

Biometric Recognition for Twins Inconsideration of Age Variability using PPG Signals

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Abstract—Recent biometric modalities involve biomedical signals such as PPG to identify individuals. This study has been motivated by this new research area using PPG signal to identify twins incorporating age variability. The proposed system is suggested to be a substitute to the current traditional methods being used widely nowadays. A total of 21 subjects were used for experimentation purposes and lowpass filter is applied to remove unwanted noise from the signal. Distinctive features are extracted from the filtered PPG signals. Later, Bayes Network (BN), Naïve Bayes (NB), Radial Basis Function (RBF) and Multilayer Perceptron (MLP) were used to classify the subjects using the discriminant features. Based on the experimentation results, classification accuracies ranging from 90% to 100% were achieved by categorizing the data into six different sets which are overall dataset, Groups I, II, III, IV and V. The result provides an alternative mechanism to identify twins using PPG signals incorporating age variability besides using the traditional methods.

Index Terms—Bayes Network (BN); Multilayer Perceptron (MLP); Naïve Bayes (NB); PPG; Radial Basis Function (RBF).

I. INTRODUCTION

Recently, with the evolution of advanced technology that have been produced and enhanced in most of the develop countries, there are some irresponsible person who misuse the technology by making a fraud especially identity fraud. As reported by Javelin Strategy and Research, identity fraud victims in US have increased significantly from 13.1 million in the year 2015 to 15.4 million in 2016 [1] as shown in Figure 1.

In addition, as reported in BBC news from UK [2], identity theft victims have escalated from 94500 in the year 2014 to 148000 victims in 2015 which shows the seriousness of this issue. It not only happens among individual but also popular among the twins. Twin is at least two persons who are most likely similar in terms of their physical appearance and can cause confusion in recognizing each of them to the society. As for example, in Arizona, a 19 years old teenager from Orlando Nembhard was framed by committing a murder. However, he was released after the judges were unable to prove whether Orlando or his twin brother, Brandon was the criminal [3].

In the report by UK Daily Mail, a 22 year old woman was caught for using her twin sister's passport to go out of Turkey by the intention to join ISIS [4]. For this reason, a system that is able to identify and differentiate an individual based on the physical and behavioral characteristic especially for twins incorporating age variable is needed. The system that satisfies the criteria is known as biometric.

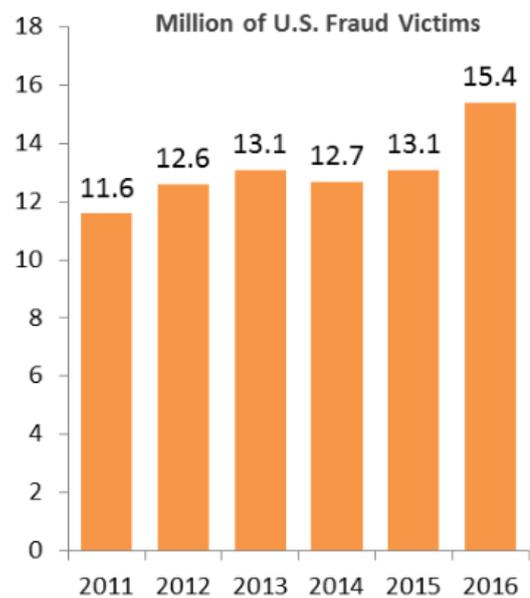


Figure 1: The statistic reported by Javelin Strategy and Research involving identity fraud [1]

Biometric system is a well-known system that has been used widely in most of the countries nowadays with the capability to recognize an individual's effectively. It can be performed by evaluating the performance of the biometric modalities such as fingerprint, iris, retina and palm print. In a lot of countries, biometric recognition using fingerprint and iris are the most popular and can be found easily, for example in airports, government agencies and financial institutions. However, these biometric modalities are not able to provide the liveness detection of the subject.

Hence, new biometric modalities from biomedical signals such as electrocardiogram (ECG), electromyography (EMG) and photoplethysmogram (PPG) were proven to have competency to distinguish individuals [5]. Furthermore, PPG based identification technique involving twins incorporating age variability is still an under-researched area.

PPG device is commonly used to evaluate the skin blood flow using infrared light. PPG signal contain a value of systolic, diastolic peak and dicrotic notch as in Figure 2 which are the essential component in a PPG signals since it is different from one and another that indicates the uniqueness of the signal's feature. PPG signals are normally used to measure oxygen saturation, blood pressure, cardiac output and assessing autonomic functions which can be obtained using pulse oximeter that is attached to the fingertip or

earlobe [6]. Compared to ECG, EMG and other biomedical signals, PPG device have a leading advantage since it is non-invasive, low cost and small in size that makes it as a convenient analytical tool.

