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DUAL-SITE PHOTOPLETHYSMOGRAPHY SENSING FOR NONINVASIVE CONTINUOUS-TIME BLOOD PRESSURE MONITORING USING ARTIFICIAL NEURAL NETWORK

by

Anas Mohammad Odeh Ali Rababah

Faculty Advisor

Dr. Mohamed Atef Abdelaal, Department of Electrical and Communication Engineering

College of Engineering

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Abstract

Millions of people worldwide struggle from high blood pressure, often known as hypertension, and it is a major health concern that can lead to serious cardiovascular diseases, including heart attacks and many other consequences. Blood pressure monitoring that is reliable and accurate is crucial to the detection and management of hypertension. Although invasive techniques, such arterial catheterization, are considered to be the most accurate means of evaluating blood pressure, they can be painful, time-consuming and carry a risk of complications.

This thesis presents the development of a real time non-invasive blood pressure monitoring system based on commercially available microcontroller unit and dual-sited photoplethysmography (PPG) sensors. The system collects PPG signals from two different body sites using two PPG sensors, which are then processed using MATLAB to extract five-time domain features that have a relationship to blood pressure. Using the extracted features, two regression models were built: a linear regression model and a neural network (NN) model to estimate blood pressure values.

The experimental results show that the proposed system can estimate blood pressure values with high precision. The models were evaluated on 15 healthy volunteers. The linear regression model had a mean absolute error (MAE) and standard deviation (SD) of 5.86± 1.70 mmHg for SBP and 5.97 ± 4.2 mmHg for DBP, while the NN model had a MAE±SD 0.29 ± 4.49 mmHg for SBP and 0.5±2.4 mmHg for DBP. The proposed dual PPG site ANN model exhibited superior performance and robustness in real-time tests compared to the linear regression and classical ANN single-site PPG models.

The proposed system has several advantages in contrast to existing non-invasive blood pressure monitoring techniques. The system's accuracy and endurance are increased by using dual-sited PPG sensors because this allowed us to accurately extract an important feature from the two acquired PPG signals which is pulse wave velocity (PWV) that has a strong correlation to the blood pressure. In addition, the implemented algorithm was able to reduce the effects of motion artifacts and physiological variations which was a major factor that affected the system’s accuracy and reliability; however, the microcontroller unit makes the system suitable for use in a clinical setting by enabling real-time processing and display of blood pressure measurements. Furthermore, the use of machine learning algorithms, such as the NN model, allows for the development of personalized blood pressure monitoring systems that can adapt to individual physiological characteristics.

In conclusion the use of dual-sited PPG sensors and microcontroller unit with linear regression and neural networks in the proposed non-invasive blood pressure monitoring system exhibit promising results for accurate and reliable blood pressure measurement. Future research can examine the system's integration with mobile devices and wearable devices for example (fitness tracking watches) for creation of individualized monitoring systems for hypertension patients.

Keywords: Non-invasive Blood pressure monitoring, Photoplethysmography (PPG), Microcontroller, Regression analysis, Neural network, pulse wave velocity.