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# 구순문 인식을 위한 복수 해상도 시스템의 패턴 커널에 관한 연구

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# On Pattern Kernel with Multi-Resolution Architecture for a Lip Print Recognition

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## 요 약

생체인식 시스템은 인간 고유의 물리적인 특성들을 이용하여 인간을 인식하는 기술이다. 그리고 특정한 물리적인 특징들을 얻기 위하여 센서를 사용하고 디지털 패턴으로 변환시켜서 저장된 패턴과 비교한다. 구순문 인식은 지문, 음성 패턴, 홍채 패턴과 얼굴 인식과 같은 신체적 특징에 비하여 상대적으로 연구가 많이 이루어지지 않았다. 구순문은 CCD 카메라를 이용할 경우 홍채나 얼굴 패턴 같은 다른 특징 요소와 연결하여 인식 시스템을 구축할 수 있는 장점을 가지고 있다. 구순문 인식을 위해 패턴 커널을 이용한 새로운 방법을 제시하였다. 패턴 커널은 여러 개의 국부 구순문 마스크 (local lip print mask)들로 구성된 함수이며, 구순문의 정보를 디지털 데이터로 전환시켜 준다. 복수 해상도를 가지는 인식 시스템은 단일 해상도의 시스템보다 더욱 신뢰적이며 인식률도 높다. 복수해상도 구조는 오인식률을 현저히 감소시키므로 복수해상도를 갖는 구순문 인식은 생체인식 시스템에 잘 활용될 수 있다.

## ABSTRACT

Biometric systems are forms of technology that use unique human physical characteristics to automatically identify a person. They have sensors to pick up some physical characteristics, convert them into digital patterns, and compare them with patterns stored for individual identification. However, lip-print recognition has been less developed than recognition of other human physical attributes such as the fingerprint, voice patterns, retinal blood vessel patterns, or the face. The lip print recognition by a CCD camera has the merit of being linked with other recognition systems such as the retinal/iris eye and the face. A new method using multi-resolution architecture is proposed to recognize a lip print from the pattern kernels. A set of pattern kernels is a function of some local lip print masks. This function converts the information from a lip print into digital data. Recognition in the multi-resolution system is more reliable than recognition in the single-resolution system. 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.

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## I. Introduction

Biometric systems are forms of technology that use unique human physical characteristics to automatically identify a person. They have sensors to pick up some physical characteristics, convert them into digital patterns, and compare them with patterns stored for his own identification [1]. Non-sophisticated biometrics have existed for centuries. Parts of our bodies and aspects of our behavior have historically been used as important means of identification [2]. The study of finger images dates back to ancient China. A person is usually remembered and identified by his face or by the sound of his voice. His signature is one of the best-established methods of authentication in banking, for legal contracts and many other aspects of his life [3]. A system to analyze the unique pattern of the retinas was introduced in the mid 1980s.

Biometric identification can eliminate such common problems 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 [4]. It can be used for identification purposes involving security access systems in information-services departments, government agencies, ATMs/banks, law enforcement, prisons, international border control, and military agencies [5] [6]. 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 [7]. Each measurement has its own merits and faults. A lip print is included among measurements of biometric systems [8]. Each person's lip has a unique lip print and differs from others [9]. A new personal identification method is proposed by using lip print recognition with pattern kernels and multi-resolution architecture. Pattern kernels use some local masks in order to analyze a lip print by a pattern-recognition method based on computation of local autocorrelation coefficients. The method has merits such as a small amount of data, and faster computation than template matching. The merit of lip print recognition by a CCD camera can be linked with other recognition systems such as the retinal/iris eye and the face, because those use the same sensors and are located in the human face.

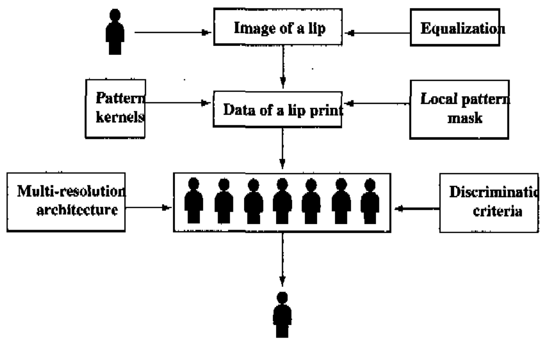
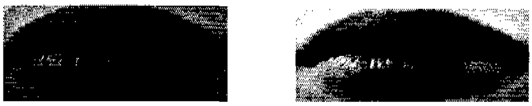



