

Intelligent Transportation System for Fatigue: Are they appropriate for older drivers?

A literature review

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25th CARSP Conference,
Ottawa, Ontario, May 27-30, 2015

Introduction

- Older drivers are increasing in most countries of the world (United Nations, 2013)
- Elderly are good and safe drivers but one of road accidents for this driver's category is fatigue
- Elderly are five times more likely to be responsible of road accidents related to fatigue than being a victim (Clarke, Ward, Bartle and Truman, 2010)
- Technologies have great potentials to improve road safety by helping older drivers drive safely and for a longer period of time (Rakotonirainy & Steinhardt, 2009)

Aim of the presentation

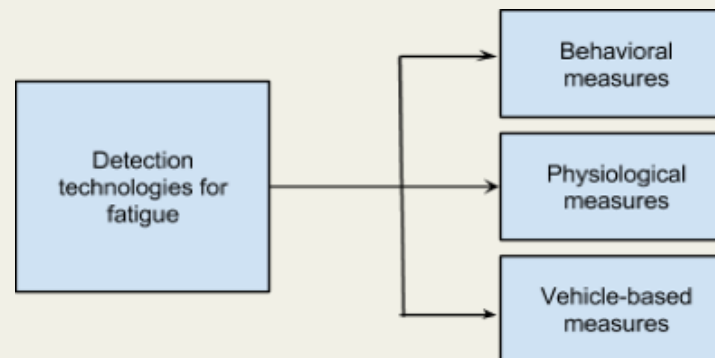
- In 2005, Williamson and Chamberlain have published a literature review of fatigue, technologies and driving
- There has been an increasing interest in the development of devices for detecting fatigue
- The aim is to examine how technology might be used to study fatigue and if existing technologies are appropriate for older drivers

What is fatigue?

- There is no unique definition for fatigue because it is an interdisciplinary concept
- Fatigue refers to a transitional state between wakefulness and sleep, which can lead to sleep if this period is not interrupted (Thiffault & Bergeron, 2003)
- Different variables which cause fatigue:
 - exogenous (i.e the environment)
 - endogenous (i.e inherited characteristics and health status)
- Fatigue impacts a large number of skills needed to drive safely
- Consequences: increased reaction time, higher inattention, difficulty in stabilizing speed, etc.

Method

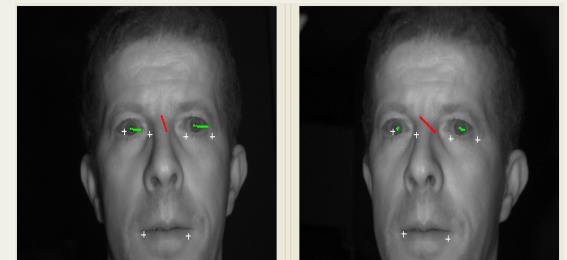
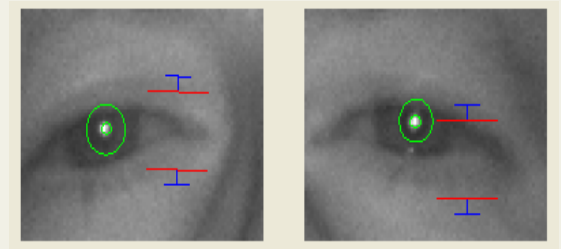
- Relevant databases:
 - PsycINFO
 - PubMed
 - IEEE Explore
 - ScienceDirect
 - Google Scholar
- Many devices developed to collect data on a driver's states with sensors and to alert, warn or assist the driver (Sahayadhas, Sundaraj & Murugappan, 2014)
- The best-known devices are divided in three categories:



Behavioral measures (1/2)

1) Eye movements

- When there is fatigue, there are modifications in the eye region that can be detected by the device
- **Eye closure**
 - PERCLOS (Zhang & Zhang, 2010)
 - Eye-blinking (Yang *et al.*, 2012)
- **Gaze tracking & Eye saccadic movements**
(Mohamad-Hoseyn Sigari *et al.*, 2014)

