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A Study of the Pattern Kernels for a Lip Print Recognition

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Abstract

This paper presents a lip print recognition by the pattern kernels for a personal identification. A lip print recognition is developed less than the other physical attributes of a fingerprint, a voice pattern, a retinal blood/vessel pattern, or a facial recognition. A new method is proposed to recognize a lip print by the pattern kernels. The pattern kernels are a function consisted of some local lip print pattern masks. This function converts the information on a lip print into the digital data. The recognition in the multi-resolution system is more reliable than recognition in the single-resolution system.

The results show that the proposed algorithm by the multi-resolution architecture can be efficiently realized.

1. Introduction

Biometric systems are technologies that use unique human physical characteristics to identify a person in some ways, and have sensors that pick up a physical characteristic, convert it into a digital pattern, and compare it with patterns stored for personal identification. Biometric measurement systems typically include voice recognition/verification, fingerprint identification, palm prints, hand/wrist vein patterns, retinal/iris eye scans, hand geometry, keystroke dynamics or typing rhythms, and signature verification.

The underlying advantages of biometric identification include elimination of common problems such as illicitly copied keys, lost or broken mechanical locks, and forged/stolen personal identification numbers which can lead to automatic teller machine and checking fraud.

Biometric systems can be used for identification purposes involving security access systems in management information services departments, government agencies, ATMs/banks, law enforcement, prisons, international border control, and military agencies.

A lip print is included among measurements of biometric systems [1]. Each person's lip has unique lip print and differs from the others. A new personal identification method is proposed by the lip print recognition using the pattern kernels and the multi-resolution architecture. The pattern kernels use some local masks to analyze and identify a lip print.

We have applied a pattern recognition method which is based on computation of local autocorrelation coefficients [2]. This method have merits such as small data, and faster computation than template matching.

The image data of a lip print is considered as a connective appearance with the directional local pattern. The local masks extract the information on its local pattern for a lip print, such as the vertical pattern, the horizontal, and the diagonal. The advantage of the pattern kernels by the local masks is a small data that represents unique personal information for recognition.

The discrimination criteria either recognize a person of the input image from classes or reject him if the input image is unknown. The next section shows the pattern kernels method and the discrimination criteria. The third section shows an experimental process using the above mentioned method.

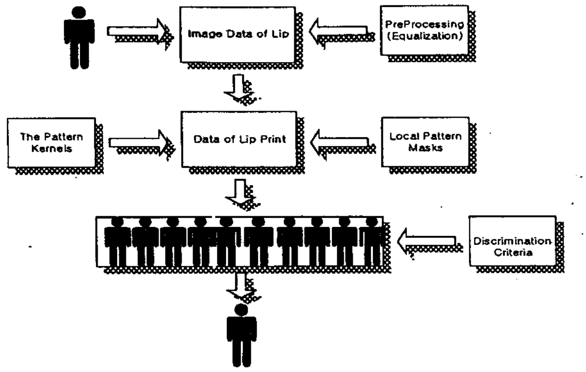


Fig. 1 The block diagram of a lip print recognition system

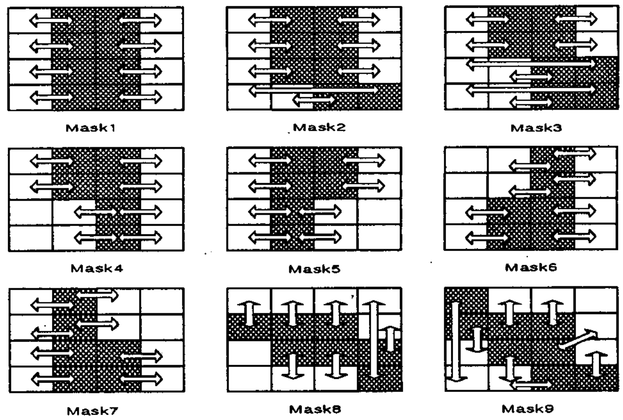


Fig. 2 The example of the local pattern masks

2. Recognition method

This section presents the pattern kernels to analyze a lip print with some local pattern masks. Fig. 1 illustrates the block diagram of a lip print recognition system. The input image of a lip print is acquired by the CCTV camera with 8 bits gray scale.

Because of some noises of camera and lack of information on the emphasized image, the input image is preprocessed by a histogram equalization which rescales the range of its pixel values to produce an enhanced image whose pixel values are more uniformly distributed. The enhanced image tends to have higher contrast.

2.1 Local Pattern Mask

The local pattern mask is defined on 4×4 pixels, and extract the uniquely local pattern information from the preprocessed image data. Some examples of local pattern mask are shown in Fig. 2, in which the arrows represent the relation between a pixel marked in white and a pixel marked in black. The relation is designed by the difference of pixel values. The image of a lip print has a vertical of horizontal or diagonal edge called as a lip print.

