Politecnico di Torino

Toward In-Cabin Monitoring: A Preliminary Study on Sensors Data Collection and Analysis

J. Sini, L. Pugliese, S. Groppo, M. Guagnano, M. Violante
Politecnico di Torino

SEPTEMBER 18-22 2023 – ALGHERO, SARDINIA, ITALY

CYBER PHYSICAL SYSTEMS SUMMER SCHOOL 2023

18th September 2023

CAD & Reliability Group

Outline

- Introduction
- State of the Art
- Proposed approach
- Experimental results
- Conclusions

Outline

- Introduction
- State of the Art
- Proposed approach
- Experimental results
- Conclusions

Introduction

- **Road accidents** causes 1.3 million fatalities every year, being the first cause of deaths in the age range 15-29.
- **Driver distraction and sleepness are major concerns for road safety.**
- Need (also enforced by regulatory bodies) of technologies to **aid drivers in reducing distracted driving**.

Outline

- Introduction
- State of the Art
- Proposed approach
- Experimental results
- Conclusions

State of the Art

Various driving monitoring systems have been developed over the years. These can be categorized as:

- **Driver behavior** analysis → Seeking patterns in the steering angle
- **Camera-based** analysis → Using cameras to assess the level of driving attention by measuring head/eye gazing and eye blinking rate (sleepiness)
- **Physiological-based** analysis → Evaluate driver's biological state to identify their level of sleepiness by analyzing physiological factors.

