

**Article Info**

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**Face Identification using HAAR Wavelet Transform**

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**ABSTRACT**

Face identification is the process of matching one or more people by analyzing and comparing the patterns of their faces. Algorithms for face identification typically extract facial features and compare them to a database to find the best match. The Haar wavelet transform has been mainly used for image processing and pattern identification due to its low computing requirements and quality to conserve and to compact the energy of a signal. In discrete wavelet transform, an image signal can be analyzed by passing it through an analysis filter bank followed by a decimation operation. Face identification has been performed in terms of correlation coefficient, Euclidean distance and sum of absolute difference.

**Keywords:** Face identification; Wavelet transform; Correlation coefficient; Euclidean distance; Sum of absolute difference.

**1.0 Introduction**

Face identification is an important part of many biometric, security, and surveillance systems, as well as image and video indexing systems. Face identification has become a popular area of research in computer vision, it is typically used in network security systems and access control systems but it is also useful in other multimedia information processing areas [1]. The face identification is addressed in wavelet domain using LL sub band image. LL sub-band is used to extract the face features. Matching of features using correlation, Euclidean distance and sum of absolute difference between test and stored database images.

A multiresolution analysis (MRA) is a radically new recursive method for performing discrete wavelet analysis. An MRA introduced by Mallat [2] consists of a sequence  $V_j : j \in \mathbb{Z}$  of closed subspaces of  $L^2(\mathbb{R})$ , a Lebesgue space of square integrable functions, satisfying the following properties:-

1.  $V_{j+1} \subset V_j : j \in \mathbb{Z}$
2.  $\bigcap_{j \in \mathbb{Z}} V_j = \{0\}, \bigcup_{j \in \mathbb{Z}} V_j = L^2(\mathbb{R})$ ,
3. For every,  $L^2(\mathbb{R}), f(t) \in V_j \Rightarrow f(2t) \in V_{j+1}, \forall j \in \mathbb{Z}$

4. There exists a function  $\phi(t) \in V_j$  such that  $\{\phi(t - k) : k \in \mathbb{Z}\}$  is orthonormal basis of  $V_j$ .

The function  $\phi(x)$  is called scaling function of given MRA and property 3) implies a dilation equation as following:-

$$\phi(t) = \sqrt{2} \sum_{k \in \mathbb{Z}} h_k \phi(2t - k) \quad \dots(1)$$

where  $h_k$  is low pass filter and is defined as:-

$$h_k = \int_{-\infty}^{\infty} \phi(x) \phi(2t - k) dt \quad \dots(2)$$

The wavelet function  $\psi$  is expressed as:-

$$\psi(t) = \sqrt{2} \sum_{k \in \mathbb{Z}} g_k \phi(2t - k) \quad \dots(3)$$

where,  $g_k = (-1)^{k+1} h_{1-k}$  We can express a signal in terms of bases of  $V_j$  space such that,

$$V_j = V_{j+1} \oplus W_{j+1}, \forall j \in \mathbb{Z} \quad \dots(4)$$

where  $W_{j+1}$  is the orthogonal complement of  $V_{j+1}$  in  $V_j (V_{j+1} \perp W_{j+1})$ . By iteration, we can write,

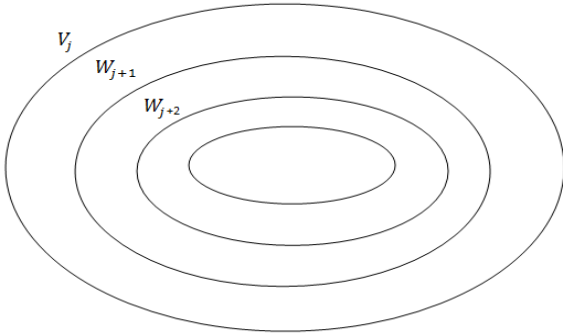
$$V_j = W_{j+1} \oplus W_{j+2} \oplus W_{j+2} \quad \dots(5)$$

Let  $S = \{S_n : n \in \mathbb{Z}\}$  be a function sampled at regular time interval,  $\Delta t = \tau$  where  $\mathbb{Z}$  is an integer.  $S$  is split into a "blurred" version  $a_1$  at the coarser interval  $\Delta t = 2\tau$  and "detail"  $d_1$  at scale  $\Delta t = \tau$ . This process is repeated and gives a sequence  $S, a_1, a_2, a_3, a_4, \dots$  of more and more blurred versions together with the details  $d_1, d_2, d_3, \dots$  removed at every scale.

