Featured Articles

Cross-industry Deployment of Core Technology and Associated IP Management Support

—Finger Vein Authentication Technology—

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OVERVIEW: Approximately 400,000 of Hitachi's finger vein authentication devices, which verify people's identity by reading and checking their finger vein patterns, are currently in operation. The technology is being adopted in Japan and overseas in the form of solutions that provide customers with safety and security in applications such as access control, banking, and IT. Hitachi leads the world in its research into finger vein authentication technology, and has published numerous papers on the subject and filed for more than 600 patent applications. Hitachi is a leader in this field of research, with total paper citations numbering more than 700. Hitachi's patents have been recognized for their quality as well as their quantity, including winning the Prize of the Minister of Education, Culture, Sports, Science and Technology at the 2007 National Commendation for Invention awards ceremony in Japan.

INTRODUCTION

BIOMETRICS technology, which identifies people from their physical characteristics, has attracted attention in recent years as an important technology for creating a safe and secure society that can provide a more reliable means of personal identification. However, past technologies based on fingerprints, irises, or faces have suffered from security problems because they worked by sensing surface features of the body, making them too easy to forge. This created a need for a new form of biometrics technology that would be difficult to forge and could be used with confidence.

Hitachi became interested in finger veins as a new form of biometric identification in 1997 and proceeded with the research and development of its own biometrics technology. This attracted attention as a new form of biometric authentication that was resistant to forgery because it uses finger vein patterns under the skin that are not visible to the naked eye. Within just a few years of the technology being commercialized, it was adopted for use in access control, banking, and information technology (IT), with a total of approximately 400,000 units currently in operation. This Japanese technology is also being deployed globally, including its adoption as an identification device for Internet banking by a major UK bank.

This article describes the research and development of finger vein authentication technology, its deployment in different industries, and Hitachi's unique initiatives for creating and exercising the associated intellectual property (IP).

HISTORY OF FINGER VEIN AUTHENTICATION TECHNOLOGY DEVELOPMENT

Hitachi first embarked on research into this field based on the expectation that the primary means of making payments would shift from the automated teller machine (ATM) to Internet banking. Discussions on this subject concluded that Internet banking would require a safe and reliable form of personal identification, and Hitachi therefore embarked on basic research into finger veins as a new biometric marker that could be used for authentication. The interest in fingers for this purpose was prompted by the expectation that the technology would be used in offices or on the personal desktop. It was anticipated that using fingers would enable future authentication devices to be made smaller and easier to use.

Research and development commenced in 1997 and proceeded through the four stages of basic research,

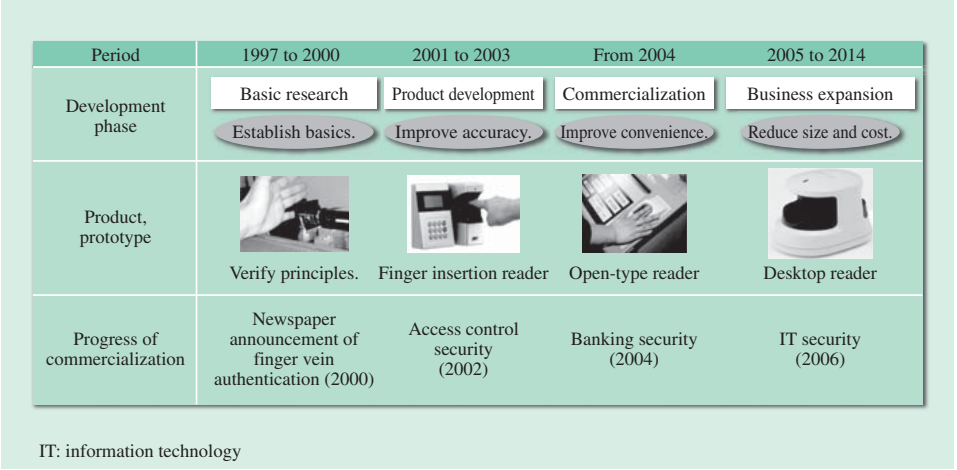

Fig. 1—Development History of Finger Vein Authentication Technology.
Research and development into the use of finger veins as a new form of biometric identification commenced in 1997 and proceeded through the four stages of basic research, product development, commercialization, and business expansion. The core technology has since been utilized in various businesses, including access control, banking, and IT.

