Palm Vein Authentication Technology

Soichi Hama
Senior Researcher
Authentication & IoT Security Project
FUJITSU LABORATORIES LTD.

1. Introduction

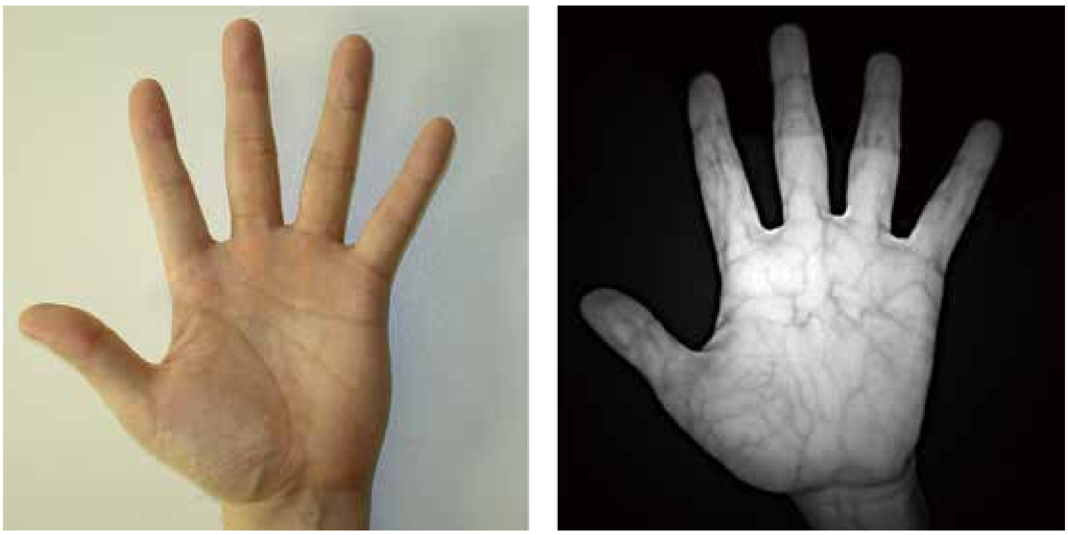
Biometrics encompasses a range of personal authentication technologies based on physical characteristics such as facial features, fingerprint, and iris; and behavioral characteristics such as voice and signature. While passwords and ID cards are a security liability if they are lost or stolen or lent to a buddy, biometric authentication is resistant to misappropriation and impersonation or spoofing. Biometric technologies are being incorporated in ever more areas as people become increasingly aware of security issues, and we anticipate a greater range of applications in the years ahead. This paper will provide a broad overview of palm vein authentication, a biometric technology whose time has come and is being more widely adopted every year.

2. Vein Authentication Technology

Vein authentication works by comparing the vascular pattern under the skin, which are unique to each individual. Since vascular patterns exist inside the body, vein authentication has a number of advantages over other biometric techniques. First, vein patterns are unaffected by environmental changes or by grime or dirt on the users' hand, and thus is perfectly stable and reliable under these conditions. Second, vascular patterns—the authentication feature—are invisible under normal visible light conditions, which makes it virtually impossible for a would-be identity thief to steal someone's authentication data without that person being aware. This second advantage is particularly important in areas requiring a high degree of authentication security. Third, vein authentication is completely contactless, which means that users are identified without actually touching the authentication device. This contactless design minimizes hygiene concerns and psychological resistance when the authentication device is used in public places by an unspecified large number of users.

Let us next consider the near-infrared technology for photographing vascular patterns. Visible light is largely absorbed by the body, so very little light penetrates beneath the skin. Mid-infrared and longer wavelength light is absorbed by H2O, and therefore it too does not penetrate the body. Intermediate between these two light sources is the near-infrared band ranging from 650 to 1000 nanometers, the so-called "biological optical window", that penetrates the body to a significant depth, and is used to photograph the vascular pattern. When the near-infrared is used to irradiate and photograph the body, light is scattered by body tissue but some of the light makes its way back to the surface and clearly reflects the tissue that it passed through. Deoxidized hemoglobin absorbs near-infrared light, which reduces the reflection rate and causes the veins to appear as a black pattern in contrast to the surrounding area. Photo 1 shows an example of a hand photographed with visible light on the left and the

Photo 1: Palm vein images (L: visible light, R: near-infrared light)



same hand photographed with a near-infrared light experimental system on the right. One can see that the vascular pattern is practically invisible under visible light, but clearly revealed under near-infrared light.

There are two types of sensors used to photograph veins, the reflection type and the transmission type. With the transmission type, the palm is positioned between the camera and the light source, and the camera captures light passing through the hand. In the reflection type, the camera and light source are in approximately the same location, and the camera captures light that is reflected off the hand. The palm vein authentication technology employs a reflection type sensor.

