AD VITAM

ADAPTIVE DRIVER-VEHICLE INTERACTION TO MAKE FUTURE DRIVING SAFER

Elena Mugellini, Stefano Carrino, Jean-Pierre Bresciani, Andreas Sonderegger, Leonardo Angelini, Marine Capallera, Quentin Meteier, Emmanuel de Salis

"We can't sustain attention, especially in boring environments like highway driving"
Mary Cummings

"Expecting the human to be able to just step in when we know they haven't been paying attention is a huge problem"
Mary Cummings

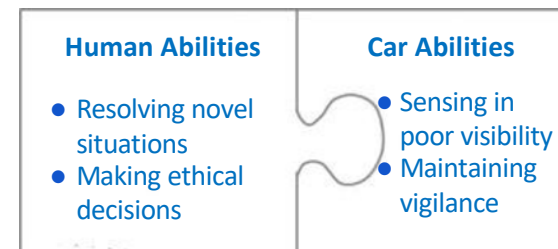- Car **automation promises** to **free our hands**…
- …but is **demanding more** from **our minds**!

Use it (& improve it) or lose it

Haute école d'ingénierie et d'architecture Fribourg
Hochschule für Technik und Architektur Freiburg
UNI FR
UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG
EPFL+ECAL LAB
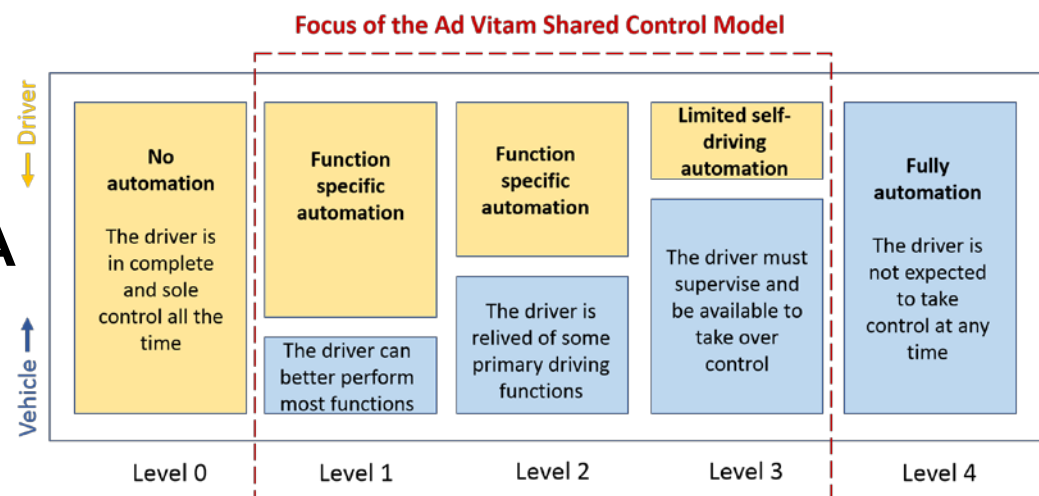haute école neuchâtel berne jura · arc ingénierie · www.he-arc.ch
HASLERSTIFTUNG

OUR VISION: THE CAR AS A COMPANION

- *"Automation does not remove the human from the driving task. It "simply" changes their role within it".*

- **Shared-control**: The driver and the "car" collaboratively and interactively control the vehicle

- Smartly **adapt** the **interaction** to **individual driver's** current **needs** and **emotional state,** and **environment**

- Context: semi-autonomous vehicles - **levels 1-2-3, NHTSA Taxonomy**

Human Abilities
- Resolving novel situations
- Making ethical decisions

Car Abilities
- Sensing in poor visibility
- Maintaining vigilance

Focus of the Ad Vitam Shared Control Model

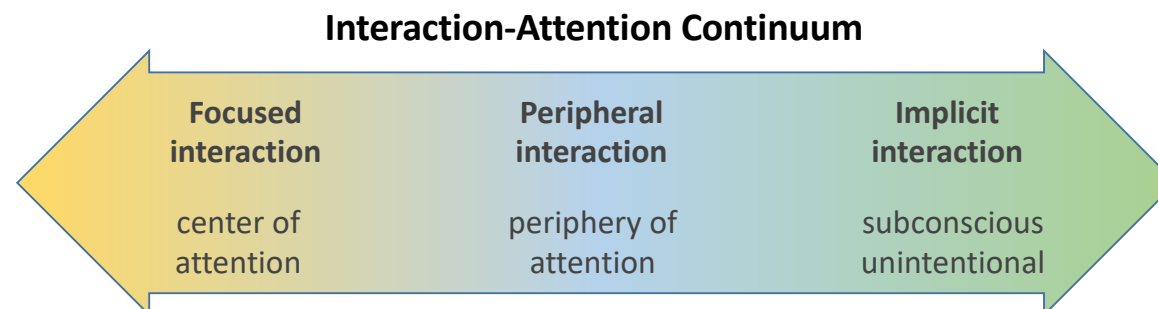|	No automation	Function specific automation	Function specific automation	Limited self-driving automation	Fully automation
	The driver is in complete and sole control all the time	The driver can better perform most functions	The driver is relived of some primary driving functions	The driver must supervise and be available to take over control	The driver is not expected to take control at any time
	Level 0	Level 1	Level 2	Level 3	Level 4

