A Study on Three Preferable Biometric Characteristics of Finger Vein Biometrics

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Hitachi-Omron Terminal Solutions, Corp.
Contents

1. Finger vein authentication technology
2. Financial applications in Japan
3. Medical opinions on universality, uniqueness and persistence
4. Statistical study on uniqueness
1-1. Capture of Finger Vein Images

- Near infrared light is absorbed by hemoglobin in the blood and the vein pattern is captured as a shadow.
- Finger vein image is quite stable due to inner structure of body.
- Resistance against environmental condition or body surface

![Diagram of vein imaging process]

**Near infrared light**

The contrast of finger vein images is optimal in this band.

- UV rays
- Visible light
- Infrared rays

Wavelength:
- 0.4 μm: Short
- 0.7 μm: Long
- 1 μm: Long

**Diagram details**
- Near-infrared Light
- Absorbed
- Pass through

**Camera**
1-2. Features of Finger Vein Biometrics

- **High Availability**
  - Low False Non-Match Rate (FNMR), regardless of occupation, living habit, environmental conditions
  - Low Failure to Enroll Rate
    - 0.08% by IBG CBT-6
  - IBG CBT-6: International Biometrics Group's Comparative Biometrics Test 6

- **High Security**
  - Low False Match Rate (FMR)
    - 0.01% at 1.26% of FNMR by IBG CBT-6

- **Ideal for**
  - Huge variety of end-users’ age, occupation, living habit, etc…
  - Difficult to control environmental conditions
  - Public Sectors, Financial Services, etc…
2-1. Actual Achievement in Banking Systems

Bank Network

- **Teller window**
  - Banking Terminal System with Authentication Device
  - Finger Vein Authentication + Smart Card
  - Check Finger Vein Data in Smart Card with Samples from Customer

- **ATM**
  - ATM with Authentication Device
  - Finger Vein Authentication + PIN
  - Finger Vein Data Stored in Smart Card

- **Vault**
  - Gate with Authentication Device
  - Finger Vein Authentication + PIN
  - Finger Vein Data Stored in Smart Card

*Expansion to Internet Banking*

*Internet*

*Home*

**Templates: Stored in Smart Card to Protect Personal Information**

**Verification at Window**
- Deter unauthorized Withdrawal by Stolen Passbook

**Verification at ATM**
- Deter unauthorized Withdrawal by Stolen Card & PIN

**Verification at Vault**
- Security Enhancement & Laborsaving
2-2. Finger Vein Devices on ATMs

Bank ATM

Bank ATM

Convenience store ATM
2-3. Frauds at ATMs in Japan

Trends in Fraudulent Withdrawal with Fake / Stolen ATM Cards

Mega banks announced installing finger vein devices on ATMs

Hitachi Finger Vein Authentication has been successfully adopted by 81% of Japanese bank branches, making FV by far the most dominant biometric deployed in the Japanese banking sector.

Japanese biometric market share in financial sector

(As of Jan. 2008. Survey conducted by Hitachi-Omron Terminal Solutions, Corp.)
2-5. Applications in Other Countries

**Poland**

- Poland's bank started the installation in May 2010 of ATMs that include an option for finger vein authentication.
- The first ATMs of this kind to be deployed in Europe.

**USA**

- L-1 unveiled 4G FingerVein Station, biometric access control device based on Hitachi’s finger vein recognition technology.

- Jackson County Jail has been utilizing Avion’s INTACT (Inmate Tracking and Control Technology) software with Hitachi’s finger vein authentication system.
A lot of track records shows FV biometrics satisfies users' demands. High accuracy of FV biometrics is shown by experimental tests.

However, does FV pattern itself meets requirements for biometrics in terms of
- Universality: Does everyone have finger vein pattern?
- Uniqueness: Does everyone have different finger vein pattern?
- Persistence: Will finger vein pattern not change?

Introduction of research and study on above questions
- Universality, uniqueness and persistence in medical aspect
  - Workshop with medical doctors
- Uniqueness of FV pattern in statistics aspect
Objective
Getting Medical Opinions from medical doctors as specialists

Number of Workshops held: Four

Organizer
- Hitachi, Ltd., Central Research Laboratory
- Hitachi-Omron Terminal Solutions, Corp.

