A New Method to Improve Multibiometric Recognition

Rodolfo Vertamatti
Signal Processing Laboratory
Escola Politécnica – University of São Paulo
Av. Prof Luciano Gualberto, trav. 3, 158
05508-970, São Paulo-SP, Brazil
rvertama@usp.br

Miguel Arjona Ramirez
Signal Processing Laboratory
Escola Politécnica – University of São Paulo
Av. Prof Luciano Gualberto, trav. 3, 158
05508-970, São Paulo-SP, Brazil
miguel@lps.usp.br

***Abstract*—Multibiometrics performs better than respective monobiometrics and minimizes noise and spoof attack problems. However, if similarities are in all traits, multiple source processing does not improve performance. To distinguish extreme similitude, epigenetic and environmental influences are more important than DNA. This study examines phenotypic plasticity in human asymmetry as a tool to ameliorate multibiometrics. A technique called Bilateral Processing (BP) is described here to analyze discordances in left and right trait sides. BP tested visible and infrared spectrum images using Cross-Correlation, Wavelets and Neural Networks. Chosen traits were teeth, ears, irises, fingerprints, noses and cheeks. Acoustic BP was also implemented for vibration asymmetry evaluation during vocalic sounds and compared to MFCC plus Vector Quantization speaker recognition. Image and acoustic BP assessed 9 adult male brothers over one year. For test purposes, left biometrics was impostor to right biometrics from the same individual and vice-versa, which led to 18 x 18 identification matrix per trait. Results achieved better performance in all biometrics treated with BP than without BP.**

***Index Terms*—Biometrics, Human Fluctuating Asymmetry, Multibiometrics**

I. Introduction

Ensemble of biometric sources using proper fusion methods outperforms each of the individual source performances. Besides, noise and impostor attacks can be circumvented by the use of multi-sensor, multi-modal biometrics [1].

Notwithstanding, multibiometrics becomes useless in extreme biometric similarities, as for monozygotic twins. Results tend to mistake twins and extra traits do not raise separability. To solve this, biometrics should consider human features in which DNA is not the determinant factor in order to overcome limits imposed by narrow genetic distance.

Human bilateral trait sides (BL) are composed of two quasi-identical mirrored images (left and right). Despite pertaining to the same person, if one of the sides is reversed, one can look for BL idiosyncrasies.

With enough resolution, each human trait is one-of-a-kind – including BL of a person – as observed in ears [2], irises [3], fingerprints [4], etc. Differences in equal DNA entities (like BL) are caused by epigenetic or environment influences.

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This study introduces a non-holistic technique called Bilateral Processing (BP) that stresses left / right peculiarities. Seven biometric traits, captured by three sensors, are tested in three recognition systems. BP is compared to "without BP" systems under same circumstances. Implementation structure is presented in section II, along with the obtained results.

II. Bilateral Processing Implementation

Figure 1 shows the recognition system block diagram divided in sensors, pre-processing, BP, classification and fusion. Iris is shown as an example of biometric trait. The diagram is divided in database formation (training) and test. BP is divided in alignment, segmentation and bilaterism.

In alignment, samples are centralized by trait-specific reference marks. Segmentation divides the trait in potential biometric areas. Bilaterism outputs a list of asymmetric segments. This list is used during the test phase to localize idiosyncrasies.

Traits, sensors, test conditions, algorithm and results are described below.

A. Biometric Traits in accordance to Sensors

1) Visible Spectrum Images

Images taken in the 0.39 μm to 0.75 μm wavelength region. Selected traits were: teeth shape, ears veins and contours, irises pattern, fingerprints ridges and nostrils formats.

2) Infrared Spectrum Images:

Images taken in the 8 μm to 13 μm spectrum range. Human thermal emission peaks around 9.5 μm. Infrared images indicate internal vascular system and organ activities. This study monitored facial cheeks inequalities.

