A study on the merits of Biometrics to perform e-Health

Yasumitsu Tomioka[1,2], Toshihiko Kitano[1], Naoki Aida[1], Kei Kakehi[1],
M.A.Sadiq[2], Hiroshi Juzoji[2], Isao Nakajima[2]
[1]Office Tomioka Inc.,
[2] Tokai University School of Medicine

Abstract

The merits of biometrics to perform e-Health are discussed in this paper. We feel that the optical sensor (fingerprint, finger-vein, face, iris, and retina) using the videophone system is a promising biometrics system for e-Health, e.g. telemedicine. We propose the inclusion of optimized biometric methodologies and guidelines as a theme of ITU's E-Health standardization.

1. Objectives

The merits of biometrics to perform e-Health, e.g. telemedicine, are discussed in this paper.

We propose the inclusion of optimized biometric methodologies and guidelines as a theme of ITU's E-Health standardization.

2. Background

2-1. What is biometrics?

Biometrics is an individual identification technology utilizing the unique biological characteristics of humans, and is typically used to identify the owner of forms of identification such as cash cards, driver's licenses, and health insurance ID cards. The conventional technique is to compile information on individuals in the form of a database and then identify individuals using a PIN, password, and ID cards based on the stored information. This technique, however, is vulnerable to illegal acts such as forgery, theft, tapping, and identity theft.

The biometric method measures biological objects having the following three characteristics:

1. Universality (characteristics common to everyone)

2. Uniqueness (characteristics unique to each individual)

3. Permanence (characteristics that do not change over time)

Such individual characteristics--well-known examples include fingerprints, the retina, iris, voice, hand shape, palm print, and face--are stored in a database for identification.

This technique simply analyzes the biological characteristics that are expressed using images and signals, and estimates the probability of pattern matching with the data in the database. As a result, the output is only a positive recognition or negative recognition, as shown in Fig. 1; note that the matching probability is not 100%.

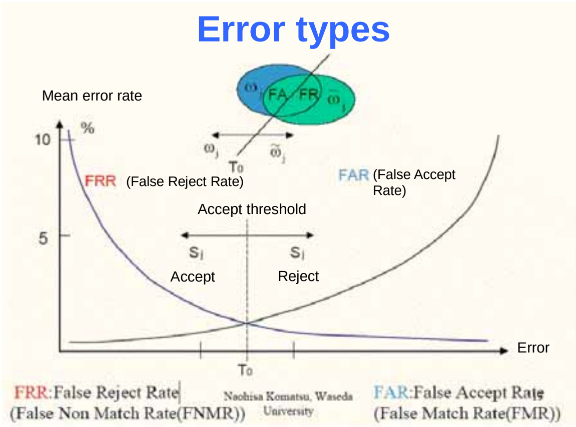

Figure 1. Error types

2-2. Market

Increasing global concerns about terrorist activity and identity have boosted the demand for improved security. Increased media attention has raised end users' awareness of the potential of biometric technologies in security applications. Significant market opportunities are thus emerging in application areas such as physical access control, citizen identity, network security, financial services, entitlement and healthcare. For example, InfoShop-Japan reports that the world market size for access management (keyless entry) alone was USD13 million in 2002 and will reach USD70 million in 2007(Fig. 2). As shown in Fig. 3, 50% of 2004 biometric products are fingerprint sensors. Non-contact sensors are expected to increase in popularity in the near future. If they are used in the areas of telehome care and geriatric care, the market may explode in advanced countries.