product development, commercialization, and business expansion. As it worked through each phase, Hitachi encountered new problems and encouraged the growth of the business by preemptively solving them. Commercialization commenced in 2002 with access control applications, followed by deployment in the banking and information technology (IT) sectors. The sequence of deployment was also the sequence in which societal needs arose. Use in Internet banking, the objective of initial research, came in 2014 when the technology was adopted in the UK, with a plan to roll it out progressively to corporate customers from 2015 onward[(1)]. This sequence can be understood by thinking of this as an application that arises out of the fusion of banking and IT (see Fig. 1).

This deployment across multiple industries requires robust core technology[*1] that supports a broad range of businesses. The solutions to specific problems that arose during the product development, commercialization, or other phases for particular business sectors have been incorporated into the core technology for Hitachi's finger vein authentication technology. In this way, Hitachi is able to provide cross-industry support to a wide variety of businesses extending from access control to banking and IT by making ongoing enhancements to the core technology, not just in the basic research phase.

Basic Principles

Finger vein authentication technology identifies individuals by utilizing the fact that the patterns formed by the large number of veins that run through people's fingers vary from person to person. To achieve this, Hitachi proposed using a finger vein imaging technology that can obtain clear images of finger veins by passing near-infrared light through the finger in an appropriate way to obtain reliable images of subcutaneous finger veins that are not visible to the naked eye. While near-infrared light with wavelengths of between 700 and 1,200 nm can pass easily through biological tissue, it is strongly absorbed by the hemoglobin in the blood that flows in veins. Hitachi developed an imaging technology that takes advantage of this difference in properties to clearly highlight veins as dark lines.

Next, to ensure that the imaged veins could be compared with precision, despite variations in blood vessel width or the angle of placement of the finger, Hitachi devised a high-performance pattern matching technique that could extract the central shape features

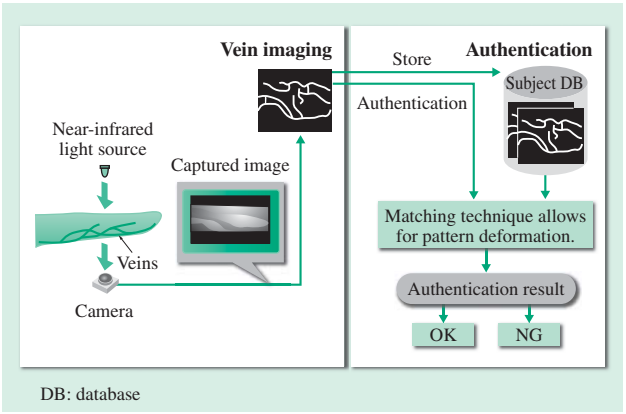

Fig. 2—Basic Principles of Finger Vein Authentication.
Finger vein authentication works by shining near-infrared light through a subject's finger to obtain an image of the internal vein pattern, and then matching this pattern against their pattern on file to confirm their identity. Because it uses a biological characteristic that is not visible to the naked eye, forgery is extremely difficult.

*1 Technology that provides the basis for a variety of applications.

of the veins and allow for deformations in their shape, and thereby achieved world-leading authentication accuracy (see Fig. 2).

The technology is being adopted for applications such as access control to important facilities and IT security that protects important information.