Driver ← → Vehicle

AD VITAM OBJECTIVES

- Development of a **psychophysiological model** of the driver
  - Understand how to use psychophysiological data to assess driver state

  PhD 1

- Study of driver's **attention** and **reactiveness** processes
  - Understand how to support the driver's ability to suddenly regain vehicle control when required

  PhD 2

- Investigate advanced **Human-Vehicle interaction** modalities
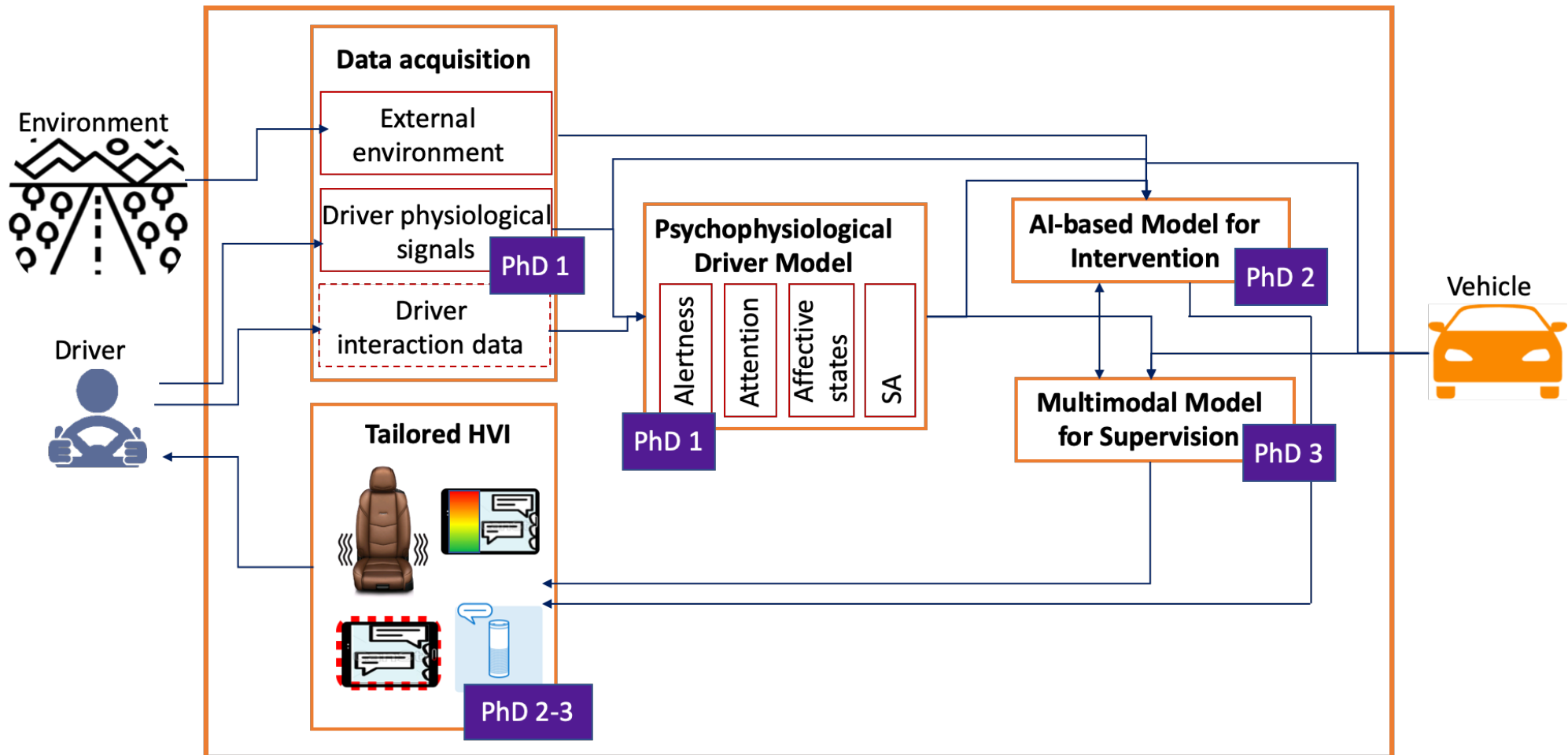 - Understand how peripheral and subtle multimodal interaction can foster **situational awareness** (**SA**)

  PhD 3

Interaction-Attention Continuum

| **Focused interaction** | **Peripheral interaction** | **Implicit interaction** |
| center of attention | periphery of attention | subconscious unintentional |

GLOBAL OVERVIEW OF THE 3 PhD THESES

Haute école d'ingénierie et d'architecture Fribourg
Hochschule für Technik und Architektur Freiburg

