Person identification system using an identikit picture of the suspect

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Article presents persons identification system, which may work with sketches. Sketch is often used in practice, an investigative tool to search for the perpetrators of unknown identity. With a portrait of the perpetrator can make the identification. When the face database for comparisons is large, this is becoming tedious. With the help of a computer system of face identification, this process becomes quick and easy.

Keywords: person identification, face recognition, biometrics, sketch.

1. Introduction

Sketch is often used in practice, an investigative tool to search for the perpetrators of unknown identity. A contemporary sketch has two forms: descriptive description, and the image that is a form of visual looks the person's face [1].

Sketch is an important part of investigate, because in the absence of a real image allows to identify the suspect. This allows the police to find the trail through which may be covered the offender. Historically, portraits were done in the form of a sketch drawing based on the testimony of witnesses or victims. It is currently being established by computer, adjusts the relevant elements of the face such as nose, eyes, lips eyebrows, face shape by using ready patterns of these elements from a database , and then generates the resulting facial image (Fig 1).

With a portrait of the perpetrator there may be made the identification. When face database for comparisons is large, this is becoming tedious. With the help of a computer system of face identification, this process becomes a quick and easy.

Computer faces identification systems use mathematical tools to compare the pattern. Such systems operate in two modes: training and testing. The first mode is used to enter the pattern to the base faces (Fig.1). However, the second mode is used to identify the suspect, that is comparison portrait of the perpetrator with images in the database and point the most similar (Fig.2).

Fig.1. Sample of sketch.

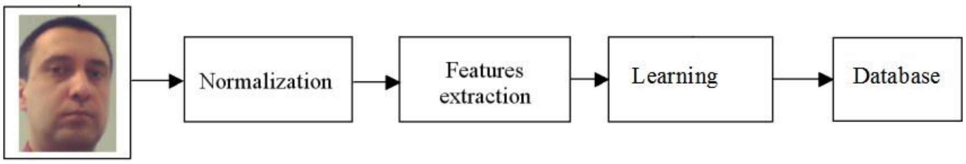

Fig.2. Scheme of identification system in learning mode.

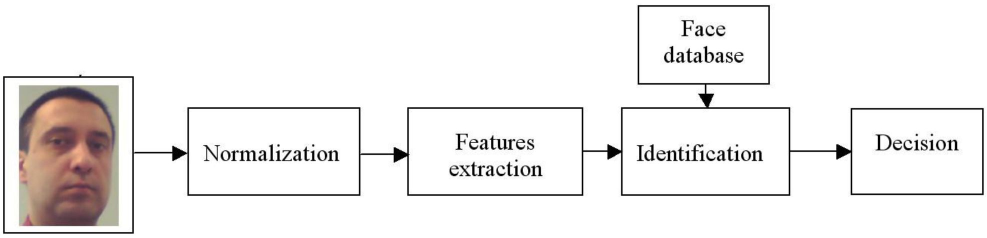

Fig.3. Scheme of identification system in testing mode.

2. User Identification

The user identification process work on the basis of the frontal facial image, in which the fusion of Wavelet Transformation (WT) and Hidden Markov Models (HMM) are used for the three parts of face (eyes, nose, mouth); the decision is made on the basis of the sum maximalisation of likelihood of generating of the models observation.

The most popular method of face identification is Principal Component Analysis (PCA) [2]. Other popular methods use Wavelet Transform [3] or Hidden Markov Models [4]. Analysis of the existing solutions revealed their defects, which caused their weak effectiveness. The disadvantages of these methods are as follows:
– In case of the new user's registration, process of learning and addition his/her facial image to a database, requires repeated learning of the whole system.
– They work with whole face.
– They are computationally very expensive.