Some pixel values of the lip print have lower than other pixel values. (A gray value of the black pixel is set to 0 and a gray value of the white pixel is set to 255.)

Each pattern mask is scanned over the entire input image, and the mask is compared with the input image. If the mask is matched with the region of the input image, the pattern kernels are computed in the region.

The local pattern mask represents a mask consisting of pattern of the lip print. The Fig. 2 shows that the mask 1 denotes the vertical pattern, and mask 3 denotes from the vertical to the diagonal direction pattern. The mask 9 denotes east-south direction pattern.

The pattern of the lip print is mixed with patterns which represent the local pattern mask in a limited region.

2.2 Pattern Kernel

The human lip has his own pattern of a lip print [1]. The pattern kernels acquire the various patterns. Each kernel extracts a uniquely global pattern from information on the input image and transforms it into the proposed vector.

Since the kernel acquires infomation on the global pattern, a lip print is represented by the information on the global pattern. The pattern kernels use some local masks to analyze information on the local pattern, and to synthesis the local information.

The characteristics of a lip print are explained by three measures. The first is its length. The second is its frequency. The third is its shape. The pattern kernels must recognize these measures and convert them into digital data.

Therefore, the design of the pattern kernel is based on these measures. Whenever any pattern of the object is detected by the local pattern mask, a kernel of the detected pattern is executed. All the products corresponding to a kernel are stored so as to provide the pattern information. This operation is performed by the 5 different pattern kernels, providing the 5-information vectors.

Table 1 The 5 different pattern kernels

The pattern kernel 1	Vertical direction detector
The pattern kernel 2	ES (east-south) diagonal direction detector
The pattern kernel 3	WS (west-south) diagonal direction detector
The pattern kernel 4	W(west) horizontal direction detector
The pattern kernel 5	E(east) horizontal direction detector

Fig. 3 illustrates the flowchart of the pattern kernel 2 to provide information on the east-south direction pattern. The mask (m) [i][j] denotes the local pattern mask representing the m^{th} 4×4 mask of the location [i][j] (i = row, j = column) in the image. The C2 denotes the counted number of matching the mask(m) represented by coefficients of information on the direction pattern.

Therefore, the length of a lip print is measured by the C coefficient. The frequency of a lip print is measured by the number matched by the pattern kernel. The shape of a lip print is measured by the number matched by the pattern kernel that describes any pattern print. These measures are stored in the information vector.

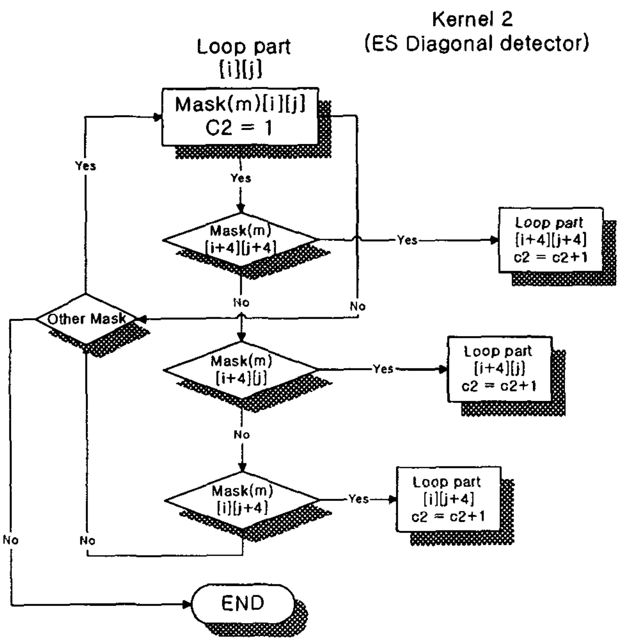


Fig. 3 The flowchart of the pattern kernel 2

2.3 Discrimination Criteria

The discrimination criteria discriminate an information vector of the input image from other vectors. The input image is transformed to the 5-information vectors. The vectors consist of three parts that are personal information, kernel name, pattern information and row-vector.

Table 2 The information vector structure (I = 1,2...5)

Vector of Kernel (I)		
Personal Information	Kernel Name	Pattern Information

Table 2 shows that the personal information denotes personal name, and the kernel name denotes the specific pattern kernel, and the pattern information denotes a value of the pattern kernel.

Equation(1) illustrates discrimination criteria of the information vectors. A threshold value is set on the minimum value and the information vector. If T exceeds a threshold value from the information vector, the specific information vector is rejected.

$$T = \sum_{p=1}^{5} \frac{\sqrt{(K_p^s - K_p^m)^2}}{(K_p^s + K_p^m)} \qquad (1)$$

for (m = 1, 2, 3, . . . N)

K_p^s = the specific information vector

K_p^m = the information vector

where N is the number of the information vector.

