J. Bobulski, Wavelet Transform in Face Recognition,In: Saeed K., Pejaś J., Mosdorf R., Biometrics, Computer Security Systems and Artificial Intelligence Applications, Springer Science + Business Media, New York, USA 2006, 23-29

Wavelet Transform in Face Recognition

Janusz Bobulski

Czestochowa University of Technology
Institute of Computer and Information Science
Dabrowskiego Str. 73
42-200 Czestochowa, Poland
e-mail: januszb@icis.pcz.pl

Abstract: One of the parts person's identification systems is features extraction. This process is very important because effectiveness of system depend of it. Wavelet Transform successful can be use in systems of persons' identification and pattern recognition.

Keywords: *Face recognition, face identification, features extract, biometrics.*

1 Introduction

A problem of person's identification is one of the main questions of many research centres at present. Interest of this discipline is a result of potential possibilities of practical application of new possibilities in person's identification in the systems demanding authorizations of person's access entitled to use potential resources.

One of the parts person's identification systems is features extraction. This process is very important because effectiveness of system depend of it. There are many difference way features extraction eigenface, Fourier Transform etc. This paper proposes in order to do this use Wavelet Transform (WT).

The features extraction has to get out information from a signal (image), which will be base for person identification. The separation of useful information from nose is very important, because this data will be use to identification and should describing clearly the face.

2 Wavelet Transform of Images

2.1 One-level Wavelet Transform

One major advantage afforded by wavelets is the ability to perform local analysis -- that is, to analyse a localized area of a larger signal. In wavelet analysis, we often speak about approximations and details. The approximations are the high-scale, low-frequency components of the signal. The details are the low-scale, high-frequency components [1].

Using 2D WT (Fig. 1.), the face image is decomposed into four subimages via the high-pass and low-pass filtering. The image is decomposed along column direction into subimages to high-pass frequency band *H* and low-pass frequency band *L*. Assuming that the input image is a matrix of *m* x *n* pixels, the resulting subimages become *m/2* x *n* matrices. At second step the images *H* and *L* are decomposed along row vector direction and respectively produce the high and low frequency band *HH* and *HL* for *H*, and *LH* and *LL* for *L*. The four output images become the matrices of *m/2* x *n/2* pixels. Low frequency subimage *LL* (A_1) possesses high energy, and is a smallest copy of original images (A_0). The remaining subimages *LH*, *HL*, and *HH* respectively extract the changing components in horizontal (D_{11}), vertical (D_{12}), and diagonal (D_{13}) direction [2].