Essentially, vein authentication works as follows. First an image of the hand is captured using near-infrared light as described above, then the vascular pattern in the image is extracted using image processing technology, and stored as an encrypted biometric template. An individual's identity is established by photographing and extracting the user's vascular pattern as described above, then matching the pattern against the biometric template that was previously stored.

3. Vein Authentication Technology: Application Examples

We shall now briefly describe some application examples of palm vein authentication. Using palm veins has a number of advantages over other parts of the body. The palm covers a broader area than a finger, for example, so the pattern of blood vessels running through the palm is much more random. The palm is also less affected by cold weather than the fingers, which permits accurate authentication results that are largely impervious to environmental conditions. Compared to the back of the hand, it is more natural to present the palm for authentication purposes. Also, some people have hair growing on the back of their hands which blocks light and interferes with authentication. Of course, we don't have this problem with the palm so it works well for everyone.

Fujitsu began researching palm vein authentication in 2000, and launched the world's first commercial application of the technology for bank ATMs in 2004 (Photo 2). This financial solution uses palm vein authentication to identify bank customers when they withdraw money from the bank, and capitalizes on the accuracy and contactless features mentioned earlier. The product delivers exceptional accuracy with a false acceptance rate of less than 0.0008% and a false rejection rate of 0.01%.

Following the roll out of palm vein authentication bank ATMs, this form of biometric authentication has been extended to physical access control systems (Photo 3), computer login control (Photo 4), and other applications. Starting with banks, palm vein authentication is also being widely adopted in overseas markets. Particularly in developing countries where a secure infrastructure for identifying people is not yet available, there are high expectations for palm vein authentication with the various advantages described. So far more than seventy million people have had an opportunity to use palm vein authentication, and we anticipate that this number will only continue to grow in the years ahead.

■ Photo 3: Access control panel featuring palm vein authentication

■ Photo 2: ATM featuring palm vein authentication

■ Photo 4: Mouse with build-in palm vein authentication sensor

4. Miniaturization of Palm Vein Sensors

Since the first palm vein authentication systems were put into service, palm vein sensors have steadily shrunk to accommodate a growing number of mobile applications. Referring to Photo 5, the large unit on the right is the sensor developed for the initial bank ATM back in 2004, the square unit in the middle is the current mainline sensor, and the two smaller sensors on the right have been scaled down for mobile applications.

Let us take a closer look at some of the mobile applications that will likely adopt biometric authentication in the near future. Notebook PCs, tablet computers, and other mobile devices are now available that are as powerful both in terms of processing power and functionality as the desktop computers of just a few years ago. Laptop computers and other mobile devices have quickly emerged as a primary tool of business, so it is only natural that people are becoming increasingly concerned about the security of their mobile devices.

Mobile devices are generally carried around and used in different locations, and this makes them susceptible to loss or theft. The security of mobile devices is especially important when they are used to store personal and/or confidential information.

We observed earlier that palm vein authentication uses reflection photography. The obvious advantage of this approach over transmission photography is that the camera and the light source can be integrated, which means that the sensor can be downscaled and made much thinner. In order to implement a compact/thin palm vein sensor that can provide accurate authentication, design of the optical system is critically important. For this, Fujitsu used computer simulations to develop a specialized low-distortion wide-angle lens that provides the same angle of view as a conventional lens and a lighting component for compact/thin sensor packages. The lighting component was designed to provide a wide radiation range and very bright luminosity despite its compact implementation by carefully positioning the LED and optimizing the shape of the waveguide. The authentication algorithm was also upgraded to better match the properties of images captured by the miniature sensor.

Through these initiatives, Fujitsu developed a practical palm vein authentication sensor that is appreciably thinner and more compact than other sensors (Photo 6), and Fujitsu is now bringing