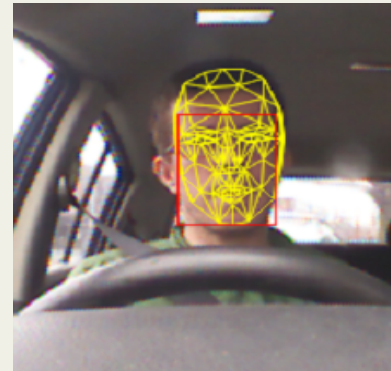


Behavioral measures (2/2)

2. Head movements

- Mouth and Head orientation suggest fatigue
- **Yawning**
(Vural *et al.*, 2010)
- **Head orientations**
 - Head nodding (May & Baldwin, 2009)

Systems that detect eyes and head movements seem robust and show good accuracy to predict fatigue (Varma, Arote, Bharti and Singh, 2012)



Physiological measures

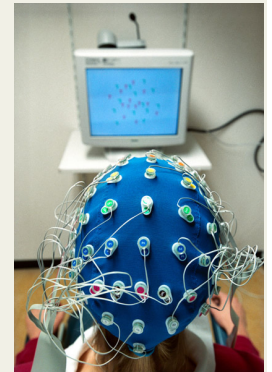
1. Electrocardiogram (ECG)

- ECG signal records heart rate and heart rate variability
- Gomez-Clapers & Casanella (2012) developed a monitoring system of ECG signal by using a wireless steering wheel



2. Electroencephalogram (EEG)

- Lin *et al.* (2010) used a real-time wireless signal acquisition module to measure EEG signals
- New methods with the Harken project: sensors are placed on the seat and on the safety belt strap (Solaz, Rosario, Gameiro & Bande, 2015)



Performance measures

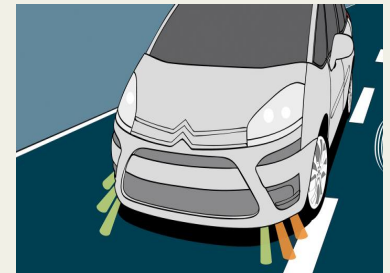
1. Steering wheel



- Steering wheel movement is a robust measure to detect fatigue
- Krajewski, Sommer, Trutschel, Edwards and Golz (2009) worked on a steering wheel behaviour monitoring system to detect driver's fatigue. Results have shown a recognition rate of 86,1%

2. Lane tracking

- Detect when a car is crossing the middle or the sideline
- Some recent cars include lane-tracking devices (e.g. Citroën C4)



Are they appropriate for older drivers?

	Advantages	Limits
Behavioral measures	<ul style="list-style-type: none"> - Non-intrusive method - Saccadic eye movements are good predictors of fatigue 	<ul style="list-style-type: none"> - Wearing of glasses - Ambient light conditions - Skin color
Physiological measures	<ul style="list-style-type: none"> - ECG: non-invasive and can detect cardiovascular diseases 	<ul style="list-style-type: none"> - Relatively expensive - Ambient light conditions - Difficulty to use
Performance measures	<ul style="list-style-type: none"> - Non-intrusive - Not distracting - No problem with environmental conditions - Feedback with vibrations 	<ul style="list-style-type: none"> - No studies on performance measures and fatigue of older drivers

Discussion

- The success of technologies to detect fatigue depends on various factors, particularly driver's acceptance of these technologies
- The usefulness of driver fatigue detection devices. Older drivers' approach new technologies differently than other groups of drivers (Shaw *et al.*, 2010)
- Fatigue detection devices were perceived negatively, because participants believed that their own perception of their fatigue was more accurate than the one obtained with a device (Musselwhite and Hadad, 2007)
- More studies are required to combine subjective measures (driver's perception) and objective measures (e.g., data for the devices)
- The design of devices have to be adapted to the age-related deficits of older drivers (e.g., arthritis incapacitation, visual deficit, etc.)

Conclusion

- Present some technologies designed to detect driver's fatigue, and their advantages and limitations for older driver
- Research in this domain is pretty active. Solutions to fatigue detection are very promising, such as behavioural, physiological and vehicle performance measures, which can predict fatigue with high accuracy
- However, current solutions are not adapted to senior drivers and their specific needs
- The new technologies and the growing number of older drivers compel for driving fatigue detection solutions adapted to this population

THANK YOU



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ACKNOWLEDGEMENTS

We want to particularly thank the Canadian Automobile Association (CAA) Foundation, Section of the Quebec Province, for funding the research works

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