The proposed method is a combination of two mathematical tools, Wavelet Transform (WT) and Hidden Markov Model (HMM). Both were mainly used for speech recognition. Here, WT is used for features extraction, and HMM for identification. This system works in two modes, learning and testing. These modes differ from each other. The algorithm of this method consists of four main parts:

1. Pre-processing: normalization and face division into three parts
2. Features extraction: WT of the face image
3. Learning: generating and learning HMM for each part of the face
   Testing: testing models from the database
4. Learning: saving to database the learned models of the face
   Testing: making a decision - maximum likelihood of the model

2.1 Pre-processing

The normalization consists of fixing the centres of the eyes, and then respective scaling of face so that the distance between them equals 120 pixels. This is a necessary process by which it is possible to compare objects, such as in this case faces. The idea of standardization is the appropriate scaling of the facial image, so that they can be compared. The first step in the standardization process is to determine centres of the eyes. This is done by calculating the gradient of the whole image, and then summing these values for each row and column (fig.4).

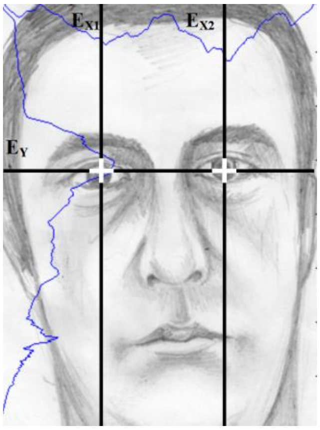

Fig.4. Determine of eyes centres

$$\begin{cases} W1 = \sum_{i=1}^{i-1} \left| m_{ij} - m_{i+1,j+1} \right| \\ W2 = \sum_{j=1}^{j-1} \left| m_{ij} - m_{i+1,j+1} \right| \end{cases} \quad (1)$$

$$\begin{cases} E_Y = \max(W1) \\ E_{X1} = \max(W2(1:j/2)) \\ E_{X2} = \max(W2(j/2:j)) \end{cases} \quad (2)$$

The second part of this process is division of the normalized face into three parts: the area of eyes, nose, and mouth (Fig.5).

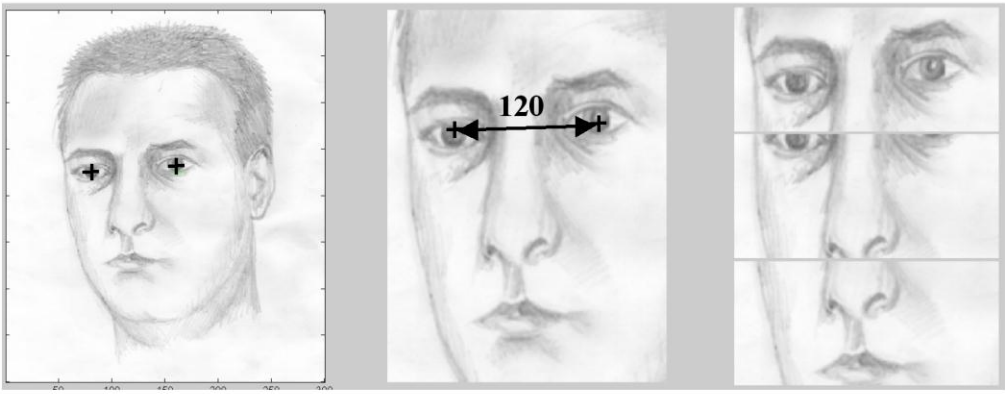

Fig. 5. Pre-processing of the face image

2.2 Features extraction

WT is used for features extraction. Using 2D WT (Fig.6), the face image is decomposed into four sub images via the high-pass and low-pass filtering. The image is decomposed along column direction into sub images 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 sub images become $m/2$ x n matrices. At the 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 sub image LL (A_1) possesses high energy, and is a smaller copy of the original images (A_0). The remaining sub images LH, HL, and HH respectively extract the changing components in horizontal (D_{11}), vertical (D_{12}), and diagonal (D_{13}) direction [5].
Wavelet Transform of the second level (Fig.7) is used for features extraction in the proposed technique. After first level wavelet decomposition, the output images become the input images of the second level decomposition. The results of two-level 2D WT are coded in this way, so that they can be applied in HMM (Fig.9). One of the simplest methods of reduction and information coding is calculating of standard deviation or mean value. Each part of the face is transformed separately by discrete wavelet transform (Fig.8). The bank filters' selection is an important thing in this transformation. It guarantees a good recognition rate [6].

