PDIoT Coursework 3 [70%]

INFR11239 (UG)/INFR11150 (PG)

Release Date: 18 September 2024
Progress demonstration/formative feedback: 16 October 2024
Final demonstration/formative feedback: 20 November 2024 (10:00 – 13:00)
Final Report Submission: 17 January 2025
Final Report Feedback Return: 31 January 2025

Task Description

This coursework involves the development, demonstration, and final written report (max. 10,000 words) for the activity recognition system.

Implementation

Your task will be to implement an activity recognition system for a set of activities listed below, by applying machine learning techniques on the IMU data and displaying real-time results in an Android app.
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 sensor data analytics using machine learning techniques, mobile application development, user interface design, and system integration and testing.

There will be an opportunity to demonstrate progress and receive written formative feedback in Week 5. The final presentation to showcase your prototype with a live demonstration is scheduled on 20 November 2024 (10:00-13:00). Your final written report will be due on 17 January 2025.

Tasks

There are four main tasks to be completed for Coursework 3. They are outlined as follows.

1. Daily Physical Activity Classification

You should implement a model or set of models using only the Respeck device or the Respeck device and the Thingy (you cannot only use the Thingy) that is able to classify the following classes:

1. Sitting or Standing (Here you should combine sitting and standing data files into one class)
2. Lying down on your left side
3. Lying down on your right side
4. Lying down on your back
5. Lying down on your stomach
6. Walking normally
7. Running/jogging
8. Ascending stairs

9. Descending stairs
10. Shuffle-walking
11. Miscellaneous movements

2. Social Signals Classification

You should implement a model or set of models that is able to classify the following classes:

1. **Breathing normally** (all stationary activities performed while breathing normally should be combined into one class)
2. **Coughing** (all stationary activities performed while coughing should be combined into one class)
3. **Hyperventilating** (all stationary activities while hyperventilating should be combined into one class)
4. **Other social signals** (talking, eating, singing, and laughing activities performed while stationary should be combined into one class)

3. Sleep-Wake Analysis

From sleeping data and questionnaire data which have been collected, you should be able to perform the following:

1. Classify sleep-wake cycles
2. Count the number of positional changes
3. Sleep efficiency ((time spent sleeping / time spent in bed) x 100)
4. Sleep quality index – based on calculations made in 1-3, can you calculate a sleep quality index?

5. Android App Implementation

You should integrate the methods developed in Tasks 1-3 into your Android application. Your app should be able to classify physical activities and social signals in real-time. Your app should also be able to keep a history of the different activities and social signals formed each day. For example, users should be able to see that on July 17, they spent 1 hour walking, 10 hours sitting/standing, coughed 30 times, etc.

Coursework Deliverables

1. Demonstration

Each group is allocated 5 minutes, which should be roughly allocated as follows:

- 2-minute presentation
- 2-minute demonstration
- 1-minute Q&A

The audience is the entire PDIoT class and course instructors. You should limit your presentation to around 5 slides and include the following:

- An annotated block diagram
- The algorithms/models used for activity classification
- The Android App Design and Features
- The performance of the implementation:

- Accuracy: *What is the real-time accuracy of your models? To demonstrate this, each of your group members can perform each activity a number of times and report how many times the correct classification result is shown on your app in terms of %.*
- Communication latency: *How long (in seconds) does it take for the classification output to be shown on your mobile app after performing the activity?*
- Power consumption: *How much battery does your mobile app consume while collecting data?*
- CPU cycles: You can monitor CPU usage through tools like Android Studio's Profiler, which reports CPU time and utilization to ensure the app does not consume excessive CPU resources.
- Memory usage: How much RAM does your android app use?

You should next demonstrate the implementation of your Android app using a combination of live and recorded data (the latter for activities that would be difficult to demonstrate live, such as ascending or descending stairs). You should share your mobile phone screen, so that it works seamlessly on the day, and note that timekeeping will be strict!

Please submit your slides to Learn by 9:00 AM on the morning of the presentation.

