Advanced AI Research Topics
COMP6011

RESEARCH TASK 3

Due Date: Friday 30-May-2025, 5:00pm Perth time.
Weight: 40% of the unit mark.

Note: *This document is subject to minor corrections and updates. Announcements will be made promptly on Blackboard and during lectures. Always check for the latest version of the assignment. Failure to do so may result in you not completing the tasks according to the specifications.*

1 Research Problem Description

Cardiovascular diseases (CVDs) remain the leading cause of death worldwide, accounting for approximately 32% of all global deaths. In Australia alone, one in four deaths is attributed to heart-related conditions. Among these, Atrial Fibrillation (AFIB) is a particularly critical concernit is a major cause of stroke and increases the risk of stroke by five times compared to individuals without AFIB. Patients presenting with symptoms such as chest pain, palpitations, or fainting are often admitted to hospital emergency departments where timely and accurate diagnosis is essential. However, diagnosing heart conditions is not always straightforward, as symptoms can overlap and one condition may mask or complicate another. This diagnostic complexity has made artificial intelligence (AI) an increasingly attractive tool to support cardiologists in making rapid and reliable clinical decisions.

The electrocardiogram (ECG) is the most widely used non-invasive tool for diagnosing CVDs, particularly arrhythmias such as AFIB. A standard clinical ECG uses 12 leads placed at strategic locations on a patients body to record the hearts electrical activity over time. These traces provide crucial insight into the functioning of the heart and are interpreted visually by cardiologists, who often also consider supporting clinical data (e.g., patient history, medications, comorbidities). While ECG interpretation is a powerful skill, it is time-consuming and requires extensive training. Automating aspects of this process with AI offers the potential to improve both speed and diagnostic accuracy.

You will assume the role of the AI Chief Scientist leading a research and development project to design a machine learning system that can diagnose heart conditions using ECG data. The system will be deployed in hospitals to support cardiologists, with the key objective of improving diagnostic accuracy and clinical workflow efficiency. Your AI solution must be capable of:

- Producing highly accurate diagnoses,
- Providing transparent reasoning or evidence for its predictions to build trust with clinicians, and
- Flagging cases with low confidence so that clinicians can review them manually.

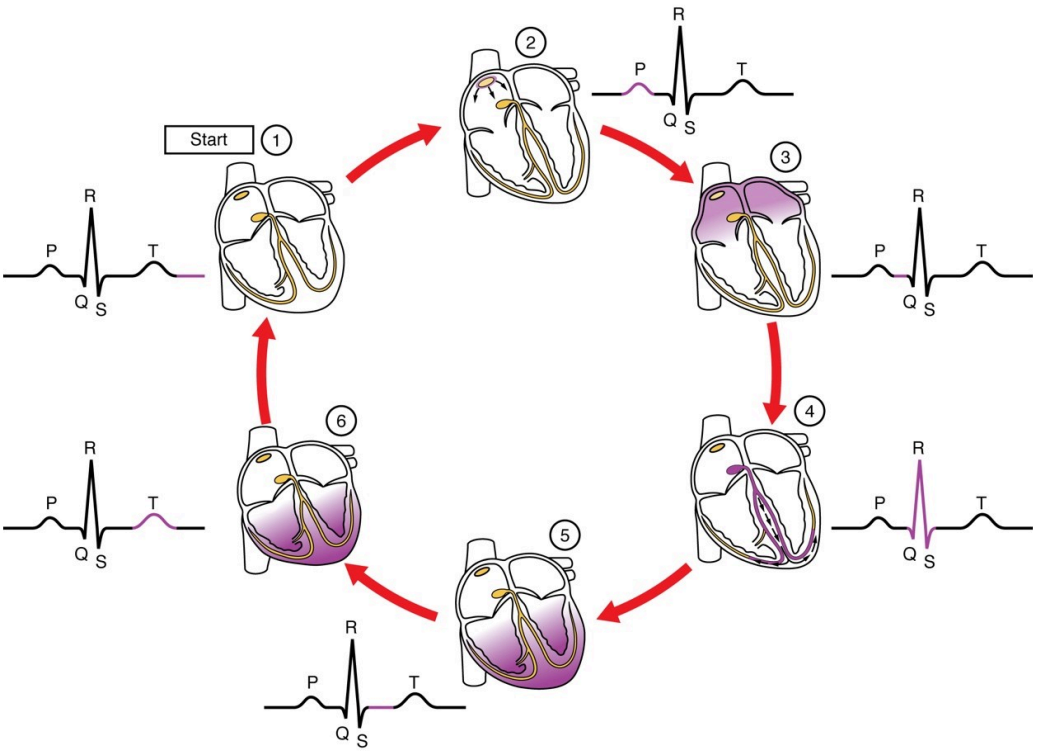

Figure 1: Heart activity and the correspoding waves of the ECG. Source: `https://clinical.stjohnwa.com.au/`.

