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Research On Blood Pressure Estimation from PPG using DL

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Abstract - This paper presents an innovative technique for the current non-invasive measurement of systolic (SBP) and diastolic (DBP) blood pressures and BGL (blood glucose level). Blood glucose and blood pressure are the most significant factors which mark health issues, adequate measurement of these parameters is required by a vast range of people. This project focuses on the fact that the measurement of these parameters can be effectively and accurately achieved through photoplethysmography (PPG) which is one of the non-invasive methods. The analysis of the PPG signals is also made to check the accuracy of the device. This review paper focuses on understanding the BP-related features from PPG and explores the growth of this technology in terms of validation, sample size, and diversity of topics, based on the datasets used over the period between 2010 - 2019. The data are pre-processed through normal Deep learning techniques and the algorithm of artificial intelligence and neural networks are applied to it. From this analysis, the accuracy of the data is also checked. All these methods are used for the continuous monitoring and evaluation of blood pressure and glucose level using PPG signals in a non-invasive way.

***Key Words*:** PPG, Biomedical Engineering, Machine Learning, CNN, ECG, Deep Learning, LSTM Algorithm

1.INTRODUCTION

In the human body the Blood glucose level (BGL) and the Blood pressure (systolic and diastolic pressure) were managed at the range of 70-100 mg/dl and 120-80 mmHg. With the advancement of recent technology, researchers have invented several invasive and non-invasive techniques.by the insulin produced in the human body. In the current system, the measurement of glucose levels craves the invasive method which is more tedious and brings pain for the user. Nowadays there is a common disorder called hypertension among both old age people and youngsters due to their stress in work. This hypertension disorder can lead to several heart disorders like stroke, heart failures, and kidney failures. To prevent these emergency situations, we need continuous measurement of the blood pressure in the human body.

Real-time analysis is very important for this purpose. recent trends and developments have been made such as wearable technologies used by human beings, these devices, such as heart rate variability monitoring etc., may perform some advanced tasks. Blood pressure is mechanically assessed by considering the difference in pressure between the blood vessels and peripheral agent obtrusive inflatable cuffs (the cuff that crunches the arm). An estimate is developed with the comparison of the pressures. Several methods like interstitial fluid harvesting, pulse arrival time, infrared light spectroscopy and others are invented for non-invasive blood glucose and blood pressure measurement. An alternative technique to these methods is the adoption of photoplethysmography (PPG) signals template which is one of the promising non-invasive methods. This can be achieved with a pulse oximeter.

PHOTOPLETHYSMOGRAPHY(PPG)

Photoplethysmography (PPG) is a non-invasive method that is optically based and aids in the assessment of changes in the volume of the blood. Hertzman and colleagues in 1937 issued the first paper that describes the measurement of fluctuation of blood in fingers. In order to its candor and booming nature, it has been widely utilized in the healthcare field. A lot of medical devices have been invented in the market commercially and are designed using the same principle. The fundamental PPG system depends only on a few components of optoelectronics which illuminates the tissue and consists of a photodetector that converts the irradiant changes that happen in the finger where fluctuation in the arterial volume of the blood occurs. The first paper explaining the measurement of blood fluctuation in fingers was published by Hertzman and colleagues in 1937. This technology is a low-cost and appropriate tool that can be used in many ways to track the cardiovascular system's heart rate, oxygen saturation, endothelial function, etc. The various different types of waveforms of PPG which have been noticed and it correlates with pathology cardiovascular and age. As the distension and volume of the arteries are related to the arteries pressure and the pulse waveforms of PPG signal that are common to waveforms of pressure that are generated with the help of tonometry. PPG gives a benefit that it can continuously measure inexpensive, miniature and optical electronics that are wearable. Addison in 2016 found STT (slope transit time) a single feature that connects PPG signal with Blood Pressure. STT shows a steep trend to the pulse wave that rises and it is slope parameter that is evaluated from the peak to foot of the waveform of systole. The PPG signal is collected with the help of Pulse data acquisition method. The PPG signal is recorded for three minutes from the individuals and data are stored BGL values. The collected data was thoroughly observed entirely for the three minutes with baseline drift and the interference of the power line. The samples of the signals are corrupted by baseline drift, noise and discontinuity are neglected from the training dataset. The complex can be reduced by extracting the window signal of a minute from the