3) Skin Vibration during Vocalic Sounds:

Several kinds of acoustic waves (longitudinal, transverse, surface, etc) propagate inside the body during voiced sounds. As consequence, complex vibrational modes appear on the skin surface. Due to body asymmetry, vibrational modes are asymmetric as well. Sensors positioned in symmetrical areas measured left and right facial vibrations during constant pitch diphthong ("a" + "i") phonation.

B. Sensors

1) Visible spectrum sensor:

A full-frame sensor was used with 21.1 Mpixels and radiometric resolution of 14-bit per red, green and blue channels. Lens had f/2.8 of maximum aperture, f/16 of minimum aperture and magnification from 1 to 5 times.

2) Infrared sensor:

Uncooled focal plane array microbolometer with 19.2 Kpixels, ±0.1°C of precision, ±2ºC of accuracy and 3.1mrad of instantaneous field of view.

3) Acoustic sensor:

Two capacitive contact microphones symmetrically located on left and right buccinator muscles. Sampling rate to both channels was 48KHz and 16384-sample window was used to detect low-frequency variations (below 15Hz).

C. Test Conditions

Test population was composed of nine adult male brothers (brothers have the lowest genetic distance with the exception of twins). Up to 20 samples per trait were taken over one year. For test purposes, right biometric trait was impostor to the left one and vice-versa. BL of 9-persons population turned into 18x18 identification matrix per biometric trait.

D. Specific Bilateral Processing

Two image BP (Correlation and Wavelet + NN) and one acoustic BP were implemented. Both image BP processed visible and infrared spectrum images. No execution of segmentation and bilaterism characterized the image non-BP, and whole trait images were used instead of segments. Whole trait and segments were formatted to equivalent image sizes. The three methods are described next along figures 2 to 4.

Figure 2 presents the matrix obtained by the Correlation Pattern recognition method [5], exemplified by irises. This figure displays the database composed of 18 bilateral sides, left and right of each person. Test samples and database are divided in two sets: "with BP" and "without BP", to be confronted later. "With BP" uses 5 segments positions per person and the whole trait is presented for "without BP".

Wavelet parametrization [6] and Neural Network classification [7] method is illustrated on figure 3. 18 whole traits for non-BP and 810 segments (5 segment positions per person) for BP are transformed in wavelet coefficients and compared to the database via two-layers neural network.

In the acoustic BP, the vocalic signal is segmented in each of the harmonics of the voice pitch. Figure 4 depicts an example: 4th harmonic is extract from diphthong [ai] and left and right channels are confronted by a normalized difference equation, whose amplitude variation is shown. Phase and amplitude behavior of each harmonic are particular to each person and his/her left and right channels. Differently to the image BP, acoustic BP cannot be adapted as non-BP, thus a new speaker recognition system based on 20-triangular-filter MFCC [8] and 16-centroid Vector Quantization [9] was created to identify the 9 left and 9 right channels.

E. Results

Tables below show results obtained for "with BP" and "without BP". Table I exhibits the results of both image recognition methods. In both cases, bilateral processing improved substantial performance. The acoustic data from table II indicates that non-BP identified persons, but confused their channel sides, while BP identified persons and if the recording is from left or right channel.

TABLE I. WITH AND WITHOUT IMAGE BILATERAL PROCESSING

Image Biometric Trait	Cross-Correlation: Minimum Genuine/Impostor Relation		Wavelet + Neural Networks	
	Without Bilateral Processing	With Bilateral Processing	Without Bilateral Processing	With Bilateral Processing
TOOTH	0,85	1,01	28%	100%
EAR	0,72	1,46	25%	100%
EYE	0,96	2,48	12%	100%
FINGER	0,88	1,48	30%	100%
NOSE	0,57	1,13	34%	100%
CHEEK	0,75	1,10	33%	100%

TABLE II. WITH AND WITHOUT ACOUSTIC BILATERAL PROCESSING

Acoustic Biometric Trait	Non-BP by MFCC and Vector Quantization		BP by normalized channel subtraction (18 channels)
	(9 persons)	(18 channels)	
VOICE	100%	44%	100%

III. CONCLUSIONS

Results show that Bilateral Processing was necessary to achieve maximum identification at segment level in small and low genetic distance population. Chosen segments proved stability over one year.