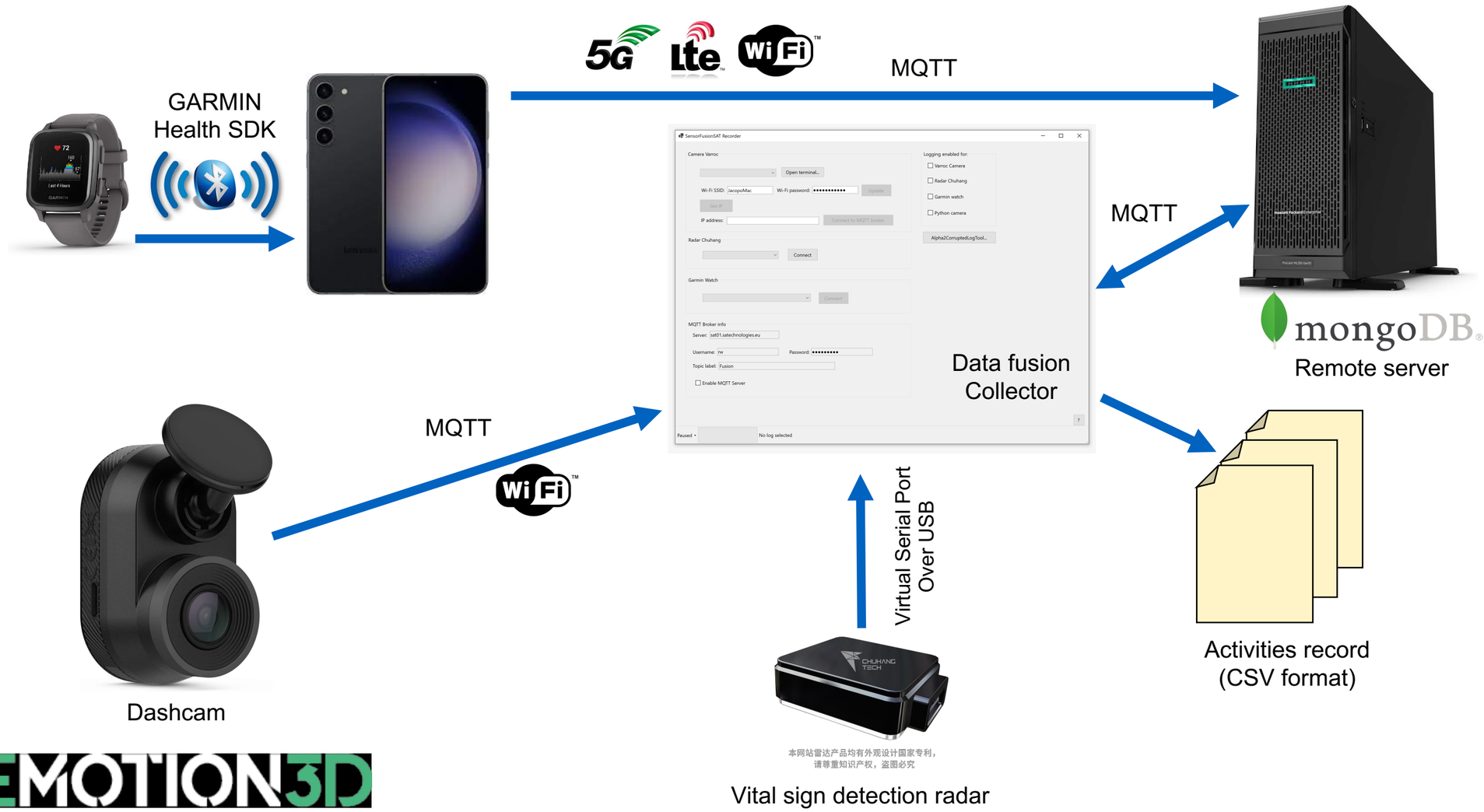
Outline

- Introduction
- State of the Art
- Proposed approach
- Experimental results
- Conclusions

Proposed approach

- Provide a warning to the driver if **distraction** is detected.
- Exploit redundancy to improve specificity and sensitivity of the system, in particular:
  - **Physiological-based** (RR, HR, HRV) → rKSS (sleepiness)
  - **Camera-based** (face orientation vertical angle, blinking) → distraction + sleepness
  - **Radar-based** (RR, HR) → rKSS (sleepness)

System Architecture



The architecture of the data fusion system

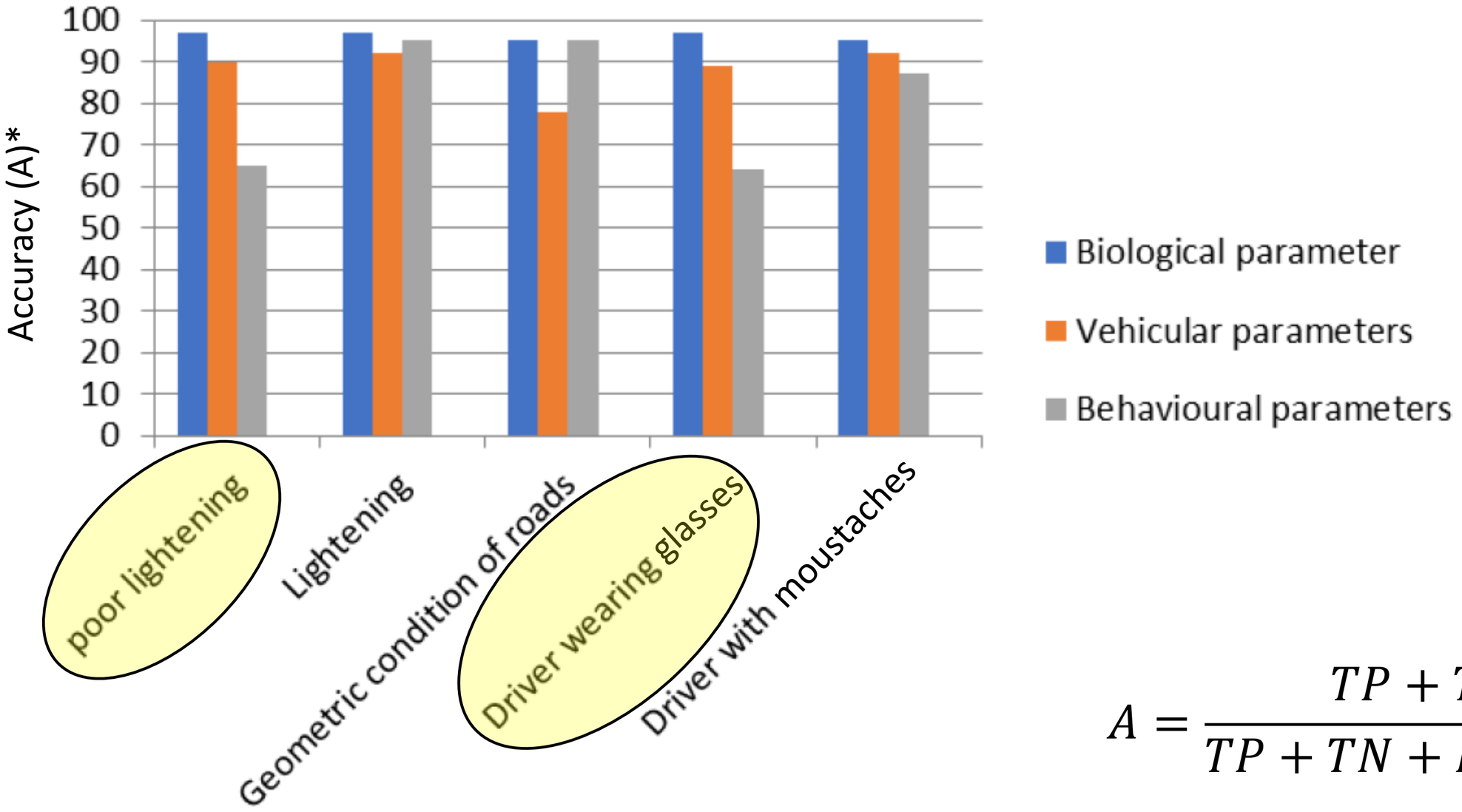
Data Collection and Fusion?

