Deciphering the Heartbeat: Towards an Explainable AI Approach using ECG Signals for Exploring Aging-in-Place Intelligence

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Motivation

As societies worldwide face the burgeoning challenges of an aging population, the concept of "Aging-in-Place" (AiP) has emerged as a pivotal model in gerontology and public health.

In this work, we propose an Explainable Electrocardiogram (ECG) Anomaly Detection Framework to enhance the safety and health monitoring of seniors in their own homes. This approach utilizes sophisticated algorithms to analyze ECG data collected from wearable devices, enabling the early detection of cardiac abnormalities. By employing Explainable Artificial Intelligence (XAI), not only are clinicians able to receive alerts about potential heart issues, but they can also understand the rationale behind the AI's decisions.

Related Work

The aging population in several countries presents unique challenges and opportunities for the AiP concept [1, 2]. The intersection of technology and AiP has been explored to enhance older people's independence and quality of life [3].

Ott et al. (2023) [4] employed deep-learning models along with tree-based classifiers to discern age-related changes in ECG data, using XAI techniques to reveal specific ECG features and signal characteristics that differentiate between age groups. Greenfield (2012) [5] emphasized ecological frameworks for integrating health care and community initiatives for AiP.

References

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Explainable ECG Anomaly Detection Framework for Aging-in-Place Intelligence

Our proposed framework includes a pipeline for training a classification model on a public 12/15-lead ECG dataset, identifying features associated with myocardial infarction versus healthy controls, and generating explanation maps to highlight the reasoning behind the model's decisions on the single-lead ECG recorded from an edge device.

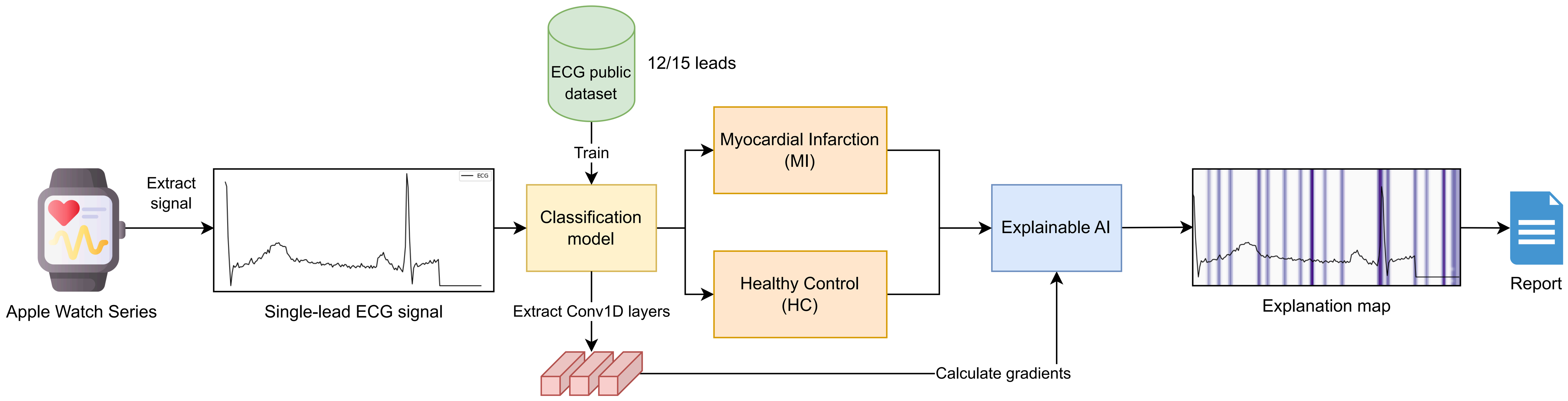


Figure 1. The architecture of Explainable ECG Anomaly Detection Framework for Aging-in-Place Intelligence