Few researches consider human asymmetry in biometrics. It is a field of great potential to extend analysis to larger population, different sensors and biometric traits. It brings double dimension to match decisions and intensifies epigenetic and environmental influences.

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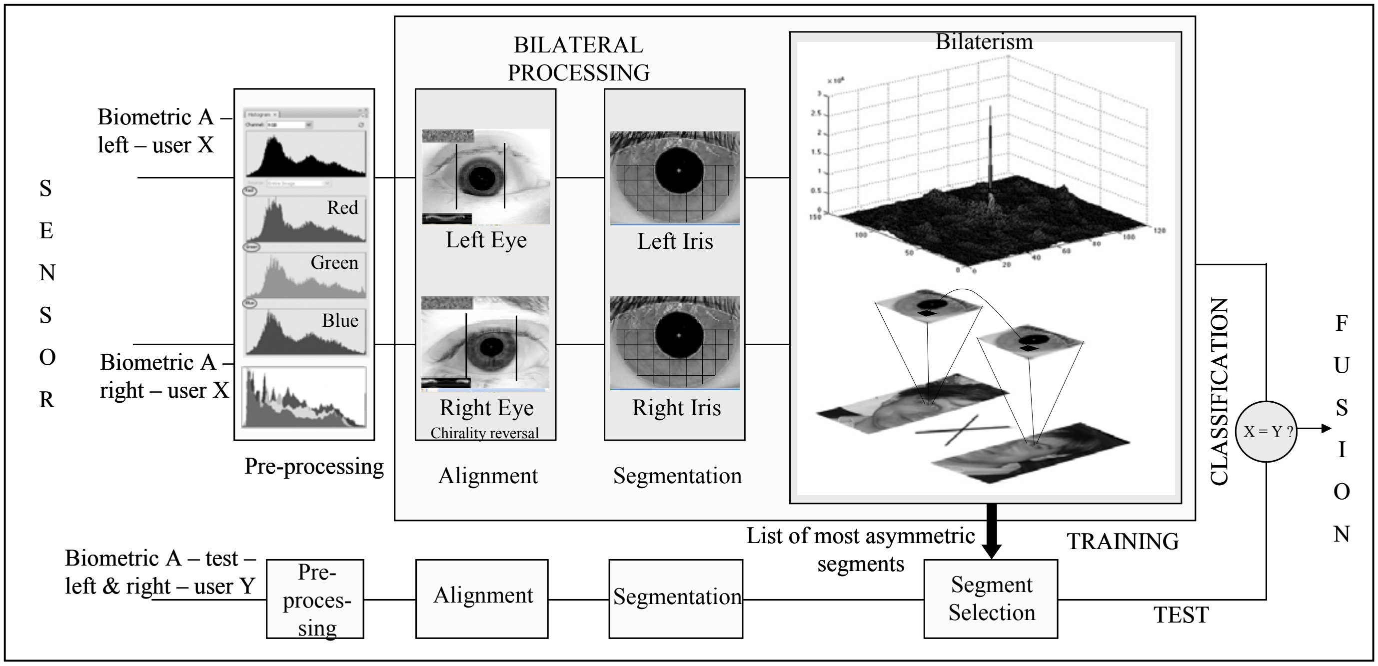

Figure 1: Block Diagram of the Recognition system with Bilateral Processing (BP) incorporated. It is divided in training and test. Database access is implicit. Training, besides database formation, outputs a list of the positions of the most asymmetric segments. This list is used to select segments to be classified.

