Automatic Identification of Participants in Haptic Systems

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Agenda

• Introduction
• Haptics-Biometric Systems
• Approach
• Results
• Conclusions and Further Work
Introduction

Authentication Systems

• Something that you have (e.g., key)
• Something that you know (PIN)

Biometrics Systems

– Allow identification of individuals
  • Something that you are/do
    – Iris Recognition
    – Voice Recognition
    – Face Recognition
    – Fingerprint

Haptics Systems

– Introduce the complex sense of touch, force and hand kinesthetic in human-computer int
Can we authenticate using haptics?

- Exploring the feasibility of automatically identifying participants using haptic systems
- It would lead to important and interesting applications (e.g., control access in haptic systems)
- Propose a research avenue for identification
- To explore the user’s behaviour
Methodology

• **Data Acquisition**
  – Haptic-based applications
  – Simple maze solving experimentation

• **Analysis:**
  – First Degree Statistics
  – Dynamic Time Warping
  – Spectral Analysis
Data Acquisition

• Haptic-Based Application

• Description:
  – 3D Elastic Membrane Maze solving process

• Software:
  – Python-VRML/Reachin API implementation

Hardware:
  – Reachin Display system
    • Phantom, Display and Stereo-glasses
Experiment

• To construct a Haptic maze on an elastic membrane
• User is asked to navigate the stylus through the maze
• Each person performed exactly the same maze 10 times.
• A group of 22 volunteers took part in the experiment
First Degree Statistics

- Each subject's comparable positions through the maze were evaluated.
- Velocity was calculated in pixels/per second.
- Velocity was relatively steady for most of the subjects.
- Subjects with higher stylus speed showed different acceleration values.
Analysis: Dynamic Time Warping

- Dynamic time warping analysis creates a match score (MS) of two data sets $d^1$ and $d^2$
- Comparing their respective strokes; i.e. changes in direction on the 2D plane.
- This technique is used for false rejection rate and false accept rate (FRR/FAR) calculations
The frequency spectrum of the 3D position data is analyzed based on windowed discrete time Fourier transform. 

- data₁ and data₂ are from the same user and data₃ from different user.
Results

• To quantify the performance of the proposed algorithms:
  – Standard verification analysis was applied

• A Probability Verification (PV) of 78.8% at 25% FAR

• Equal Error Rate (EER) stands at 22.3% with a threshold MS of 0.195
Conclusions and Further Work

- We have investigated the possibility of automatic identification in Haptic systems.
- Results are mixed. Basic analysis appears to show a relatively low PV.
- On the other hand, further analysis appears to show improvements in system performance.

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<tr>
<th>PV</th>
<th>Training Effect</th>
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<tbody>
<tr>
<td></td>
<td>With</td>
<td>Without</td>
</tr>
<tr>
<td>Time Warping</td>
<td>49.0%</td>
<td>60.1%</td>
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<tr>
<td>Spectral Analysis</td>
<td>67.6%</td>
<td>78.8%</td>
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