The 10th International Conference on Managing Fatigue

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

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ACS

Life Saving Innovations

Background

- 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).

https://inscopeca.wordpress.com/fatigue-information-2/employer-and-hse-fatigue-information/

http://www.drivingschoolireland.com/what_not.html

Alcohol Countermeasure System Corp. (ACS)

Research collaborations with academic sector

In-house R & D

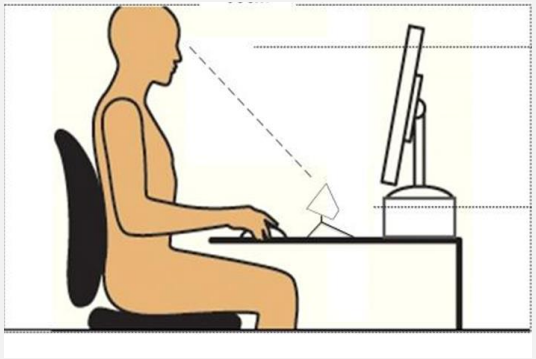
- An international group of companies (beginning in 1970) with a Canadian headquarter
- Pioneer in alcohol detection technology and road safety
- Scientific research, product development, and manufacturing

Objective

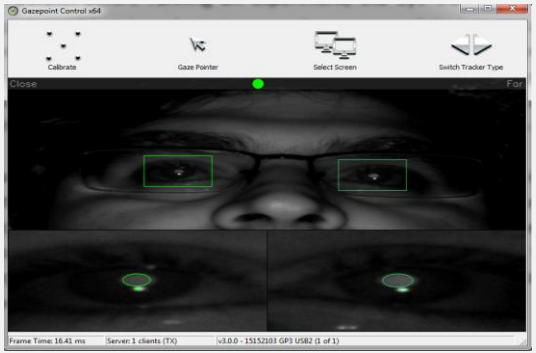
To develop non-intrusive real-time techniques to reliably assess the state of vigilance, which is critical for managing fatigue in people and reducing motor vehicle collisions and human fatalities.

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



GazePoint GP3 Eye Tracker



Methods

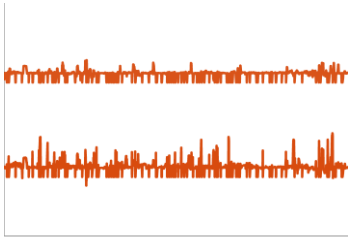
Feature Extraction (25 features)

General Gaze	**STD, median, scanpath, velocity**
Fixation	**Duration, frequency, percentage, scanpath, velocity**
Saccade	
Blinking	**Duration, frequency, percentage**

Dimensionality reduction

- Fisher's discriminant analysis (FDA)

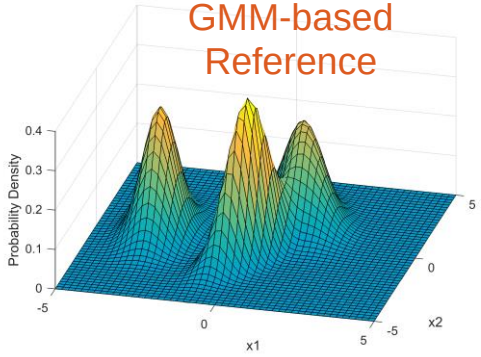
Methods



Pre-processing

Feature Extraction - Dimensionality Reduction

GMM-based Reference



Compare

Raw Drowsiness Index

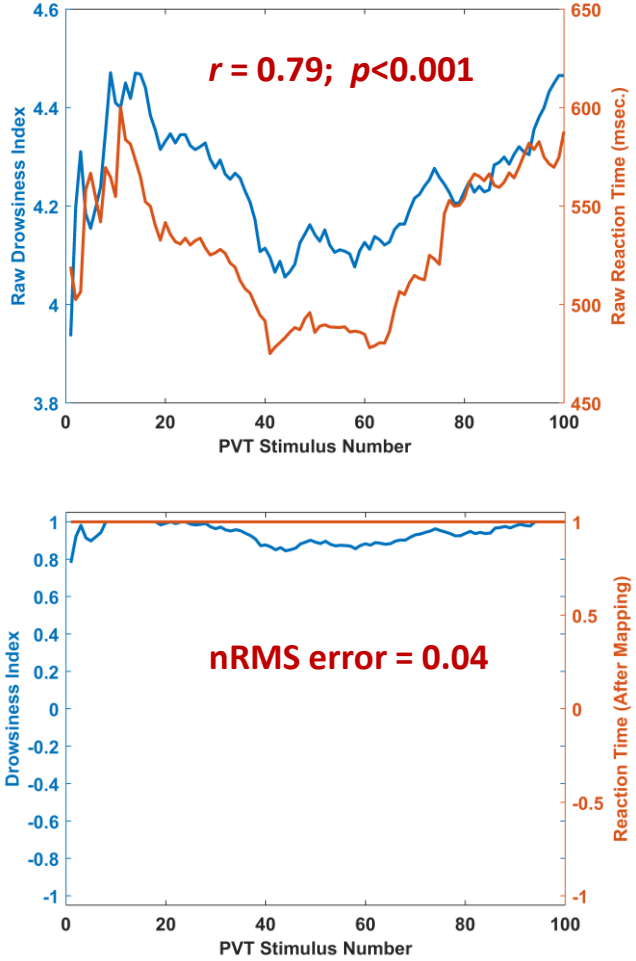
Piece-wise-linear model

Drowsiness Index

Results

Case 1.

