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CORRELATION STUDIES OF PPG FINGER PULSE PROFILES FOR BIOMETRIC SYSTEM

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ABSTRACT: Biometric system employing finger scan may be impersonated either by use of artificial replica or by putting a thin film of the finger-print of the person to be impersonated, on the living finger of the imposter. This paper explores the possibility of using pulse PhotoPlethysmoGraphic finger profile as an additional parameter used in conjunction with the finger scan. Uniqueness of finger pulse-profile is validated in the preliminary study.

Keywords: Biometric system, Finger scan, PhotoPlethysmoGraphy (PPG), Finger Pulse Profile, Correlation.

1. INTRODUCTION

To establish the identity of any person, normally three major methods are employed i.e., what you have, what you know and what you are [1]. For example when we want to withdraw money from ATM, the ATM card is what you have and the ATM password is what you know. In addition to this for high security application we often go for third method-what you are, wherein some unique unchanging physiological parameter of a person is recorded. This may include finger print, iris scan, hand scan, facial scan and interestingly even gait of a person [2, 3]. Often finger scan method is considered to be time-tested and reliable since centuries. However this method suffers from some serious deficiencies and therefore needs to be improved by incorporating finger pulse-profile taken with Photo PlethysmoGraphy (PPG). PPG is an optical measurement technique used to detect blood volume changes in the micro vascular bed of tissues. Invisible infra-red light is sent in the tissue and the back-scattered light corresponds with the variation of the blood volume. The detection of PPG peaks helps in finding the beat-to-beat varying parameters. Dicrotic notch detection is very important in the assessment of hemodynamic parameters. Additionally, the shape of the PPG waveform differs from subject to subject, and varies with the location and manner in which the pulse oximeter is attached [4]. The method of recorded PPG, thus needs to be standardized.

2. PROBLEM DEFINITION

Biometric technology primarily establishes the identity of a person i.e., "I AM, WHO I AM" using some physiological parameters [5]. One of the commonly used biometric parameter is finger-print. In order to rule out the possibility of any imposter making use of an artificial replica of the finger, many modern techniques crosscheck that the finger-print is scanned from a living finger. Here too the possibility exists that the imposter may coat his living finger with thin film of finger-print copied from the subject to be impersonated. In order to rule out this possibility as well, we are proposing a method in which PPG finger pulse-profile of a subject is recorded in conjunction with the finger print-scan for high security applications. It is therefore required to establish that the finger pulse-profile of a subject for a given finger shall have higher correlation with its own finger than with any other finger of any other subject. Further it needs to be verified that this correlation for the same subject in same finger remains the highest over extended period of time under different physiological conditions as well.

3. METHOD

The MP150 data acquisition system of Biopac is utilized to take the measurements. The PPG100C amplifier is coupled with the TSD200 photoplethysmogram transducer, which is placed on the tip of the finger. The data is acquired at 10,000 samples per second. Band-stop IIR filter at 50Hz frequency is used to remove noise. Profile of one finger is taken at a time and the data is acquired for at least 10 second. This process is repeated for the remaining fingers of both the hands. This procedure is followed for acquiring the data of seven different subjects, and this is repeated over a period of one month. As the pulse of each finger is taken at different time so it is first normalized on time-scale to eliminate any differences on account of the variation in beat to beat interval. This is done by taking 200 samples from peak to peak of two alternative pulses (say between peak1 and peak 3), irrespective of the peak to peak duration. The correlation of each finger profile-data with respect to other fingers profile-data of same and different subjects is calculated. The two profile-data are made to slide over each other by at

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least half the duration of pulse width with step size of one sample duration. The maximum of the correlations so obtained is retained. The formula to find correlation is given as:

$$r_{xy} = \frac{\Sigma x_i y_i - n\bar{x}\,\bar{y}}{(n-1)x_x s_y} = \frac{n\Sigma x_i y_i - \Sigma x_i \Sigma y_i}{\sqrt{n\Sigma x_i^2 - (\Sigma x_i)^2}\sqrt{n\Sigma y_i^2 - (\Sigma y_i)^2}}$$

Where $\bar{x}$ and $\bar{y}$ are the sample means of X and Y, s_x and s_y are the sample standard deviations of X and Y, n is number of pairs of measurement, $\Sigma x_i y_i$ is the sum of product of paired variables, Σx_i sum of X variable, Σy_i sum of Y variable, Σx_i^2 sum of squared X variable, Σy_i^2 sum of squared Y variable.

