# PDIoT Coursework 1 [10%]

INFR11239 (UG)/INFR11150 (PG)

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## Coursework Objective

The first coursework for the PDIoT course involves practical hands-on experience with IoT wearable devices. In this assignment, you will use the RESpeck device, a wearable sensor, to collect data while engaging in various physical activities and run code to pre-process the data collected to clean it. This assignment aims to familiarise you with sensor data collection, analysis, and the potential applications of IoT in real-world scenarios.

## Task Description

### 1. Wearable Devices and Mobile App

In Coursework 1, each group will be provided with the following:

- A wearable RESpeck device: The RESpeck is a wearable device consisting of a tri-axial accelerometer and gyroscope, which allow it to record accelerations and angular velocities in three dimensions (x,y,z). The collected data is wirelessly transmitted to an Android App through Bluetooth Low Energy (BLE) technology, which operates at a sampling rate of 25 Hz. The device maintains continuous activity, automatically transmitting data to the connected mobile device.
- Respeck accessories: plastic bags, which you will put the RESpeck device inside, and MeFix tape, which you can use to attach the RESpeck device to your body.
- A Nordic Cube (Thingy): a compact multi-sensor prototyping platform based around the NRF52 SoC. Similar to the RESpeck device, it is capable of recording linear accelerations in three dimensions.

In this coursework, you will need to pair the sensors to a mobile application to receive incoming data. Instructions to set this up can be found in the document for *Lab 1*. You will need a smartphone running Android 6.0 or higher to run the apps needed for the course. If no one from your team owns an Android phone, we can provide you with one upon a special request.

### 2. Data Collection

The first coursework assignment is to collect motion data for a defined set of activities. Each student will wear the RESpeck monitor, worn as a plaster on the chest, and the Thingy placed snugly inside a right-hand pocket of their clothing. Detailed information on this step can also be found in the document for *Lab 1*.

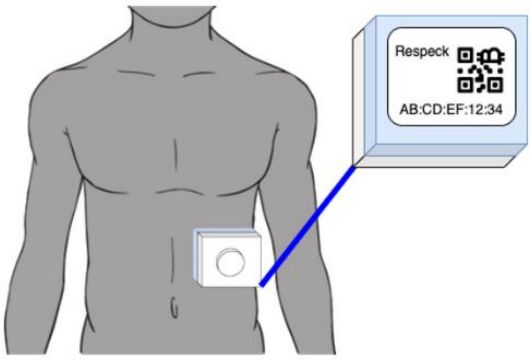
## 2.1. Sensor Placement

RESpeck

Everyone will need to wear the sensors in the same places to ensure consistency across the data. The **Respeck** sensor should be placed on the **left lower ribcage – just below the ribs**, with the blue half against the skin. Make sure that the RESpeck is first put into the small plastic bag provided. You should be able to read the RESpeck label when placing it on your chest – this ensures the sensor is held the right way up, as shown in the figure below. Secure the sensor to the chest using the MeFix tape provided. If you run out of tape, you should let us know, and we will provide you with more.

Thingy

The Thingy sensor should be placed in the **front right pocket of your trousers**, with the circle placed in the upper right corner and the USB port facing downwards.





## 2.2. Activities to be Recorded

Next, you will have to perform a series of activities while wearing the sensor. A total of 46 activities are to be collected. The list of activities to be recorded can be found below. Each activity recording should be 30(±2) seconds long.

Activities can be divided into three categories: (1) Physical activities, (2) Stationary activities with respiratory responses, and (3) Stationary activities with other behaviours.

*If specific personal circumstances, such as disability, injury, or illness, prevent you from collecting data for certain activities, please come speak with us.*

## (1) Physical activities

A total of 12 physical activities are to be recorded. These activities should be performed while wearing BOTH the RESpeck and Thingy devices. Those activities are listed below.

