# Chapter 4
# A Medical Comparative Study Evaluating Electrocardiogram Signal-Based Blood Pressure Estimation

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## ABSTRACT

*In general, blood pressure (BP) is measured using standard methods (medical monitors), which are widely used, or from physiological sensor data, which is a difficult task usually solved by combining several signals. In recent research, electrocardiogram (ECG) signals alone have been used to estimate blood pressure. The authors present a comparative study that evaluates ECG signal-based blood pressure estimation using complexity analysis to extract features, comparing the results obtained with a random forest regression model as well as with the combination of a stacking-based classification module and a regression module. It was determined that the best result obtained is a mean absolute error range of 3.73 mmHg with a standard deviation of 5.19 mmHg for diastolic blood pressure (DBP) and 5.92 mmHg with a standard deviation of 7.23 mmHg for systolic blood pressure (PAS).*

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## 1. INTRODUCTION

The electrocardiogram (ECG) records the electrical activity of the heart, which circulates blood throughout the body. The heart has four chambers, the two upper chambers called atria and two lower chambers called ventricles (Geselowitz, 1989). Among the most important factors to be monitored for the prevention of cardiovascular diseases (CVD) is blood pressure, which is defined as the force exerted by the blood flowing through the walls of blood vessels (Klabunde, 2005). CVD is one of the leading causes of death worldwide.

There is a risk of infection and pain associated with invasive (direct) blood pressure measurement using an intraarterial catheter (Pessana et al., 2019), and accurate blood pressure measurement using non-invasive methods such as Korotkoff sounds (Pickering et al., 2005) and oscillometry (Baker et al., 1997) is difficult, because certain parameters, including arrhythmia, obesity, and postural changes, tend to obscure arterial amplitude pulses detected with a cuff, resulting in errors in these measurements (Anastas et al., 2008; Sala et al., 2005). These are two traditional methods of measuring blood pressure. There have been several cuffless blood pressure methods proposed based on electrocardiograms (ECG) and photoplethysmograms (PPG), such as pulse transit time (PTT) and multiparameter approaches (Ding et al., 2016; He et al., 2015). An ECG and PPG can be used to calculate the pulse transit time (PTT), which measures how long it takes a pulse wave to propagate between two points in the cardiovascular system. In contrast, pulse wave velocity (PWV) is a very common method (Peter et al., 2014). In the tanks, pulse wave velocity (PWV) is the propagation speed of the pressure wave. It is based on the theory of wave propagation in elastic pipes.

There have been many attempts to fit regression models for BP estimation using PTT (Kumar, 2014; McCombie, 2006; Poon & Zhang, 2006), but none have met the standard criteria. According to (Gesche et al., 2012), this dependence could be eliminated by using a calibration procedure. Nevertheless, such calibrations are only reliable for a short period of time (Cattivelli & Garudadri, 2009). Calibration-based methods cannot be relied upon to replace conventional blood pressure measuring devices, but can be used to monitor blood pressure at short intervals (Kachuee et al., 2016). A robust and reliable method for non-invasive and continuous estimation of blood pressure is still a subject of research, leading researchers to develop other methods using machine and deep learning techniques using ECG signal only. Specifically, we compare two papers that estimate blood pressure via the ECG signal in terms of technique used for the extraction of statistical characteristics, complexity analysis, and machine learning modeling.

The reset paper is organized as follows, in section one we find the method, followed by results and discussion in the second section, and finally the conclusion.

## 2. METHOD

### 2.1 Data base

The method is trained and tested on data from CHARIS (Kim et al., 2016), plus three sets obtained from commercial ECG sensors, and MIMIC III waveforms with a wide range of blood pressure values (Moody et al., 2020).