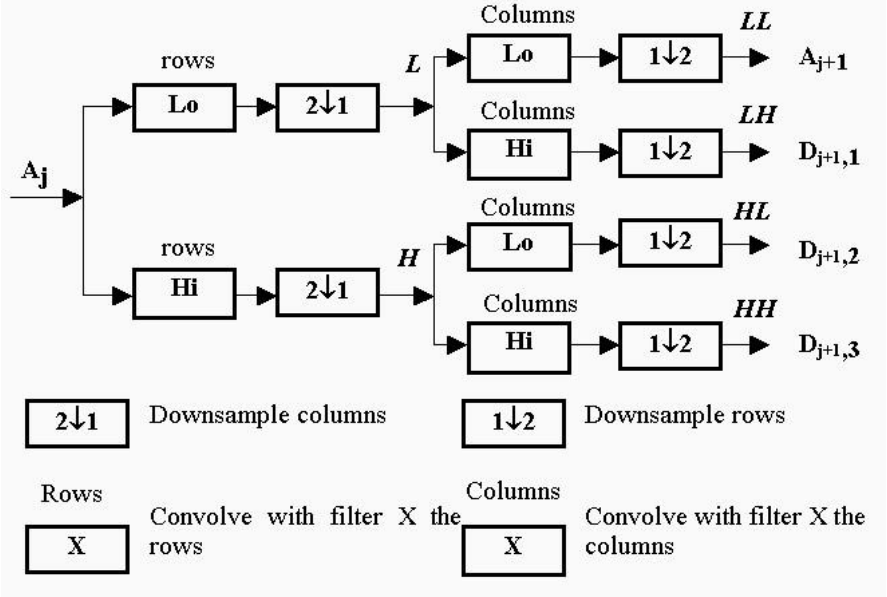


Fig.1 Scheme of one-level two-dimensional Wavelet Transform

The effect of use 2D WT on real image of face shown on Fig.2. The size of output images is the same as the input image. It is result of down sampling that is rejection of every second row and column. This operation don't increase amount of data and simultaneously don't cause loss of information.

2.2 Multi-level Wavelet Transform

The process of decomposition of image can be repeated by recurrence. The result of this is more detailed data about process information. After first level wavelet decomposition, the output images become input images of second level decomposition (Fig. 3) [3]. The results of two-level 2D WT are shown on Fig. 4.

Similarly can be made the multi-level WT. The tree of two-level decomposition is shown on Fig. 3.