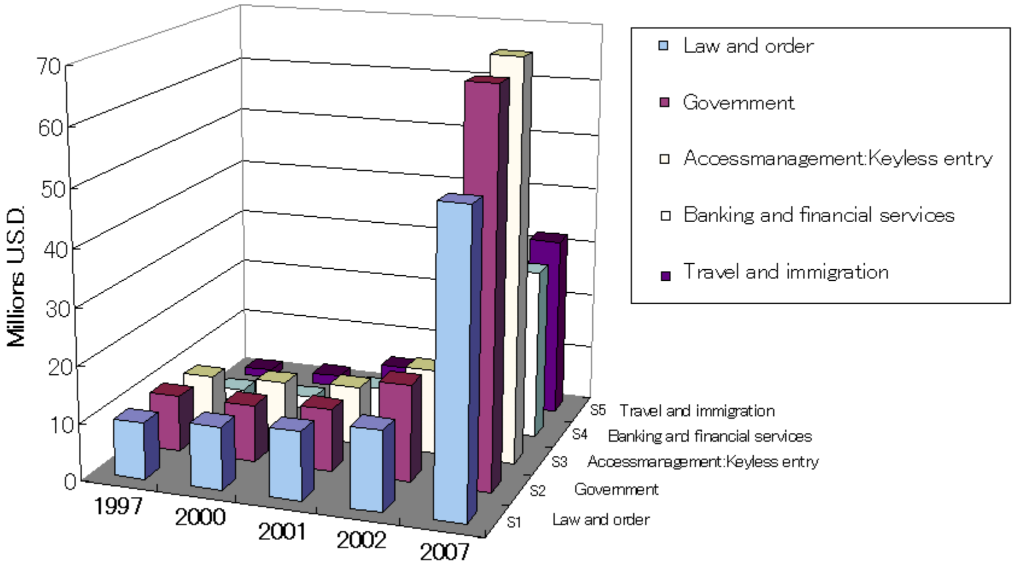

Figure 2　The World Market for Biometrics

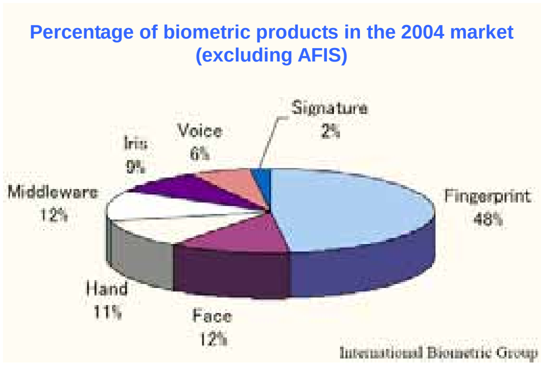

Figure 3　Percentage of biometric products

2-3. Necessity of biometrics in telemedicine

With the increasing importance of the comprehensive management of medical information in our aging society, individual identification is essential not only for telemedicine but for information management for individual information browsing and making insurance payments. Japan is facing the problem of an increase in the number of people who do not pay health insurance fees. As the number of clients who attempt to receive medical services in an illegal manner through identification theft is expected to grow, the importance of individual identification will be enhanced.

We have identified the following needs in telemedicine for individual identification:

1. Health insurance ID certificate (or ID card in some countries)

2. Remote consulting

3. Emergency transport

4. Health check (except for diseases)

5. Return of medical fees

6. Client chart browsing (for the client only)

The above six applications require identification accuracy as high as that needed for the online banking system.

3. Proposal

We feel that the following optical sensor using the videophone system is a promising biometrics system for telehomecare.

3-1. Face

A　Methodology:

In telemedicine, it is possible to monitor the face of a client by using a videophone system. Since there is no compulsory or forcible feeling for the client to use the videophone system, it would be acceptable for the client to use the videophone system rather than to use the other system or applications. In the case wherein the simple videophone system is used, it would be indispensable to develop the following technical elements. Generally in telemedicine, since the client stands so as to face the front surface of the client toward the camera of videophone, an accuracy of individual identification is relatively high by contriving the direction of lighting optimally, compared with the face identification system used in a system for administration of entering into and/or exiting from a building.

B Cut-off and detection of face:

It is necessary to maintain a distance between the client and the camera of videophone. It should be noted that the brightness of image is widely altered corresponding to age, gender, race and size of the client. By the general methodology, a pyramidal image was produced at first, and then a NN (Neural Network) which is common to different face size was detected from the pyramidal image.

NN methodology is sorted into two learning method, one is so-called "learning with teacher" in which the problem is gradually optimized by inputting the teacher signals (correction) and the other is so-called "learning without teacher" in which it is unnecessary to use the teacher signals. In a case where the definite solution is prepared, the "learning with teacher" is utilized, while in a case of data-clustering, the "learning without teacher" is utilized.

As a result, the dimension of the solution is reduced even any NN methodology is selected. Thus, it would be able to get a good solution by employing a relatively small amount of calculation, even though the problem involves the multi-dimensional data such as "images" and "statistics" and is not able to apply a "linear-analysis". Accordingly, the NN methodology is widely applied to not only pattern-matching procedure and data-mining procedure but also several fields. It should be noted that, in the face certification, it is possible to resolve in high-speed by employing NN methodology.