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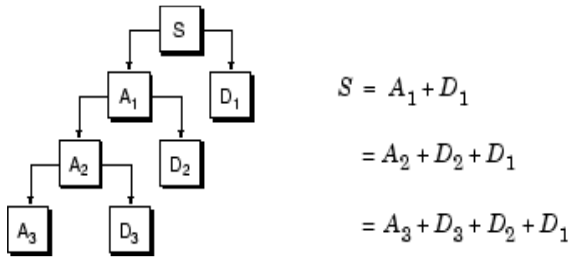
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**Figure 1: Decomposition of Vector Space**



( $\Delta t = 2^m \tau$  in  $a_m$  and  $d_{m-1}$ ) [3, 4]. Here  $a_m$ 's and  $d_m$ 's are approximation and details of original signal. After N iteration S can be reconstructed as  $S = a_N + d_1 + d_2 + d_3 + d_4 + d_5 + \dots + d_N$ . The approximations are the high-scale, low-frequency components of the signal. The details are the low-scale, high-frequency components. Thus the original signal passes through two complementary filters in which one is low pass filter and second one is high pass filter as shown in figure 2.

**Figure 2: Decomposition of 1D Signal**



**2.0 Haar Wavelet Transform**

The Haar transform is one of the oldest transform functions, proposed in 1910 by the Hungarian mathematician Alfred Haar. Haar wavelet is discontinuous, and resembles a step function. The Haar wavelet's mother wavelet function  $\psi(t)$  can be described as [5]:

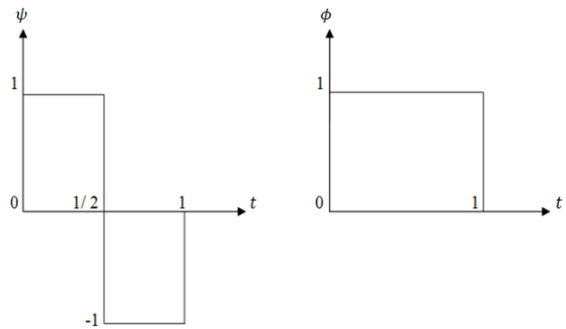
$$\psi(t) = \begin{cases} 1 & 0 \leq t < \frac{1}{2} \\ -1 & \frac{1}{2} \leq t < 1 \\ 0 & \text{otherwise} \end{cases}$$

Its scaling function  $\phi(t)$  can be described as:

$$\phi(t) = \begin{cases} 1 & 0 \leq t < 1 \\ 0 & \text{otherwise} \end{cases}$$

It conserves the energy of signal and compaction of the energy of signals. In discrete form, Haar wavelets are related to a mathematical operation called the Haar transform. Due to its low computing requirements, the Haar transform has been mainly used for image processing and pattern identification. From this reason two dimensional signal processing is an area of efficient applications of Haar transform due their wavelet like structure. It is found effective in applications such as signal and image compression in electrical and computer engineering as it provides a simple and computationally efficient approach for analysing the local aspects of a signal. It shows orthogonal, biorthogonal and compact support. Its wavelet and scaling functions are shown below in figure 3.

**Figure 3: Haar Wavelet and Scaling Function**



This transform decomposes the signal into mutually orthogonal set of wavelets. The discrete wavelet transform provides sufficient information both for analysis and synthesis of the original signal, with a significant reduction in the computation time. In the discrete wavelet transform, an image signal can be analysed by passing it through an analysis filter bank followed by a decimation operation. This analysis filter bank, which consists of a low pass and a high pass filter at each decomposition stage, is commonly used in image compression. When a signal passes through these filters, it is split into two bands. The low pass filter, which corresponds to an averaging operation, extracts the coarse information of the signal. The high pass filter, which corresponds to a differencing operation, extracts the detail information of the signal. The output of the filtering operations is then decimated by two. A two level decomposition of image signal is shown in figure 4 [6].