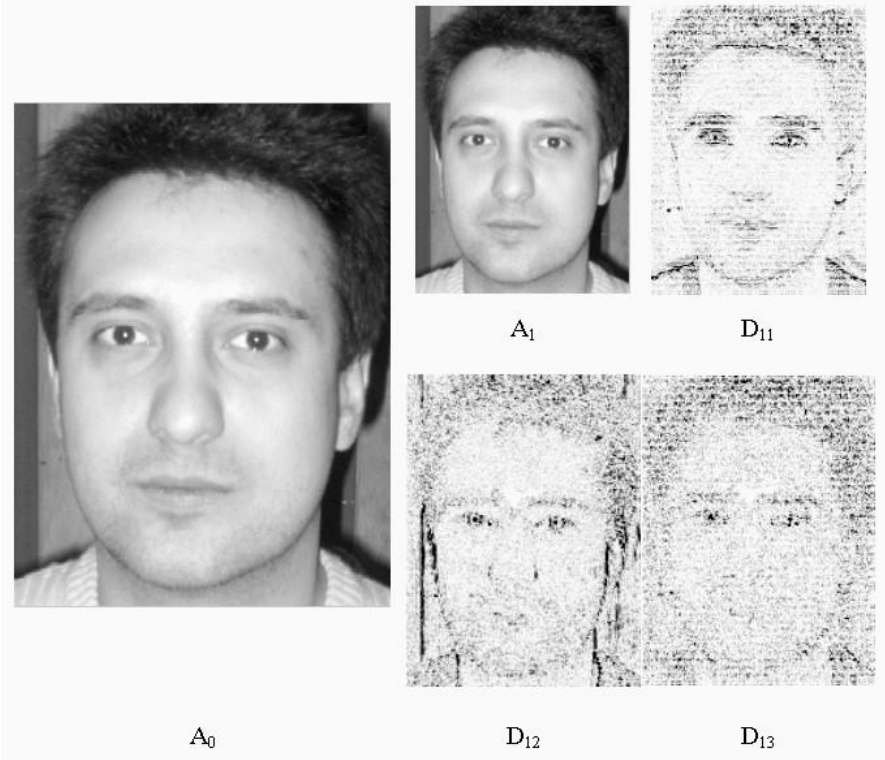


Fig. 2 Result of one-level two-dimensional Wavelet Transform

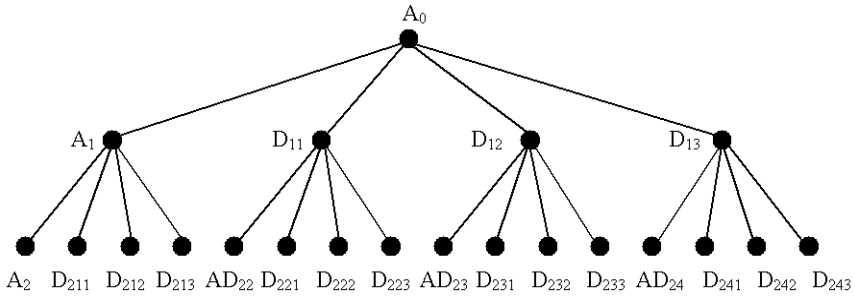


Fig. 3 The wavelet decomposition tree

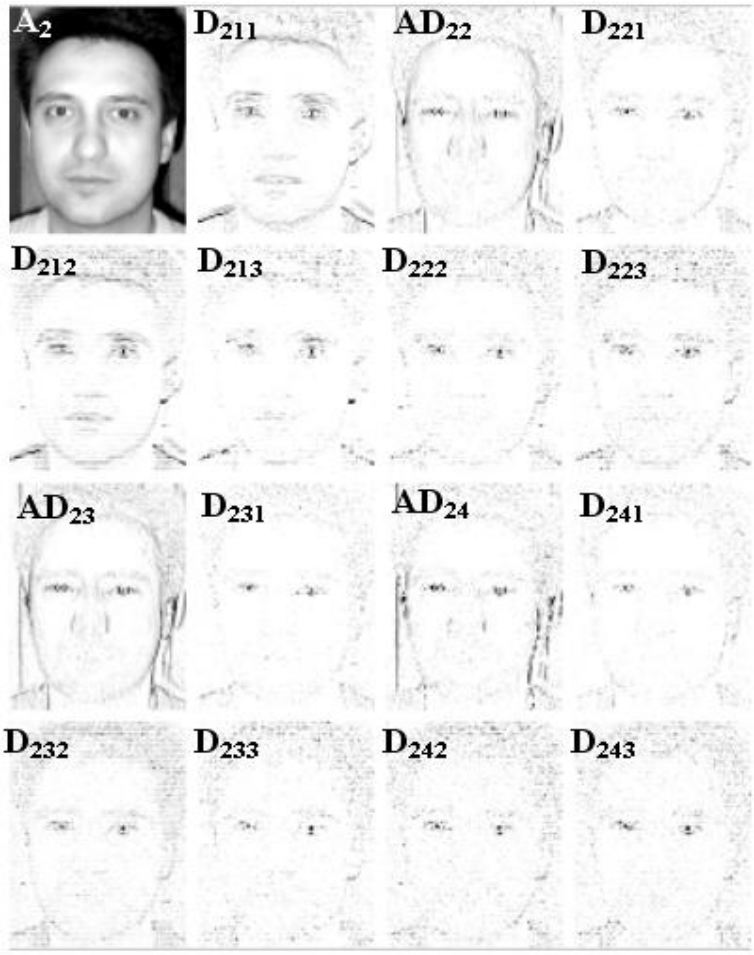


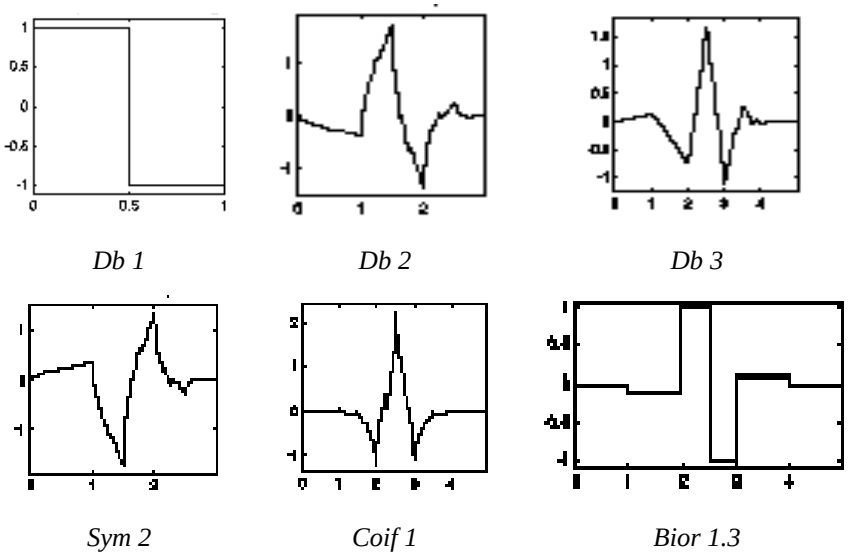
Fig. 4 Example of level 2 of the wavelet decomposition of image