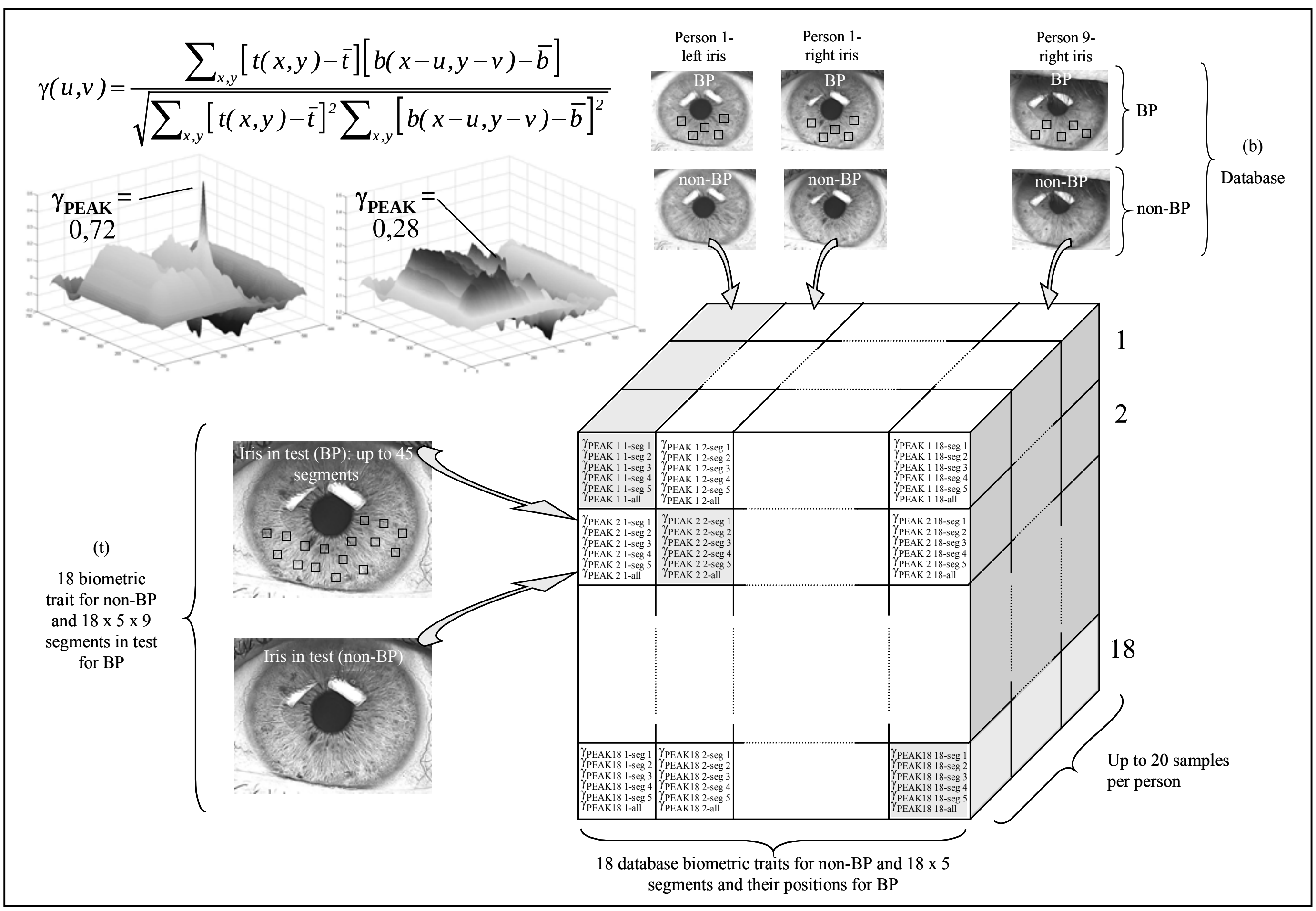

Figure 2: Matrix of normalized cross-correlation coefficients (γ) for segments (BP) and the whole trait (non-BP). Cross-correlation curves show high peak when there is a match and a low peak for unrelated segment/whole trait. Lowest genuine γ_{PEAK} divided by the highest impostor γ_{PEAK} hints the distributions separation.