PPG signal of three minutes. Neutral network requires a huge amount of data for reliable performance and training purposes. Other than this, the disturbed samples are uniformly distributed from the normal range to high diabetic condition, so that the neural network is created reliably

2. LITERATURE REVIEW

1. Joohyun et al. estimated ABP by employing a two-channel ultrasound system. PWV was calculated based on a combination of arterial vessel cross-sectional area and elasticity of the vessel. A flow phantom including a diaphragm pump, a soft latex rubber, and a reservoir was designed for the experimented setup. The pre-processing of signals was done by a bandpass filter to remove all the RF signal noise on both channels. The feasibility of ABP waveform calculation was shown in this research and the effect of PWV reflection on ABP was discussed. The measured PWV, using 16 cardiac cycles of data was 8.47 ± 0.63 m/s with an associated scaling error of −1.56 ± 14.0% in a direct pressure waveform comparison, showing minimum error on average. To meet the standard accuracy, the feasibility of this technique in vivo needs to be further validated.

2. Jayaraj et al. They Present the calibration-free technique using a dual magnetic plethysmograph (MPG) transducer and a single-element ultrasound transducer. has been presented. The measurement of arterial dimensions, along with local PWV, was needed for calibration-free evaluation. Therefore, an arterial compliance probe from the carotid artery was designed and validated for pulse pressure measurement on superficial arteries. The results of this study validated with ten volunteers highlights the value in tracking local PWV changes and carotid pulse pressure. Although the measured local PWV obtained a large correlation with brachial BP, the absolute value of local PWV and calculated carotid pulse pressure correlated at lower than the previously reported value.

3. Aaron et al. placed an ultrasound probe with force measuring capability, on the carotid artery and then the contact force between the probe and the patient's skin was slowly increased. Meanwhile, the ultrasound images and contact forced data video were recorded. An optimization MATLAB algorithm was used to calculate the BP from the video segmentation done by a Star-Kalman filter. Each time the pressure was reported, an algorithm calculated the patient-specific artery stiffness making it suitable for the patients with atherosclerosis. Moreover, the pressure measurement can apply to any artery and does not require medical supervision. Nevertheless, obtaining BP through this method takes a long time, and the result did not validate with any clinically approved technique.

4. **Braiam et al.** calculated the PAT as the difference time between R-peak of ECG and two points of PPG waveform. First is the maximum amplitude of PPG and second is the sharpest slope of the rising edge of PPG. After initial filtering, eight subjects from the MIMIC database were selected for the experiment. A linear regression model was used to show the relationship between the PAT and the systolic, diastolic and mean BP. The results showed a strong correlation between BP and PAT, but the sample size was not large enough to meet the clinical standards.

5. Zunyi et al. Presented, A chair-based method using PART-based technique This system consists of an ECG with four electrodes, a PPG sensor with green lighting LED and a photodetector. Additionally, a control circuit with a Bluetooth module and a high-capacity battery was mounted on a common armchair. The ECG and PPG signals were collected from users while they are 19 in a sitting position. All the collected data transfer to a PC to calculate the beat-to-beat PAT. A cuff-based method was considered as a reference and the results were validated on 12 subjects with no CVD histories. In spite of the acceptable results of this method, elderly subjects and hypertensive people need to be involved in further validation and a cuff-less calibration method needs to be considered.

6. Qiang et al. used a Kalman filter to improve signal quality and overcome this issue. The MIMIC II database was used to evaluate the method and the twenty signals, including the ECG, ABP, and PPG were selected. An FIR band-pass filter was employed to filter all signals during the process and the Pan Tompkins algorithm was considered to select the R-peak of ECG. The PAT was then calculated as the time difference between the R wave and the synchronized PPG signal. The least square algorithm was used to calibrate the PAT to BP every 30 minutes. A joint signal quality index (JSQI) was used to adjust the Kalman filter and reduce the effect of noise and artefacts on the PPG and ECG signals. The simple computation of the proposed algorithm makes it very suitable for wearable devices. Nevertheless, the MIMIC II database has small BP variation, and a different database needs to be used for validation of such a technique.

