User Authentication

COMP 435
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Authentication

- Something you know
- Something you have
- Something you are
- Something you do

Biometrics: something you are or do

Measurement of some physical characteristic

Biometrics in Practice
Registration
- Identification
- Sensing
- Digitization
- Feature (template) extraction

Credentials
- (ID, template)

Relying Party
- Identification
- Sensing
- Digitization
- Feature (template) extraction
- (ID, template)

Verifier
Given (template, ID)
\[ \text{template}_{\text{stored}} := \text{db}(\text{ID}) \]
\[ \text{template}_{\text{stored}} \neq \text{template} \]
Verification Challenges

\[ \text{template}_{\text{stored}} \neq \text{template}_{\text{presented}} \]

Biometric Verification

\[ f(s) \]

probability density function, \( f(s) \)

Alice’s template

Biometric Verification

false positives possible

\[ f(s) \]

Bob’s template

Alice’s template

Biometric Verification

false positives possible

Threshold

Biometric Verification

chance for FP
**Biometric Verification**

- **Template score, \( S \)**
- **Threshold**
- **Chance for FN**

**Incorrect Verification**

- **False Positive:** authenticating when you shouldn’t
- **False Negative:** failing to authenticate when you should

**Detection Procedures**

<table>
<thead>
<tr>
<th>Test is positive</th>
<th>Is the claimant</th>
<th>Is not the claimant</th>
</tr>
</thead>
<tbody>
<tr>
<td>True Positive</td>
<td>False Positive</td>
<td></td>
</tr>
<tr>
<td>False negative</td>
<td>True Negative</td>
<td></td>
</tr>
</tbody>
</table>

**Incorrect Verification**

- **Sensitivity:** \( \frac{TP}{TP+FN} \)
- **Specificity:** \( \frac{TN}{TN+FP} \)
- **Accuracy:** \( \frac{(TN+TP)}{(TP+FN+TN+FP)} \)
- **Prevalence:** \( \frac{(TP+FN)}{(TP+FN+TN+FP)} \)
Incorrect Verification

- **Sensitivity:** \( \frac{TP}{TP+FN} \)
- **Specificity:** \( \frac{TN}{TN+FP} \)
- **Accuracy:** \( \frac{(TN+TP)}{(TP+FN+TN+FP)} \)
- **Prevalence:** \( \frac{(TP+FN)}{(TP+FN+TN+FP)} \)

- **TP Rate:** sensitivity
- **FP Rate:** 1 - specificity
- **Positive Predictive Value:** \( \frac{TP}{TP+FP} \)
- **Negative Predictive Value:** \( \frac{TN}{FN+TN} \)

Pros and Cons of Biometrics

- Hard to forge
- Even harder to revoke
- Special equipment
- Single point of failure

Identification vs Authentication with Biometrics: The Base Rate Fallacy

**Relying Party**

- Identification
- Sensing
- Digitization
- Feature (template) extraction
- (ID, template)

**Authentication with Biometrics**

- **Registration**
- **Claimant**
- **Relying Party**
- **Verifier**
- **Credentials**
Authentication with Biometrics

Verifier
Given (template, ID)
$\text{template}\text{\_stored} := \text{db}(\text{ID})$
$\text{template}\text{\_stored} \triangleq \text{template}$

Identification with Biometrics

Identifier
Given (template)
$\text{template}\text{\_stored} := \text{find\_match}(\text{db}, \text{template})$

Identification with Biometrics

matches = set()
for (entry in DB)
  if (is_match(template\_given, entry))
    matches.add(entry)
return matches

Base Rate

Rate of incident in a population
False Positives and the Base Rate

If the rate of incidence is low compared to the rate of false positive detection, most of the "detected" results returned will be false.

Conditional Probability

\[ P(A|B) = \frac{P(A \cap B)}{P(B)} \]

Given A and B:

\[ P(A) = P(B|A)P(A) \]

\[ P(A|B) = \frac{P(A \cap B)}{P(B)} \]

\[ P(A) = P(B|A)P(A) \]

\[ P(A|B) = \frac{P(A \cap B)}{P(B)} \]

Base rate

\[ P(\text{true ID} | \text{match}) = \frac{P(\text{match} | \text{true ID})P(\text{true ID})}{P(\text{match})} \]

\[ P(\text{true ID}) = 0.0001 \]

\[ P(\text{match} | \text{not true ID}) = 0.01 \]

\[ P(\text{true ID} | \text{match}) = 0.0099 \]

Given a match, this is the chance it is the right person!

Threat

An ID returned by the identifier is more likely to be the wrong ID than to be the right ID.