UNI FR
UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG

EPFL+ECAL LAB

haute école
neuchâtel berne jura
arc ingénierie
www.he-arc.ch

HASLERSTIFTUNG

PHD 1 – PSYCHOPHYSIOLOGICAL MODEL OF THE DRIVER

4-COMPONENTS MODEL

- **Alertness** and **Attention**
  - main factors that lead to bad driving performances and poor takeover request

- **Affective state** and **SA**
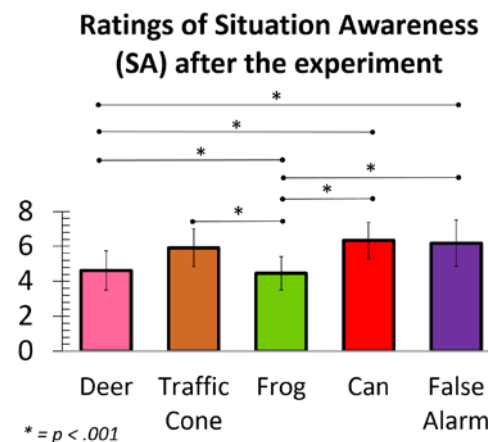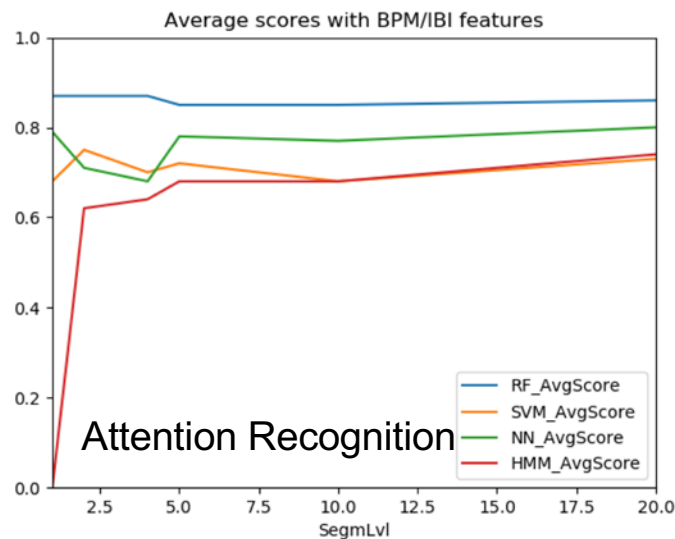 - important factors to adapt the interaction and dialog

Driver **physiological signals dataset**
  - ECG, EDA and respiration
  - approx. **150 participants**
  - about **75h of recordings**
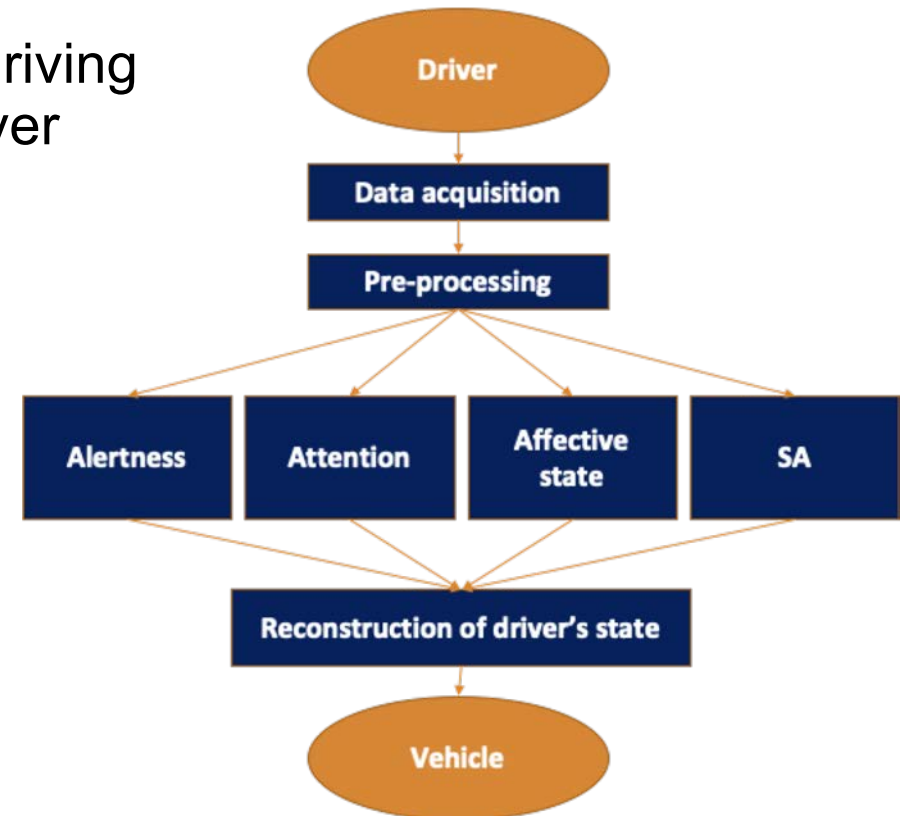
PHD 1 – PSYCHOPHYSIOLOGICAL MODEL OF THE DRIVER

- ## Drivers' studies

- ## Attention detection
  - 90% of accuracy (yes/non state)