Why collect time-aligned data and try to fuse them?

- **Camera** allows a **fast detection** of distraction and more sensible to sleepness (especially when based on eye blinking), **but generates many false positives (FP)** due to the more noisy measure environment.

- **Physiological** data analysis (from RADAR and wearable) is **slower** to detect sleepness and cannot detect distraction, **but has a better specificity** to sleep onsets.

Technical solutions



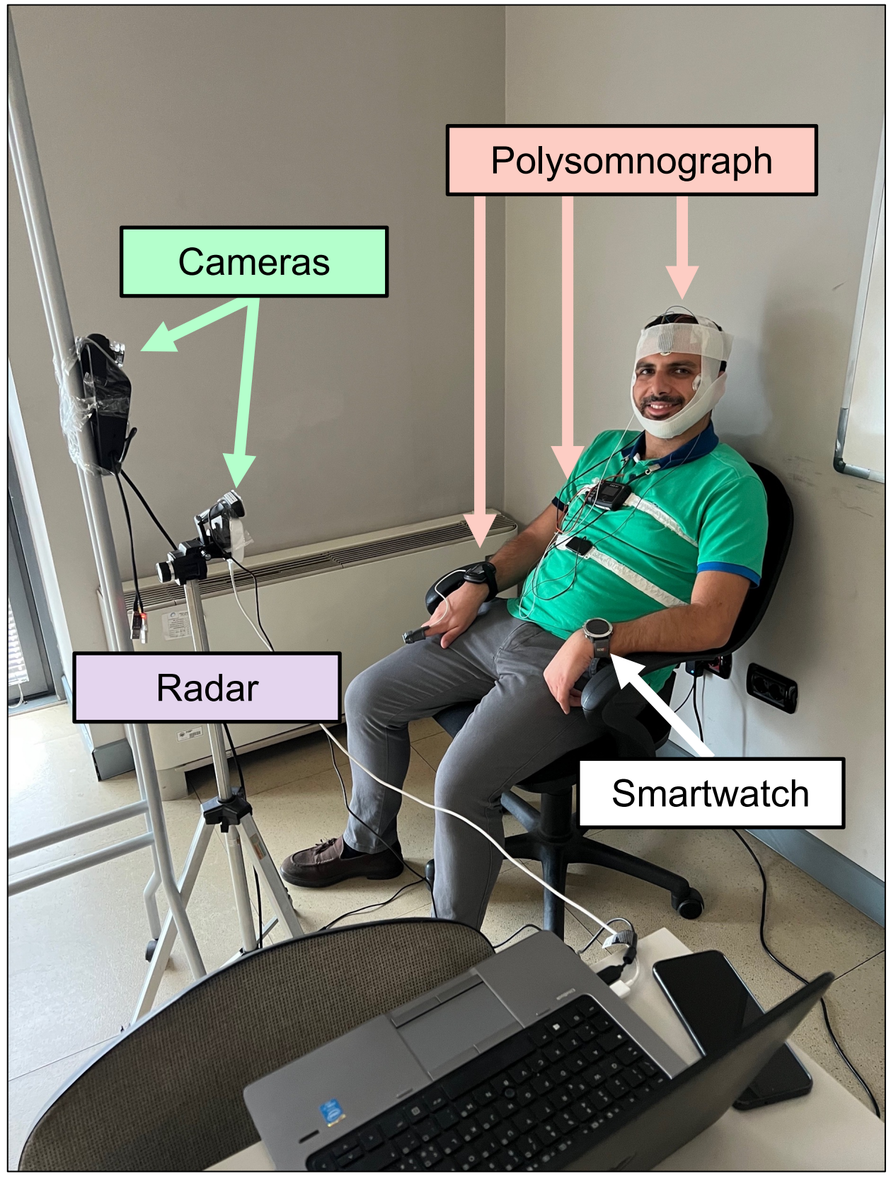
$$A = \frac{TP + TN}{TP + TN + FP + FN}$$

*Study from: Ramzan, M., Khan, H. U., Awan, S. M., Ismail, A., Ilyas, M., & Mahmood, A. (2019). A survey on state-of-the-art drowsiness detection techniques. IEEE Access, 7, 61904-61919.