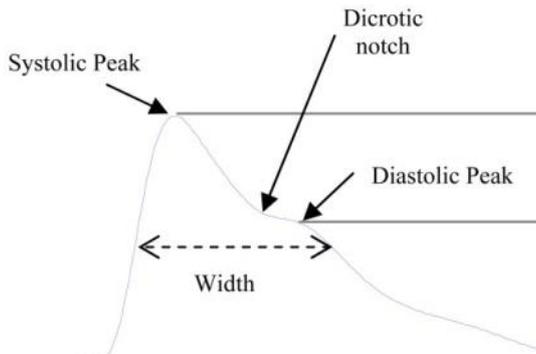


Figure 2: Main component of PPG signal

The continuing sections in this paper are organized as follows; in Section II, the related works of biometric identification system based on PPG are briefly discuss. Next on the Section III, the proposed method is explained further and later in Section IV, the experimentation and results are elucidated. Finally, Section V concludes the study based on the experimentation results of the previous section.

II. RELATED WORKS

The studies related to the PPG based biometric identification system have been performed. This section briefly explains on PPG based biometric identification system from previous literatures.

Chakraborty et. al in [7] elaborates on PPG recognition system by using Linear Discriminant Classifier (LDC). The study begins with signal acquisition of 15 subjects age range of 20-45 years old by using BiopacMP device. Then, the data are preprocessed by removing all the unwanted noise in the signal by using a low pass FIR filter. Later, the processed data are calculated and separated into first and second order derivatives. The data were examined and the salient features were extracted from the overall datasets. Each of the extracted signals contains 12 fiducial point and the final stage of verification is done by using LDC. As a result, 100% of classification accuracy were achieved which shows the proficiency of the proposed system. However, the study is unreliable since it was only tested with a small datasets using one classifier. The research should be tested with larger datasets with other types of classification techniques.

In another study continued by Choudhary et. al in [8], it presented the robust PPG biometric recognition for health applications. In this study, the data were acquired from MITBIH Polysomnographic Database (slpdb) and Challenge 2014 Training Set (Challenge/2014/set-p) which consists of 30 subjects. Next, the research continued with preprocessing stage by using Gaussian derivative filter (GDF) to eliminate the artifacts inside the signal. Then the processed signal undergoes the systolic peak detection stage by identifying three different steps which are: 1) Squaring and Adaptive thresholding, 2) Shannon Energy Envelope (SEE) Signal Extraction and 3) Peak Location Determination and Correction Rule. Later, all of the extracted signal were combined and observed. Finally, the efficiency of the variable data including, normalized cross correlation (NCC), wavelet weighted-based PRD (WWPRD) and wavelet

distance measure (WDIST) were measured by template matching technique. As a result, 99.5-100% of performance accuracy were achieved which shows the competency of the study. However, the study does not clearly explain on the uses of the proposed system for health application.

A study by Jindal at. al in [9] explained on PPG recognition system based on an adaptive deep learning technique. The process started by collecting the data from TROIKA database which involved 12 male subjects with the age range between 18 until 35. Then, the study continued with preprocessing stage by using seventh order Butterworth filter to remove the noise and smoothen the signals. Later, the segmentation process is done by identifying the discriminant features of the PPG signals. Afterward, the interpolation and extrapolation stages are performed by acquiring a total of 125 points for each of the segmented feature. The feature of PPG signals were later extracted and clustered by separating the data into different groups: 1) C1, 2) C2 and 3) C3 based on the specifications of gender, obese or non-obese. The performance of this method were measured from three clusters C1, C2, C3 with accuracies of 96.4%, 95.7%, 96.1% respectively from the classification stage involving Deep Learning classification indicating the ability of the study. However, the study was limited in terms of data since it only has male subjects and could focus on wider age range.

To summarize, biometric identification by using PPG signals have proven its capability to recognize a person. However, these previous studies did not consider twins incorporating different age as the essential component. Thus, in this work proposes a twin recognition method based on PPG signal.

III. METHODOLOGY

This study proposed four stages of PPG based biometric identification which start with signal acquisition, preprocessing, feature extraction and classification algorithm which can be summarize as in Figure 3 and are explained further in the next subsection.