7. Yali et al. validated the accuracy of the PAT method on 24 subjects, including 15 hypertensive patients. A PAT-based cuff-less armband wearable device including one PPG sensor and two pieces of e-textile ECG patch was used every 15 to 30 minutes to monitor the BP during daily activities. At the same time, an experienced nurse measured the BP with an sociometric BP device attached to the upper arm of the subjects. The Bland-Altman plots were employed to estimate mean SBP and DBP during the day and nighttime activities. The results showed that the PAT-based method could replace the traditional BP monitoring for night-time ABP monitoring via cuff-less and convenient monitoring methods. However, the accuracy of this method on day-time is not as accurate as at night-time.

8. Satu et al. used an arm ECG and finger PPG to measure the PAT in four different methods. The PAT was estimated as the time interval between the ECG R peak and four different points in the PPG. 10 subjects in a seated position were involved for measurements and the signal processing was completed by using the MATLAB program. The results of different measurement techniques were compared, and the first PPG signal derivative was considered as the most promising method. To enhance the accuracy and increase the reliability of the measurement, the signal quality in noisy environments needs to be further investigated and improved.

3. METHODLOGY

The proposed method uses the PPG technique to monitor blood pressure apart from other techniques. The obtained pressure values are collected and a database is created. The database is given to a machine learning algorithm i.e LSTM module which predicts the future blood pressure values. The main advantage is that it's not a static measurement system hence providing continuous pressure values. So, anyone can accurately predict future pressure values. If the future health condition of a person can be predicted in this way, early disease prediction and prevention are possible.

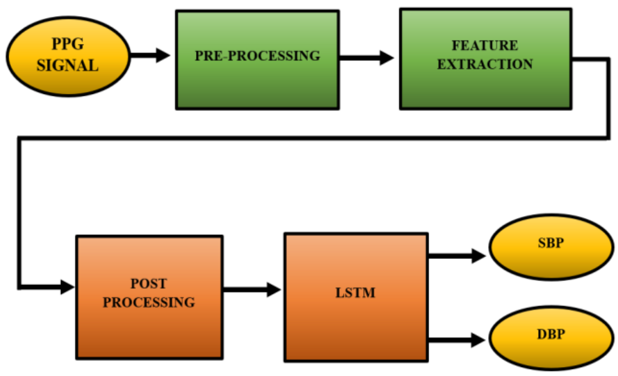

Figure 1. Block Diagram of System

FLOW CHART

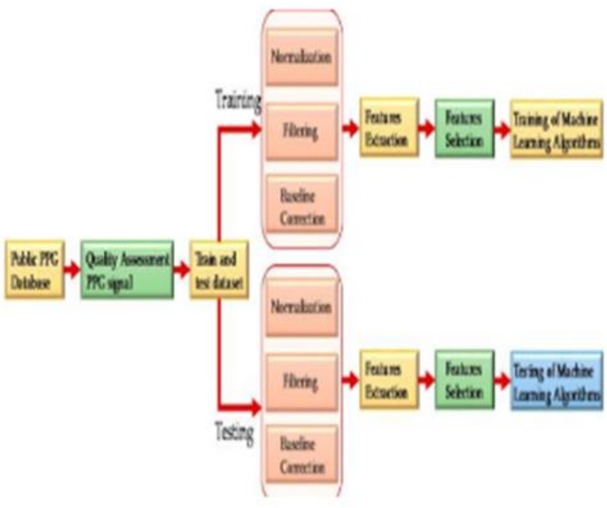

Figure 2. Flow Chart of System

WORKING

In this project, Photoplethysmography (PPG) technique is used to monitor blood pressure. PPG involves shining a light on the skin and detecting changes in the light as it passes through the blood vessels. These changes are caused by the pulsation of blood through the vessels. The PPG signals are collected and the corresponding blood pressure values are also collected simultaneously. This data is used to create a database. Long Short-Term Memory (LSTM) is a type of recurrent neural network (RNN) that is capable of processing sequential data. In this method, the collected PPG signals are fed to the LSTM module which is trained to predict the future blood pressure values. The advantage of this method is that it provides continuous monitoring of blood pressure values as the PPG signals are obtained in real-time. This allows for continuous prediction of future blood pressure values. By continuously monitoring blood pressure values, it is possible to detect changes in the values which may indicate the onset of a disease or health condition. Early detection and prevention can lead to better health outcomes for individuals.