Outline

- Introduction
- State of the Art
- Proposed approach
- Experimental results
- Conclusions

Experimental setup



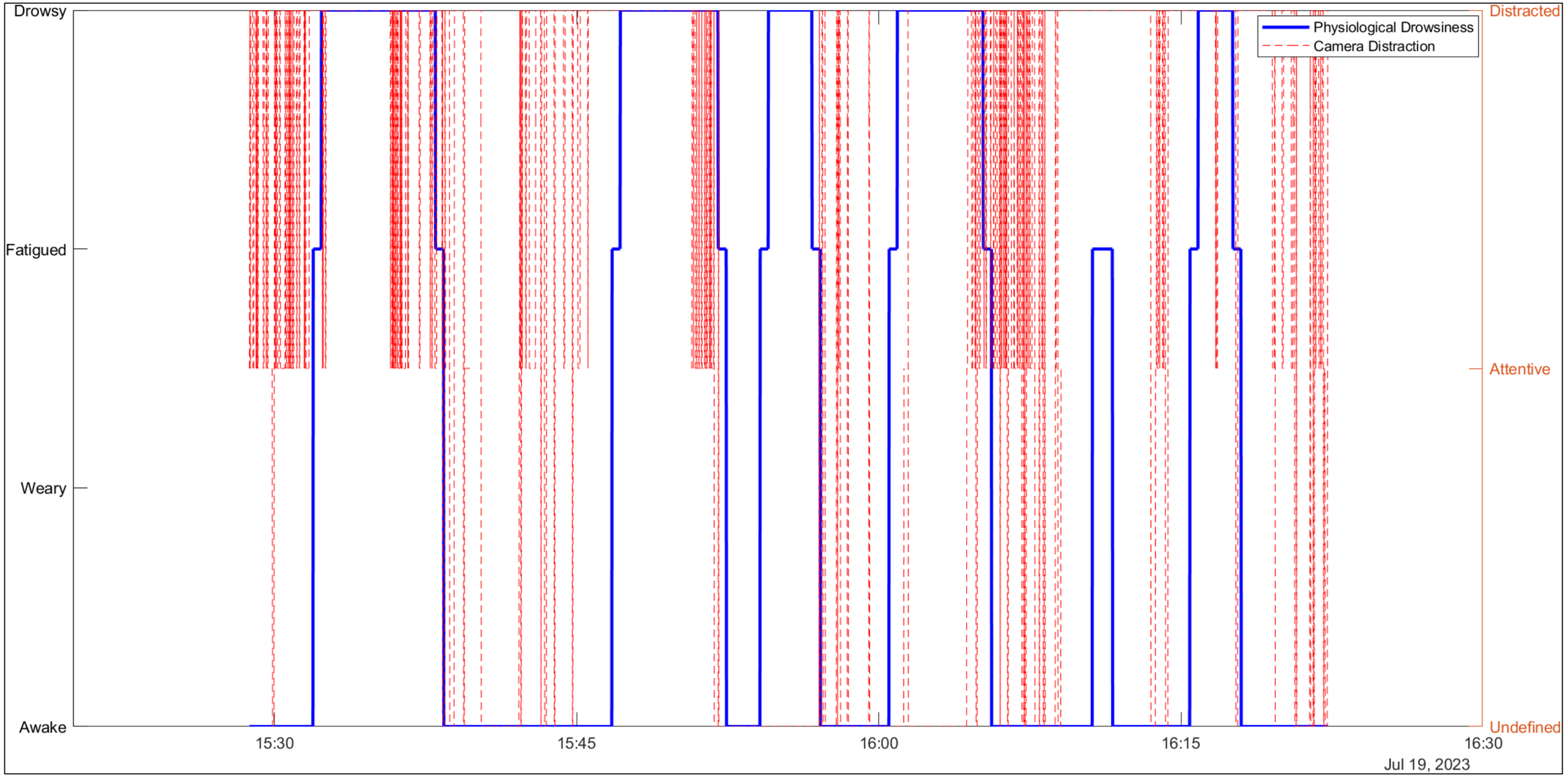
16 volunteers:

- 5 woman
- 11 men

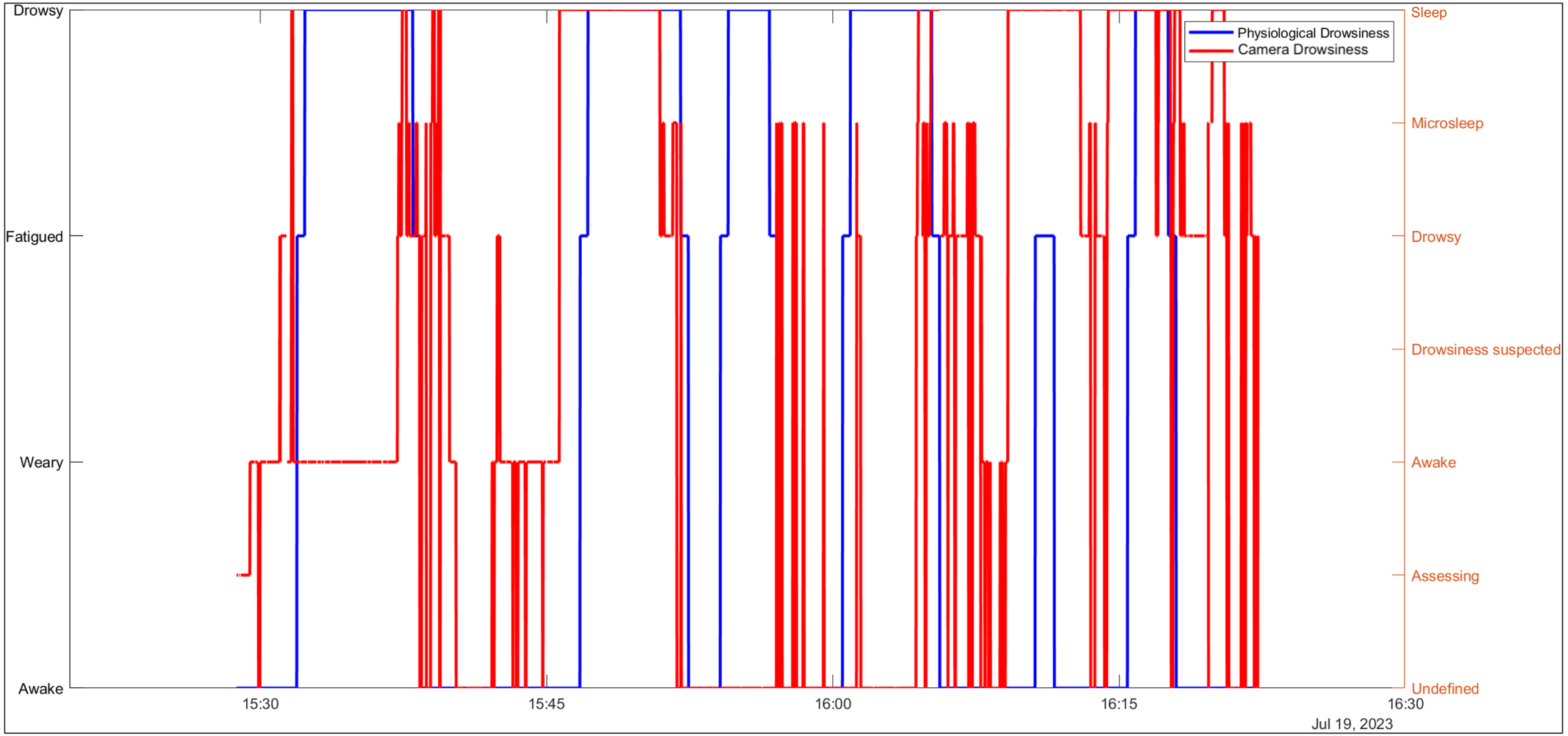
aged 25-32.

Each test, defined as **Maintenance Weakfullnes Tests,** 90 minutes long, where the volunteer is asked to remain awake while sit into a comfortable environment.
They are asked to do nothing during this time.

Distraction detection performances



Sleepness detection performances



Outline

- Introduction
- State of the Art
- Proposed approach
- Experimental results
- Conclusions

Conclusions

- **Camera** useful to **calibrate** the **wearable**…
- …**wearable** and **RADAR** useful to **filter** the **camera**!

- All the three sensors are also available stand-alone, with many evidences of their strong and weak points.
- Data fusion is needed to **improve sensitivity and specificity** of the system: this has a crucial role on increasing **users' trust** on these Advanced Driving Assistance Systems.

Future work

- Collect more data with these tests (> 100 volunteers) to obtain data with statistical significance, expecially increasing the age range.

- Develop a Data Fusion algorithm to be run on the edge device thanks to these data.

Thank you for your attention

CONTACTS

Jacopo SINI

Politecnico di Torino - DAUIN

C.so Duca degli Abruzzi 24

10129 Torino, Italy

Tel. +39 011 090 7091

jacopo.sini@polito.it

Politecnico di Torino

CAD & Reliability Group