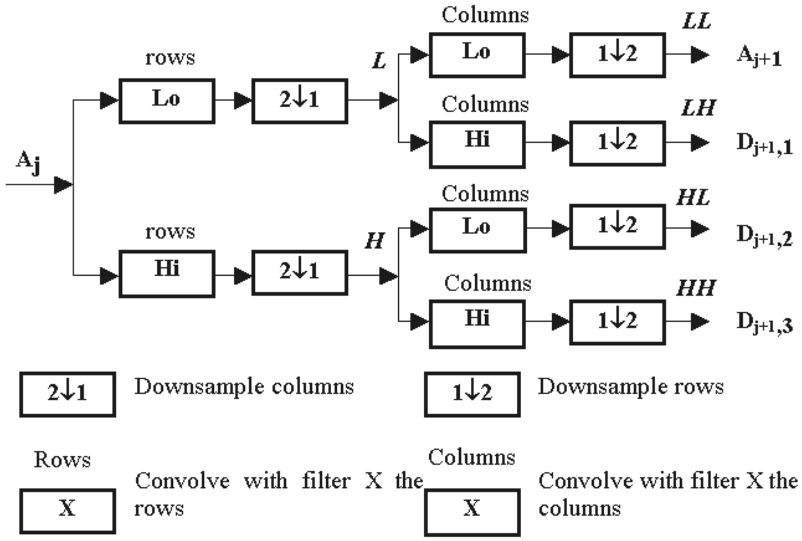

Fig. 6. Scheme of one-level two-dimensional wavelet transform [9].

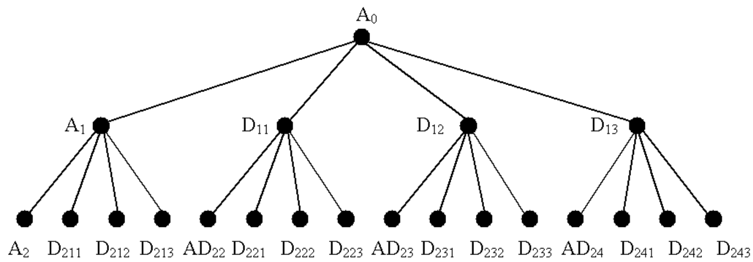

Fig. 7. The wavelet decomposition tree.

Fig. 8. Example of level 2 of the wavelet decomposition of image of eyes area.

2.3 Training system

HMM is used for the identification process. HMM is a double stochastic process with underlying stochastic process that is not observable (hidden), but can be observed through another set of stochastic processes that produce a sequence of observation.
Let $O=\{O_1,,O_T\}$ be the sequence of observation of feature vectors, where T is the total number of feature vectors in the sequence. The statistical parameters of the model may be defined as follows [7].

- The number of states of the model, N
- The transition probabilities of the underlying Markov chain, $A=\{a_{ij}\}, 1 \leq i,j \leq N$, where a_{ij} is the probability of transition from state i to state j subject to the constraint $\sum_{j=1}^{N} a_{ij} = 1$
- The observation probabilities, $B = \{b_j(O_T)\}, 1 \leq j \leq N, 1 \leq t \leq T$ which represents the probability of the t_{th} observation conditioned on the j_{th} state.
- The initial probability vector, $\Pi = \{\pi_i\}, 1 \leq i \leq N$.

