Hybrid Finger Scanner and Multi-modal Biometric Authentication Technology

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Abstract

Biometric authentication technology is progressing from single-modal to multi-modal authentications that are capable of increasing the certainty of biometric authentications. The biological features that coexist in the same area of the human body may be perceived as a means of multi-modal authentication. Biometric authentication using blood vessel patterns or fingerprints are seen as promising technologies for the biometric authentication domain of the future. This is because the scanning of these body areas is a relatively simple process that is easily done compared to the multi-modal authentication of other body features.

Keywords

multimodal biometric authentication, fingerprint recognition
blood vessel (vascular) pattern authentication

1. Introduction

Biometric authentication methods applied to various parts of the human body have been proposed and implemented. Technologies have been developed pertaining to fingerprints, palmprints and face recognition as well as for DNA matching. These and other representative technologies including authentications using iris patterns or blood vessel (vascular) patterns of the finger or palm have been dealt with in other papers in this special issue. Handwritten signatures and habitual behavior patterns such as specific actions can also be used in biometric authentication. The recognition technologies for these individual features are referred to as modes or modalities.

Each of these modes has its own characteristics related to the ease of input, accuracy, ease of acceptance by users, etc. For example, the fingerprint is regarded as being less easy to accept because it has the image of being a tool for aiding police or judicial investigations. **Table** indicates the general tendencies that characterize the major modes, though details may vary depending on the age group, system or authentication method.

Table Typical characteristics of authentication modes.

Mode	Ease of use	Ease of acceptance	Accuracy
Fingerprint	○	×	○
Palmprint	△	△	○
Face	○	○	△
DNA	×	?	○
Iris	△	△	△
Vascular pattern	△	○	△
Hand signature	?	○	×

In general, the various modes of biometric authentication have common problems that are caused due to the existence of "ambiguity" because the targets are living body parts. In other words, authentication may be difficult depending on environmental conditions including greatly variable body and health conditions as well as on the measuring conditions. There are some modalities that are unusable with certain persons due to the effects of disease, etc. (DNA may be regarded as the ultimate mode, but its application takes a very long time using the current technology).

To deal with these problems, a biometric authentication technology using multiple modalities or the multi-modal authentication technique is proposed.

Below, we introduce the multi-modal authentication technology as it is applied to features of the finger, which are the fingerprints and blood vessel patterns. The development of a hybrid finger scanner that captures the images of fingerprints and blood vessel patterns simultaneously is proposed.

2. Fingerprint/Blood Vessel Pattern Recognition Technologies

Various biometric authentication technologies have been proposed according to the pattern of the targeted features.

Fig. Feature points, minutiae in fingerprint.

Images are processed with regard to their characteristics and whether the matched person is identical to or different from the registered person. They are judged from the degree of matching of the shapes and feature positions. The general method of fingerprint authentication is to extract the positions of end points and branching points (called the feature points, minutiae; see **Fig** .) of the print pattern and judgments are made based on the relationships of their positions. NEC boasts the world's top performance in this field, as is described in another paper in this special issue "Fingerprint/Palmprint Matching Technology" (pages xx to xx). Blood vessels have a structure that is similar to tree branches and authentications based on them are generally performed by pattern matching of the more prominent blood vessels. The blood vessels between the first and second joints of a finger are easiest to observe and therefore more suitable for matching, which may be understood well from viewing Photo 3 below.

3. Characteristics of Multi–modal Fingerprint Recognition

Even when one of the features used in multi-modal authentication becomes less discernible or unusable, the remaining modes can compensate for the authentication accuracy. When all of the modes are free of problems, the authentication accuracy (such as the probability that a person is the identical person) is improved thanks to the increase in the amount of relevant data.

However, if a multi-modal authentication is a combination of independently hard-to-use modes, the authentication becomes even more difficult to achieve. In addition, measuring two modes successively one after another is a task that is likely to be disliked by the users.

On the other hand the issue described above may be solved if two modes in the same area can be measured simultaneously. When using multiple modes, it is important that the user remains unconscious of them.

If the fingerprint and blood vessels in a finger are used as the modes, they are located in adjacent locations so that the multi-modal authentication of fingerprint and blood vessels is possible with the single action of placing the finger above the scanner. Since the fingerprint and finger blood vessels are relatively popular modes, combining them thus can be expected to improve authentication accuracy.