3. Experiment

The input image is composed of a lot of pixels with the 8 bits gray level. Its value is from 0 to 255. In this paper, the image data maintains the 8 bits gray level until all processes end, preprocessed with histogram equalization for acquiring an enhanced image.

The lip print holds some information in small part of the region. Therefore, if we preprocess with threshold method, a part of information on the lip print will vanish from the input image. However, it has a technical difficulty.

When the local pattern mask is compared with the preprocessed input image, it is not easy for the mask to find the same pattern of the input image because of its data with the 8 bits gray level. That kind of difficulty can be resolved by using some statistical factors such as mean, standard deviation.

In the Fig. 2, for example, the mask 1 has 8 pixels marked in black and 8 pixels marked in white. The pixels marked in black are a part of the lip print. While the mask 1 scan some region of the image, its mean and standard deviation are computed. The mask 1 uses this value whether region has same pattern or not.

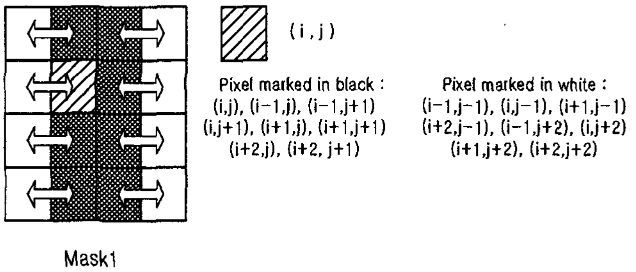


Fig. 4 The pixels of the mask 1

Fig. 4 shows pixels of the mask 1 and its two-dimensional location. Pixel (i, j) is a center pixel of the mask.

P_b = the pixel marked in black

P_w = the pixel marked in white

$$M_b = \frac{1}{8} \sum_{i=1}^{8} P_b \quad (2)$$

$$S_b = \sqrt{\frac{1}{8} \sum_{i=1}^{8} (P_b - M_b)^2} \quad (3)$$

$$M_w = \frac{1}{8} \sum_{i=0}^{8} P_w \quad (4)$$

$$S_w = \sqrt{\frac{1}{8} \sum_{i=0}^{8} (P_w - M_w)^2} \quad (5)$$

M_b = mean of the pixel marked in black

M_w = mean of the pixel marked in white

S_b = standard deviation of the pixel marked in black

S_w = standard deviation of the pixel marked in white

The statistical factors show the relation of the pixel marked in black and white, and especially determine the output of the local pattern mask. It could be true or false. If the output of any mask is true, the pattern kernel corresponding to a mask is computed in the region which includes a location of the detected mask.

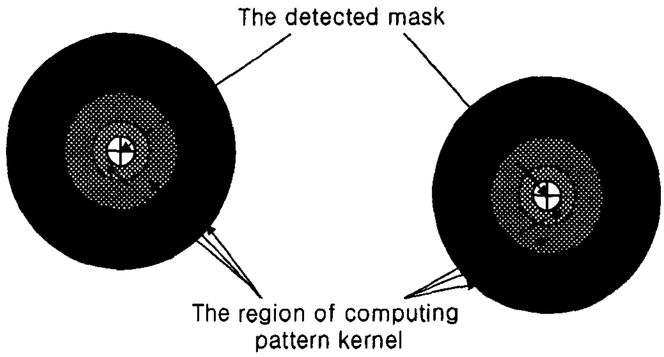


Fig. 5 The region of computing pattern kernel corresponding to any mask

If a condition is satisfied with the pattern kernel algorithm, the region in Fig. 5 extends from small circle to large circle. The role of the 5 different pattern kernels recognizes its length, frequency, and shape of a lip print. Each of the pattern kernel represents its shape and the extended region in Fig. 5 implies its length. The number detected by the pattern kernel represents its frequency. The information is converted into the vector data.

Some examples of a lip print are shown in Fig. 6, in which the picture illustrates the various pattern of the lip print.

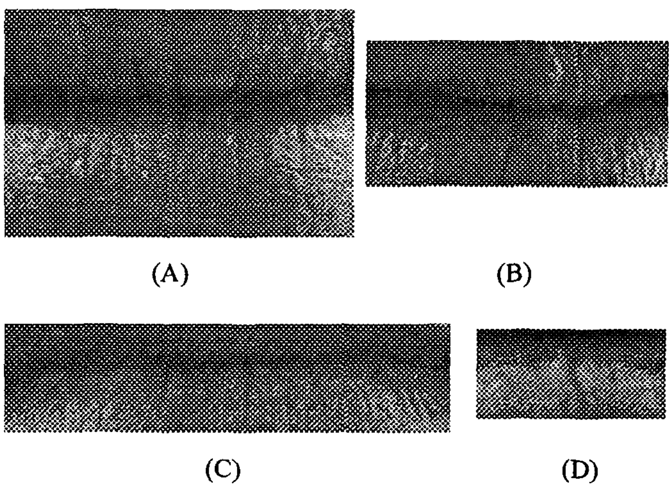
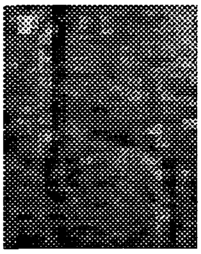


