Behavioral Patterns and Biometrics

Things that we do customary e.g. often enough as part of our daily activities:

- walking - cameras, sensors under the floor (can you recognize somebody by his/her gait without seeing the person’s face?).
- handshaking - not just the geometry of a hand but also its handshaking pattern (a dynamic component)
- typing - not just what you type (e.g. a password) and how many mistakes you make (e.g. fuzzy passwords) but also the way you type (timing between keystrokes, applied keystroke forces, etc.)
- signing …

Behavioral Patterns and Biometrics

Should be unique enough and tractable:

- signing vs. writing (your) name (signing by writing a name)
  
  How to write my name – Carmen, Camen, Kamen?
  
  I can easily explain by just giving you the right spelling. How to write my name in Japanese – 佳明, 仮面, …
  
  Ka(か): 佳, 科, 可, 火, 課, 加, 故, 仮, …
  
  men(めん): 明, 面, 綿, 免, 緬, …
  
  Can I explain by "just giving you the right spelling"? Japanese resort to "showing" how to write their names by gestures or more precisely "by writing in the air".

- Natural behavior vs. conducting a (specific) action vs. making a (specific) gesture - just walking vs overcoming and obstacle on the way (turns, doors, stairs, etc.) vs. "writing your name in the air"

Behavioral Patterns and Biometrics

Should be difficult to mimic and thus forge

- static signatures - if a sample is available it can be copied or closely reproduced after some practice. Example: a signature on the back of a stolen credit card can be forged for unauthorized purchases.
- dynamic signatures - practically impossible to reproduce even if samples are available and the signing process was observed/recorded. Example: Your dynamic signature is your ID with UniCredit.
- handwritten text samples - in principle can be tied up to a given person even if he tries to alter his handwriting style. Example: Graphology analysis (an analysis of the physical characteristics and patterns of handwriting purporting to be able to identify the writer)

3D Gesture Based Authentication

Camera Based Hand Gesture Recognition

A user is performing an authentication gesture in front of a short range depth camera.

Is a simple camera sufficient or do we need a depth sensor?
3D Gesture Based Authentication
The Fundamental 3-point Posture Problem

M. Vynnycky, K. Kanev.
Mathematical Analysis of the Multi-solution Phenomenon in the P3P Problem
(J Math Imaging Vis DOI 10.1007/s10851-014-0525-0)

\begin{align*}
\alpha &= \angle BPA, \quad \beta = \angle APC, \quad \gamma = \angle BPC, \\
\ell_1 &= |PA|, \quad \ell_2 = |PB|, \quad \ell_3 = |PC|, \\
\delta_{12} &= |AB|, \quad \delta_{13} = |AC|, \quad \delta_{23} = |BC|, \\
p_1 = \cos \alpha, \quad p_2 = \cos \beta, \quad p_3 = \cos \gamma.
\end{align*}

3D Gesture Based Authentication
Microsoft’s Kinect Depth Maps

Kinect for Windows
640 × 480 @ 30 Hz (RGB camera)
640 × 480 @ 30 Hz (IR camera with an IR laser projector for depth-finding)

3D Gesture Based Authentication
Game Input Devices

Some mobile devices are specifically designed to serve as gesture interfaces when playing computer games, controlling multimedia presentations, and others.

Nintendo
Sony

Example: Kanji Sports
Writing kanji vs. general gestures?
Learning the kanji stroke order by exercising painting gestures on an imaginary wall using a Wii remote controller.

Wii-remote (Nintendo)
Kanji Sports

Example: Kanji Sports
Built-in sensors

Accelerometer (movement) and gyroscope (rotation) sensing about the main axes of the local coordinate systems

Accelerometer
Gyroscope

3D Gesture Based Authentication
General Purpose Devices

General purpose devices, including smart phones, can be programmed to perform similar functions.

The iPhone® 4 was the first Smartphone to integrate a 9-axis sensor array, integrating a gyroscope with an accelerometer and a magnetometer to provide an immersive motion-enabled user experience.
Kanji Sports with a Smartphone?

Wii Kanji-based Authentication?
Hand stroke based (dynamic!)

Stroke Patterns

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</table>

Look carefully at the three Japanese characters below

The letter “ho”   The word “tree”   The digit “6”

Here is the way to write them

What are the differences between the three characters below?

Note that the writing stroke order is different for the last character!

Japanese commonly resort to “showing” how to write their names by gestures or more precisely “by writing in the air”.

Japanese characters:

ホ 木 六

The letter “ho” The word “tree” The digit “6”
Look carefully at the three Japanese characters below

The letter “ho” Tree The digit “6”

Following the correct stroke order try to:
- write the above characters on a sheet of paper
- write them again but with your eyes closed
- “write” them on a sheet of paper with your finger
- “write” them in the air with your finger

Can you distinguish them?

Writing Japanese Characters in the Air
Some Japanese characters are derived from real physical objects. Does the flat 2D “tree” character here resemble the pictured trees below?

What about a 3D Japanese character for a “tree”?

3D Kanji Models

The 3D Kanji constructed following our approach are truly three-dimensional objects with projections being equal to 2D Kanji. Such 3D objects are capable of exposing the same Kanji character when seen from different directions, and in case of symmetrical characters, from all four directions.

Kanji and Gesture Biometrics

2D Kanji
- 2D Kanji are flat and need a writing surface
- Writing a 2D kanji in the air is as if drawing on a virtual surface.
- Confining a gesture to an imaginary surface without tactile feedback is quite difficult.

3D Kanji
- 3D kanji are not flat and do not need a writing surface
- Writing a 3D kanji in the air is direct with no reference to a virtual surface.
- Mental models of 3D Kanji are more individualized, i.e. depend on person’s perception and imagination.

Enhancing Gesture Biometrics (matching kanji pairs)

Authentication example:
- System prompts user with a kanji component
- User gestures back a matching kanji component

Thank You