Fig. 1 Block diagram of a lip print recognition system

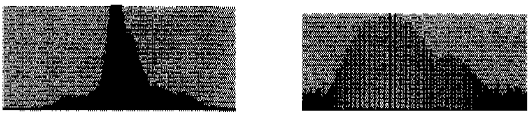
Figure 1 illustrates a block diagram of a lip print recognition system with multi-resolution architecture. The image data from a lip print is considered a connective appearance with the directional local pattern [10] [11]. The local masks extract information from local patterns for a lip print, including the vertical, the horizontal, and the diagonal patterns. One of the advantages of the pattern kernels through the local masks is the small amount of data required to represent unique personal information for recognition. The discrimination criteria either recognizes a person from the classes of his input images or rejects him if the input image is mismatched [12] [13]. The multi-resolution architecture is proposed in order to reduce both the noise and false recognition rates.

## II. Multi-Resolution Architecture

The multi-resolution architecture is proposed to utilize the information vector at different image resolutions and to overcome the fault of the



(a) Original image (b) Equalized image



(c) Histogram of original image (d) Histogram of equalized image

Fig. 2 Histogram of original image and its equalized image.

single-resolution system of a lip print recognition method. It is caused by the speciality of a lip print such as a chapped lip, and by an unexpected noise. A pre-process is used to reduce the noise as illustrated by a histogram equalization in Fig. 2.

However, this method has limitations when removing the various noises from the image of the lip print. The multi-resolution system has more merits than the single-resolution, because of the robustness of the noise and the reliability of the system [14] [15]. The smoothing effect on averaging has proved to be more beneficial to the reduction of noise and the chapped lip.

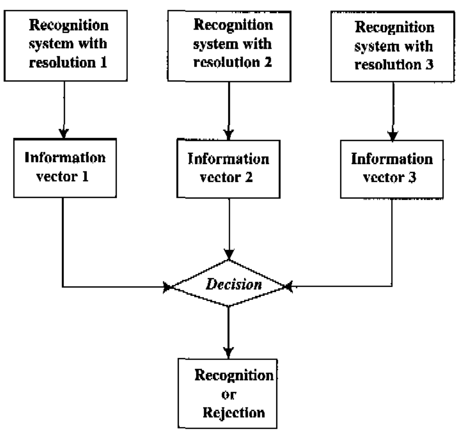



Fig. 3 Architecture of multi-resolution system

Figure 3 illustrates the architecture of the multi-resolution system. The recognition system corresponding to a resolution of the image produces a single information vector and discriminates its output. The last products of these modules are combined so as to decide the final result which indicates a recognition or a rejection. Recognition with a three- or two-resolution system is much more reliable than recognition with a single-resolution system.

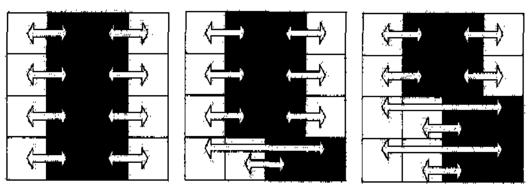
The input image is composed of many pixels with the 8-bit-gray level. Its value ranges from 0 up to 255. In this paper, the image data maintains the 8-bit-gray level until all processes end, pre-processed with the histogram equalization for acquiring an enhanced image. The lip print holds some information in the small part inside the region.

If the input image is pre-processed with the threshold method, a part of the information on the lip print will vanish from the input image. When the local pattern mask is compared with the pre-processed 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-bit-gray level. This kind of difficulty can be resolved by using some statistical factors such as its mean and its standard deviation.

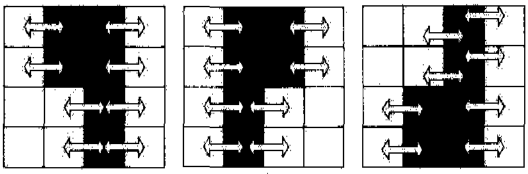
In Fig. 4, for example, mask 1 has 8 pixels marked in black and 8 pixels marked in white. The pixels marked in black are a part of the lip print. While mask 1 scans some regions of the image, its mean and its standard deviation can be computed. The computational results can be used for mask 1 to find out whether its region has the same pattern or not.