2.3 Choice of Wavelet Function

The very important aspect of features extraction with WT is suitable choice of wavelet function [4,5,6]. The choice should adapt shape of wavelet to individual case and take into consideration the properties of the signal or image. The bad choice of wavelet will cause problems of analysis and identification processed signal [7,8].

In order to point the best wavelet function was used *FaMar* system of person's identification. This method is combination two mathematical tools, Wavelet Transform (WT) and Hidden Markov Model (HMM). Here, WT is used for features extraction, and HMM for identification [9]. The results of experiment are presented in Table 1. Experiment was carried out on the basis of the *BioID* face database in which there are 24 subjects. The best result achieve for function *Db1* from among accessible function of *Wavelet Toolbox* of set *MatLab.*

Analyse the result of Wavelet Transform (Fig. 6-9) we can see differences in contrast of fixed of boundary of face's elements. It is consequence of use different wavelet function (Fig. 5). Some of them (*Db1*) are better to features extraction because more clearly appoint contour of eyes and eyebrow.



Db 1 *Db 2* *Db 3*

Sym 2 *Coif 1* *Bior 1.3*

Fig.5 The shape of wavelet functions

Table 1. The result of experiment

Name of wavelet	*Error rate* [%]
Db1	**10**
Db2	30
Db3	35
Sym2	20
Coif1	40
Bior1.3	25

