Biometrics for Personal Verification/Identification

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Outline

- ♣ What is Biometrics?
- ♣ Motivation by Evidence
  - ♡ Iris Image Pattern Analysis
  - ♡ Handwriting/Handprinting Verification
  - ♡ Personal Signature Verification
  - ♡ Hand Geometry Verification
  - ♡ Voice (Speech) Pattern Recognition
  - ♡ Face Image Recognition
  - ♡ Fingerprint Image Verification/Identification
  - ♡ Palmprint, Ear shape, Gesture, ...
- ♣ Fingerprint Classification and Verification
- ♣ Opportunities and Challenges

Left Index Fingerprint

Professor C. C. Chen

What and Why is Biometrics?

- **What is Biometrics?**

Biometrics is the science and technology of interactively measuring and statistically analyzing biological data, in particular, taken from *live* people.

- **Why Biometrics?**

(1) The banking industry reports that false acceptance rate (FAR) at ATMs are as high as 30%, which results in financial fraud of US$2.98 billion a year.

(2) In U.S., nearly half of all escapees from prisons leave through the front door, posing as someone else.

(3) Roughly 4000 immigration inspectors at US ports-of-entry intercepted and denied admission to almost 800,000 people. There is no estimate of those who may have gotton through illegally.

(4) Personal verification/identification becomes a more serious job after the WTC attack on September 11, in the year 2001.

$\diamondsuit$ The evidence indicate that neither a PIN number nor a password is reliable.

(a) (b)

(c) (d)

(a) Arch, (b) Whorl, (c) Right loop, (d) Left loop.

Iris Image Pattern Analysis

◇ The **iris** is the portion of texture regions surrounding the pupil of an eyeball.

◇ The *iris image* can be sensed by a CCD camera under a regular lighting environment.

◇ An ancient French criminologist Berthillon did exploratory work linking *iris pattern* to prisoner identity.

◇ In 1980's, opthamologists Leonard Flom and Aran Safar posited that no two irises were alike.

◇ In 1994, Professor John Dougman develop algorithms using 2D Gabor filters according to Flom and Safar's concept to extract iris features for the use in human authentication.

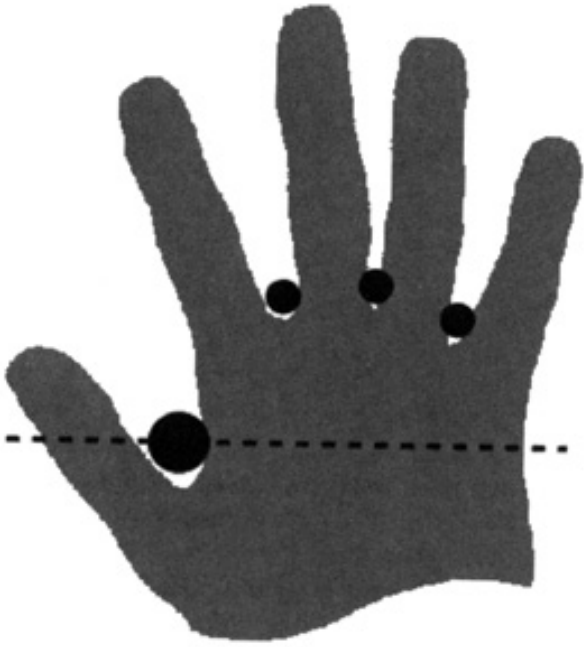
◇ *IrisCode*, the feature vector of an iris, consisting of 512 bytes is recorded and stored in the database for future recognition/matching. It takes less than 2 seconds in a Pentium III machine to compute an IrisCode.

◇ Potential applications for iris scanning biometrics are widespread and installations have been undertaken in the financial sectors for CityBank ATMs as well as in some international airport for passenger identification.

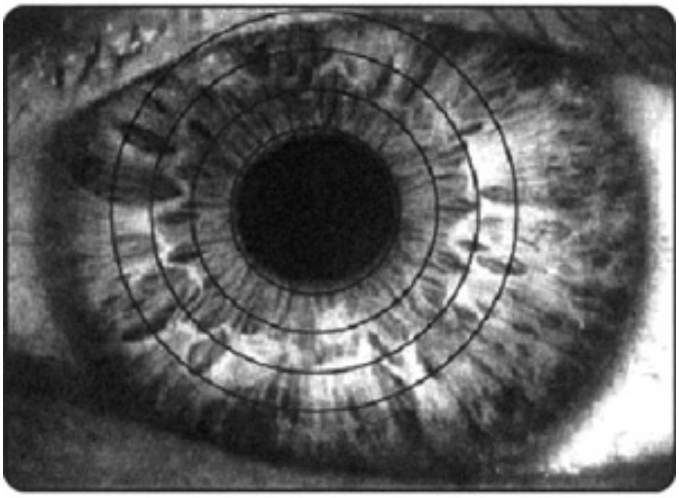
♠ http://www.astrontech.pl/html/body_iridian_merged.html

(a)

(b)



(c)



(d)

(a) Digits, (b) Face, (c) Hand, (d) Iris.