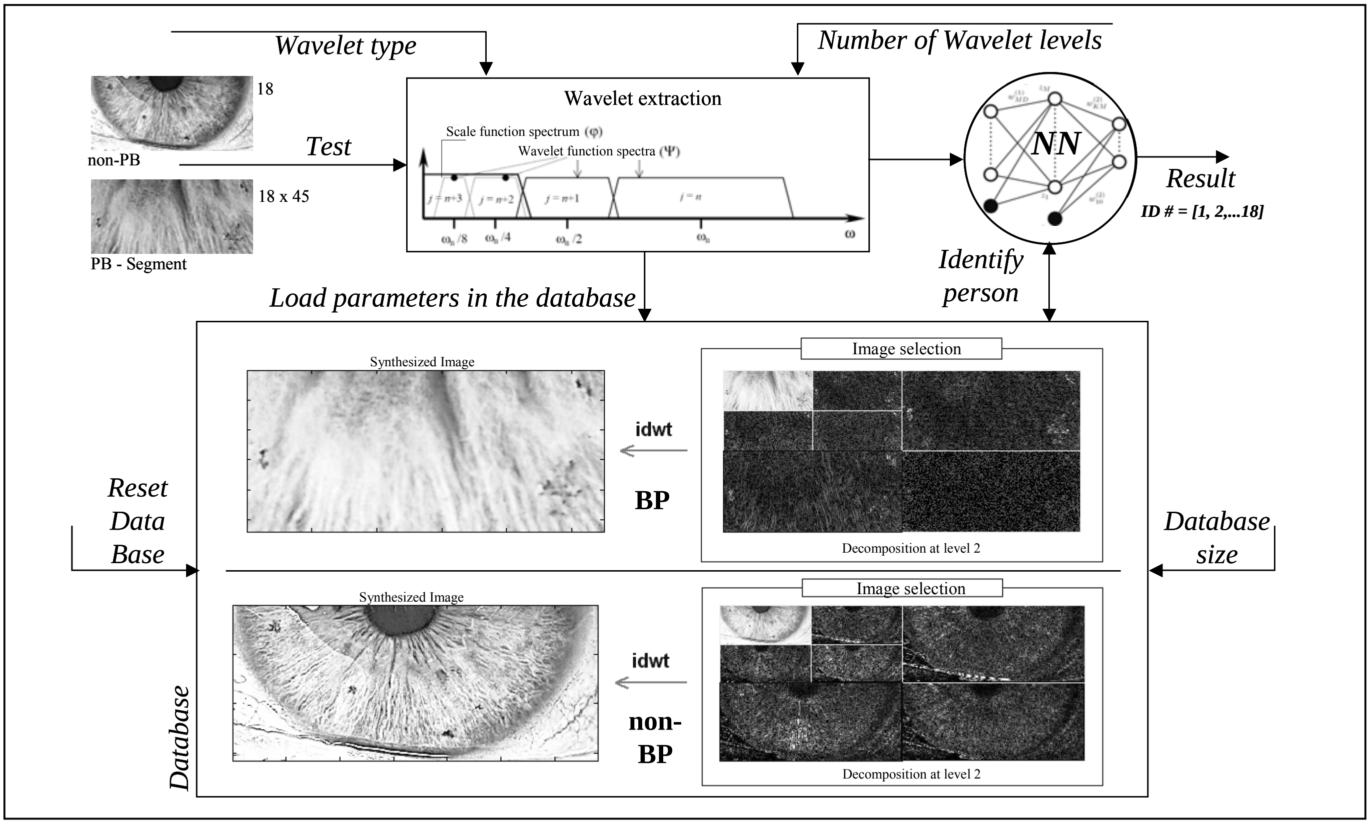

Figure 3: Wavelet parametrization and Neural Network Classification. Commands of the implemented routine are displayed, e.g., wavelet type selection, database reset, etc. Test and database wavelet parameters are classified by NN. Only the ID number from #1 to #18 is output for segments (BP) or whole trait (non-BP).

