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Multimodal Driving Simulator

1. Multimodal Driving Simulator

Coordinators:
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Abstract:
Based on a first workshop at eNTERFACE 2005 focusing on an augmented driving simulator, this project aims at designing and developing a multimodal driving simulator that is based on both multimodal driver's focus of attention detection and driver's state detection (i.e., stress and fatigue) as well as multimodal interaction for enhancing a driver's task. Capturing and interpreting the driver's focus of attention and state will be based on video data (e.g., facial expression, head movement, eye tracking) as well as physiological signals (e.g., ECG, Electrocardiogram and GSR, Galvanic Skin Response). For multimodal interaction, we will focus on multimodal presentation of alert messages (output of the system) as well as multimodal ways for confirming an alert (input of the system) based on text and graphics displayed in the windshield and on mini-screens, on speech, on alerting tones and on a force-feedback wheel.

2. Project Objective

The project aims to combine multimodal signal processing analysis and multimodal interaction for supporting a driving task. Facing the sophisticated sensing technology available in modern cars, multimodal interaction in cars defines a very challenging domain. The key issue in terms of interaction design is that the main task of the user is the driving one, a critical task which requiring a driver to keep her/his eyes on the road. Indeed a driving task relies on local guidance that includes sub-tasks involving control of the vehicle and knowledge of the environmental situation. In this context of a driving task, our goals are:

- to capture a driver's focus of attention and state using various sensors (also called attentive user interface),
- to detect dangerous situations (fatigue, stress, hypo-vigilance),
- to provide an efficient user interface for presenting and confirming alarms.

3. Background information

Several projects focus on User Interfaces (UI) in cars and involve various interaction technologies such as trackpad fixed on the steering wheel, dedicated buttons, mini-screens as well as head-up display (HUD) technology. For example HUDs are used for displaying icons and texts, usually found on the dashboard of a car, in the windshield. We distinguish two main classes of UI studies in cars: design of interactive dashboards that nowadays include a screen (e.g., graphical user interface for controlling the radio and so on) and Augmented Reality (AR) visualizations. Several on-going projects focus on Augmented Reality (AR) visualizations for the driver using head-up display (HUD) technology. For example for displaying navigation information or for guiding the driver's attention to dangerous situations, transparent graphics (e.g., transparent path of the route) are directly projected onto the windshield, making it possible for the driver to never take her/his eyes off the road.

Complementary to these projects, our task focuses on supporting the driving activity by monitoring and predicting the state of the driver. Instead of focusing on external dangers (e.g. a potential collision with a car coming from behind), the project aims at detecting dangerous situations due to the driver's state and focus of attention. From the Human-Computer Interaction point of view, the project focuses on multimodal input and output interaction that combines passive modalities (implicit actions of the driver) for detecting dangerous situations and active modalities (explicit actions of the driver) for perceiving and confirming alarms.

4. Detailed technical description

-a- Technical description

We expect to significantly contribute to the three following technical points:

1. Developing new algorithms for data acquisition, analysis, fusion , prediction and interpretation.
2. Developing interaction modalities and multimodal interfaces for presenting and confirming alarms.
3. Developing a flexible platform that will enable us to quickly test various design solutions in terms of passive and active modalities embedded in the driving simulator.

The project is therefore particularly challenging and ambitious but relies on existing building blocks:

- software developed during eNTERFACE 2005 (available online at www.enterface.net),
- "off the shelf" interaction modalities such as a speech recognizer,
- the integrating platform OpenInterface that contains software components that can be graphically assembled to develop several design options,
- existing fusion OpenInterface components.

We identify three types of activities for developing the multimodal driving simulator:

- Developing new OpenInterface components from scratch
- Developing new OpenInterface components from existing codes
- Assembling components for designing several design solutions that will be experimentally tested.

These types of activities will be dedicated to different parts of the user interface including:

- Sensing modalities (passive modalities)
- Interaction modalities (active modalities)
- Fusion of modalities
- Interpretation mechanisms

-b- Resources needed

Equipment

- One fast computer per participant with IEEE 1394 interface and 3D video card with OpenGL Linux driver
- A set of captors and effectors including webcams for video acquisition and IEEE1394 digital cameras, a mini-screen, a microphone for speech acquisition, heartbeat captor, EEG captor, force-feedback steering wheel, a video-projector for large display of the driving simulator. Part of the required devices could be provided by the INPG_LIS Lab.
- One fast computer with all the captors and sensors connected to it will be dedicated to the multimodal driving simulator.

Software

- Linux and Windows OS
- OpenInterface platform

- OpenInterface components for fusion (multimodal interaction)
- Driving simulator TORCS : torcs.sourceforge.net
- Software developed during the eNTERFACE 2005 workshop www.enterface.net
- Speech recognizer

Staff

- Experienced researcher(s) in signal processing analysis
- Experienced researcher(s) in multimodal interaction
- One experienced engineer, expert on software engineering and the component-based OpenInterface platform

-c- Project management

17-26 July 2006: Alice Caplier
26 July - 3 August 2006: Laurent Bonnaud
3-11 August 2006: Laurence Nigay

This could be modified if Dimitrios Tzoradas confirm his participation.