- ## Obstacle dangerousness (SA)
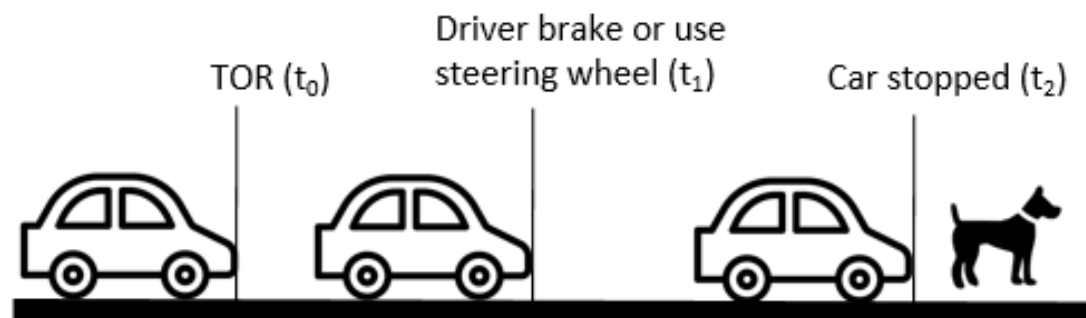 - Perceived SA differences between obstacles
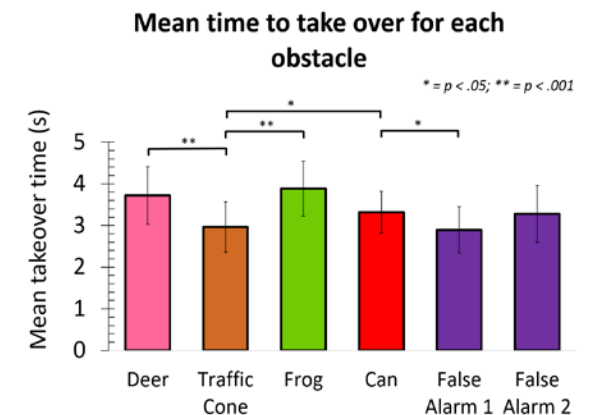
PHD 2 – HUMAN-VEHICLE INTERACTION FOR INTERVENTION

State-of-art
- Take-over is impacted by different factors
- There is **no perfect TOR** (**Take-over request**)
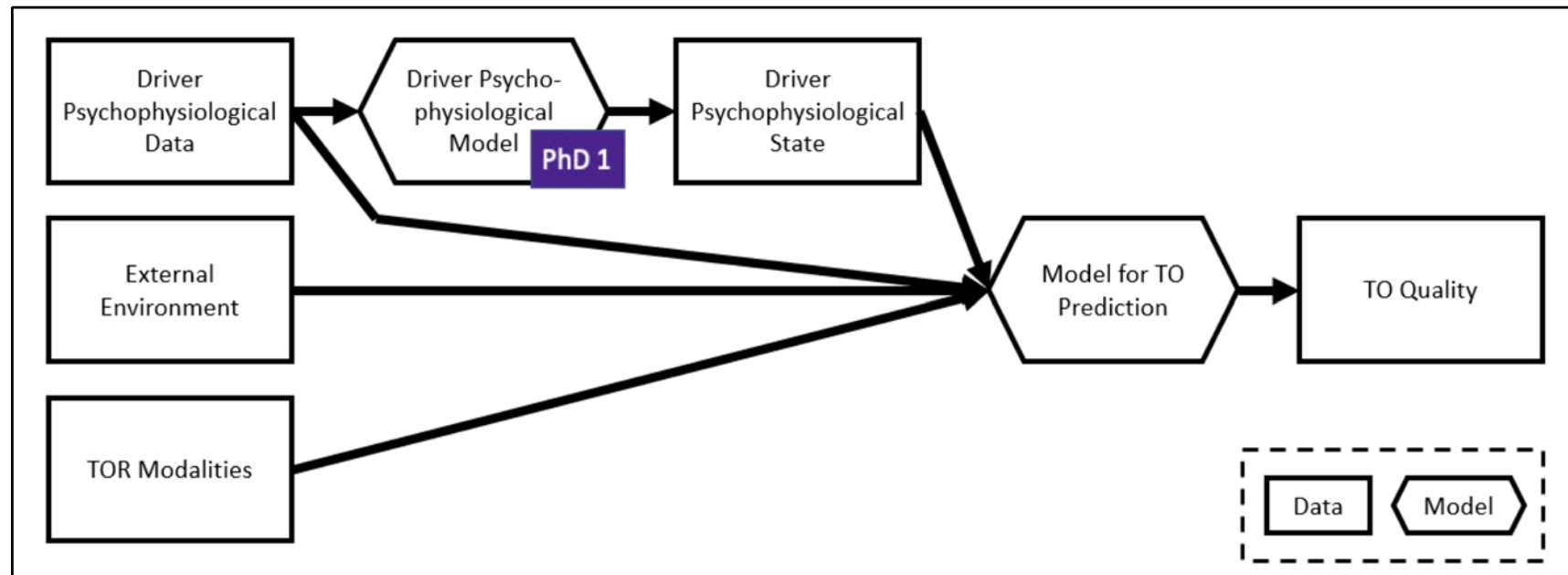
AI-based Agent for Intervention