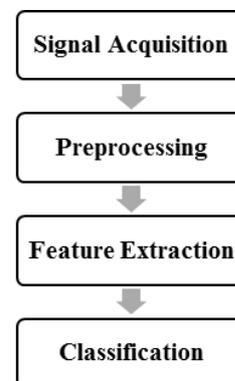


Figure 3: The proposed method of PPG based biometric identification for twins incorporating age variability

A. Signal Acquisition

The study starts by collecting of raw PPG signals from 21 individuals consisting of nine couple of twins and a couple of triplet twins. The subjects involve of 15 females and 6 males in resting condition with the age range between 6 until 30 years old as categorized in Table 1.

Table 1
Grouping of data

Group	Age range
I	6-10
II	11-15
III	16-20
IV	21-25
V	26-30

B. Preprocessing

The raw and unfiltered PPG signals later undergo the preprocessing stage by removing the unwanted noise using the low pass filter. As a result, the filtered signal will be smooth and contains less noise after the preprocessing procedure.

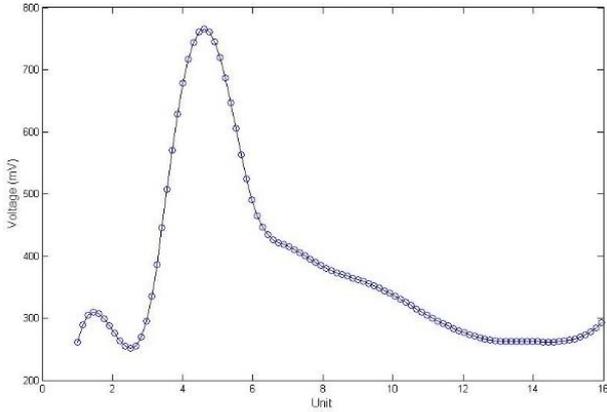


Figure 4: Extracted PPG signal consists of 100 fiducial point

C. Feature Extraction

Next, 100 fiducial points as in Figure 4 consists of systolic peak, diastolic peak and dicrotic notch are extracted from the overall signals to be used as unique features since the value are different because every trait that a person has differs from others.

D. Classification

Finally, to evaluate the performance of the proposed system, the PPG signals are classified by using four different classifiers which are Bayes Network (BN), Naïve Bayes (NB), Multilayer Perceptron (MLP) and Radial Basis Function (RBF). The result and analysis are performed based on these classification algorithm processes.

IV. EXPERIMENTATION AND RESULTS

In this section, the experimentation and result according to the proposed biometric recognition system as shown in Figure 3 is explained in detail. A total of 21 PPG signals were taken from the twins. Next, these raw PPG signals are processed using a low pass filter to remove the noise. The outcome of this step is illustrated as in Figure 5 and Figure 6.

Then, the filtered PPG signals undergo feature extraction process which all of the unique feature of an individual were extracted as in Figure 7 and Figure 8.