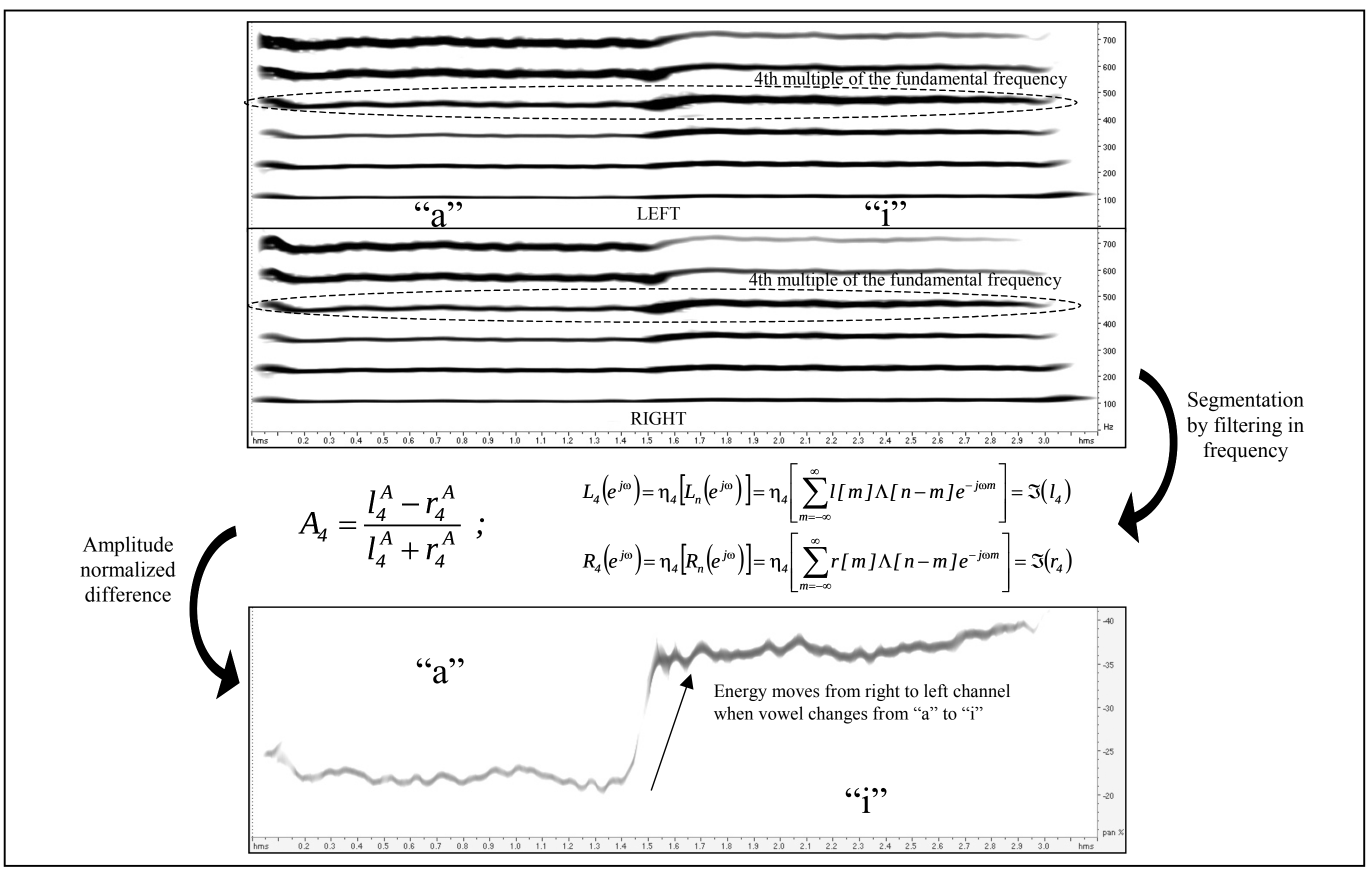

Figure 4: Acoustic BP. Left (*l*) and right (*r*) channels of each harmonic of the pitch are extracted by a filter (η) and their difference is normalized. *L* and *R* are FFT (ℑ) of *l* and *r*. 16384-sample kaiser window (Λ) was used to perceive infrasound variations. This figure exemplifies the amplitude curve of the 4th harmonic (A_4).