Specialists of Attended Representative Japanese Researchers
- Cardiovascular Physiology
- Plastic and Reconstructive Surgery
- Vascular Systems Biology
- Molecular Oncology
- Molecular Mechanism in Blood Vessel Formation and Angiogenesis
- Morphological Analysis of blood vessels
- Dermatology
- Molecular and Vascular Medicine
3-3. Medical Opinions on Universality

Fact known to medical science:

- Veins and arteries are essential for circulating oxygen and nutrients to the finger tissues.

- The approximately 0.3 to 1.0 mm thick vein* in the skin surface layer basically exists in all people.

* It is targeted for the authentication
Patterning of the vascular network in ontogenesis:

- The patterning of the vascular network undergoes change from its initial state
- The vascular network is formed subject to the effects of low oxygen and blood flow.
- This process takes place under genetic constraints, but is not deterministic; it includes many probabilistic elements.

- Large individual differences in the pattern of the vein
- High utility as the basis for personal authentication
3-5. Medical Opinions on Persistence

Vascular structure:

- The basic pattern of the blood vessels is formed during the fetal stage (unborn baby).
- After that, tight interactions between the blood vessels' cell and the surrounding cells keep 0.3 to 1.0mm thick blood vessels stable.
- The blood vessel targeted by the authentication is assured of a permanent flow of blood.

- The approximately 0.3 to 1.0mm thick blood vessel targeted by the authentication maintains relatively stable vascular structure.
- The blood vessel is extremely unlikely to be lost with aging in healthy adults.
4-1. Statistical Study on Uniqueness


Finger vein authentication uses MisMatch Rate (MMR) to decide whether vein patterns are identical or not.

\[
\begin{align*}
\text{If } & \text{ MMR} \leq C \quad \rightarrow \quad \text{Similar pattern (identical)} \\
& \text{MMR} > C \quad \rightarrow \quad \text{Different pattern (unrelated)}
\end{align*}
\]

The mismatch rate (MMR) is defined as

\[
\text{MMR} = \frac{\text{total number of mismatched pairs}}{\text{total number of pixels classified into VEIN in the two finger patterns}}.
\]

Distance between MMR of identical pattern pairs and MMR of unrelated pattern pairs is related to uniqueness.
4-2. Statistical Study on Uniquenessness

Histogram of the MMR

Histograms of the MMR computed from 1,012 (506 persons) pairs of identical right index fingers and 255,350 (506 X 505) pairs of unrelated right index fingers.

Two histograms are separated

- Genuine
- Imposter

Different unrelated individuals
4-3. Statistical Study on Uniqueness

- Two fingers are identical if and only if they are the same finger in the same hand of same person.
- All the other cases can be treated simply as unrelated.
4-4. Statistical Study on Uniqueness

FRR and FAR estimated from the mathematical models of MMR’s histograms

Histograms of MMR computed from identical right index fingers (empirical 1,012 pairs) and fitted beta-binominal distribution

Histograms of MMR computed from unrelated right index fingers (empirical 2.5M pairs) and normal distribution

<table>
<thead>
<tr>
<th>Cut-off point</th>
<th>FRR</th>
<th>FAR</th>
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<tbody>
<tr>
<td>0.270</td>
<td>3.16E-06</td>
<td>1.31E-12</td>
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<tr>
<td>0.275</td>
<td>2.03E-06</td>
<td>4.10E-12</td>
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<td>0.280</td>
<td>1.30E-06</td>
<td>1.25E-11</td>
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<td>0.285</td>
<td>8.23E-07</td>
<td>3.73E-11</td>
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<tr>
<td>0.290</td>
<td>5.20E-07</td>
<td>1.08E-10</td>
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<tr>
<td>0.295</td>
<td>3.27E-07</td>
<td>3.07E-10</td>
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<td>0.300</td>
<td>2.04E-07</td>
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<td>0.305</td>
<td>1.27E-07</td>
<td>2.28E-09</td>
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<tr>
<td>0.310</td>
<td>7.86E-08</td>
<td>5.97E-09</td>
</tr>
</tbody>
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Finger Vein pattern itself has potential to achieve quite high accuracy for uniqueness
1. Features of finger vein biometrics and applications
   - A lot of track records, High accuracy and usability

2. Universality, Uniqueness and Persistence in medical aspect
   - Introduction of medical researcher’s opinions
   - FV has universality, uniqueness and persistence

3. Uniqueness in statistics aspect
   - Introduction of Kurume Univ. and Kagoshima Univ. works
   - FV pattern has potential to achieve quite high accuracy