EEG Sensor Based Classification for Assessing Psychological Stress

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About the Project

- Project IMod-Intelligent Concentration Monitoring and Warning System for Professional Drivers

*Image courtesy: Volvo CE image gallery*
Monitor drivers’ level of performance

Tiredness, drowsiness, stress and lack of concentration effects while operating industrial equipment

Stress Diagnosis system
- Finger temperature
- Heart Rate Variability

Case-Based Reasoning

EEG Sensor based classification

Multi-sensor Data Fusion
- Multivariate Multi-scale Entropy Analysis (MMSE)
Data Acquisition

- EEG Sensor
  - Fp1, Fp2, Cz (ground), A1 and A2 (references)
- Heart Rate
- Respiration Rate
- Finger Temperature
- Skin Conductance
Data Acquisition cont.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Duration</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>3 minutes</td>
<td>Relaxation</td>
</tr>
<tr>
<td>Stressful Events Thinking</td>
<td>4 minutes</td>
<td>Thinking</td>
</tr>
<tr>
<td>Happy Events Thinking</td>
<td>2 minutes</td>
<td></td>
</tr>
<tr>
<td>Mental Arithmetic Work</td>
<td>2 minutes</td>
<td></td>
</tr>
<tr>
<td>Relaxation</td>
<td>2 minutes</td>
<td></td>
</tr>
</tbody>
</table>
Data Preprocessing

Stressed
- 4 minutes stressful events thinking
- 2 minutes mental arithmetic work

Relax
- 2 minutes relaxation
- 2 minutes happy events thinking
- 2 minutes relaxation
Entropy usage

- Healthy system dynamics more complex than pathologic system
- Complexity decreases with aging, disease
- In terms of complexity
  
  Healthy System > Pathologic System
Multivariate Multiscale Entropy Analysis (MMSE)

- Supports complexity analysis of multivariate biological recordings
- Define scales by using coarse-graining method
- Evaluate multivariate sample entropy (MSampEn) for each coarse grained multivariate data
Coarse-grained process

- Scale factor dependent on data length
- MMSE estimates are consistence for data length \( N \geq 300 \)
Classification Techniques

• **Sensor-fusion Based Classification**

  1. Remove artifacts from the EEG signals
  2. 2-channel EEG data fusion using MMSE
  3. Formulate cases using the vector obtained from MMSE
  4. Case-base reasoning
  5. Display most similar cases as output

• **CBR Classification based on brain waves frequency features**

  1. Remove artifacts from the EEG signals
  2. FFT on 2-channel EEG data
  3. Feature calculation ($\alpha, \beta, \theta$)
  4. Building cases
  5. Case-base reasoning
  6. Display the most similar cases as output
Evaluation

<table>
<thead>
<tr>
<th>Criteria/Indices</th>
<th>Classification based on sensor fusion</th>
<th>Classification based on brain wave features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cases</td>
<td>K=1</td>
<td>K=1</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Accuracy</td>
<td>59%</td>
<td>38%</td>
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<tr>
<td></td>
<td>84%</td>
<td>75%</td>
</tr>
</tbody>
</table>
Summary

• Investigating the EEG data in identifying individual response during mental stress
• CBR for classification
  – MMSE technique is used for data fusion
  – Brain waves frequency