Emotion based E-learning System using Physiological Signals

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Outline

- Introduction
- Existing Research works on Emotion Recognition
- Research Methodology
- Results
- Emotion based e-learning system
- GUI
- Future Work
- MATLAB tools
- Publications
Introduction

Emotions

- Mental and physiological state associated with feelings, thoughts and behavior
- Learnt in diverse areas like Psychology, Cognitive Science, Philosophy and Computer Science, However there hasn’t been an universally accepted definition or categorization of emotional states
- Highly subjective and an integral part of any communication, learning, perception and decision making
Introduction (Cont.)

Need of Emotion Recognition System

- Intelligent machine interfaces for smooth interaction between machines and human
- Human Computer Intelligent Interaction (HCII) for natural interaction between human and machines
- Improves mutual empathy
- Smart classrooms, Computer based Training, Medical applications
Introduction (Cont.)

Emotion Recognition Methods

- SELF REPORT methods
  - Questionnaires, Ratings and descriptions provided by the subject
  - Participant biased
Introduction (Cont.)

Emotion Recognition Methods (Cont.)

- OBSERVOR (BEHAVIOUR) methods
  - Facial, Vocal and gesture cues
  - Dependant on external circumstances and prone to social masking
Introduction (Cont.)

Emotion Recognition Methods (Cont.)

- NEURO-PHYSIOLOGICAL signal processing methods

- Physiological response of the Central Nervous System (CNS) and Autonomous Nervous System (ANS)

- Electroencephalogram (EEG), Electrocardiogram (ECG), Electromyogram (EMG), Galvanic Skin Response (GSR), Skin Temperature (ST), Skin Conductance (SC) etc.,

- Complex, but provides the TRUE emotional state of the person.
Introduction (Cont.)

Applications of Emotion recognition systems

- Robots
- Dialogue systems
- Computer based learning
- Smart Classroom
- Therapists for ASD
- Medical Doctors
E-learning systems

- Feedback mechanisms in existing e-learning systems help to study at the pace of the user.
- They take into account only the ‘understanding on the subject’ and not the state such as ‘fatigue’, ‘emotions’ etc.,
Introduction (Cont.)

Emotion based E-learning systems

- Increases the receptiveness and productivity of the user
- Suggests appropriate action to be taken depending on the emotional state of the learner
## Existing research works on Emotion Recognition

<table>
<thead>
<tr>
<th>REFERENCES</th>
<th>BIOSIGNALS</th>
<th>NO OF SUBJECTS</th>
<th>NO OF EMOTIONS</th>
<th>EMOTIONAL STIMULI</th>
<th>CLASSIFICATION RATE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Picard, Vyzas et al. 2001)</td>
<td>EMG, BVP, SC, RR</td>
<td>1</td>
<td>8</td>
<td>Personalized Imagery</td>
<td>81 (User Dependent)</td>
</tr>
<tr>
<td>(Lisetti and Nasoz 2004)</td>
<td>GSR, HR, ST</td>
<td>29</td>
<td>6</td>
<td>Movies</td>
<td>72 (User Dependent)</td>
</tr>
<tr>
<td>(Lan and Ji-hua 2006)</td>
<td>ECG, ST, SC, RR</td>
<td>60</td>
<td>3</td>
<td>Movies</td>
<td>84 (User Dependent)</td>
</tr>
<tr>
<td>(Maaoui and Pruski 2008)</td>
<td>BVP, EMG, SC, ST, RR</td>
<td>25</td>
<td>6</td>
<td>Visual (IAPS)</td>
<td>88 (User Dependent)</td>
</tr>
<tr>
<td>(Jonghwa and Ande 2008)</td>
<td>EMG, ECG, SC, RR</td>
<td>3 (22 trials)</td>
<td>4</td>
<td>Music</td>
<td>95 (User Dependent)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MIT database</td>
<td></td>
<td></td>
<td>70 (User Independent)</td>
</tr>
<tr>
<td>(Kim and André 2009)</td>
<td>EMG, ECG, SC, RR</td>
<td>3 (22 trials)</td>
<td>4</td>
<td>Music</td>
<td>95% (user dependant)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MIT database</td>
<td></td>
<td></td>
<td>70% (user independent)</td>
</tr>
<tr>
<td>(Kim and André 2009)</td>
<td>EMG, ECG, SC, RR</td>
<td>3 (22 trials)</td>
<td>4</td>
<td>Music</td>
<td>91% (user dependant)</td>
</tr>
</tbody>
</table>
Existing research works on Emotion Recognition (Cont.)