2. Final Group Report

A single group report describing the activity recognition system will be due by 17 January 2025. The final report should not exceed 10,000 words (excluding Bibliography and Appendices) and should be organised into the following chapters:

Title Page

- PDIoT Coursework 3 (2024-25)
- Project Title
- Names
- Matriculation Numbers
- Abstract

Introduction

- Project aims and objectives
- Brief description of the method adopted and summary of results

Literature Survey

- A review of the state-of-the-art for activity recognition systems

Methodology

- A description of the system and its implementation
- Algorithms and methods used for activity recognition
- Algorithms and methods used for sleep analysis
- Mobile application implementation
    - Tools used to develop the app, functions and features of the app, app user interface

- Software organization
- Testing

Results and Discussion

- Accuracy results of machine learning models implemented. Please report this using K-Fold cross validation where K=5. The classification accuracy for each class should be reported.
- Accuracy of real-time classification. You can report this by having each member in your group perform each activity a number of times and counting how many times the correct classification was reported by your app. Please include a table of the activities performed and the classification results and a final accuracy percentage calculation.
- Results of sleep analysis – were you able to accurately analyse sleep data based on questionnaire answers provided?
- Critical analysis of results: Why do you think certain methods worked better than others? What are the flaws of your current implementation and how can it be improved?
- Android app performance
    - Communication latency, power consumption, CPU usage, memory usage

Conclusions

- Summary of your project and reflection
- Areas for future works

Please note that is only a rough outline of the sections and topics that we expect to see in your report. You are free to add more information as necessary.

Assessment Criteria [100 marks, 70% of grade]

Students will be awarded marks out of 100, based on the demonstration presentation and final written report. The criteria for assessment are as follows:

Demonstration [5/100 marks]

The demonstration will be marked based on the quality of the oral presentation, slides and demonstration.

Project Report [95/100 marks]

Analysis [25/95 marks]

- Detailed and clear description of the system including hardware and software components. Thorough explanation of the algorithms and methods used for the tasks.
- Clear description of app features and functionality with appropriate and well-justified tools.
- Clear methodology for testing and evaluation of the system.
- Clear presentation of model performance results using K-Fold cross-validation (K=5) and interpretation
- Detailed results including a table of activities and real-time classification outcomes, with final accuracy percentage calculation

- Analysis of why certain methods performed better or worse, identification of flaws, and suggestions for improvement
- Detailed assessment of app performance in terms of communication latency, power consumption, and memory usage
- Critical analysis using quantitative methods and performance analysis is presented as graphs, with a balanced interpretation of the results.

Project Technical Evaluation [70/95 marks]

In terms of the technical evaluation of your project, you will be marked based on four categories of the project: (1) Physical Activity Classification, (2) Social Signals Classification, (3) Sleep-wake analysis, and (4) Android App Implementation.

For tasks 1-3, 25% of marks will be subtracted if gyroscope data was used for the classification.

1. Daily Physical Activity Classification [15/70 marks]

- Obtain a mean classification accuracy of 90% for static activities – static activities include sitting/standing, lying down on your left side, lying down on your right side, lying down on your back, and lying down on your stomach. *(6 marks)*
- Obtain a mean classification accuracy of 90% for dynamic activities – dynamic activities include walking, ascending stairs, descending stairs, running/jogging, shuffle walking, and miscellaneous movements. *(9 marks)*

2. Social Signals Classification [20/70 marks]

- Obtain a mean classification accuracy of 80% for normal breathing. *(5 marks)*
- Obtain a mean classification accuracy of 80% for coughing. *(5 marks)*
- Obtain a mean classification accuracy of 80% for hyperventilation. *(5 marks)*
- Obtain a mean classification accuracy of 80% for other social signals. *(5 marks)*

3. Sleep-Wake Analysis [15/70 marks]

- Sleep-wake cycle classification *(6 marks)*
- Number of positional changes *(3 marks)*
- Sleep efficiency *(3 marks)*
- Sleep quality index *(3 marks)*

4. Android App Implementation [20/70 marks]

- Real-time classification of Task 1 on the mobile app *(5 marks)*
- Real-time classification of Task 2 on the mobile app *(5 marks)*
- Real-time classification of Task 3 on the mobile app *(5 marks)*
- App features and functionality (allowing users to view historic data etc) *(5 marks)*
- App user interface *(5 marks)*