C Face characteristics detection: In the face characteristics detection, both of "Gabor-Kernel wavelet" and "Graphic matching" methods are employed. In the "Gabor-Kernel wavelet", as mentioned later in iris identification, since a directionality edge and a selectivity of frequency component are good, the accuracy of the edge extraction from the image is enhanced. Thus, it is possible to certainly grasp the characteristic structures on the face, such as eye, nose and mouth.

In graphic matching method, at first, 10 to 20 characteristic points in the structures of the face were previously extracted, and then these characteristic points are found out by matching.

Several different methodologies are devised and by using the opened face data-base, each of methodologies is evaluated.

D De-interlace:

In non de-interlacing, each of odd field and even field on an image is reduce to 1/30, while in de-interlacing to 1/60, as the scanning lines are into halves. Because of adding the odd field and even field, striped noise is produced. In order to eliminate the striped noise, it is necessary to mathematically execute the de-interlacing to the even field as well as to the odd field, after taking the striped noise by digital data. If it is not possible to execute the de-interlacing, either one of odd field and even field should be employed. In the case where either one is employed, the quality of the image would be deteriorated by 3dB in the longitudinal direction.

E Optical specification:

In a case where the telemedicine is executed using the face identification in future, as shown in Fig. 4, the client should stand in front of the camera of videophone, by radiated the lights from both sides of the camera, in order to erase the shadow from the face of client. By doing so, it would be possible to capture the principal constructions on the face, such as eye, nose and mouth.

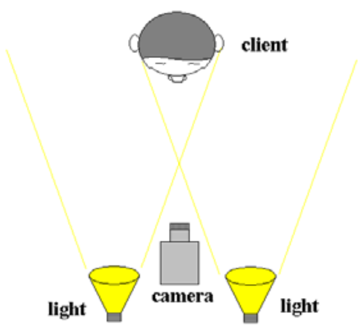

Figure 4 Face identification

3-2. Iris

A Methodology: Individuals can be identified based on the iris pattern, which is unique to each person. The iris pattern is formed within six months after birth and stabilizes within one year after birth, and does not change until death. Two devices can be used to measure the iris pattern, as follows.

1. If the videophone system is equipped with a zooming function, it can work as an iris identification device.

2. A dedicated light-reaction device can measure the speed of light reaction and examine the iris pattern simultaneously.

In the identification process, the analysis zone is selected from the iris pattern sampled using the CCD, its profile is extracted using a Gabor filter and then coded. This code is used to select the closest iris code in the database based on the Hamming distance value. The error rate is 2^{-244}, the same probability of a coin toss ending with the same result 244 times in a row.

B Advantages: Non-contact, easy to use, and accurate. It would be very difficult to fake an iris, even with advanced plastic surgery and eye operation techniques. In combination with the light-reaction device, it can measure the iris reaction speed (which aids in diagnosis of problems with the brain stem and oculomotor nerve) and identify the iris pattern simultaneously.

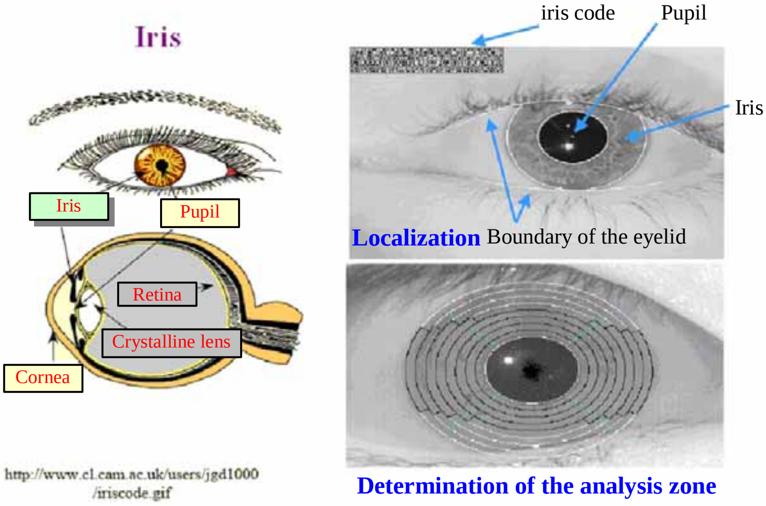

Figure 5 Analysis of the iris

3-3. Retina

A Principle: The vessels pattern of the retina can be used for identification. This vessels pattern remains unchanged unless the veins shrink due to diabetes or other illness. It is normally difficult to see the vein pattern without expanding the iris using chemicals (e.g., Mydrin). In recent years, however, a device has been developed that can see the vein pattern without the use of iris-opener chemicals. As dedicated equipment is necessary in both cases, it is not possible to conduct retina identification using a normal videophone system alone.