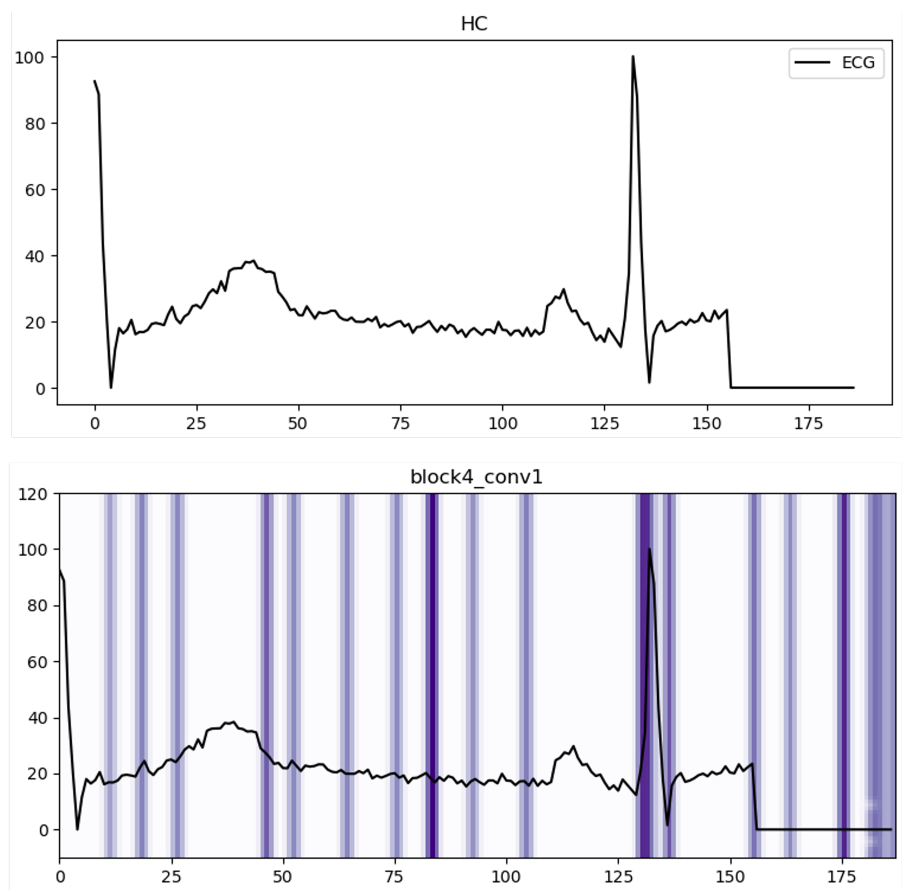
Experiments

- Public ECG dataset: PTB Diagnostic ECG Database:
  - Sampled frequency: 125Hz.
  - Number of Samples: 14552.
  - Number of Categories: 2 – Myocardial Infarction (MI) and Healthy Control (HC).
- Explanation method: The gradients of the target class with respect to the selected layer's output are pooled and combined with the layer's output to generate a heatmap.
- Wearable device: Apple Watch Series 5.

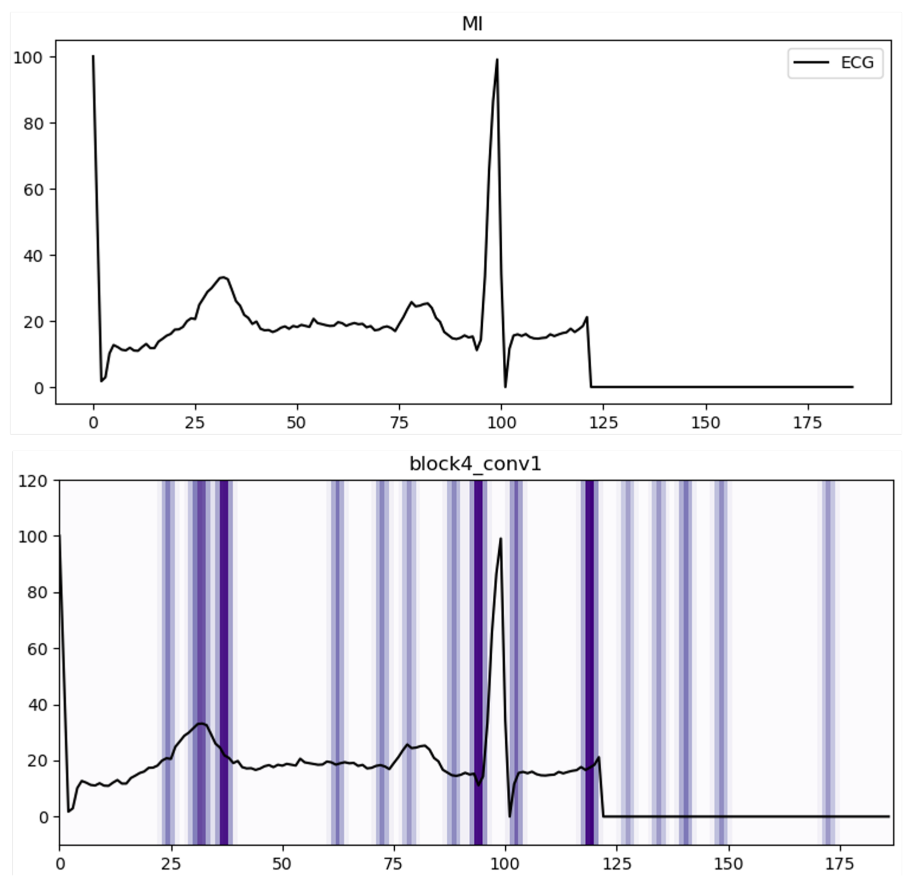
Preliminary Results

Our initial results for Healthy Control (HC) and Myocardial Infarction (MI) classifications:

- HC: minimal highlights in the explanation map are observed, concentrated in the mid-segments of the ECG, indicating less relevance to the model's classification.
- MI: substantial highlighting is shown, particularly in the early and mid-segments of the ECG signal. This suggests these areas significantly influence the model's decision to identify features associated with myocardial infarction.



(a) Healthy Control (HC)



(b) Myocardial Infarction (MI)

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