4. Development of the Hybrid Finger Scanner

The bio-feature scanner for multi-modal authentication can be implemented relatively easily by combining existing biometric authentication scanners. Scanning for fingerprints and blood vessels can also be implemented by separately developed scanners, but this is not advantageous from the viewpoints of both cost and packaging considerations.

Therefore, we decided to take the approach of developing a multi-modal authentication scanner with a single imaging system that could simultaneously capture two modes in adjacent areas, as in the finger, namely those of the fingerprint and blood vessels. As this system is effectively a hybrid fingerprint/blood vessel scanner based on composite technologies, we decided to call it the "Hybrid finger scanner."

Photo 1 shows the first prototype of the scanner. The blood vessel pattern is imaged using a near-IR light of around 850 nm wavelength that can absorb the hemoglobin, the main constituent of blood. It is thus able to easily transmit clear images of living organisms. The prototype uses an LED light source because LEDs of this wavelength are relatively easily available.

Photo 1 First prototype.

The LED is placed at the upper part of the scanner prototype and the near-IR light transmitted through the finger is imaged with an IR camera.

The fingerprint is imaged using reflected light. As the prototype was fabricated to obtain approximate images in order to check the viability of implementation, the images obtained from it were considered not to be good. Therefore, we improved its performance by arranging the positioning of transmitted light and reflected light sources as shown in **Photo 2** . **Photo 3** shows the blood vessel pattern image obtained with the improved prototype and **Photo 4** shows the fingerprint image obtained by it.

The blood vessel pattern image captures the transmitted light from the light source above the finger and the fingerprint image captures the reflection of the light from the light source at the lower part. Lighting both light sources simultaneously makes it possible to obtain the image of both the blood vessel pattern and fingerprint (**Photo 5**).

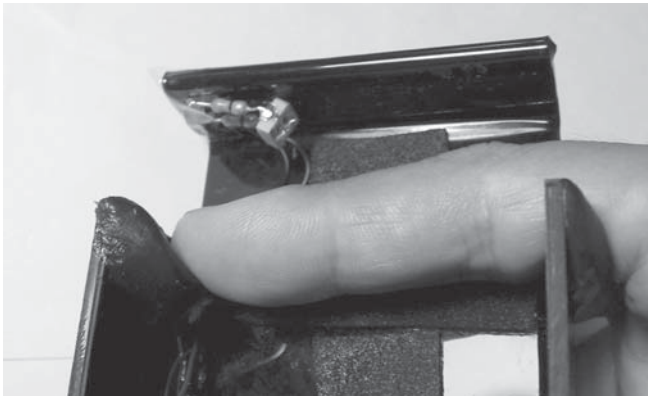

Photo 2 Improved prototype.

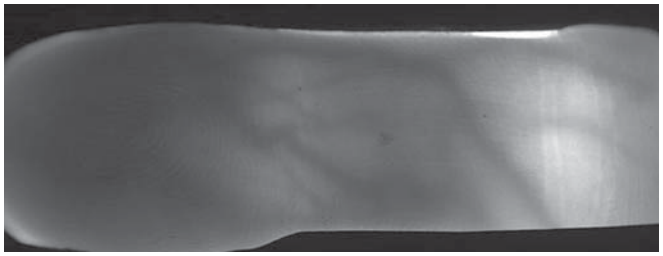

Photo 3 Blood vessel pattern image captured with transmitted light.

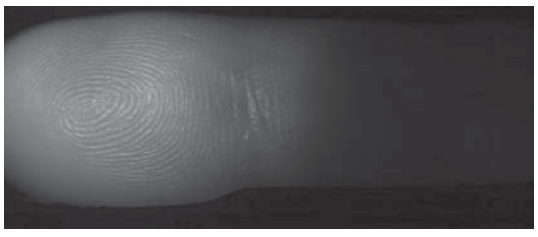

Photo 4 Fingerprint image captured with reflected light.

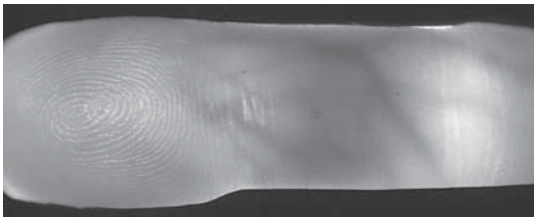

Photo 5 Fingerprint/blood vessel pattern images captured with transmitted + reflected light.