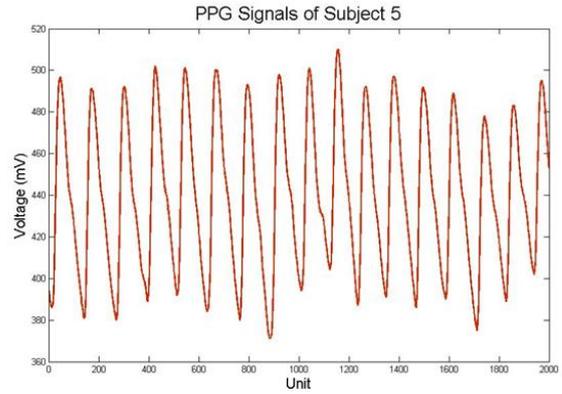


Figure 5: The filtered PPG signals of subject 5

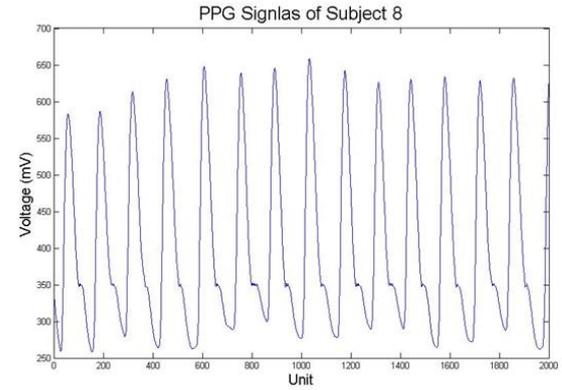


Figure 6: The filtered PPG signals of subject 8

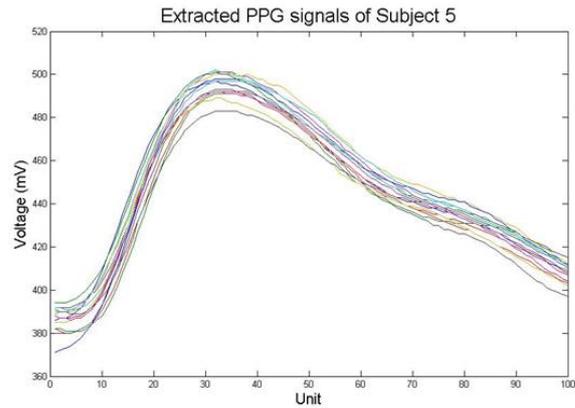


Figure 7: Extracted PPG signals of subject 5

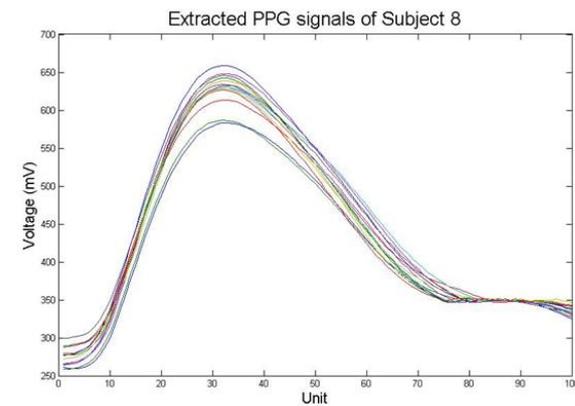


Figure 8: Extracted PPG signals of subject 8

Last but not least, all the extracted signals were classified by commonly used classifiers which are BN, NB, MLP and RBF. The results are separated into six different categories

which are 1) overall dataset, 2) Group 1, 3) Group 2, 4) Group 3, 5) Group 4, and 6) Group 5 as in Table 2.

According to the results obtained in Table 2, Group II and Group IV obtain high accuracy with 100% for all BN, NB, MLP and RBF followed by Group I with 100 % on MLP, and 97.5% for BN, NB and RBF. Group III and V are having slightly lower classification accuracies with 96% from MLP and RBF and 90% and 92% for BN and NB respectively for Group III whereas for Group V, BN and NB obtain 95% classification accuracy and 90% and 92.5% for MLP and RBF correspondingly. For all dataset, the classification accuracies of 90.48%, 93.33%, 92.38% and 94.29% were achieved via BN, NB, MLP and RBF suggest the capability for the whole system.

Table 2
The performance accuracy of the proposed method

Group	Accuracy (%)			
	BN	NB	MLP	RBF
All Dataset	90.48	93.33	92.38	94.29
I	97.5	97.5	100	97.5
II	100	100	100	100
III	90	92	96	96
IV	100	100	100	100
V	95	95	90	92.5

Based on the experimentation, it is found out that the result are not fixed for all dataset, however, children do have a slightly higher accuracy than an adult as can be seen in Group I and V. This is because they have a higher metabolism level compared to adults which might influence the accuracy of the proposed system [10]. Besides that, from the overall outcome, it is found out that MLP and RBF from neural network classifier are having better accuracy as compared to Bayes theorem by using NB and BN. This is due to neural network capabilities which are [11]:

- Nonlinearity
- Input–Output Mapping
- Adaptivity
- Evidential Response
- Contextual Information
- Uniformity of Analysis and Design

In a nutshell, the result, the study proved that PPG based biometric identification for twins incorporating age variability obtained high accuracy rates. Thus, it suggest that PPG based biometric identification for twins incorporating age variability is practicable to be used and compliments traditional recognition methods

V. CONCLUSION

As a conclusion, PPG signals proved its capabilities to be used for twin recognition incorporating age variability. Four stages have been accomplished and the method of biometric

recognition also has been understood. Based on the experimentation results, the proposed system is capable of recognizing individuals regardless of the twin characteristic from different age. Hence, the result delivers a possible technique to recognize individuals. Besides that, PPG signals also have an advantage which is the proof of life that is not obtainable in non-bio signal biometric modalities. This factor contributes to the reliability of the proposed technique since each of the PPG signals of individuals is unique, cannot be duplicated and the person need to be present during the process of data acquisition.

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