- Sitting (while breathing normally)
  This can include sitting on a chair straight, sitting bent forward, sitting bent backward. Breathe normally for 30 seconds. During this, try not to move excessively, talk, cough, or laugh.
- Standing (while breathing normally)
  Stand up with your back straight. Breathe normally for 30 seconds. Try not to move, talk, cough, or laugh during this recording.
- Lying down on your left side (while breathing normally)
  Lie down on an even surface, such as a bed or a sofa. Make sure your torso is completely horizontal. Turn onto your left side. Breathe normally for 30 seconds. Try not to move, talk, cough, or laugh during this recording.
- Lying down on your right side (while breathing normally)
  Lie down on an even surface, such as a bed or a sofa. Make sure your torso is completely horizontal. Turn onto your left side. Breathe normally for 30 seconds. Try not to move, talk, cough, or laugh during this recording
- Lying down on your back (while breathing normally)
  Lie down on an even surface, such as a bed or a sofa. Make sure your torso is completely horizontal. Turn onto your back. Breathe normally for 30 seconds. Try not to move, talk, cough, or laugh during this recording.
- Lying down on your stomach (while breathing normally)
  Lie down on an even surface, such as a bed or a sofa. Make sure your torso is completely horizontal. Turn onto your stomach. Breathe normally for 30 seconds. Try not to move, talk, cough, or laugh during this recording.
- Normally walking (while breathing normally)
  Find a space where you can walk in a straight line for 30 seconds or take as few sudden turns as possible. Walk at a normal pace and try not to stop during the recording.
- Ascending stairs (while breathing normally)
  Find a space where you can continuously climb a flight of stairs for 30 seconds, for example, Appleton Tower. Walk up the stairs at a normal pace and do not stop for the 30 seconds of the recording.
- Descending stairs (while breathing normally)
  Find a space where you can continuously descend a flight of stairs for 30 seconds, for example, Appleton Tower. Walk down the stairs at a normal pace and do not stop for the 30 seconds of the recording.
- Running or jogging
  Find a space where you can run or jog in a straight line for 30 seconds or take as few sudden turns as possible. Try not to stop during the recording.
- Shuffle walking (while breathing normal)
  Find a space where you can shuffle walk *(not referring to the dance move!)* for 30 seconds. Shuffle walking, also known as a shuffle gait or shuffling gait, refers to a specific manner of walking that is often associated with certain medical conditions or movement disorders. It is characterized by short steps, a stooped posture, and a dragging or shuffling of the feet along

the ground. This type of gait can result in a distinctive shuffling sound as the feet slide forward without being lifted off the ground as much as in a normal walking pattern.

Video examples of shuffle walking are listed below.

- https://www.youtube.com/watch?v=yhj1PktNA1c
- https://youtube.com/shorts/tkbM29OCGlk?si=LDtaOtfRl8c0S_Of

- **Miscellaneous movements (while breathing normally)**
  This includes transition activities, random movements, or activities that would not fall in any of the categories listed above, including but not limited to:
  - Getting up from a chair
  - Sitting down on a chair
  - Getting up from lying down
  - Lying down from a previously upright position
  - Spinning, jumping, swaying, etc.

## (2) Stationary activities with respiratory responses

A total of 12 stationary activities with respiratory responses are to be recorded. These activities should be performed while wearing the **RESpeck only**. Those activities are listed below.

- Sitting down + [coughing, hyperventilating]
- Standing + [coughing, hyperventilating]
- Lying down on your back + [coughing, hyperventilating]
- Lying down on your right side + [coughing, hyperventilating]
- Lying down on your left side + [coughing, hyperventilating]
- Lying down on your stomach + [coughing, hyperventilating]

**Hyperventilation** — Hyperventilation is a breathing pattern characterized by rapid and shallow breaths. You can simulate hyperventilation by taking rapid, shallow breaths and breathing in and out quickly. A visual example can be seen in this video. (https://www.youtube.com/watch?v=rgRsQp1oCS0).

## (3) Stationary activities with other behaviours

A total of 20 stationary activities with other behaviours are to be recorded. These activities should be performed while wearing the **RESpeck only**. Those activities are listed below.

- Sitting down + [talking, eating, singing, laughing]
- Standing + [talking, eating, singing, laughing]
- Lying down on your back + [talking, singing, laughing]
- Lying down on your right side + [talking, singing, laughing]
- Lying down on your left side + [talking, singing, laughing]
- Lying down on your stomach + [talking, singing, laughing]

***Why are these activities being collected?*** *These activities can be confused for respiratory responses; therefore, it is important that the model we create does not misclassify these other behaviours as coughs or hyperventilation.*

(4) Sleep Data

Each of you will have to collect data for one night of sleeping. You will ideally wear the Respeck from the moment you go to bed and take it off the next morning when you wake up. You should ensure the Respeck is fully charged before as this consumes battery. You should also ensure that your phone and app is constantly kept open throughout the night to ensure that data is being collected continuously.