<table>
<thead>
<tr>
<th>REFERENCES</th>
<th>Biosignals</th>
<th>NO of Subjects</th>
<th>NO of Emotions</th>
<th>Emotional Stimuli</th>
<th>Classification Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Chuan-Yu, Jun-Ying et al. 2010)</td>
<td>ECG, RR, GSR, BVP</td>
<td>11</td>
<td>3</td>
<td>Movies</td>
<td>90.6% and 90.2% (user independent)</td>
</tr>
<tr>
<td>(Maaoui and Pruski 2010)</td>
<td>BVP, EMG, ST, SC, RR</td>
<td>10</td>
<td>6</td>
<td>Visual (IAPS)</td>
<td>90 (User Dependent) and 45 (User independent)</td>
</tr>
<tr>
<td>(Gouizi, Reguig et al. 2011)</td>
<td></td>
<td>4</td>
<td>6</td>
<td>Visual (IAPS)</td>
<td>85% (user dependent)</td>
</tr>
<tr>
<td>(Valenza, Lanata et al. 2012)</td>
<td>EDA, ECG, RR</td>
<td>35</td>
<td>2</td>
<td>Visual (IAPS)</td>
<td>90% (user independant)</td>
</tr>
<tr>
<td>(Vanny, Park et al. 2013)</td>
<td>BVP, ST, SC</td>
<td>4</td>
<td>4</td>
<td>Visual (IAPS)</td>
<td>100% for fear and joy, 60% for disgust and neutral (User dependent)</td>
</tr>
<tr>
<td>(Chang, Chang et al. 2013)</td>
<td>ECG, GSR, BVP</td>
<td>11</td>
<td>4</td>
<td>Movies</td>
<td>89.2% (user independant)</td>
</tr>
</tbody>
</table>
Existing research works on Emotion Recognition (Cont.)

- Emotion classification rate varies from 45% to 100% for the different research works.

- They cannot be compared as they vary in,
  - Number of subjects
  - Type of elicitation
  - Type of physiological data
  - Number and placement of electrodes
  - Type of analysis (user dependency)

- Though there is no standardization, some of the significant advances are
  - IAPS, IADS database for emotion induction
  - Development of AuDB database (4 emotional states)
  - Statistical features for emotion recognition (Picard et al., 2001)
Existing research works on Emotion Recognition (Cont.)

**Challenges**

- Emotion database of physiological signals
  - Emotional states must be elicited internally
  - The sensors should be less intrusive and at the same time capture the emotional changes
- Methodology
  - Complex, non-linear and non-stationary nature of physiological signals
  - Subject dependence of emotions
- Reliability
Research Methodology

Step 1: Development of Emotional data base (ECG, EMG)

Step 2: Preprocessing

Step 3: Feature Extraction (Linear and non-linear methods)

Step 4: Fusion of emotional features derived from ECG and EMG

Step 5: Emotion Classification

Step 6: Development of GUI
Results

Performance of Emotion Recognition System

<table>
<thead>
<tr>
<th></th>
<th>Maximum Classification Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG</td>
<td>78.47</td>
</tr>
<tr>
<td>EMG</td>
<td>64.62</td>
</tr>
<tr>
<td>ECG and EMG</td>
<td>82.54</td>
</tr>
</tbody>
</table>
Emotion based E-Learning system

- Detects emotional state from ECG and EMG signals
- Suggests the activity based on the detected emotional state
- User can recheck the emotion again before proceeding further

<table>
<thead>
<tr>
<th>EMOTIONAL STATE</th>
<th>SUGGESTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>Start Lessons</td>
</tr>
<tr>
<td>Happiness</td>
<td>Start Lessons</td>
</tr>
<tr>
<td>Sadness</td>
<td>Listen to Music</td>
</tr>
<tr>
<td>Fear</td>
<td>Listen to Music</td>
</tr>
<tr>
<td>Surprise</td>
<td>Calm Down</td>
</tr>
<tr>
<td>Disgust</td>
<td>Play a game</td>
</tr>
</tbody>
</table>
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GUI

You are currently in SAD state!!!

Relax by listening to instrumental music

Choose menu on the right - Later recheck emotion
Future Work

- On-line system
- Develop efficient algorithms to capture the emotional states
- More Automation
- Integrate with mobile apps, robots and other personalized devices
MATLAB TOOLS

- **Signal processing**
  - Filter Design for pre-processing
  - Feature Extraction algorithms – Wavelets, Fourier Transform, Hilbert Huang Transform, Empirical Mode Decomposition, Hurst exponent

- **Machine Learning**
  - Pattern Recognition – KNN, Regression Tree, Bayesian Classifier
  - Confusion Matrix

- **SIMULINK**
  - Development of GUI
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Publications

International Journals


- **Arun Sahayadhas**, Kenneth Sundaraj and Murugappan Murugappan, (2013) "Drowsiness detection during different times of day using multiple features", Australasian Physical & Engineering Sciences in Medicine 36(2), 243-250 (ISI Impact Factor 0.885).

- **Arun Sahayadhas**, Kenneth Sundaraj M Murugappan, “Electromyogram signal based hypovigilance detection”, Biomedical Research 2014; 25(3), ISI Impact Factor 0.177.

- **Arun Sahayadhas**, Kenneth Sundaraj M Murugappan, Rajkumar Palaniappan, “A Physiological Measures-Based Method for Detecting Inattention in Drivers Using Machine Learning Approach”, Biocybernetics and Biomedical Engineering, Accepted for publication, ISI Impact Factor 0.157
Publications

International Conferences


- M Murugappan, NQI Baharuddin, **S Jerritta**, “DWT and MFCC based human emotional speech classification using LDA”, International Conference on Biomedical Engineering (ICoBE), 2012.


- **Arun, S.**, Sundaraj, K., & Murugappan, M. (2012). “Driver inattention detection: A review”. In Sustainable Utilization and Development in Engineering and Technology (STUDENT), 2012 IEEE. (pp. 1-6)
thank you