4. SYSTEM REQUIREMENT

1. Processor: Intel Core i7- 8th Gen
2. Installed memory (RAM): 4.00GB
3. System Type: 64-bit Operating System

SOFTWARE REQUIREMENT

- Python Software IDE

MODULES USED

- Os
- Tensor Flow
- Scipy
- Pandas
- Nummy
- Matlobib
- Keras

IMPLEMENTATION

Implementation carried out in various Steps

Step 1: The implementation of the proposed DL model is carried out using importing the nummy, pandas, seaborn, scipy, and pyplot from Matlobib And the OS. Import the Linear regression and Random Forest Regression.

Step 2: Load all Samples. the total samples are 1000. The Sample size is 125.

Step 3: Reshaping the PPG, ECG, and BP data into the Column vector.

Step 4: plot the graph by using Matlobib of PPG and ECG and BP.

Step 5: Train and Test Using Linear Regression model.

Step 6: Train and Test Using Decision Tree Regression

Step 7: visualized by plotting graph using pyplot of The Train Error and True BP values and Predicted BP values.

Step 8: Predicting On test Set

Step 9: Cross Validation

Step 10: Load the Model by Importing the Kereas and Tensor flow.

Step 11: Define Model

Step11: Input Dim for Train

Step 12: build Model

Step 13: calculating The Epoches

Step 14: Predicting the Test Set Using the NN model

RESULT

The Result of the Proposed Model is plotted by using Pyplot. The Graph is plotted between the Train Loss and Means Absolute Error.

Input

```
25] plt.title('Train loss against mean_absolute_error')
    plt.ylabel('Loss')
    plt.xlabel('Epoch')
    plt.plot(history.history['loss'])
    plt.plot(history.history['mean_absolute_error'])
    plt.legend(['Loss', 'Mean_absolute_error'])
```

Figure 3. Shows the Input of the graph between the Train Loss and the Means Absolute Error.

Output

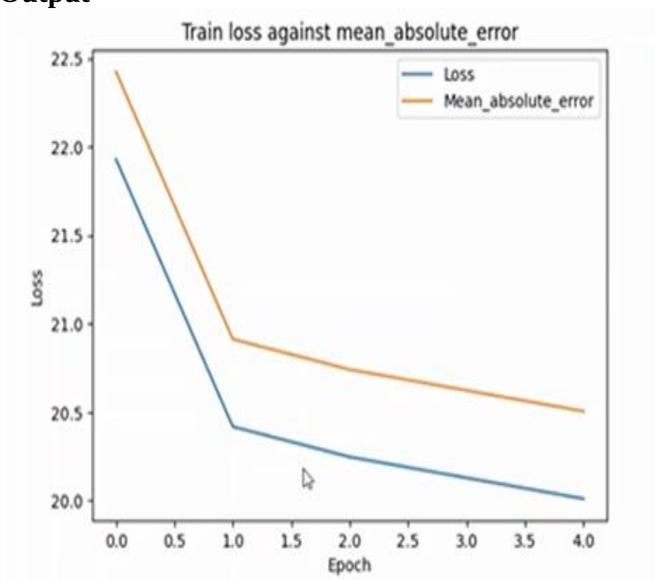

Figure 4. shows the Output of the graph between the Train Loss and the Means Absolute Error.

5. CONCLUSION

In this study, we propose a non-invasive and beat-to-beat method of BP estimation determined only from the PPG signals. This is achieved using a typical-structure CNN. With the wearable PPG sensor becoming an increasingly popular technology, this method has practical significance as part of a big data solution.

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BIOGRAPHIES

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