

CSC 591/791, ECE592

Fall 2023

Homework Assignment # 4

Instructions

- You must do this assignment in groups.
- Submit your final codes and other documents (mentioned later in the description) via Moodle.
- The due date and time for this assignment: November 13, 2023, 11:45pm ET.

Objectives

1. Get hands on experience working with analytics tools and cloud platform using real sensors

Description

In this assignment, you will develop an inertial measurement unit (IMU) and cloud based system that will identify door open and door close events. You will attach the IMU sensor to a door, and use values from the IMU to determine when it has been closed and opened.

An IMU usually comprises a 3-axis analog gyro and a 3-axis accelerometer. Here is a link to one: <https://www.amazon.com/dp/B075TDWJ9L/>. IMUs are primarily used to sense and measure motion. The phones use them, for example, to switch screen orientation when you rotate the phone. Search online and you will find several tutorials on what an accelerometer and a gyro are and how to use them programmatically.

You will attach the IMU sensor to a door, and interface the IMU sensor with an IoT device (any IoT device of your choice, such as a Raspberry Pi, Beaglebone, Arduino etc.), which will collect the values from the sensor. You will run a classification algorithm, either locally on the IoT device or in the cloud service, whichever you prefer, that will monitor the values it receives from the sensor. Whenever the door is opened or closed, the classification algorithm should automatically identify whether the door has been opened or closed, respectively. The cloud service should receive this decision from the IoT device (unless, you run the classification algorithm in the cloud, in which case, the cloud service will receive the classification decision from your classification algorithm running in the cloud) and then send this decision to an application running on your personal device (can be a laptop or smart phone). This application will continuously show the current status of the door (i.e. whether the door is closed or open).

For the classification technique, you can use support vector machines. I will recommend that you use the libSVM implementation (<https://www.csie.ntu.edu.tw/~cjlin/libsvm/>). You are free to use any other classification algorithm/method if you choose not to use SVM. The communication protocol between the IoT device and the Cloud must be MQTT. The decision on each door opening and closing must be sent to a laptop/smart phone. Both the IoT device and the laptop/smartphone will be MQTT clients. IoT device will be publisher; laptop/smartphone will be subscriber. The laptop/smart phone should show the current status whether the door is opened or closed. Every time a new door open/close event is detected by the cloud service and pushed to the laptop/smart phone, the laptop/smart phone should update the decision it is showing to the user and also show the time of latest decision.

For the classification scheme to work, you will need training instances. To collect training instances, you will attach the IMU to a door. The height of the sensor does not matter but distance from the hinge may. I would suggest that you refrain from attaching the IMU at the opening edge of the door because if you collect all your training data from the edge of a door, your scheme may not work on another door with different size. You are free to require the door to be moved by a certain angular distance before making a decision. For example, your implementation may require that the door must be opened by at least 45 degrees to detect and recognize an open event. Similarly, when closing the door, you can say that your implementation can detect and recognize a door close only when the door moves by at least 20 degrees etc. Your choice! But make sure that one motion of door opening is recorded as one door open event not multiple. Same applies to door closing. For example, if you require the door to be closed by at least 20 degrees to detect a door close event, but if you move the door by 70 degrees in one go, then that should be detected as a single door close event, not 3 door close events.

Demo

The demos will be conducted around the submission deadline. You will schedule a time-slot for the demo with the TA. The demos can be conducted in-person. In the demo, following things will be done:

Before starting the demo, you will set up your IMU. You will attach your IMU (and IoT device if you like) to the door using tape, or any other non-intrusive method you prefer. The TA will provide you with a sequence of door opens and door closes. You will open and close the door in that sequence. After every door open/close, you will tell the TA that you are done, and then the TA will record the decision shown on the laptop/smartphone along with the time of the decision. Note that it is possible that you close the door and your laptop/smartphone is also showing the status as "close", but that decision was an old decision, and no new decision was posted when the door is closed. In that case, this door close event is not correctly classified (or not classified at all) and will be marked as incorrect classification. The sequence will have 20 door opens and closes (almost half will be door open events and half will be door close events). The sequence may look something like this: Open, Open, Close, Open, Close, Close... etc. Note that the first two steps are: Open followed by Open. In this case, to execute the first door open, you will open the door, the TA will record the decision your laptop/smartphone shows. Then you will close the door. The TA will not record the decision when closing the door. Then to execute the second door open, you will again open the door and the TA will record the decision your laptop/smartphone shows. Then you will close the door to execute the third item in the sequence, which is door close, and the TA will record the decision. A major part of your grade will depend on the percentage of correct decisions among the 20 door opens and closes. Your code should automatically determine (using the values from IMU) when a door movement starts and when it ends. You should not have to manually tell your code when the door movement starts and when it ends.

During the demo, you will also provide to the TA access to your cloud implementation where the TA can verify that the values are indeed being received by the cloud platform from the IoT device. For this, on the webpage of your Cloud project, you should incorporate some information such as the values being received from IoT device along with their time stamps, and decisions being sent to the subscriber laptop/smartphone.

What to submit

By November 13, in a single .zip file, each team must upload the following

1. Code for laptop/smart phone and a detailed readme file explaining how to execute the code
2. Code for IoT device and a detailed readme file explaining how to execute the code
3. A document providing an overview of how your entire system works. The document should further include schematics diagram of connection of the IoT device with the sensor, explanation of your feature extraction and selection methods, and explanation of your classifier training method.
4. A document containing names of each team member, what each team member did, and percentage contribution of each team member.

Grading

Grade assigned to the stuff you submit in the .zip file: 15%

Grade assigned to the decision on the sequence of 20 door opens and closes: 55%

Receiving data from IoT device on Cloud and showing on an appropriate user interface of your cloud project: 20%

Sending decisions from the Cloud to the subscriber laptop/smartphone and showing on the user interface of your cloud project: 10%