5. Work plan

1st week:

The first week is dedicated to

- discussion, to learn about each others' expertise
- set up the computers
- understand the provided software building blocks and in particular the OpenInterface platform
- explore the design space for the multimodal driving simulator
- design solutions to be developed
- design the overall software architecture and the components
- disseminate the work based on the designed software architecture
- develop and integrate planning

At the end of the first week:
Design solutions
Software architecture
Development and integration planning

2nd week:

During the second week, each participant will work on independent tasks, developing components for:

- Sensing modalities
- Interaction modalities
- Fusion of modalities
- Interpretation mechanisms

At the end of the second week:
Software components for a multimodal driving simulator

3rd week:

The third week will focus on software integration (incremental integration between components as well as integration of the multimodal interface with the driving simulator functional core). The components will be integrated and tested within the OpenInterface platform. A graphical assemblage of the defined components will lead to a first multimodal driving simulator.

At the end of the third week:
A first multimodal driving simulator developed by assembling OpenInterface components

4th week:
The fourth week will be dedicated to final integration of components within the OpenInterface platform and the design by assembling components of several multimodal solutions. Controlled usability tests will be done on the design of multimodal solutions.
Moreover, during this week, a report describing the results and future work to be done will be written and a presentation along with a demonstration will be prepared for the general assembly.

At the end of the fourth week:
Final design solutions for the multimodal driving simulator
Report on results and future work
Demonstration
Presentation

6. Benefits of the research: expected outcomes of the project

We identify three major research benefits of this project

- Research targeting a concrete application: several design solutions for a multimodal driving simulator and better understanding of multimodal interaction in cars.
- A set of reusable OpenInterface components that will populate the OpenInterface platform.
- A truly interdisciplinary experience combining signal processing and user interface studies.

7. Profile of team

-a- Leaders

Laurent Bonnaud was born in 1970. He graduated from the École Centrale de Paris (ECP) in 1993. He obtained his PhD from IRISA and the Université de Rennes-1 in 1998. Since 1999 he is teaching at the Université Pierre-Mendès-France (UPMF) in Grenoble and is a permanent researcher at the Laboratoire des Images et des Signaux (LIS) in Grenoble.
His research interests include segmentation and tracking, human motion and gestures analysis and interpretation.

Alice CAPLIER was born in 1968. She graduated from the École Nationale Supérieure des Ingénieurs Électriciens de Grenoble (ENSIEG) of the Institut National Polytechnique de Grenoble (INPG), France, in 1991. She obtained her Master's degree in Signal, Image, Speech Processing and Telecommunications from the INPG in 1992 and her PhD from the INPG in 1995. Since 1997, she is teaching at the École Nationale Supérieure d'Électronique et de Radioélectricité de Grenoble (ENSERG) of the INPG and is a permanent researcher at the Laboratoire des Images et des Signaux (LIS) in Grenoble. Her main interest concerns the analysis and the interpretation of human motion. She works in the domain of facial expressions classification, human postures recognition, Cued Speech language classification and head rigid or non rigid motion analysis.

Laurence Nigay (PhD in Computer Science) is a Professor at Université Joseph Fourier (UJF, Grenoble 1) and at Institut Universitaire de France (IUF). She has been a member of the Engineering for Human-Computer Interaction group of the CLIPS-IMAG (Communication Langagière & Interaction Personne Système) laboratory since 1994. Her research interests focus on the design and development of user interfaces. In particular her research studies centre on Multimodal and Augmented Reality (AR) user interfaces such as the component-based approach named ICARE (Interaction Complementarity, Assignment, Redundancy and Equivalence) for the development of multimodal and AR interfaces and new interaction modalities combining the real and the physical worlds such as tangible user interfaces, embodied user interface and mobile augmented reality.
She has published more than 100 articles in conferences, journals and books. Laurence Nigay has received several scientific awards (including the CNRS Bronze medal in 2002 and the UJF gold medal in 2003 and again in 2005) for excellence in her research and is involved in many international scientific societies and events, as well as European research projects.

Dimitrios Tzoradas (to be confirmed)

-b- Staff proposed by the leaders

- **Alexandre Benoit** is a PhD student at the LIS laboratory in Grenoble working on head motion analysis.
- **Marcos Serrano** is a research engineer and a master student at the CLIPS-IMAG laboratory in Grenoble, specialist of component-based approach for multimodal interaction.
- **Lionel Lawson** is a research engineer responsible of the development of the OpenInterface component-based platform.

-c- Other researchers needed

Researchers in the following domains would be very useful for the project:

- Signal processing/analysis and in particular physiological signal processing/analysis
- Human-Computer Interaction and in particular multimodal interaction
- An expert in controlled usability test

- An expert in prediction of human fatigue (modeling human fatigue and predicting fatigue)

8. Reference materials

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- Similar OpenInterface Deliverables www.similar.cc
  D58 Architecture of the OpenInterface platform.
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