B Advantages: Non-contact and accurate, but not easy to use. The biological origin of the retina is the same as that of the brain. In fact, it is possible to estimate the condition of the blood in the brain from that in the retina, and the brain pressure from the optic papilla on the retina. Some easy-to-use devices are expected to be developed in the future. We should focus on the retina device as a promising telehomecare device.

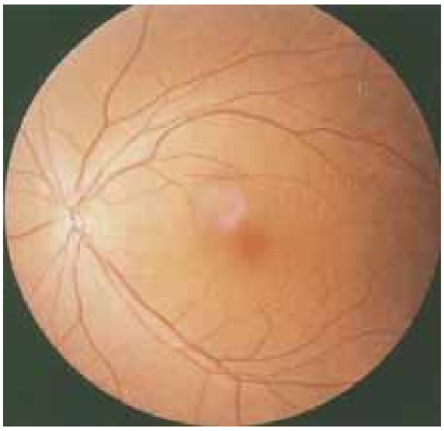

Figure 6 The pattern of retinal blood vessels (Artery and Vein)

4. Prospects

4-1. Reluctance to use fingerprints

The U.S. Visit Program employed by the immigration authorities in 2004, which uses fingerprints for individual identification, has been poorly evaluated by those visiting America. This is due to the fact that this FBI technique, known as AFIS (Automated Fingerprint Identification System), has been used to identify criminals in the United States. Many people may not accept the use of such a criminal identification system for totally different medical use. Most users may prefer non-contact-type biometric techniques that do not use fingerprints. Diagnosis using the videophone system provides information on the client's physical characteristics. Thus, it is natural to use such physical information for user identification.

4-2. Three accuracy levels

A number of biometrics companies have developed a variety of identification techniques using fingerprints, vein patterns of the palm, face, iris, and retina characteristics. These techniques are completely unrelated to each other.

Although more than one algorithm and measurement device are available, the identification result can only be one for each individual. As in the case of mathematics, there is only one correct answer. If the identification accuracy is not sufficiently high, users will be inconvenienced. Unless an identification system is shared by many users, as many sensors and devices as the number of such systems will be necessary. This is unreasonable for users. Since the 9/11 terrorist attacks, homeland security has been focused on, so it is currently difficult to establish an international standard for individual identification. However, at least objective accuracy guidelines should be considered. We feel that the following accuracy evaluation should be included in such guidelines.

1. Accuracy evaluation of the matching algorithm: Numeric degree of pattern matching between two input images

2. Accuracy evaluation of the matching device: Accuracy of hardware, including sensors

3. Accuracy evaluation of identity matching: Accuracy of identification of the correct person

Without these three accuracy evaluations, no identification technique can be objectively evaluated. Objective evaluation is the first step toward international standardization.

4-3. Efforts for standardization

The standardization of biometrics is underway in ITU-T SG-17 Telebiometrics and ISO/IEC SC37/SC17/SC27. However, there is no forum for discussing applications to telemedicine. If E-Health is standardized by ITU-T SG-16 Q-28 in 2004-2007, discussions on the standardization of biometrics for telemedicine should be kicked off as early as possible jointly with SG-17. As mentioned above, the medical needs are diverse and the telemedicine market is growing faster than expected. We feel that biometrics for telemedicine should be included in the ITU scope. If we lose this opportunity, the importance of telemedicine standardization by ITU will fall drastically. This is due to the fact that the ICT technology will involve the elderly, who often do not go out for medical care, and to the fact that the biometric market is expected to explode. If there is no international standard, the market may be driven by a de facto standard. Although de facto standards are acceptable for applications in a free market, they may cause many problems in medical applications that should be under national control. As a result of such problems, many developing countries and the weak and elderly will be left behind. Therefore, ITU is required if standardization is to be achieved in a timely manner.

References

01. The World Market for Biometrics Equipment, http://www.infoshop-japan.com/study/iz17629_biometrics_equipment_toc.html

02. Task Group M1.4. . Scenario Testing and Reporting Draft 3.0. Biometric Performance Testing and Reporting Part 3: INCITS M1/03-0563, INCITS 1602-D

03. Jafar M. H. Ali Aboul Ella Hassanien. An Iris Recognition System to Enhance E-security Environment Based on Wavelet Theory, AMO - Advanced Modeling and Optimization, Volume 5, Number 2, 2003.