AD VITAM

ADAPTIVE DRIVER-VEHICLE INTEGRATION 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
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

Focus of the Ad Vitam Shared Control Model

Human Abilities

- Resolving novel situations
- Making ethical decisions

Car Abilities

- Sensing in poor visibility
- Maintaining vigilance

Level 0
No automation
The driver is in complete and sole control all the time

Level 1
Function specific automation
The driver can better perform most functions

Level 2
Function specific automation
The driver is relieved of some primary driving functions

Level 3
Limited self-driving automation
The driver must supervise and be available to take over control

Level 4
Fully automation
The driver is not expected to take control at any time
AD VITAM OBJECTIVES

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

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

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

Interaction-Attention Continuum

<table>
<thead>
<tr>
<th>Focused interaction</th>
<th>Peripheral interaction</th>
<th>Implicit interaction</th>
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</thead>
<tbody>
<tr>
<td>center of attention</td>
<td>periphery of attention</td>
<td>subconscious unintentional</td>
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GLOBAL OVERVIEW OF THE 3 PHD THESSES
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

![Attention Recognition Chart](chart.png)

**Average scores with BPM/IBI features**

![Ratings of Situation Awareness (SA) after the experiment](ratings.png)

**Ratings of Situation Awareness (SA) after the experiment**

![Mean time to take over for each obstacle](mean_time.png)

**Mean time to take over for each obstacle**

* $p < .001$  
** $p < .01$
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
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).
**PhD 3 - Human-Vehicle Int. Model for Supervision**

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
**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**
SIMULATOR AND TEST ENVIRONMENT
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.
AdVitam

Adaptive Driver-Vehicle InTerAction to Make future driving safer
DISSEMINATION ACTIVITIES - I

Project website

Home

Welcome to AdVitam Project Website

Overview

AdVitam stands for Adaptive Driver-Vehicle InTerAction to Make future driving safer. It is a 3 years (2018-2021) research project co-funded by Hasler Foundation.

AdVitam explores how human-vehicle interface (HVI) can be designed at different level of attention in shared control driving to keep the driver at the optimum cognitive load and to fully support the potential of semi-automated driving.

The project aims at contributing to the vision of a car as a companion where the driver and the car work collaboratively and interactively as team-members to control the vehicle.

This project involves three PhD students. The first one works on multi-sensory experiences considering the entire car interior in order to support driver supervision tasks and increase situational awareness. The second one investigates how to use different modalities and combine them to improve the intervention of the driver during take-over requests. The third one studies how we can use several psychophysiological signals in order to assess the driver state in real-time.

The work of the three students will outcome in a novel collaborative interaction model between the driver and the vehicle in shared-control driving.

23.10.2019

Workshop Cyber Human Systems - Bern
DISSEMINATION ACTIVITIES - II

Scientific publications


- 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

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://sites.google.com/view/explainableai-autoui19/)
  
  • [https://www.auto-ui.org/19/](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 the 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
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
THANK YOU FOR YOUR ATTENTION!