Open-type Authentication Method

This research included not only achieving a high level of accuracy but also the development of a technique that would be easy for anyone to use. The transmitted-light imaging technology for veins described above plays an important part in acquiring clear vein patterns with high contrast[(2)] to achieve highly accurate authentication. Transmitted-light imaging is typically performed by placing the object to be imaged between a light source and a camera, with the result that the light source obscures the space above the finger. To reduce psychological aversion and smooth the process of the user placing their finger in the authentication device, the light source is positioned on the left and right sides of the finger leaving the top open. Transmitted-light imaging can still be performed with this configuration because the light shone on the finger is scattered in all directions and therefore reaches the camera. However, because this arrangement of light sources results in the light being brighter closer to the light source, making it difficult to acquire vein images, the system alternately captures two images each illuminated from one side only and then combines the two halves where the light level is appropriate to obtain the image to use for authentication. In this way, the system achieves both the accuracy of the transmitted-light method and the ease of use that comes from having the user simply place their finger on the reader (see Fig. 3).

For financial institutions that demand high security and the ability to work with a wide variety of customers, the technology is being adopted as a key technique for personal bank deposit protection, and it has become the de facto standard in Japan with finger vein authentication being the choice of approximately 80% of financial institutions that use biometric authentication.

Benefits of Research and Development

In 2006, Hitachi contracted the International Biometric Group (IBG) to assess its authentication accuracy. IBG is a third-party assessment agency for biometric authentication in the USA. The assessment gave the finger vein authentication technology a level 3 rating, at that time the highest rank for any biometric authentication technology anywhere in the world. In addition to low levels for false rejection rate[*2] and false acceptance rate[*3], the failure to enroll rate[*4] in particular is an order of magnitude lower than fingerprint and iris technologies[(3)].

Hitachi has published a large number of papers on finger vein authentication technology in Japan and overseas since 2000[(2), (4)–(15)]. A review of data using Google Scholar[*5], an academic search service provided by Google Inc., found more than 700 citations for the papers. The most commonly cited paper[(7)] had 323 citations, placing it at the head of its field (see Fig. 4).

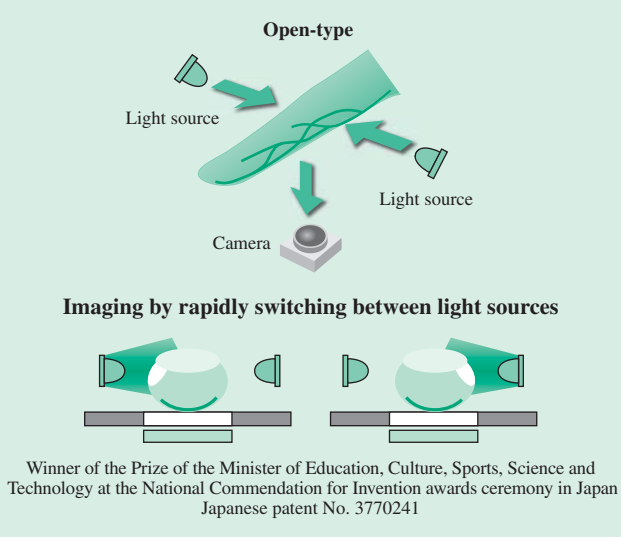

Fig. 3—Open-type Authentication Method.
While transmitted light imaging has in the past required the finger to be placed between the light source and camera, the open-type authentication method positions light sources on the left and right of the finger and captures two images by illuminating each side in turn. This enables a sharp finger vein image to be obtained by merging these two images, meaning that authentication can be performed simply by having the subject place their finger on the reader.

CROSS-INDUSTRY DEPLOYMENT OF FINGER VEIN AUTHENTICATION TECHNOLOGY

Cross-industry Deployment Based on Societal Needs

Hitachi's security business is expanding in accordance with the sequence in which societal needs emerge. The

*2 Proportion of instances in which the system erroneously rejects a person.
*3 Proportion of instances in which the system erroneously accepts a person.
*4 Proportion of people whose biometric information is not accepted by the system.
*5 Google and Google Scholar are trademarks or registered trademarks of Google Inc.