**Figure 4: Decomposition of 2D Signal**

LL2	LH2	LH1
HL2	HH2	
HL1		HH1

**3.0 Experimental Analysis**

We are developing a face identification system, in which we are using seven images out of which two images are of same person. In this system, we take one image as test image that is compared with six images that are stored in image database.

**Figure 5: Test Image T<sub>1</sub>**



**Figure 6: Database Image (D1- D6)**



We select original image as a test image T<sub>1</sub> for experiment analysis. We take Haar wavelet and at

level 2 and retrieve LL subband. Euclidean distance examines the root of square differences between the coordinates of a pair of objects. For testing we used the Euclidean distance classifier, for calculating the minimum distance between the test image and image to be recognized from the database [7]. In signal processing, correlation is a measure of similarity of two series as a function of the displacement of one relative to the other. Sum of absolute difference (SAD) is used for measuring the similarities between the images by calculating the absolute differences between the pixels of the image. The SAD algorithm is the simplest metric which considers all the pixels in the block for computation and also separately, which makes its implementation easier and parallel [8].

**Table 1: Wavelet Statistical Analysis of Test Image and Database Images**

S. No.	Test image and database image	Correlation Coefficient	Euclidean distance	S.A.D.
1.	T <sub>1</sub> -D <sub>1</sub>	0.64633205	7.1719×10 <sup>3</sup>	2398080
2.	T <sub>1</sub> -D <sub>2</sub>	0.449733361	1.0643×10 <sup>4</sup>	3185200
3.	T <sub>1</sub> -D <sub>3</sub>	0.5263451501	1.0828×10 <sup>4</sup>	2708816
4.	T <sub>1</sub> -D <sub>4</sub>	0.51404803142	1.1807×10 <sup>4</sup>	3232144
5.	T <sub>1</sub> -D <sub>5</sub>	0.3001736427	1.2257×10 <sup>4</sup>	3394368
6.	T <sub>1</sub> -D <sub>6</sub>	0.5410996575	1.0968×10 <sup>4</sup>	3061184

**4.0 Results and Conclusions**

From table 1, it is obvious that correlation coefficient between test image and database image 1 is larger compared to the correlation coefficient between test image and rest database image (D2-D6) for level 2. Also the Euclidean distance and sum of absolute difference between test image and database image 1 is smaller compared to the Euclidean distance and sum of absolute difference between test image and rest database image (D2-D6). By virtue of these results, we can say that wavelet transform technique provides a simple and accurate framework to investigate the images for the face identification.

**References**

[1] Mohit P. Gawande, Prof. Dhiraj G. Agrawal, Face identification using PCA and different distance classifiers, IOSR Journal of Electronics and Communication Engineering (IOSR-JECE), 9( 1), 2014, 01-05.

- [2] S.G. Mallat, A theory for multi resolution signal decomposition: the wavelet representation, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 11(7), 1989, pp. 674-693.
- [3] J. P. Antoine, "Wavelet analysis: A new tool in Physics", Wavelets in Physics, J. C Van Den Berg, ed., Cambridge University Press, Cambridge, 2004, 9-21.
- [4] A. Cohen, I. Daubechies and P. Vail, "Wavelets on the interval and fast algorithms", Journal of Applied and Computational Harmonic Analysis, 1, 1993, 54-81.
- [5] J. Chopra, M. Singh, "Face identification using HAAR wavelet transform and correlation coefficient from group photograph", International Journal of Advanced Research in Computer Science and Software Engineering , 4(9), 2014, 292-296.
- [6] M. Kumari, A. Kumar, "Optimum wavelet selection for 2d signal using set partitioning in hierarchical trees (spiht) method", International Journal of Engineering Science and Mathematics, 6(6), 2017, 178-187.
- [7] B.B.S. Kumar and P.S. Satyanarayana, "Image Analysis using Biorthogonal Wavelet", International Journal of Innovative Research And Development, 2(6), 2013, 543-565.
- [8] A. Kumar and M. Kumari, "Image compression by discrete wavelet transforms using global thresholding", International Journal of Advance Research and Innovation, Special issue, 2016, 1-5.