- Design TOR on the fly

- Maximize the quality of take-over

  - Reaction time, max steering wheel angle, time-to-collision

TOR (t_0) · Driver brake or use steering wheel (t_1) · Car stopped (t_2)

Haute école d'ingénierie et d'architecture Fribourg
Hochschule für Technik und Architektur Freiburg
UNI FR
UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG
EPFL+ECAL LAB
haute école neuchâtel berne jura arc ingénierie www.he-arc.ch
HASLERSTIFTUNG

PHD 2 – HUMAN-VEHICLE INTERACTION FOR INTERVENTION
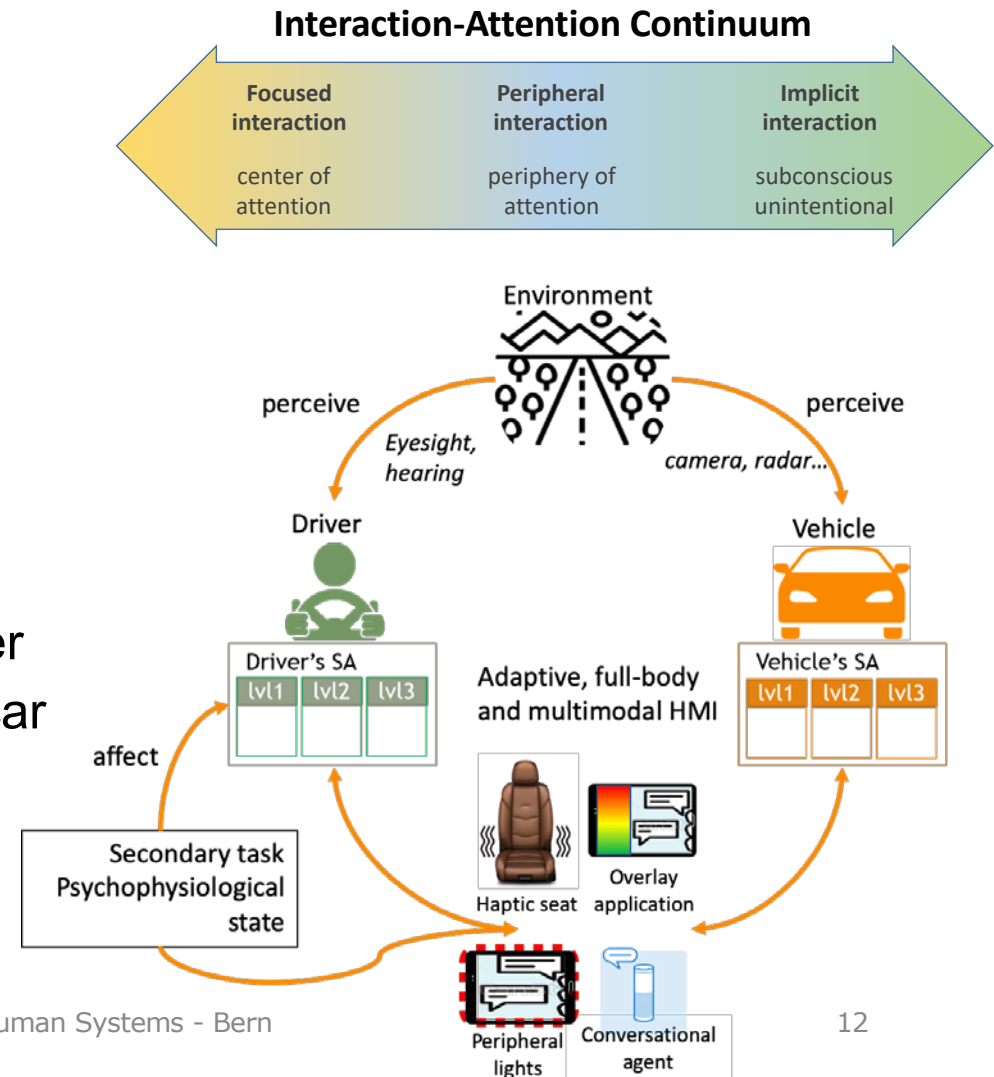
AI-based Agent for Intervention model

- Given a psychophysiological state of the driver (e.g. drowsiness)
- and a given environment (e.g. foggy weather and music playing)
- evaluate the best TOR modalities (e.g. haptic seat with high vibration & stopping the music with a message)