Drowsiness Index vs. Reaction Time (baseline)



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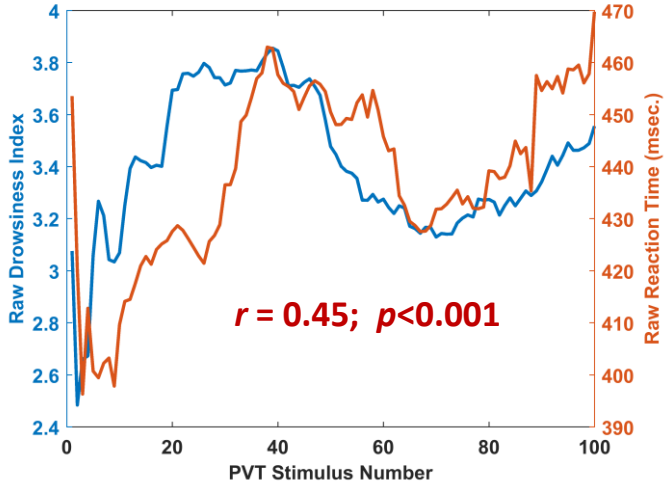
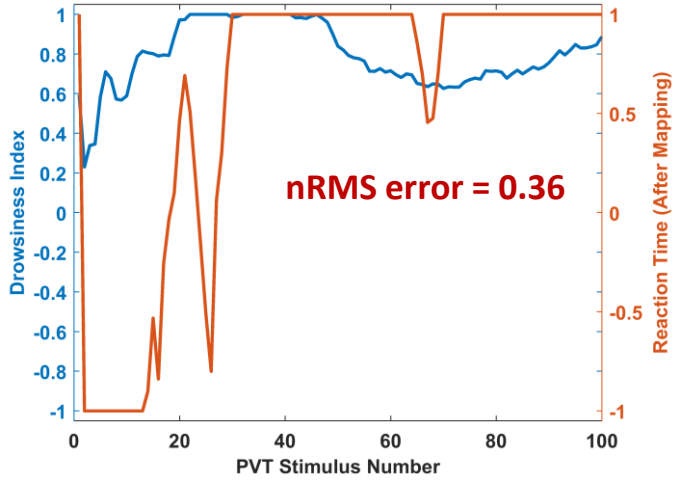
2017.03.20

Results

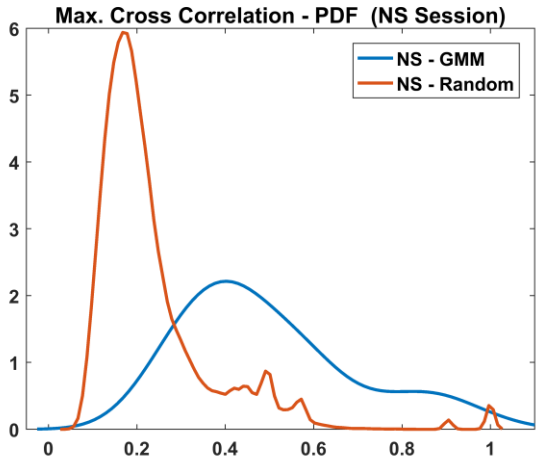
Case 2.

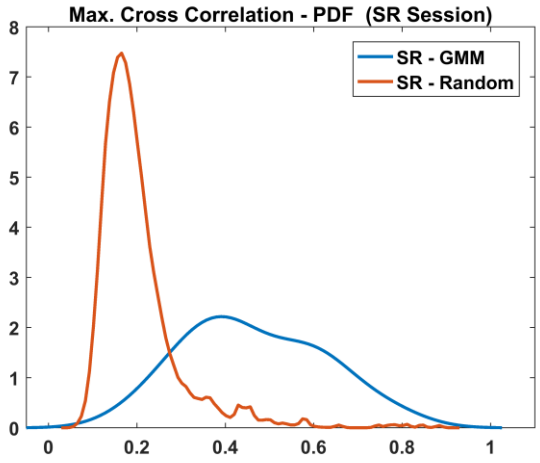
Drowsiness Index vs. Reaction Time (baseline)

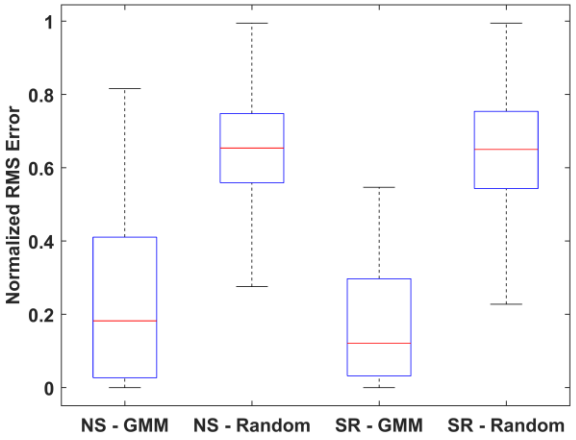




Results


Max. Cross Correlation - PDF (NS Session)
NS - GMM
NS - Random
0
1
2
3
4
5
6
0
0.2
0.4
0.6
0.8
1


Max. Cross Correlation - PDF (SR Session)
SR - GMM
SR - Random
0
1
2
3
4
5
6
7
8
0
0.2
0.4
0.6
0.8
1


Normalized RMS Error
0
0.2
0.4
0.6
0.8
1
NS - GMM
NS - Random
SR - GMM
SR - Random

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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