Environnements virtuels et modèles de décision pour l'interaction

Journée GT RV-IA / 09-03-2022

Marc Macé, ***marc.mace@irisa.fr***

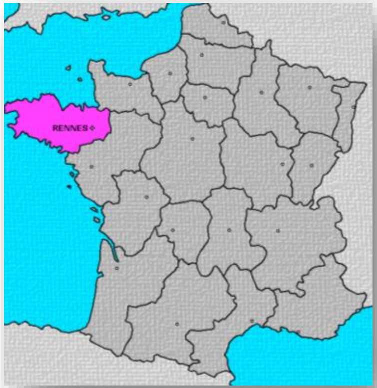
Hybrid team

IRISA-INRIA, Rennes, France

N=40

Founded in 90's

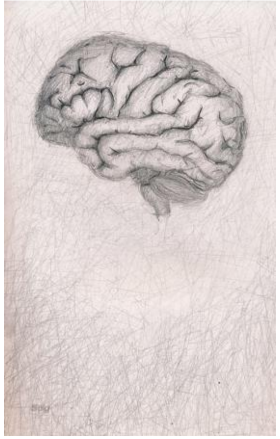
Topic : ***Virtual Reality***



Hybrid team project

Research topic:

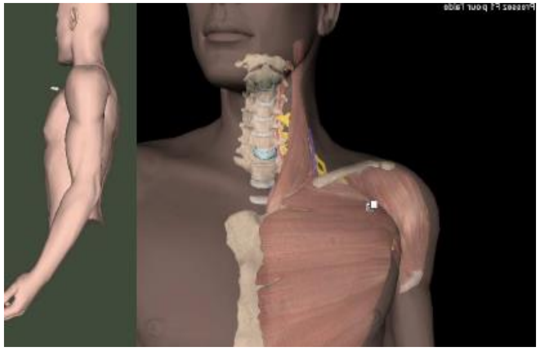
3D Interaction with Virtual Environments Using Body and Brain Inputs



Objectives:

- ✓ Improve Immersion (*presence*)
- ✓ Improve Interaction (*performance*)

Applications : Medicine, Industry, Construction, Cultural Heritage, Entertainment, Arts..



BCI approach @Hybrid

General objective :

Study Human-Computer Interaction based on BCI&VR

Research axes :

1. Studying Neuromarkers using VR paradigms
2. Characterizing the BCI user experience
3. Designing BCI-based interaction techniques in VR
4. Developing new immersive systems : medicine, sport, entertainment…

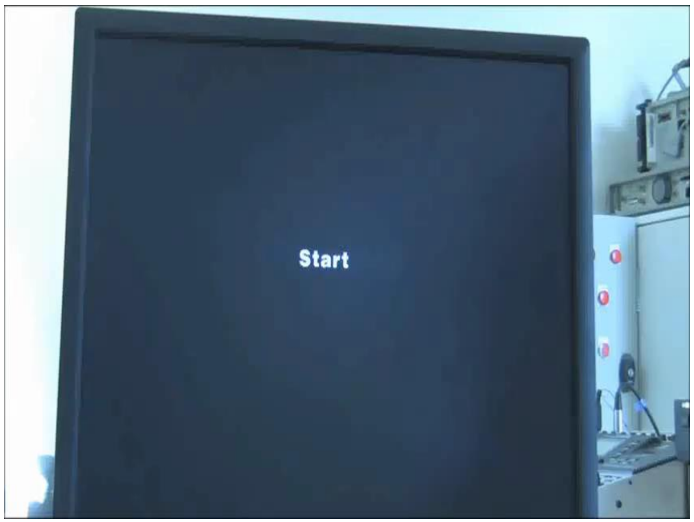
Approach :

- ✓ Combination of complex technologies : EEG/fMRI, 3D displays, haptics, gaze-tracking, machine learning, etc
- ✓ Real-time and on-line experiments with participants