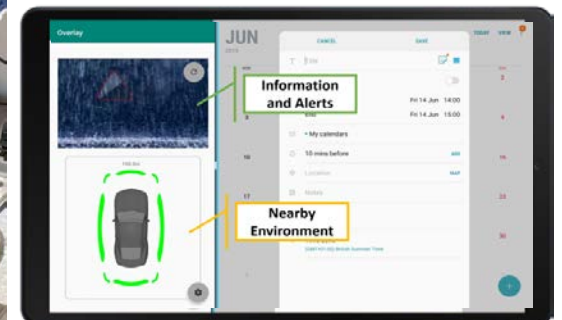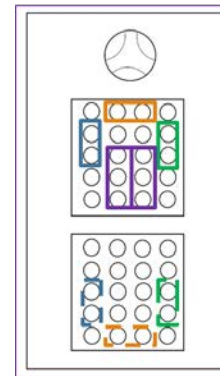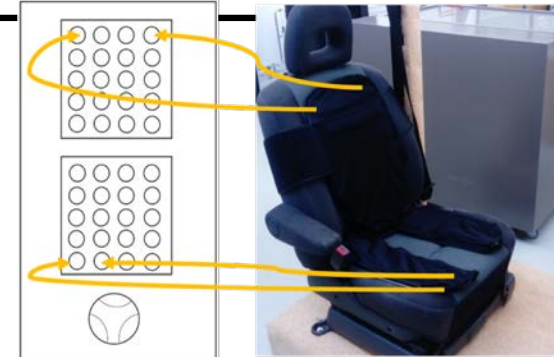## Multimodal Interaction Model for Supervision

- Support interaction that can happen at different levels of attention

- Human-Vehicle dialog
  - Driver and Vehicle SA
  - Adapt interaction to the driver
  - Explain the behavior of the car

Interaction-Attention Continuum

Focused interaction	Peripheral interaction	Implicit interaction
center of attention	periphery of attention	subconscious unintentional

HAUTE ÉCOLE D'INGÉNIERIE ET D'ARCHITECTURE FRIBOURG
Hochschule für Technik und Architektur Freiburg
UNI FR
UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG
EPFL+ECAL LAB
haute école neuchâtel berne jura arc ingénierie www.he-arc.ch
HASLERSTIFTUNG