After you have collected this data, you should fill out a questionnaire regarding your sleep. The questionnaire can be found on Learn under the name **sleep_questionnaire.docx**.

## 3. Obtaining the recorded files

Please check *Lab 1* for instructions on how to obtain your recording files. Make sure there are no test recordings in your file collection - you can check this by the timestamp appended to each file. Copy the files on your computer and store them in a folder for easy access.

## 4. Data Pre-processing and Cleaning Guidelines

Please refer to ***Lab 2*** on how to properly clean and pre-process your data so that it adheres to the requirements prior to submission!

- Ensure that you have all recorded activities
  Refer to the list of activities provided in Section 2 of this document. You can also make use of the checklist provided to ensure that you are not missing any activities.
- Ensure that your sensor was positioned correctly when collecting your data.
  Refer to the placement section on how you can verify this. If the orientation of your sensor is incorrect, it will be reflected in your data.
- Ensure that the header information has been removed from the clean data files
  Please refer to the instructions from *Lab 2* on how to do this.
- Ensure that your clean data file contains the expected data columns
  Please refer to the instructions from *Lab 2* on how to do this. Your clean data file should contain the following columns: `timestamp, accel_x, accel_y, accel_z, gyro_x, gyro_y, gyro_z`
- Ensure that each of your data files is 30(±2) seconds long
  Please refer to the instructions from *Lab 2* on how to check the length of your data. Anything below 28 is seconds or above 32 seconds is not accepted.
- Ensure that each of your data files was collected at a sampling rate of 25(±1) Hz
  Please refer to the instructions from *Lab 2* on how to check the sampling rate of your data. After trimming or cleaning data, this can cause the sampling rate to change. Make sure that your data after cleaning is roughly 25Hz.
- Ensure that there are no unnecessary gaps of inactivity in your data recordings
  Carefully review your recordings and remove any portions where no relevant activity is taking place. Please check the instructions from Lab 2 on how you can verify this.

- Ensure that only ONE activity is being performed in each of your data recordings
  Please check the instructions from *Lab 2* on how you can verify this. This means that a data file for 'running' should not contain any instances of you standing or sitting.
- Ensure that you have visually verified all your recordings so that activity starts at the very beginning of the recording and stops at the very end
  You can achieve this by either trimming the start and end of your recordings or by starting the recording while you are already performing the activity. Please check the instructions on *Lab 2* on how to do this.

## 5. Submission

You will be asked to submit **both your clean and unprocessed (original) data files** to **Learn** to the submission box titled **'Coursework 1: Data Collection'**.

> By "unprocessed" data files, we are referring to the original full-length file(s) of your data recording *prior* to any cleaning or trimming.

The format of your files should look like this:
`{sensorName}_{studentUUN}_{activityType}_{subActivityType}_{cleanOrUnprocessed}_{timestamp.csv}`

Examples:
```
Respeck_s1234567_Sitting_Coughing_clean_07-10-2022_10-33-49.csv
Respeck_s1234567_Sitting_Coughing_unprocessed_07-10-2022_10-33-49.csv
Thingy_s1234567_Standing_Coughing_clean_07-10-2022_10-33-49.csv
Thingy_s1234567_Standing_Coughing_unprocessed_07-10-2022_10-33-49.csv
```

For your sleep data, your csv file can be named as such:
`Respeck_{studentUUN}_Sleeping_07-10-2022_10-33-49.csv`

And the questionnaire file you submit can be named:
`{studentUUN}_sleepQuestionnaire.pdf`

Gather all your files into a single folder with your student ID as the title. Your upload structure should look something like this.

```
.
+-- s1234567
|   +-- Respeck_s1234567_Sitting_Coughing_clean_{timestamp}.csv
|   +-- Respeck_s1234567_Sitting_Coughing_unprocessed_{timestamp}.csv
|   +-- Respeck_s1234567_Standing_Coughing_clean_{timestamp}.csv
|   +-- Respeck_s1234567_Standing_Coughing_unprocessed_{timestamp}.csv
|   +-- ...
|   +-- Thingy_s1234567_Standing_Coughing_clean_{timestamp}.csv
|   +-- Thingy_s1234567_Standing_Coughing_unprocessed_{timestamp}.csv
|   +-- ...
```

# 6. Marking Criteria

You are to submit a total of 56 cleaned activity data files and at least 56 unprocessed data files (some students may have more than 46 unprocessed data files if they make multiple recordings per activity and concatenate them).

