Chapter 1

Introduction

1.1 Background

Cardiovascular diseases (CVDs) were responsible for 19.8 million deaths worldwide in 2022, making them one of the leading causes of death (World Health Organization, 2025). This group of diseases affects the cardiovascular system, the heart and blood vessels, and among them, myocardial infarction (MI) or heart attack, was a major cause of CVD related deaths in 2022. MI is frequently caused by prolonged myocardial ischemia, leading to permanent myocardial damage due to the restricted blood flow to the heart muscle (Ojha & Dhamoon, 2023). Myocardial ischemia is often caused when the heart's need for oxygen is not met by the supply, which is most commonly the result of atherosclerosis, where plaque would accumulate in the coronary arteries. This condition has been linked to risk factors like hypertension, hyperlipidemia, smoking, diabetes, alcohol consumption, obesity, physical inactivity, and even psychosocial factors. While myocardial ischemia may be temporary and reversible, chronic or severe ischemia that is left untreated can cause myocardial necrosis, resulting in MI (Warner & Tivakaran, 2023). As a result, early detection of ischemic changes before infarction is crucial for timely intervention and better patient outcomes. Furthermore, in MI, ST-segment elevation myocardial infarction (STEMI) is indicated by a persistent ST-segment elevation on an ECG, which usually indicates total occlusion of a coronary artery, which could result in a substantial myocardial damage. Whereas a non-ST-segment elevation myocardial infarction (NSTEMI) would not show ST-segment elevation and instead is associated with ST-segment depression, T-wave abnormalities, or other ECG abnormalities which is caused by partial coronary artery occlusion (Basit et al., 2023).

To detect myocardial ischemia, electrocardiograms (ECGs) are often used because it is non-invasive, requires low cost, and is often readily available (Sattar & Chhabra, 2023). ECG records the heart's electrical activity using surface electrodes, enabling the identification of characteristic waveform abnormalities associated with myocardial ischemia, which are ST-segment elevation or ST-depression and T-wave changes (Ricci et al., 2025). In particular, ECG is the primary diagnostic tool for ST-elevation STEMI, and it is frequently employed as the first screening tool for NSTEMI as well. These characteristics make ECGs particularly useful in emergencies, initial hospitalization, and situations that require continuous monitoring. However, ECG interpretation has its limitations, as signal noise, patient-specific variability, electrode location, and overlapping waveform features between different cardiac conditions all have an impact on ECG diagnostic accuracy. Furthermore, manual ECG interpretation is largely reliant on the expertise of the physician and is prone to inter-observer variability, time limits, and diagnostic bias (Kraik et al., 2025). These difficulties are especially prominent in urgent and environments with limited resources, when delayed or incorrect interpretation might lead to incorrect or delayed MI diagnosis.

These limitations led to the growth of digital ECG evaluation methods to help with clinical decision-making. Traditionally, ECG recordings have been regarded as one-dimensional (1-D) signals, representing changes in voltage across time (Daydulo et al., 2023). Signal-based analysis allows for the exact identification of clinically relevant periodic variables such as amplitudes, durations, and intervals, which serve as the foundation for traditional ECG interpretation and many automated analysis methods (Boulif et al., 2023). As a result, many traditional and artificial intelligence systems rely on signal processing techniques and customized features. However, while such approaches are useful in organized settings, they may be limited in their capacity to record complex waveform morphology and subtle visual patterns associated with early ischemia and infarction-related changes that physicians frequently detect visually (Prakash et al., 2025).

With the recent advancements in artificial intelligence (AI), alternative ECG formats that are able to better capture the morphological data has been explored further. When ECG signals are turned into images, the general waveform shape and spatial relationships that are looked at during visual ECG interpretation are kept. This change makes it possible to use methods based on computer vision, such as convolutional neural networks (CNNs), that can learn the useful morphological features straight from the visual data without having to do any sort of feature engineering (Hannun et al., 2019). Recent developments in deep learning have made this method even stronger, with CNN-based models used on ECG images showing they can find patterns linked to MI, such as ST-segment deviations and ischemic waveform abnormalities (Hong et al., 2020). These findings suggest that ECG image-based deep learning methods can effectively capture subtle morphological changes associated with MI.

Therefore, an implementation of a vision-based AI model into an application may provide real-time guidance on decisions for early cardiac ischemia diagnosis, allowing for prompt treatment and lowering the risk of progression to ischemic heart disease. As a result, such an application would be especially useful in emergency care, remote medical care, and resource-constrained environments.

1.2 Objective

To train an AI model and develop an application that can detect myocardial infarction such as STEMI and NSTEMI from ECG abnormalities in ECG images which are ST-elevation, ST-depression, T-wave inversion, and T-wave peaked.

1.3 Hypothesis

H0: The vision-based AI model cannot accurately detect ST-segment and T-wave abnormalities associated with myocardial ischemia from ECG images.

H1: The vision-based AI model can accurately detect ST-segment and T-wave abnormalities associated with myocardial ischemia from ECG images.