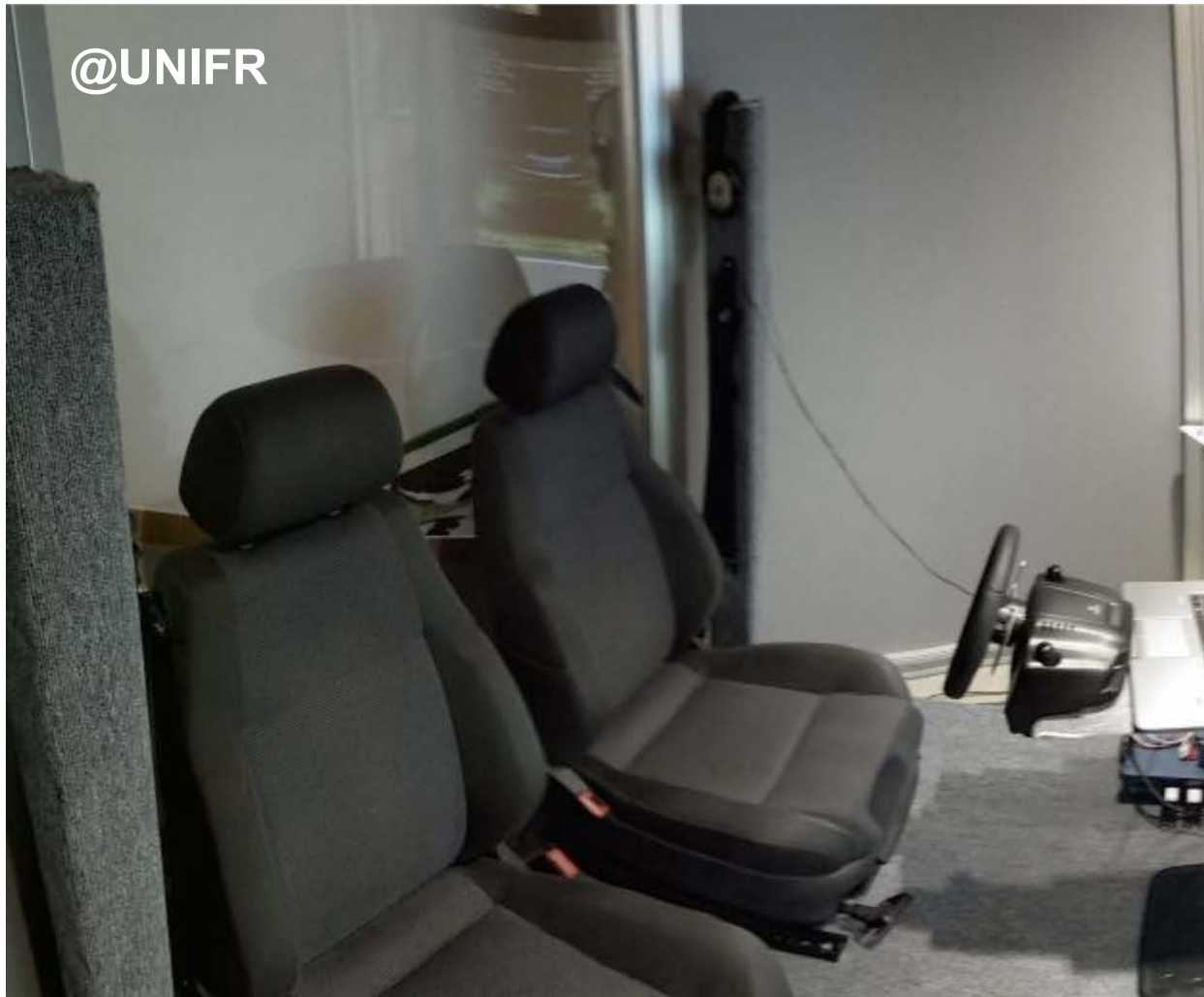# PHD 3 - HUMAN-VEHICLE INT. MODEL FOR SUPERVISION

Interaction modalities

- **Haptic seat**
  - bHaptics, 40 engines
  - Successful preliminary tests
  - Communicate obstacle presence around the vehicle

- **Personal mobile device**
  - **Light** peripheral interaction
    - Strip LED around the tablet
  - **Overlay application**
    - Information and alerts
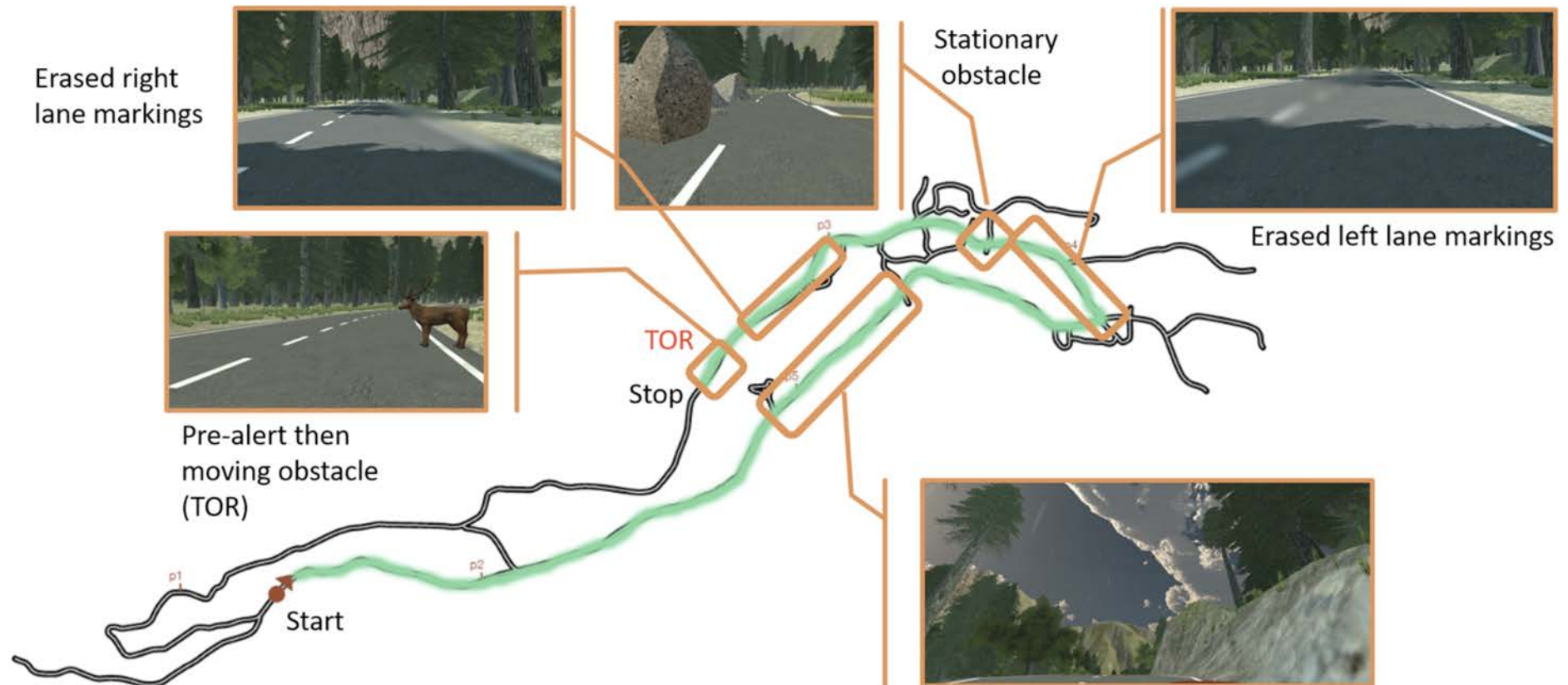   - Nearby environment

- **Conversational agent**

Haute école d'ingénierie et d'architecture Fribourg
Hochschule für Technik und Architektur Freiburg

UNI FR

UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG

EPFL+ECAL LAB

haute école
neuchâtel berne jura
arc ingénierie
www.he-arc.ch

HASLERSTIFTUNG

SIMULATOR AND TEST ENVIRONMENT

@UNIFR

@HEIA-FR

EVALUATION FRAMEWORK

- Define a set of driving scenarios with different levels of difficulty with respect to supervision and intervention tasks.
- Used to compare and assess the effectiveness of different interface solutions, alert messages as well as of the developed psychophysiological model

