How are people identified?

• People are identified by three basic means:
  – Something they have (identity document or token)
  – Something they know (password, PIN)
  – Something they are (human body)

Problems with Possession- or Knowledge-based Approaches

• Card may be lost, stolen or forgotten
  – Password or PIN may be forgotten or guessed by the imposters
• ~25% of people seem to write their PIN on their ATM card
• Estimates of annual identity fraud damages:
  – $59.6 billion in credit card transactions in U.S. alone in 2005*
    – 0.25% of internet transactions revenues, 0.08% of off-line revenues
  – $1 billion in fraudulent cellular phone use
  – $3 billion in ATM withdrawals
• The traditional approaches are unable to differentiate between an authorized person and an impostor

* Spectrum July, 2006

Requirements for an Ideal Biometric Identifier

1. Universality
   – Every person should have the biometric characteristic
2. Uniqueness
   – No two persons should be the same in terms of the biometric characteristic
3. Permanence
   – The biometric characteristic should be invariant over time
4. Collectability
   – The biometric characteristic should be measurable with some (practical) sensing device
5. Acceptability
   – One would want to minimize the objections of the users to the measuring/collection of the biometric

Behavioral vs Physical Traits

• Physical Characteristics
  • Iris
  • Retina
  • Vein Pattern
  • Hand Geometry
  • Face
  • Fingerprint
  • Ear shape

• Behavioral Characteristics
  • Keystroke dynamics
  • Signature dynamics
  • Walking Gait
  • Voice
Iris Recognition: Eye

Every eye has its own totally unique pattern of blood vessels.

Face Recognition: Correlation

Hand

Palm

Vein
Comparison of Biometric Techniques

Note: Further from center is better (angledoesn’t mean anything)

Applications

*There are ~500 million border crossings/year in the U.S.

UCSD Biometric Soda Machine (Chez Bob)

*As part of the enhanced procedures, most visitors traveling on visas will have two fingerprints scanned by an inkless device and a digital photograph taken. All of the data and information is then used to assist the border inspector in determining whether or not to admit the traveler. These enhanced procedures will add only seconds to the visitor’s overall processing time.
Access Control

Using Iris Scans to Unlock Hotel Rooms

The Nine Zero hotel in Boston installed a system which uses digital photos of the irises of employees, vendors and VIP guests to admit them to certain areas, the same system used in high-security areas at airports such as New York’s JFK.

Biometrics for Personalization

- Automatic personalization of vehicle settings:
  - Seat position
  - Steering wheel position
  - Mirror positions
  - Lighting
  - Radio station preferences
  - Climate control settings

Biometrics in Afghanistan

- Iris
- Face
- Fingerprint

Whoops

What makes using biometrics difficult?
Why is Biometric Recognition Difficult?

- Large number of classes (e.g., millions of faces)
- Intra-class variability and inter-class similarity
- Segmentation
- Noisy and distorted images
- Population coverage & scalability
- System performance (error rate, speed, throughput, cost)
- Attacks on the biometric system
- Template ageing
- Non-uniqueness of biometric characteristics
- Addressing privacy concerns

Intra-class variability

Inter-class Similarity

Temporal Variations

Noisy Images

Attacks on Biometric Systems

- Spoofing a biometric trait
- Dummy finger created from a lifted impression
- Artificial skin/fingers (http://www.livingskin.com/)

• ~3% of the population has poor quality fingerprint images

Four impressions of a user's fingerprint
Sensor Interoperability

- Sensors used during enrollment and verification may be different

How good are Biometric Systems? i.e., Evaluation

Pattern classification

ROC Curve

Accuracy requirements of a biometric system are application dependent.
An Example

- "Sorting incoming Fish on a conveyor according to species using optical sensing"

Species:
- Sea bass
- Salmon

- Adopt the lightness and add the width of the fish

\[ x^T = [x_1, x_2] \]

Fish

\[ \text{Lightness} \quad \text{Width} \]
• However, our satisfaction is premature because the central aim of designing a classifier is to correctly classify novel input

Issue of generalization!

Bayesian Decision Theory
Continuous Features
(Sections 2.1-2.2)

Introduction

• The sea bass/salmon example
  – State of nature, prior
    • State of nature is a random variable
    • The catch of salmon and sea bass is equiprobable
      – \( P(\omega_1), P(\omega_2) \) Prior probabilities
      – \( P(\omega_1) = P(\omega_2) \) (uniform priors)
      – \( P(\omega_1) + P(\omega_2) = 1 \) (exclusivity and exhaustivity)

• Decision rule with only the prior information
  – Decide \( \omega_1 \) if \( P(\omega_1) > P(\omega_2) \) otherwise decide \( \omega_2 \)

• Use of the class-conditional information
• \( P(x | \omega_1) \) and \( P(x | \omega_2) \) describe the difference in lightness between populations of sea-bass and salmon

\[ \text{FIGURE 2.1. Hypothetical class-conditional probability density functions show the } \]  
\[ \text{probability density of measuring a particular feature value x given the pattern in } \]  
\[ \text{category } \omega_i. \text{ If } x \text{ represents the lightness of a fish, the two curves might describe the } \]  
\[ \text{difference in lightness of populations of two types of fish. Density functions are } \]  
\[ \text{normalized, and thus the area under each curve is 1.0. from Richard O. Duda, Peter E. Hart, } \]  
\[ \text{and David G. Stork, Pattern Classification. Copyright } \]  
\[ \text{© 2001 by John Wiley & Sons, Inc.} \]
• Posterior, likelihood, evidence

\[ P(\omega_j | x) = \frac{P(x | \omega_j) \cdot P(\omega_j)}{P(x)} \]  
(BAYES RULE)

– In words, this can be said as:
Posterior = (Likelihood * Prior) / Evidence

– Where in case of two categories
\[ P(x) = \sum_{j=1}^{2} P(x | \omega_j)P(\omega_j) \]

• Intuitive decision rule given the posterior probabilities:
Given \( x \):
- If \( P(\omega_1 | x) > P(\omega_2 | x) \) True state of nature = \( \omega_1 \)
- If \( P(\omega_1 | x) < P(\omega_2 | x) \) True state of nature = \( \omega_2 \)

Why do this?: Whenever we observe a particular \( x \), the probability of error is:
- \( P(\text{error} | x) = P(\omega_1 | x) \) if we decide \( \omega_2 \)
- \( P(\text{error} | x) = P(\omega_2 | x) \) if we decide \( \omega_1 \)