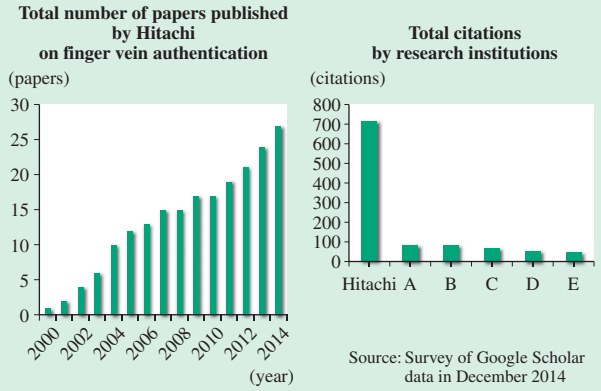

Fig. 4—Number of Papers Published and Total Number of Citations.
Hitachi has published more than 25 papers on finger vein authentication technology since 2000. Hitachi leads this field of research, with top place in the total number of citations for each research institution for the top 10 ranking most-cited papers (more than 700 citations).

Year	Application		Year	Application	
2002		Access control	2010		Multi-function printers
2004		ATM	2012		Mobile devices
2006		PC	2014		Internet banking
2008		Access control	(research currently in progress)		Gates

ATM: automated teller machine PC: personal computer

Fig. 5—Product Development History.
Hitachi has contributed to the cross-industry deployment of core technologies, commencing product development in 2002, and having developed more than 30 products to date in the fields of access control, banking, and IT.

development of its business is proceeding as it strives to be the fastest to provide solutions when societal problems arise.

(1) Access control security

The 9/11 terrorist attacks in the USA in 2001 have led to greater concern about preventing unauthorized access to important facilities such as airports. Hitachi responded to this by releasing an access control product in 2002.

(2) Bank security

In 2003, increased incidents of forged cash cards being used for unauthorized withdrawals from ATMs had created a need for ways to prevent this activity. In response, Hitachi announced an ATM with biometric authentication in 2004 and commenced shipments in the following year.

(3) IT security

In 2005, an increasing frequency of data leaks had raised concerns about companies' internal controls. In response, Hitachi released a small, low-cost device in 2006 suitable for personal desktop use.

As these examples show, products were developed separately by specialist business divisions to offer rapid solutions for businesses that specialize in different areas.

Product Development

The applications used by customers in security businesses such as access control, banking, and IT vary widely. They each differ in terms of things like size, speed, accuracy, ease-of-use, cost, and interfaces. This diversity extends from requirements that can be handled by design changes to those that require new research and development.

As a result, Hitachi developed more than 30 products from 2002 to 2014. These included devices for access control, ATMs, personal computers (PCs), multi-function printers, mobile devices, and Internet banking. For the future, research and development is currently in progress on a high-throughput gate system that can authenticate people as they walk through (see Fig. 5).

MEASURES FOR CREATING AND USING IP

Building a Strong Patent Portfolio

Patent applications for finger vein authentication have been made with respect to underlying core technologies by Hitachi, Ltd., to which the research laboratories belong, and, with respect to the distinctive technologies for specific products, by the companies to which the business divisions that developed the technologies belong (including both Hitachi, Ltd. and other group companies) as part of its research and development. During the basic research and product development phases in which the research laboratories played a central role, a large number of basic patents were created by preemptively identifying requirements, including but not limited to technical challenges, through actions such as having researchers visit customers to obtain information about their diverse requirements by demonstrating prototypes. Since around 2004 when firm orders were obtained, technologies developed in-house by business divisions