$M_b$, a mean of the pixel marked in black, is obtained by (1)

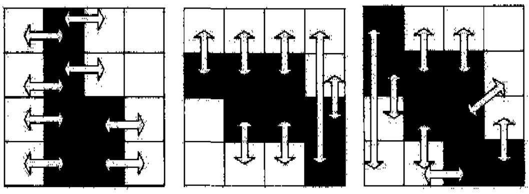
$$M_b = \frac{1}{8} \sum_{i=1}^{8} P_b \qquad (1)$$



(a) Mask 1 (b) Mask 2 (c) Mask 3



(d) Mask 4 (e) Mask 5 (f) Mask 6



(g) Mask 7 (h) Mask 8 (i) Mask 9

Fig. 4 Example of the local pattern masks

where $P_b$ is the pixel marked in black.

$S_b$, a standard deviation of the pixel marked in black, is obtained by (2)

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

$M_w$, a mean of the pixel marked in white, is obtained by (3)

$$M_w=\frac{1}{8}\sum_{i=1}^{8}P_w \tag{3}$$

where $P_w$ is the pixel marked in white.

$S_w$, a standard deviation of the pixel marked in white, is obtain by (4)

$$S_w=\sqrt{\frac{1}{8}\sum_{i=1}^{8}(P_w-M_w)^2} \tag{4}$$

The statistical factors show a relationship of the pixels 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. Since the number detected by the pattern kernel represents its frequency, it is converted into the vector data.

Some examples of a lip print are shown in Fig. 5, in which the pictures illustrate the various

(a) (b)

(c) (d)

Fig. 5 Some samples of lip print patterns.

patterns of the lip print. Figure 5(a) shows the complex pattern of the lip print. The pattern of Fig. 5(a) consists of the horizontal direction pattern, the vertical direction pattern and the diagonal direction pattern. Fig. 5(d) shows the blurred pattern of the lip print. It is difficult to analyze the pattern of this lip print. However, if a combination of several pattern kernels is used, the characteristic features of its blurred pattern can be extracted. Each picture has the various shapes, frequencies and lengths of the lip print. These features should be analyzed and transformed to get the discriminative data by the pattern kernels.

Fig. 6 Magnification of a lip print.

The magnifications of the vertical direction pattern and the WS(west-south) diagonal direction pattern are shown in Fig. 6, in which the pattern kernels inform us about the characteristics of the pattern. The vertical direction pattern inside the left image in Fig. 6 is detected by the pattern kernel 1 and the WS diagonal direction pattern is converted into digital data by the pattern kernel 3. For example, if a pattern in any location is matched with mask 1 or 4, the pattern kernel 1 will be computed to produce the information vector. The vectors corresponding to the pattern kernels are discriminated by (5)

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

where $N$ is the number of the information vector and $K_p^s$ is the specific information vector, and $K_p^m$ is the information vector.

## Ⅲ. Results and Conclusion

Figure 5(d) shows the blurred pattern of the lip print. It is difficult to analyze the pattern of this lip print. However, if a combination of several pattern kernels is used, the characteristic features of its blurred pattern can be extracted. Each picture has the various shapes, frequencies and lengths of the lip print. These features should be analyzed and transformed to get the discriminative data of the pattern kernels. Table 1 shows that the multi-resolution system with three modules achieves a recognition rate of 95.3%, but the single resolution system achieves a system error with a rate of 15%.

Tables 1 and 2 show the multi-resolution architecture algorithm improves not only the recognition rate, the false recognition rate and the false acceptance rate but also the repeatabilty rate. Its performance has been investigated for a lip print recognition based on the local pattern mask and the pattern kernels.

Table 1. Recognition rate, false rejection ratc and false acceptance rate of the recognition system

| Resolution | Recognition rate | False recognition rate | False acceptance rate |
|---|---|---|---|
| 1 | 85.0% | 12.0% | 3.7% |
| 1, 2 | 90.6% | 7.2% | 1.4% |
| 1, 2, 3 | 95.3% | 2.8% | 1.1% |

Table 2. Repeatability rate of the recognition system

| Resolution | Repeatability rate |
|---|---|
| 1 | 92.0% |
| 1, 2 | 96.1% |
| 1, 2, 3 | 98.2% |

The local pattern mask extracts information from the local pattern of a lip print. The pattern kernels detect information from the global pattern and convert a lip print into the digital data that can be 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. The lip print recognition by a CCD camera has the merit of being linked with other recognition systems such as the retinal/iris eye and the face to make the system compensated. A system with plural attributes may have more reliability than a system with a singular one.

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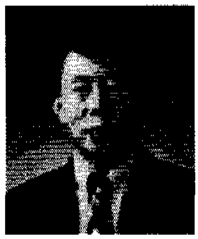

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