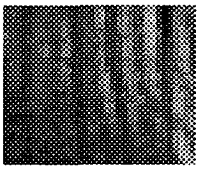
Fig. 6 Some sample of the pattern of a lip print

Fig. 6 (A) shows the complex pattern of the lip print. The pattern of picture is consisted of the horizontal direction pattern and the vertical direction pattern and diagonal direction pattern.

Fig. 6 (D) shows the blurred pattern of the lip print. It is difficult to analyze the pattern of the lip print. However, if the combination of several pattern kernels is used, the characteristic feature of its blurred pattern can be extracted.

The each picture has the various shapes and frequencies and lengths of the lip print. These feature should be analyzed and transformed to get the discriminative data by the pattern kernels.





(A) (B)

Fig. 7 Magnification of a lip print

The magnifications of the vertical direction pattern and the WS(west-south) diagonal direction pattern are shown in Fig. 7, in which the pattern kernels inform us about the characteristics of the pattern.

The vertical direction pattern in the Fig. 7 (A) is detected by the pattern kernel 1 and the WS(west-south) diagonal direction pattern is converted into digital data by the pattern kernel 3. For example, if a pattern in any location is matched with the mask 1 or 4, the pattern kernel 1 will be computed and produce the information vector. The pattern in the Fig. 7 (B) is only the vertical direction pattern. The vectors corresponding to the pattern kernels are discriminated by the equation(1).

4. Multi-Resolution Architecture

The purpose of using multi-resolution architecture is to utilize the information vector provided at different image resolutions. The multi-resolution system has more merits than the single-resolution, such as the robustness of the noise, the reliability of the system. The preprocess is used by the histogram equalization.

However, this method can't remove the various noises of the image data of a lip print. The smoothing effect on averaging is proved to be more beneficial to the reduction of the noise.

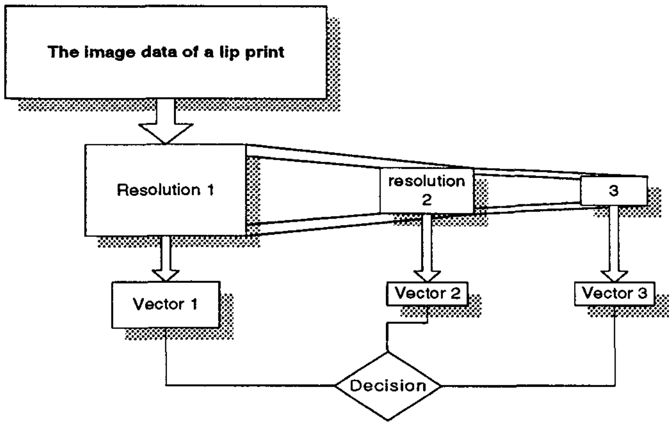


Fig. 8 Architecture of multi-resolution system

Fig. 8 illustrates the architecture of complete system. Each pattern kernel produces a single information vector, and discriminates its output. The last products of these modules are combined so as to decide the final result. The recognition in the three of two resolution system is more reliable than recognition in the single-resolution system.

5. Experimental Results

We use the 18 local pattern masks size of 4×4 pixels, the 5 pattern kernels, and images scaled down two times (denoted resolution 1-3). Its database consists of the images of 20 persons. The gray-scale image of a lip print is acquired by the CCTV camera with a depth of 8 bits and a resolution of 320×240 pixels.

Table 3 Recognition rate of the system

	Recognition rate[%]
Resolution 1	85%
Resolution 1, 2	90.6%
Resolution 1, 2, 3	95.3%

This algorithm is simulated by the windows programming (API) in the intel-pentium PC. The multi -resolution system with three modules achieves a recognition rate of 95.3%. The single resolution system achieves a system error by the rate of 15%. Table 3 shows a recognition rate of the system.

6. Conclusion

We have investigated the performance of an algorithm for a lip print recognition based on the local pattern mask and the pattern kernels. The pattern kernels convert a lip print into the digital data, and it is discriminated by the criteria. The multi-resolution architecture allows us to reduce the false recognition rate from 15% to 4.7%. This paper shows that a lip print is sufficiently used by the measurements of biometric systems.

With a new personal identification method, we have taken one step into this direction. The next step will be the ASIC implementation using VHDL or Verilog HDL.

7. References

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