Erased right lane markings

Stationary obstacle

Erased left lane markings

Pre-alert then moving obstacle (TOR)

TOR

Stop

Start

Sloping road + Rain

DISSEMINATION ACTIVITIES - I

Project website
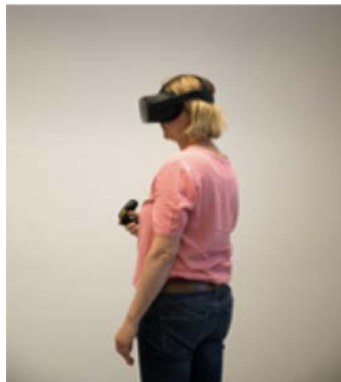
DISSEMINATION ACTIVITIES - II

Scientific publications

- Q. Meteier, M. Capallera, L. Angelini, E. Mugellini, O. Abou Khaled, S. Carrino, E. De Salis, S. Galland, S. Boll, "***Workshop on explainable AI in automated driving: a user-centered interaction approach***", AutomotiveUI '19, Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications: Adjunct Proceedings, Utrecht, Netherlands, September 22-25, 2019.

- M.Capallera, Q. Meteier, E. de Salis, L. Angelini, S. Carrino, O. Abou Khaled, E. Mugellini, "***Owner Manuals Review and Taxonomy of ADAS Limitations in Partially Automated Vehicles***", Full Paper in Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, Utrecht, Netherlands, September 22-25, 2019.

- M.Capallera, Q. Meteier, E. de Salis, L. Angelini, S. Carrino, O. Abou Khaled, E. Mugellini, "***Secondary task and situation awareness, a mobile application for conditionally automated vehicles***", Work in Progress in Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, Utrecht, Netherlands, September 22-25, 2019.

- M.Capallera, P. Barbé-Labarthe, L. Angelini, O. Abou Khaled, E. Mugellini, "***Convey situation awareness in conditionally automated driving with a haptic seat***", Work in Progress in Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, Utrecht, Netherlands, September 22-25, 2019.

- E. de Salis, D.Y. Baumgartner, S. Carrino, "***Can we predict driver distraction without driver psychophysiological state?: a feasibility study on noninvasive distraction detection in manual driving***", Work in Progress in Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, Utrecht, Netherlands, September 22-25, 2019.

- M. Capallera, Q. Meteier, E. de Salis, L. Angelini, O. Abou Khaled, E. Mugellini, "***Tâche secondaire et conscience de l'environnement, une application mobile pour véhicule semi-autonome***", accepted at IHM 2019

- M.Capallera, P. Barbé-Labarthe, L. Angelini, O. Abou Khaled, E. Mugellini, "***Conserver la conscience de l'environnement en conduite semi-autonome grâce à un siège haptique***", work in progress accepted at IHM 2019

- Q. Meteier, "***The influence of a passenger and meditation before driving on driving behaviour and emotions – a simulator study***" abstract presented at Europe Chapter - Human Factors and Ergonomics Society, Berlin, Germany, October 8-10, 2018.

DISSEMINATION ACTIVITIES - III

Organization of scientific workshop

- ***Explainable AI in Automated Driving : a User-Centered Interaction Approach***, AutomotiveUI'19 Conference
    - https://sites.google.com/view/explainableai-autoui19/
    - https://www.auto-ui.org/19/

DISSEMINATION ACTIVITIES - IV

Involving the students

- UNIFR **seminar on "Explainable AI - Human-Computer** Interaction meets Artificial Intelligence", spring semester 2020

- **Student challenge on psychophysiological dataset** in the Master Course MPRI – HES-SO

- Bachelor, master and internship students involved in the project

CONCLUSION & NEXT STEPS

- Psychophysiological driver model
  - Improve the Attention recognition (low, medium, high)
  - Manipulate driver SA to collect data to train de model

- AI-based agent for Intervention
  - Collect data and train the model

- Multimodal interaction model for supervision
  - Improve current monomodal prototypes
  - Combine modalities and evaluate them

- Evaluation framework
  - Urban environment

Haute école d'ingénierie et d'architecture Fribourg
Hochschule für Technik und Architektur Freiburg

UNI FR
UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG

EPFL+ECAL LAB

haute école
neuchâtel berne jura
arc ingénierie
www.he-arc.ch

HASLERSTIFTUNG

AD VITAM TEAM

Prof. Dr. Elena Mugellini

Marine Capallera

Emmanuel De Salis

Quentin Meteier

Prof. Dr. Stefano Carrino

Dr. Andreas Sonderegger

Dr. Leonardo Angelini

Prof. Dr. Jean Pierre Bresciani

Haute école d'ingénierie et d'architecture Fribourg
Hochschule für Technik und Architektur Freiburg

UNI FR
UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG

EPFL+ECAL LAB

haute école arc ingénierie
neuchâtel berne jura www.he-arc.ch

HASLERSTIFTUNG

THANK YOU FOR YOUR ATTENTION!