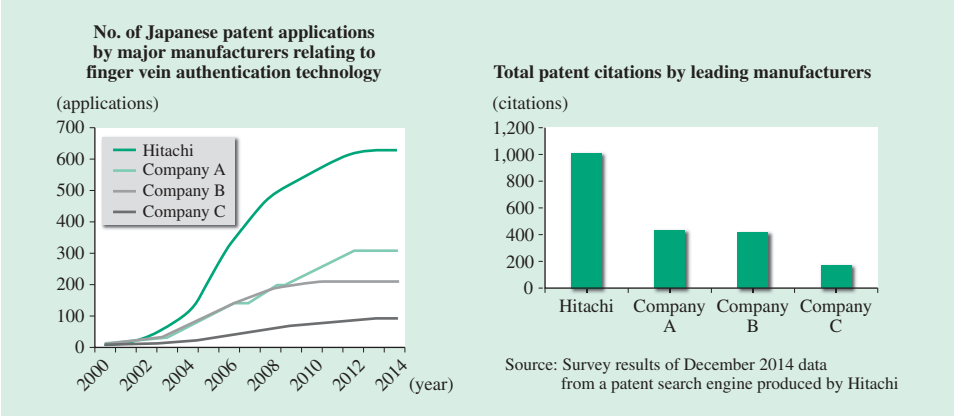

Fig. 6—Japanese Patent Applications and Total Number of Citations.
Hitachi has filed more than 600 patent applications for finger vein authentication, the most of any major manufacturer. It is building a high-impact patent portfolio, and is at the top of the total number of patent citations (more than 1,000).

as well as research laboratories began to emerge and patent applications started to be filed. In particular, a project to create finger vein patents was undertaken in 2005 by the research laboratories, business divisions, and Intellectual Property Division to build a robust patent portfolio by expanding the range of peripheral patents covering not only core technology but also applied technologies. This project exceeded its target by creating more than its target of 40 peripheral patents.

Through these activities, Hitachi has filed more than 600 Japanese patent applications to date. According to a survey by patent search engine produced by Hitachi, the total number of citations of Hitachi patents exceeds 1,000 (see Fig. 6).

The number of citations for a patent indicates how many times it has been cited in a notice of rejection. Accordingly, the high number of citations indicates that closely related inventions continue to be created, and that it is a fundamental and high-impact patent. Patents with a high number of citations tend to be created during the basic research and product development phases.

The most-cited patent, that for the "open-type authentication method" (Japanese patent No. 3770241)[16], has been cited 42 times. It received the 2007 Prize of the Minister of Education, Culture, Sports, Science and Technology at the National Commendation for Invention awards ceremony, hosted by the Japan Institute of Invention and Innovation (JIII).

As this demonstrates, Hitachi has built up a strong patent portfolio that surpasses that of other companies by conducting research and development ahead of them and by pursuing strategic patent activities.

Establishment of Hitachi Group Patent Pool System

As explained above, the patent portfolio for finger vein authentication technology was built up through patent applications relating to the core technologies developed primarily by the research laboratories in addition to applications relating to the distinctive technologies that differ between products developed primarily by each business division. Accordingly, what is needed is a centralized way of managing patents relating to finger vein authentication technology that utilizes them as "One Hitachi."

To achieve this objective, Hitachi established the "Hitachi Group patent pool system" for finger vein authentication technology in 2007. This patent pool system has a large membership made up of the Hitachi research laboratories and business divisions that develop and use finger vein authentication technology.

This Hitachi Group patent pool system provides mechanisms for the collation and centralized management of important patents held by its members, which it designates as "pool patents" (see Fig. 7). Hitachi has also established a framework for holding regular meetings of pool system members to share information on new developments relating to such things as the status of pool patents and business within Hitachi.

Furthermore, a secondary function of the Hitachi Group patent pool system is to provide a forum for the sharing of information about core technologies. This enhances management efficiency by minimizing the duplication of activities such as research or development by business divisions that operate in different industries.

Use of Hitachi Group Patent Pool System for Patent Management

This section describes examples of how the Hitachi Group patent pool system is used to utilize patents relating to finger vein authentication as "One Hitachi."

