstags.eu/2017/06/

8. Low Power Home Network Weather Monitoring
   https://embeddedcomputing.weebly.com/low-power-home-network-weather-monitoring.html

References:

https://www.ti.com/tool/TI-RTOS-MCU#technicaldocuments

1. TI-RTOS 2.20 for CC13xx/CC26xx SimpleLink™ Wireless MCUs Getting Started Guide
   https://www.ti.com/lit/ug/spruhu7d/spruhu7d.pdf?ts=1601387874640

2. CC26x0 SimpleLink Bluetooth Low Energy Software Stack Developer's Guide
   https://www.ti.com/lit/ug/swru393e/swru393e.pdf?ts=1601368901383

3. TI-RTOS 2.20 Power Management: MSP432, CC13xx/CC26xx, and CC3200 SimpleLink MCUs
   https://www.ti.com/lit/ug/sprui18c/sprui18c.pdf

4. TI RTOS power management: Essential for connected MCU-based IoT nodes
   https://www.ti.com/lit/wp/spry282a/spry282a.pdf?ts=1601392291421