You should submit 1 csv file for the sleep recording along with the sleep questionnaire. This gives a total of 57 'cleaned' sensor data files to be submitted.

Only your cleaned data files will be marked. For a data file to be considered 'correct', it must pass on the requirements listed in Section 4 of this document. Refer to the table below for how you will be marked on this coursework.

| Number of files correct | Marks (out of 10) |
|---|---|
| 0 | 0 |
| 0-10 | 1 |
| 11-20 | 2 |
| 21-30 | 3 |
| 31-35 | 4 |
| 36-40 | 5 |
| 41-45 | 6 |
| 46-50 | 7 |
| 51-53 | 8 |
| 54-56 | 9 |
| 57 | 10 |

# Previously Asked Questions

- Are the file names case-sensitive?
  - No.
- Can I make multiple recordings for an activity and concatenate them together so that they meet the 30-second requirement?
  - Yes, you can.
- Is this coursework marked individually or as a group?
  - It is marked individually.
- For the activities that require measurements from both sensors, how does one record that? On the app it is only possible to choose between RESpeck and Thingy. Is it possible to record both at the same time?
  - You should record them separately - once using the RESpeck and once using the Thingy. You can pair both sensors to the app and view live incoming data simultaneously, but there is no way to record incoming data from both simultaneously.
- Can I assume that Miscellaneous movements is many random types of movement combined in one file?
  - Yes.
- Should we start the recording before someone does the activity or is it okay to start the recording while someone is already doing the activity? For example, should we start recording and then start coughing?

    - You are free to record the data as you'd like as long as the activity starts at the very beginning and stops and the very end of the recording. There are two ways you can do this:
        - 1. Press start recording before you start performing the activity. Then, during the data processing stage, you can choose to trim the beginning and the end of the data to exclude periods of inactivity.
        - 2. As you have mentioned, you can already be performing the activity (for example, lying down on your back) then press start recording, and stop recording while you are still performing the activity. In this case, you would not need to trim the beginning and end of the data. However, this method is quite difficult to do for respiratory responses (coughs and hyperventilation); therefore, I suggest you do the former when recording respiratory responses.
- Does it matter if we lie down on a soft or hard surface?
    - No, it does not matter
- Does the clean data need to include header information?
    - No, the clean data should NOT include header information
- What are the expected columns for the clean data?
    - The expected columns are: timestamp, accel_x, accel_y, accel_z, gyro_x, gyro_y, and gyro_z. This goes for both RESpeck and Thingy data files.
- What is laughing/singing/eating/talking data supposed to look like? How do we know which parts are supposed to be discarded or kept?
    - We're not strictly looking for a specific pattern when it comes to activities like laughing, talking, singing, and eating because everyone is going to do them a bit differently, and there are many variations when it comes to performing those activities. We will only mainly be checking that you are obviously not breathing normally / inactive at any point during the recording
- Do we need to care about the up and down direction of the RESpeck?
    - Yes, you do!!! In terms of the orientation of the sensor, someone should be able to read the RESpeck label when it is placed on your chest. This ensures the sensor is the right way up. Please refer to figure in the previous sections of this document.
- I noticed that my laying down on left/right readings for acceleration are not "perfect" (results compared to rotating the RESpeck on a table). It makes sense due to body type differences and even a miniscule sensor placement difference could affect the readings. Is this okay?
    - Yes. There will definitely be variations when you're wearing the sensor, so we would not at all expect them to be 'perfect' as if you were to place the sensor flat on a surface.
- Do we need to cut out the points in the recordings where you take a breath while talking?
    - No, you can leave them.
- Do we need to remove the index column when export our dataframe to csv file?
    - It does not matter. As long as your csv contains the necessary expected columns, it does not matter what other columns you have as they will be automatically discarded in the marking process. This goes for both RESpeck and Thingy data files.
- My clean CSVs have extra columns my unprocessed ones don't. Should I remove them or is there no need?
    - You can keep them or remove them, it does not matter. When marking the most important columns that are absolutely needed are: timestamp, accel_x, accel_y, accel_z, gyro_x, gyro_y, gyro_z. This goes for both RESpeck and Thingy data files.