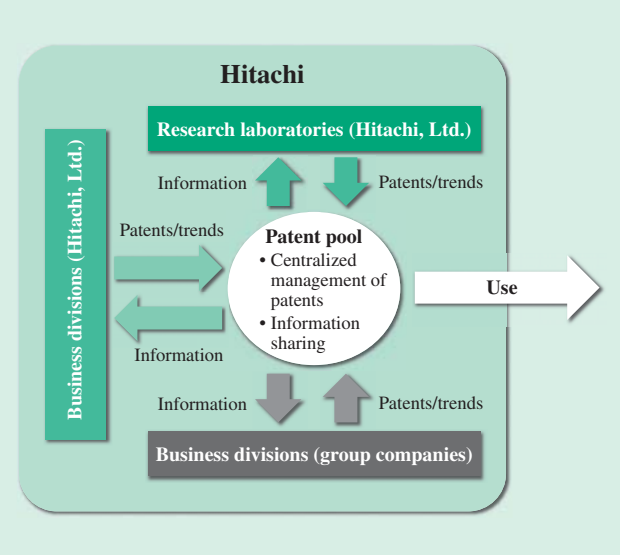

Fig. 7—Overview of Patent Pool System.
This is Hitachi's own scheme for the centralized management of the finger vein authentication patents belonging to research laboratories and business divisions and their use as "One Hitachi."

Aid to Establishing Collaborations with Partners

In October 2009, Sagem Sécurité of France (since renamed Morpho SAS) and Hitachi jointly developed a multi-modal biometric authentication device that combines fingerprint and finger vein authentication[17]. Hitachi had been considering multi-modal biometric authentication devices that incorporate other forms of biometric authentication since its initial research and development, and had already filed patent applications[18]. Those patents became the underlying support for the realization of this joint development. The collaboration targeted a wide variety of applications, such as access control, ATMs, and mobile devices, using IPs belonging to a number of business divisions, and produced joint research outcomes that were relevant to the businesses of a number of departments. Accordingly, the members of the patent pool system played a central role in gathering the views of the relevant business divisions, setting out the best possible joint research plan from a "One Hitachi" perspective, and proceeding with the collaboration with Sagem.

Informing Customers and Competitors about Patents

Utilizing the advantages provided by Hitachi's patent portfolio for finger vein authentication technology, Hitachi posted material that actively promoted the patent portfolio on a website with the aim of assisting its business activities[19].

The primary aim of this material was to promote Hitachi's technical capabilities to customers by presenting its patent technology in a form that would be easy to understand.

This involved first selecting five promotional features for enhancing the brand image of Hitachi's finger vein authentication technology, namely its, (1) accuracy, (2) easy-to-use design, (3) reliability, (4) speed and safety, and (5) ability to accommodate a variety of fingers.

In making the selection, Hitachi first asked customers for their views and collated the in-house development concepts it deemed important. Next, Hitachi analyzed patent information for trends in research and development by other companies to identify which development concepts were deemed important by competitors. These two sets of development concepts were then compared and those that appeared in both lists were deemed to have strong appeal and were selected as the five promotional features listed above.

Next, based on information obtained from consultations with customers and sales staff from the relevant business divisions, those patents that were expected to appeal most to customers were selected from among the patents that underpinned the promotional features. The patent numbers were included in promotional material and the patent technology descriptions were worked on to make them easy for customers to understand.

The selected patents were all fundamental and high-impact patents that placed high in the rankings for number of citations. Accordingly, it was anticipated that the promotional material would also be highly effective as a restraint on competitors.

In keeping with the global operation of the business, the promotional material was also translated into English and Chinese and utilized in sales.

CONCLUSIONS

This article has described the research and development of finger vein authentication technology, the deployment of core technologies in different industries, and Hitachi's initiatives for creating and exercising the associated IP.

The Hitachi Group patent pool system played an essential role in deploying core technologies in different industries. Although it was adopted as a centralized way of managing the invention of core technologies, it also proved effective at encouraging

information sharing among research laboratories and business divisions, and helped improve management efficiency through such benefits as preventing the duplication of research and development and sharing promotional material.

In the future, Hitachi intends to proceed with research and development to supply security solutions that contribute to the safety and security of society.

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