A novel non-Intrusive approach to assess drowsiness based on eye movements and blinking

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Increasingly sleep-deprived society

Fatigue, drowsiness, cognitive deficits

Negative impacts on health, safety and performance

Annual average of 83,000 sleep-related crashes on U.S. roadways (2005-2009); Drowsiness involvement in nearly 3% of US crash fatalities in 2014 (NHTSA).

Increase of fatigue-related motor vehicle fatalities from 4.6% in 2000 to 6.4% in 2013 in Canada (Traffic Injury Research Foundation).


http://www.drivingschoolireland.com/what_not.html
Alcohol Countermeasure System Corp. (ACS)

- An international group of companies (beginning in 1970) with a Canadian headquarter
- Pioneer in alcohol detection technology and road safety
- Scientific research, product development, and manufacturing

Research collaborations with academic sector

In-house R & D
To develop non-intrusive real-time techniques to reliably assess the state of vigilance, which is critical for managing fatigue in people and reducing motor vehicle collisions and human fatalities.
Methods

- Sustained vigilance task
  - Consecutive psychomotor vigilance task (PVT)
  - 100 stimulus-response trials per PVT episode
  - Two separate sessions (different sleep conditions):
    » normal sleep (NS)
    » sleep restriction (SR)
- 15 subjects (age 22.9±3.3 years; 11 females)
- Brain & Mind Sleep Research Lab. Western University, Canada
  - Multi-modal data (eye tracking, EEG, and reaction time)
  - A Gaussian mixture model (GMM) of the “alert” state
  - Reaction times to visual stimuli as the baseline
## Methods

### Feature Extraction (25 features)

<table>
<thead>
<tr>
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<th>General Gaze</th>
<th>Fixation</th>
<th>Saccade</th>
<th>Blinking</th>
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<tbody>
<tr>
<td></td>
<td>STD, median, scanpath, velocity</td>
<td>Duration, frequency, percentage, scanpath, velocity</td>
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**Dimensionality reduction**
- Fisher’s discriminant analysis (FDA)
Methods

Pre-processing → Feature Extraction - Dimensionality Reduction → Compare → GMM-based Reference

Drowsiness Index

Piece-wise-linear model

Raw Drowsiness Index

Drowsiness Index
Results

Case 1. Drowsiness Index vs. Reaction Time (baseline)

$r = 0.79; \ p<0.001$

nRMS error = 0.04
Results

Case 2.
Drowsiness Index vs.
Reaction Time
(baseline)
Results
Conclusion & Discussion

• A novel GMM-based method for non-intrusive assessment of drowsiness using eye tracking data
• Sustained vigilance task
• RTs to visual stimuli as baseline
• Preliminary study verifies the potential of the proposed methodology

Further investigations required:
• Various levels of fatigue/sleep deprivation and time of day
• Biological measures as baseline
• Simulated and real driving scenarios
Thank you!

Q & A

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