Gesture Dynamics: Features Sensitive to Task Difficulty and Correlated with Physiological Sensors

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1. Inducing stress via task difficulty can affect some multimodal measures for fixed-attention tasks:
   – Gesture duration and length.
   – Pulse rate.

2. Other multimodal measures are not affected by task difficulty for fixed-attention tasks:
   – Gesture size and pen pressure.
   – Skin temperature and respiration rates.

3. Results from this study can be used to detect onset of stress in fixed-attention tasks.
Topics

1. Experiment and Task Design
2. Data Analysis and Results
   - Task Performance
   - Gesture Dynamics
   - Physiological Sensors
3. Recent Work: Machine Learning Classification of Stress
4. Future Work:
   - Cross-Modality Comparisons
   - Events of Interest
1. EXPERIMENT AND TASK DESIGN
Experiment Task: **Non-Stress**
Experiment Task: **Stress**
Experiment Design

Two-factor mixed design:
- **Modality** of response (between-subjects)
- **Stress** / task difficulty (within-subjects)

5 modalities: gesture, speech, typing, mouse, finger tap
- This paper / talk focuses just on **gesture** modality.
- Responses entered by drawing first letter of identifier with digital stylus.
- Automatic recognition of input by Microsoft SDK.
Gesture Input Example

Normal Speed
Sensors Used

**Physiological:**
- Skin temperature
- Pulse (finger)
- Respiration bands

**Posture (chair):**
- Distance
- Pressure
Sensors Used

Physiological:
- Skin temperature
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Posture (chair):
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Sensors Used

Physiological:
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Posture (chair):
- Distance
- Pressure

Tablet PC
2. DATA ANALYSIS
Data Analysis

12 total participants (7 male)

Categories of data:

- **Task performance**—how well users did on the task during non-stress vs stress periods [P = paper, T = talk, F = future work] P
- **Gesture dynamics**—properties of the gestures users made during non-stress vs stress periods P, T
- **Physiological data**—sensor readings P, T, F
- **Posture data**—sensor readings F

Types of analysis:

- **Statistical contrasts** P, T, F
- **Machine learning classification** T, F
“Good” Gesture Dynamics

**Gesture duration**

<table>
<thead>
<tr>
<th>Gesture Duration (ms)</th>
<th>Non-stress</th>
<th>Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

**Gesture # points**

<table>
<thead>
<tr>
<th>Number of Points</th>
<th>Non-stress</th>
<th>Stress</th>
</tr>
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<tbody>
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</table>

**Gesture length**

<table>
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\[
T_n - T_1 = \text{total time} = \text{duration}
\]

\[
n = \text{total number of points}
\]

\[
\sum D_{i,i+1} = \text{total path distance} = \text{length}
\]
Inconclusive Gesture Dynamics

Marginal:
- Gesture speed

Not significant:
- Gesture height
- Gesture width
- Gesture area
- Gesture average pen pressure
- Gesture per-point pen pressure
“Good” Physiological Sensors

Pulse rate (beats per minute)

Pulse Rate (BPM)

- Non-stress
- Stress
Inconclusive Physio Sensors

Marginal:
- Skin temperature (°F)

Not significant:
- Respiration rate (breaths per minute, at chest and at waist)
Machine Learning Classification of Stress

3. RECENT WORK
Building decision trees to classify readings into “non-stress” vs “stress” classes (Weka toolkit)

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Accuracy</th>
<th>kappa</th>
<th>Best Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gesture Dynamics</td>
<td>63.9%</td>
<td>0.28</td>
<td>Best features were number of points in the gesture and length. (Correct gestures only, balanced dataset.)</td>
</tr>
<tr>
<td>Physiological Sensors</td>
<td>98.9%</td>
<td>0.97</td>
<td>Best features were respiration rate chest and abdomen.</td>
</tr>
<tr>
<td>Posture Sensors</td>
<td>84.9%</td>
<td>0.64</td>
<td>Best features were the right-front chair leg and the mid-range distance sensor.</td>
</tr>
</tbody>
</table>

- Reasonable performance
- Need to improve for real-time detection
- Combinations of sensors and more fine-grained time windows
4. FUTURE WORK
Future Work

Cross-modality comparisons

Events of interest (e.g., responses to targets, stress onsets)

New gesture features to compute

Combine features from multiple sensors / sources

Binning sensor readings to decrease noise

Collaborations?

– Goal: to detect onset of cognitive stress and adapt interaction to support user needs

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Questions?

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