Photo 5: Miniaturization of palm vein sensor

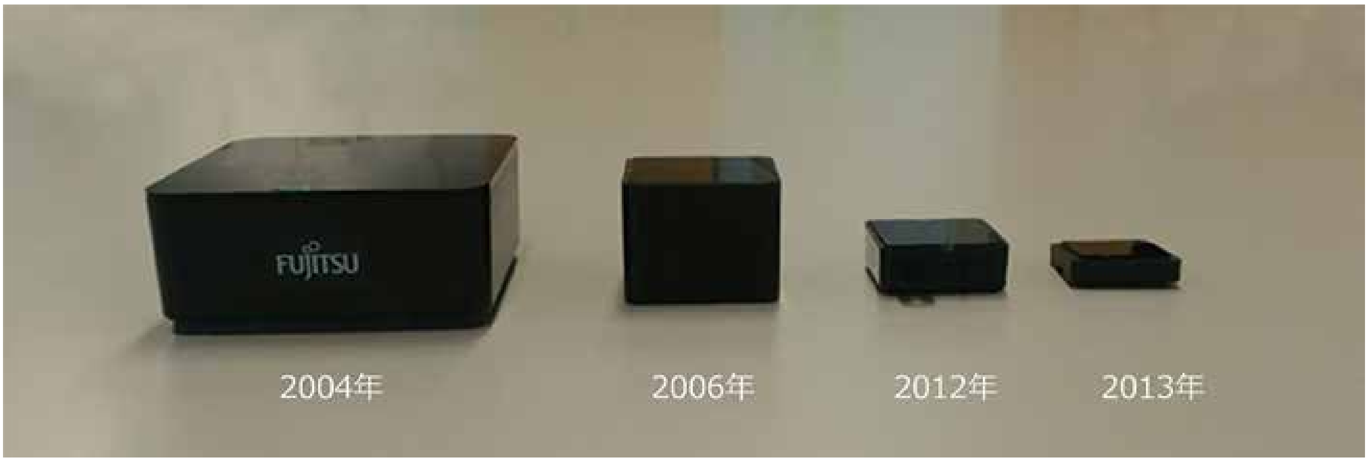


Photo 6: New compact sensors

■ Photo 7: Tablet computer with built-in palm vein sensor

■ Photo 8: Thin notebook PC with built-in palm vein sensor

mobile products to market that incorporate this sensor including a tablet computer and a slim-profile notebook PC (Photos 7 and 8). It is apparent even now that mobile devices will become increasingly important for on-site business purposes in the coming years, and the palm vein authentication technology will play a significant role in this development by safeguarding confidential and personal data through robust security. Applications using biometric authentication to identify individuals are also expected to surge when using online services for online shopping, to settle online transactions, and so on, and in this online cyber world too we can expect palm vein authentication to be widely adopted.

5. International Standardization Initiatives

International standards covering vein authentication are making headway even as research and development on this biometric technology is in progress. ISO/IEC JTC 1/SC37, which we will refer to here as Subcommittee 37 or SC37, is in charge of international standards for general biometrics. SC37 is organized into six working groups dealing with "Harmonized biometric vocabulary" (WG01), "Biometric technical interfaces" (WG02), "Biometric data interchange formats" (WG03), "Technical Implementation of Biometric Systems"(WG04), "Biometric testing and reporting" (WG05), and "Cross-Jurisdictional and Societal Aspects of Biometrics" (WG06). Focusing on applications for communications, SC37 entered into a liaison relationship with ITU-T SG17 Telebiometrics, and collaborated in drafting Recommendation / International Standard ITU-T X.1083 / ISO/IEC 24708 (Biometrics—BioAPI interworking protocol) published in 2008 that deals with interchange of biometric authentication data.

Vein authentication is a relatively new technology compared to older biometric technologies—facial recognition, fingerprints, and so on—so there wasn't much awareness of the vein authentication technology when SC37 launched. Consequently, Japanese companies took the initiative in developing vein authentication and in pushing development of international standards relating to vein authentication. For example, content pertaining to vein authentication in the 19784 Series (ISO/IEC 19784 Information technology—biometric application programming interface: BioAPI) defining standard APIs for biometric authentication applications and in 19785 Series (Information technology—Common biometric exchanges formats framework: CBEFF) defining a framework for storing biometric data clearly reflects international standards that have already been published. Moreover, standardization of data interchange formats for system interoperability includes considerable standards development work done by the author in his capacity as editor of the Vein Image Data Format Project, and was published in 2011 as International Standard, ISO/IEC 19794-9 (2011 Information technology—Biometric data interchange formats—Part 9: Vascular image data). Note that this standard is the revised second generation version of a first generation draft that was published in 2007. The second generation version adopts common headers that were harmonized to other 19794 parts which define finger, face, iris, and other modalities, and is much easier to use.

6. Future Developments

This paper presented a broad overview of palm vein authentication technology, and covered the most recent development trends and standardization activity relating to palm vein authentication. Palm vein authentication is a relatively recent biometric technology compared with fingerprint-based authentication, so there is still plenty of room for further technological progress. Fujitsu will continue to pursue multiple objectives in conducting work in this area: we will collaborate in building a large-scale social infrastructure system by continuing to improve the accuracy of sensors and systems, while at the same time continuing to reduce the size and cost of sensors. These measures will pave the way for a wider range of applications that use palm vein authentication, not just in Japan but around the globe. To take full advantage of palm vein authentication technology throughout international society, it is essential that we pay close attention to new and ongoing updating of international standards.