Figure 2: An example of a normal 12-lead ECG sample.

To keep the scope manageable, your solution will focus on the normal condition (NORM) and 5 common heart conditions:

- Atrial Fibrillation (AFIB)
- Atrial Flutter (AFLT)
- First-Degree Atrioventricular Block (1dAVb)
- Right Bundle Branch Blocks (RBBB)
- Left Bundle Branch Blocks (LBBB)

If a test sample is not normal and the detected disease(s) is/are not among those listed above, your AI model should output ‘‘OTHERS’’ for this assignment. If your model predicts multiple diseases for a given test ample, only the first prediction, which is assumed to have the highest confidence, will be used to measure the accuracy.

To effectively design your AI solution, you are required to work in a small team and conduct a comprehensive literature review into the current state-of-the-art in ECG-based disease diagnosis. This includes understanding recent advances in machine learning and deep learning models applied to ECG interpretation. Your review should critically evaluate and compare relevant techniques, identifying their strengths, limitations, and suitability for clinical use. You are expected to perform benchmarking of shortlisted methods, both qualitatively (e.g., explainability, model transparency) and quantitatively (e.g., accuracy, sensitivity, specificity), ideally across multiple publicly available datasets. This benchmarking will help you justify the final model(s) selected for further development. Your final design should demonstrate how these selected models will be adapted or combined to form your proposed solution. In doing so, you must ensure that the solution not only achieves high clinical accuracy and supports explainable AI, but also aligns closely with Australias AI Ethics Principles.

As part of this assignment, you are required to apply your selected and trained AI models to a set of test ECG samples provided on Blackboard. These samples have been chosen to evaluate whether your models are capable of accurately interpreting ECG signals and producing clinically relevant diagnoses. In addition to assessing the clinical accuracy of your predictions, you must also address the explainability of your results this is critical for the model to be trusted and used by cardiologists in real-world clinical environments. To support your development, a separate validation set, which shares similar characteristics with the test set, is also provided. You are encouraged to use this validation set to fine-tune your models and evaluate their performance before making your final predictions on the test samples. Your final submission will be assessed in part based on the performance of your model on the test set, including diagnostic accuracy and the clarity of your explanation strategy.

You must present all of the above in a professional technical report using the prescribed LaTeX template, available on Blackboard, and submit your report via Blackboard.

Page limit: Your report must not exceed 15 pages, including the cover page and references.

The report is expected to include the following parts

- Abstract
- Introduction
- Literature review
- Benchmarking results

- Methodology
- AI Ethics
- Discussion
- Conclusion
- References
- Appendices

Present the diagnosis results for the test samples in the Methodology section of the report. If more space is needed, include them in your cloud folder (e.g., Google Drive, Dropbox) and provide a link in the Appendices.

You must also complete a Declaration of Originality form, which is already included in the LaTeX template. Additionally, you are required to create a video presentation of your work on Echo360 and include the link to this video in Appendix 1. In addition, you and your group members are required to deliver an oral presentation and demonstrate your proposed solution. The schedule for this activity will be published on Blackboard closer to the date. Finally, you may provide links to relevant resources, such as your GitHub repository or a shared cloud folder, that demonstrate your work, including Python programs or other supporting materials.

2 Submission

The main report in PDF format must be submitted through Turnitin.

3 Oral Presentation

Please see Blackboard for information about the oral presentation and demo that you and your group must attend.

4 Academic Misconduct Plagiarism and Collusion

Please note the following:

Copying material (from other students, websites or other sources) and presenting it as your own work is plagiarism. Even with your own (possibly extensive) modifications,it is still plagiarism.

Exchanging assignment solutions, or parts thereof, with other groups/students is collusion. Engaging in such activities may lead to a grade of ANN (Result Annulled Due to Academic Misconduct) being awarded for the unit, or other penalties. Serious or repeated offences may result in termination or expulsion.

You are expected to understand this at all times, across all your university studies, with or without warnings like this.

END OF RESEARCH TASK 3