4. RESULT AND DISCUSSION

The shape of pulse profile of each subject is different from the other. In some cases the difference is so prominent that can be observed simply by viewing the difference in the pulse shape of say index finger of the three different subjects as shown in Fig. 1

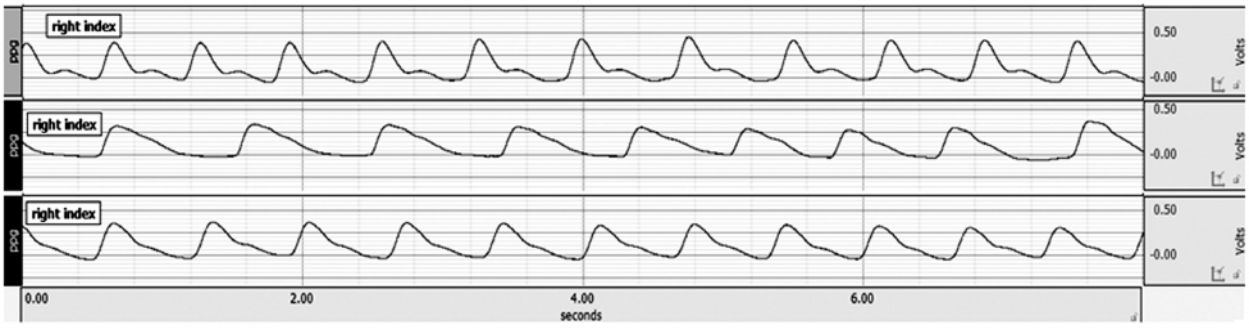

Figure 1: Right Hand Index Finger Pulse Profiles of three Different Subjects

It is seen from Table 1 that the autocorrelation i.e. correlation of the pulse profile of same subject, same finger is always higher as compared to correlation of same finger in different subjects. This result holds well in 70 out of 70 cases, repeated three times at an interval of one week. Interestingly it is observed that autocorrelation i.e. same subject, same finger is mostly higher as compared to correlation of different finger in same subject. This was found 67 out of 70 cases. Even for three remaining cases this method poses no security risk as subject is same even though finger is different.

Table1
Correlations of Different Subjects

subject 1	rightindex	rightmiddle	rightring	rightlittle	leftindex	leftmiddle	leftring	leftlittle
rightindex	0.9976	0.993	0.982	0.9957	0.9919	0.986	0.9824	0.9653
rightmiddle	0.993	0.9938	0.9577	0.9843	0.9862	0.9784	0.9732	0.9565
rightring	0.982	0.9577	0.9951	0.991	0.9786	0.9757	0.977	0.9581
rightlittle	0.9957	0.9843	0.991	0.9962	0.9926	0.9915	0.9913	0.9724
leftindex	0.9918	0.9862	0.9785	0.9926	0.9983	0.9869	0.9856	0.9669
leftmiddle	0.986	0.9784	0.9757	0.9915	0.9868	0.9943	0.9922	0.992
leftring	0.9823	0.9732	0.977	0.9913	0.9856	0.9922	0.9932	0.9807
leftlittle	0.9653	0.9565	0.9581	0.9724	0.9669	0.992	0.9809	0.9925
subject 2	0.9648	0.9553	0.9813	0.9568	0.9315	0.9496	0.9544	0.9601
subject 3	0.9721	0.9205	0.9629	0.9587	0.9669	0.9672	0.93	0.9523
subject 4	0.97	0.9308	0.9643	0.9661	0.9057	0.9467	0.958	0.9415
subject 5	0.9725	0.9002	0.9725	0.963	0.9304	0.9746	0.9479	0.9805
subject 6	0.9225	0.8739	0.9483	0.922	0.9093	0.9406	0.9153	0.9353
subject 7	0.9839	0.9062	0.9221	0.9828	0.9761	0.9777	0.9268	0.9563

5. CONCLUSION

On the basis of uniqueness of duly time-scaled pulse profile of subject, there exists a possibility of using PPG finger pulse-profile of subject as an alternative biometric parameter, in addition to fingerprint traditionally being used. This may result in higher security and reliability of biometric system. Further for establishing the pulse-profile signal as a biometric parameter the same study may be extended to large number of subjects, repeated over a longer duration of time.

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