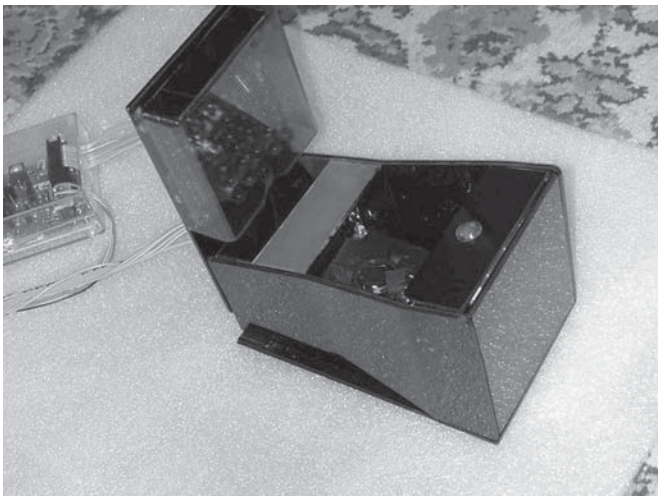

Photo 6 Experimental device for fingerprint + blood vessel pattern imaging with transmitted light.

The improved prototype has allowed us to confirm that the hybrid scanner can provide images of a high enough quality for effective matching.

We also experimented to confirm if the fingerprint and blood vessels can both be imaged simultaneously by using a single transmitted light source. **Photo 6** shows the device that was fabricated for this experiment. It has a strong light source composed of an array of 80 IR LEDs. **Photo 7** shows the image captured by the experimental device using exclusively transmitted light. This image is not considered to be practical because the blood vessels are overlapped on the fingerprint and the contrast is poor.

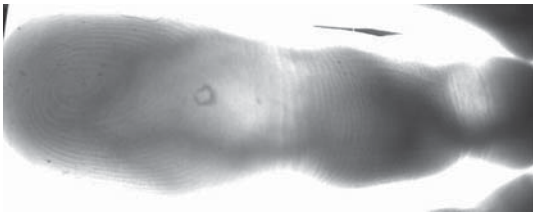

Photo 7 Fingerprint + blood vessel pattern image captured with transmitted light only.

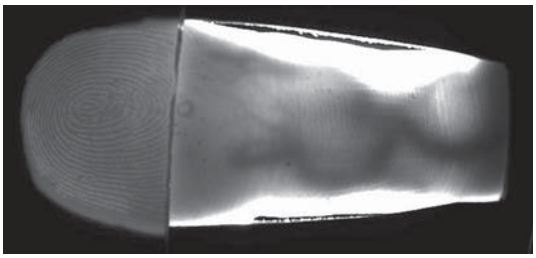

Photo 8 Compression of fingerprint area with fiber plate.

We then attempted to install a fiber plate on the fingerprint side in order to reduce the blood in the fingerprint area by compressing the blood vessels in an attempt to improve the contrast. The result is shown in **Photo 8** . The image has good contrast in spite of the fact that both the blood vessels and the finger are imaged using transmitted light from the same source.

5. Toward Product Implementation

Having confirmed the possibility of obtaining satisfactory images in the experiments described above, we intend to commercialize the product by applying enhancements that will improve its ease of use. For example, when ease of use is considered, the light source in the upper part of the scanner tends to impede bringing the finger to the required scanning position. The market needs a scanner that can offer good total balance of performance and operability by solving this problem. It is important to develop the scanner by considering the possibility that it will be embedded in another piece of equipment as well as its ease of use as a single unit.

Photo 9 shows an example of a pilot hybrid scanner product that has already been fabricated. This scanner was embedded in an automated teller machine.

Blood vessels are also present under the palm and the palm has a print that has similar properties to the fingerprint. As in the case of the finger, a hybrid scanner of the blood vessels of the palm and palmprint is also conceivable. Finally, we have prototyped a hybrid scanner for use with either finger or palm, as shown in **Photo 10** and **Photo 11** . Photo 10 shows a view of finger authentication and Photo 11 shows the palm recognition procedure with the same scanner.

Photo 9 Hybrid scanner mounted in an automated teller machine.

Photo 10 Finger recognition using finger/palm hybrid recognition machine.

Photo 11 Palm recognition using a finger/palm hybrid recognition machine.

6. Conclusion

Multi-modal technologies are capable of improving the ease of use and reliability of biometric authentication. Such technical advances are expected to make human life more comfortable and convenient as well as helping to protect the safety of society as a whole. We intend to continue to implement commercialization of this product in order to fruitfully serve these purposes.

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