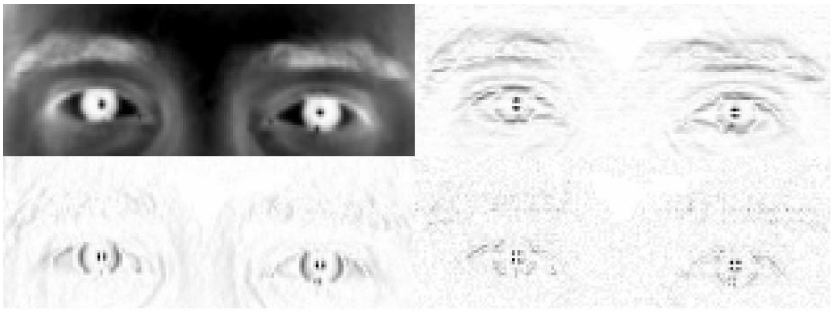


Fig. 6 Result of WT - *Db1*

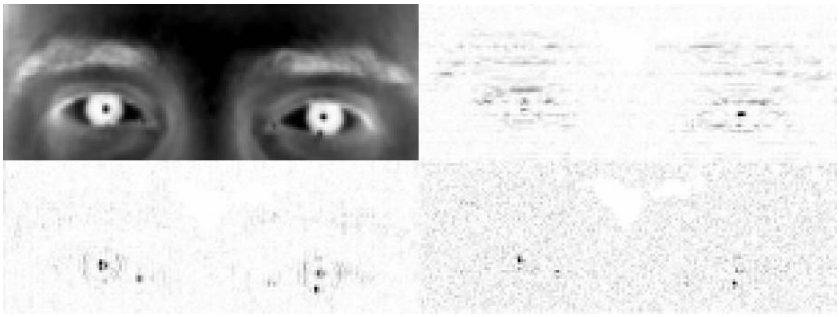


Fig. 7 Result of WT - *Db3*

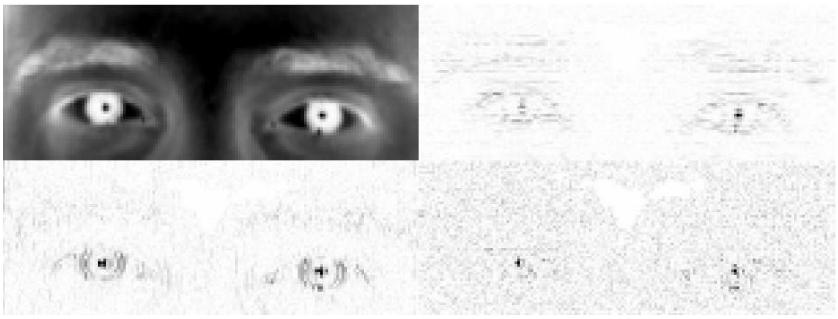


Fig. 8 Result of WT - *Coif1*

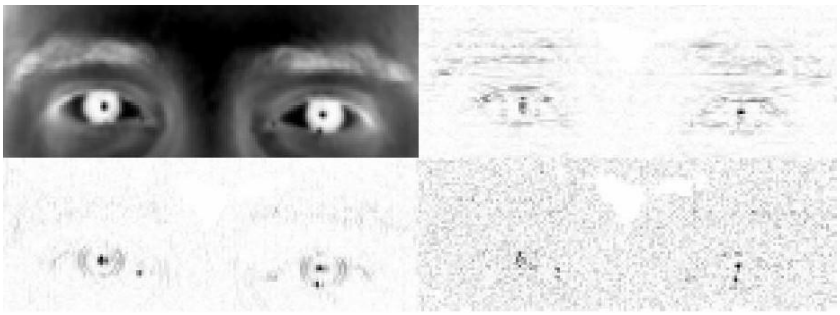


Fig. 9 Result of WT - *Sym2*

3 Conclusion

The choice of wavelet function is very important thing in features extraction. The effectiveness of recognition system depends on this selection. It guarantees a good recognition rate.

Wavelet Transform successful can be use in systems of person's identification, pattern recognition and speech recognition also.

Unquestionable advantage of WT is possibility of suite wavelet function to processed signal.

4 References

[1] Misiti M., Misiti Y., Oppenheim G., Poggi J.-M.: Wavelet Toolbox User's Guide, MathWorks (1998)

[2] Chien J.T. Wu Ch.Ch., Discriminant Waveletface and Nearest Feature Classifiers for Face Recognition'. IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 24 No. 12 (2002), pp. 1644–1649.

[3] Garcia C., Zikos G., Tziritas G.: Wavelet Packet Analysis for Face Recognition, Image and Vision Computing 18 (2000) 289-297

[4] Antoniadis A.; Oppenheim G.: Wavelets and Statistics, Lecture Notes in Statistics 103, Springer Verlag (1995)

[5] Antoniadis A., Pham D.T.: Wavelet Regression for Random or Irregular Design, Comp. Stat. and Data Analysis 28 (1998) 353–369

[6] Lavielle M.: Detection of Multiple Changes in a Sequence of Dependent Variables, Stoch. Proc. and their Applications, 83(2) (1999) 79–102

[7] Mallet Y., Coomans D., Kautsky J., De Vel O.: Classification Using Adaptive Wavelets for Feature Extraction, IEEE Transaction on Pattern Analysis and Machine Intelligence, Vol. 19 No.10 (1997) 1058-1066

[8] Laine A., Fan J.: Texture Classification by Wavelet Packet Signatures, IEEE Transaction on Pattern Analysis and Machine Intelligence, Vol. 15 No.11 (1993) 1186-1191

[9] Bobulski J.: The Method of User's Identification Using the Fusion of the Wavelet Transform and Hidden Markov Models, Computing, Multimedia and Intelligent Technique, No 1(1), Czestochowa University of Technology, Institute of Computer and Information Science (2004)