Hence, the HMM requires three probability measures to be defined, A, B, π and the notation $\lambda=(A,B,\pi)$ is often used to indicate the set of parameters of the model. In the proposed method, one model is made for each part of the face. The parameters of the model are generated at random at the beginning. Then they are estimated with Baum-Welch algorithm, which is based on the forward-backward algorithm. The forward algorithm calculates the coefficient $\alpha_t(i)$ (probability of observing the partial sequence ($o_1, \ldots, o_t$) such that state q_t is i). The backward algorithm calculates the coefficient $\beta_t(i)$ (probability of observing the partial sequence ($o_{t+1}, \ldots, o_T$) such that state q_t is i). The Baum-Welch algorithm, which computes the λ, can be described as follows [8].

1. Let initial model be λ_0
2. Compute new λ based on λ_0 and observation O
3. If $log(P(O|\lambda) - log(P(O)|\lambda_0) < DELTA$ stop
4. Else set $\lambda_0 \leftarrow \lambda$ and go to step 2.

The parameters of new model λ, based on λ0 and observation O, are estimated from equation of Baum-Welch algorithm [8], and then are recorded to the database.

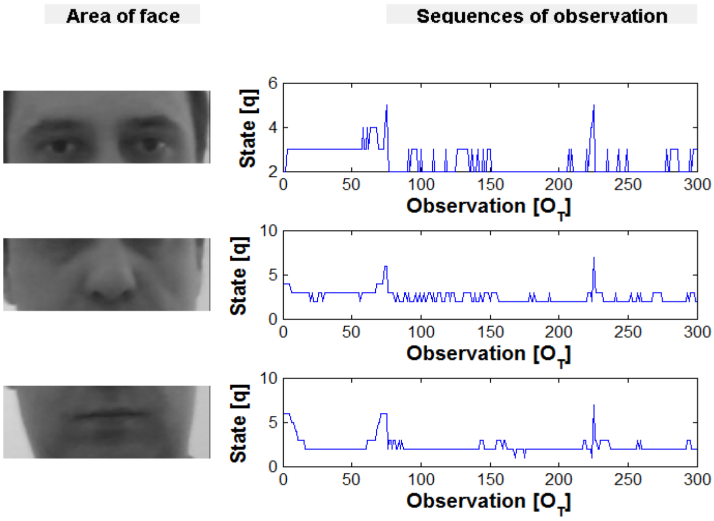

Fig. 9. Part of face and correspond them sequences of observation.

2.4 Testing system

The testing process consists of computing the probability of observation generating by the models saved in database and choosing this model for which the likelihood is maximum. In the proposed method, probabilities are calculated separately for each of the three models representing parts of the face, and then they are added. The face, for which the sum of probability is maximum, is chosen as the correct face. The probability of generating sequences of observations is computed from the equations 3-6 [8].

$$P(O \mid \lambda) = \sum_{q} P(O \mid q, \lambda) P(q \mid \lambda) \tag{3}$$

$$P(O \mid q, \lambda) = \prod_{i=1}^{T} P(o_t \mid q_t, \lambda) = b_{q_1}(o_1) b_{q_2}(o_2) \ldots b_{q_T}(o_T) \tag{4}$$

$$P(q \mid \lambda) = \pi_{q_1} a_{q_1 q_2} a_{q_2 q_3} \ldots a_{q_{T-1} q_T} \tag{5}$$

$$PF = \sum_{i=1}^{3} P(O_i | \lambda_i) \tag{6}$$

4. Conclusion

Article presents persons identification system, which may work with sketches. Recognition rate of the system is 90%. It was tested on database in Forensic Laboratory of the Regional Police Headquarters in Katowice.

The system is sensitive on face rotation. Future works would be concentrated on elimination this problem by detection and rotate face along X axis, and add other pose of face aim elimination of rotate face along axes X and Z.

On the basis of experimental research it was stated the area of eyes contains the most useful information for the persons' identification, and it could be successfully applied in specific methods of identification or detection. Proposed method of user identification is characterized by usage of the three areas of the face for identification and creating for each of them one independent HMM (which it is possible to use separately or together). This procedure gives possibility to short calculation request and permit obtaining a good recognition rate.

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