Handwriting/Handprinting Verification
Personal Signature Verification

◇ **Handwritings** and **Signatures** are behavioral biometrics rather than an anatomical biometric such as an iris pattern or a fingerprint.

◇ People handwrite digits or their names in their own special manners. An ancient Chinese calligrapher Wang, Xizhi (AD 306∼365) produced many beautiful writings such that his signature would be paid for in gold.

◇ Based on the *mechanics* of how we write is something very personal and often quite distinctive, biometric handwriting and/or signature seeks to analyz the dynamics inherent in writing the digits, characters, letters, words, and sentences.

◇ The features include how a person presses on the writing surface, how long a person takes to sign his name, how a person struggles to maintain verticalitiy, angularity in letter forms and along the baseline, plus narrow letters.

♠ http://www.handwriting.org/main/hwamain.html

Hand Geometry Verification

◇ **Hand geometry systems** work by taking a 3D view of the hand in order to determine the geometric shape and metrics around finger length, height, and/or other details.

◇ A leading hand geometry device measures and computes around 90 parameters and stores in a record of 9 bytes, providing for flexibility and storage transmission.

♠ http://cse.msu.edu/rgroups

Voice (Speech) Pattern Recognition

◇ The basis for **voice** or **speech** technology was pioneered by Texas Instruments in the 1960's.

◇ The current voice recognition uses a standard microphone to record an individual's voice and identify its unique characteristics. It attempts to analyze the physiological characteristics that produce speech, and not the sound or pronunciation.

◇ A voice identification system requires that a "voice reference template" be constructed so that it can be compared against subsequent voice identifications. Voice identification systems incorporate several variables or parameters in the recognition of one's voice/speech pattern including pitch, dynamics, and waveforms.

◇ It is estimated that the revenues from voice/speech identification systems and telephony equipments and services sold in America will increase from US$356 million in 1997 to US$22.6 billion in 2003.

◇ *Hidden Markov Model* and *Autoregressive Model*

◇ *Fast Fourier Transform* and *Wavelet Analysis*

♠ http://www.buytel.com

Face Image Recognition

◇ **Face** recognition technology works well with most of the shelf PC cameras, generally requiring 320×240 resolution at 3∼5 frames per second.

◇ Facial recognition software products range in price from US$50 to over US$1000, making one of the cheaper biometric technologies.

◇ Four primary methods used to identify or verify users by means of facial features, including *eigenfaces*, *discriminant analysis*, *neural network*, and *ad hoc methods*.

◇ *Singular Value Decomposition* and *Pattern Recognition*.

◇ *Fast Fourier Transform* and *Wavelet Analysis*

♠ http://facial-scan.com/facial-scan_technology.htm

♠ http://www-white.media.mit.edu/vismod/demos/facerec

Fingerprint Image Verification/Identification

◇ Each **fingerprint** is a map of ridges and valleys in the epidermis layer of the skin. The ridge and valley structures form unique geometric patterns.

◇ A *minutiae pattern* consisting of ridge endings and bifurcations is unique to each fingerprint.

◇ Most of the contemporary automated fingerprint identification and verification systems (AFIS) are minutiae pattern matching systems.

◇ A modern AFIS is composed of 5 primary modules: (1) Image Enhancement, (2) Image Segmentation and Thinning, (3) Minutiae Points Extraction, (4) Core and Delta Localization, and (5) Point Pattern Matching.

◇ A fingerprint forum [**?**] provided 5 sets of small databases for researchers to evaluate their identification/verification software.

◇ SecuGen EyeD and Veridicom are two leading companies selling both commercial fingerprint identification/verification systems and sensors with resolution 500dpi. Veridicom FPS110 fingerprint reader sensed a 300×300 fingerprint image in a 2cm by 2cm area.

♠ http://www.networkusa.org/fingerprint.shtml

♠ http://bias.csr.unibo.it/fvc2000

♠ http://www.fpusa.com

Which Biological Characteristic is the Best?

Using a single biometric can not reliably identify or verify an individual person even in a small database of size 30 persons due to the trade-off of false acceptance rate (FAR) and false rejection rate (FRR). This article suggests developing a system of using multiple biometrics to solve the problem based on the following statistics. Suppose that the probability of successfully verifying or identifying an identity using a single biometric technique, for example, fingerprint analysis, is $p = p_i$, for $1 \leq i \leq 6$. To identify or verify an individual who has at least three personal traits out ot six traits successfully matching those in the database is given in equaiton (1). The probabilities listed in Table 1 indicate that we have 98% recognition rate to identify a person as long as one of the three independent traits individually achieves 80% recognition rate. Therefore, a system of applying multiple biometrics technology for an individual identification or verification is more precise than using a single biometric except that the system costs a little bit more.

$$P(X \geq 3) = \sum_{k=3}^{6} C(6,k) p^k (1-p)^{6-k} \tag{1}$$

p	0.05	0.10	0.15	0.20	0.25	0.30
P($X \geq 3$)	0.9999	0.9987	0.9941	0.9830	0.9624	0.9295