Salient projects

OpenViBE Project

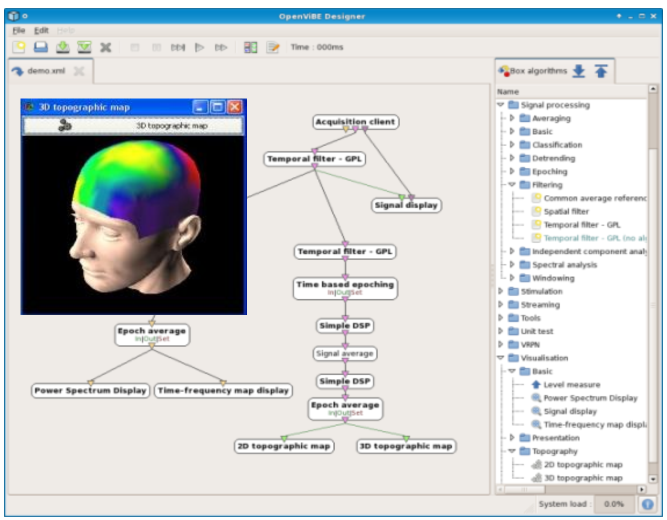
Handicap



OpenViBE software

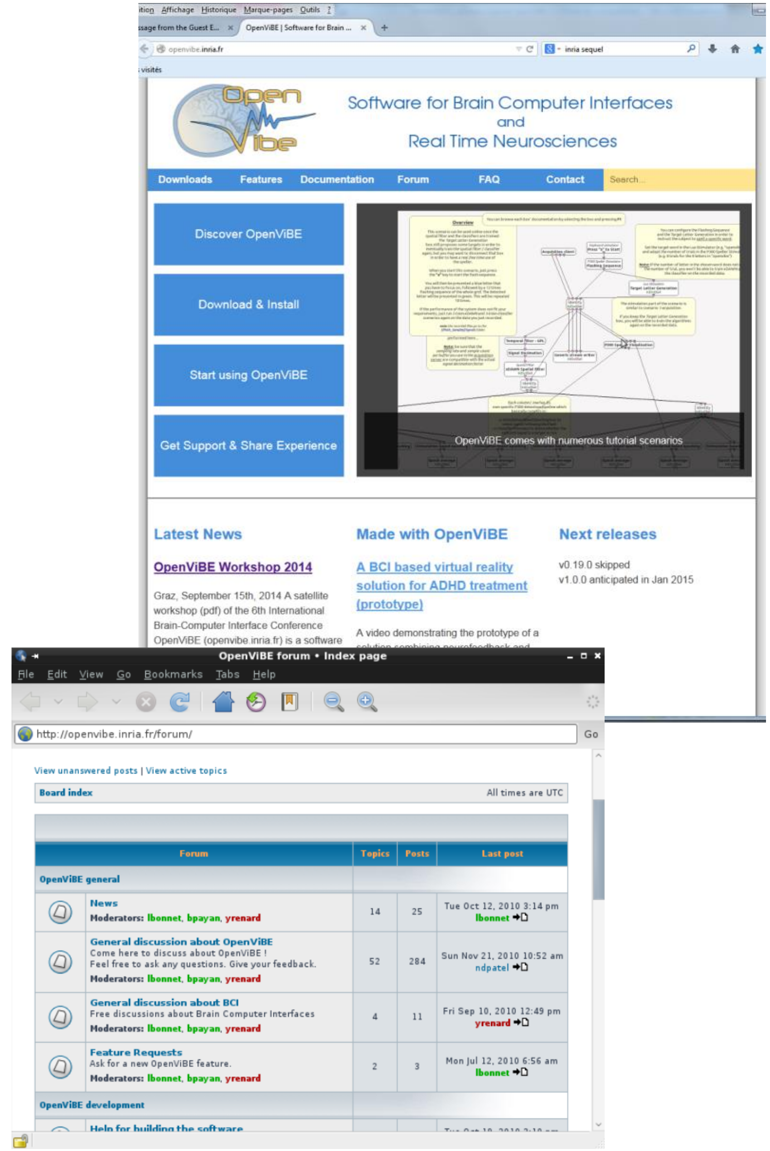
http://openvibe.inria.fr

Download OpenViBE Installer
for Windows 64bit

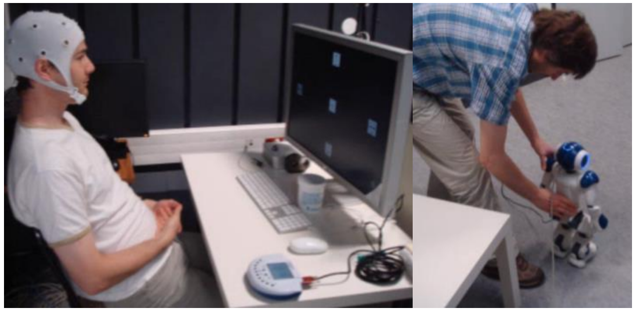


OpenViBE key figures

- Releases : ~30, version 3.2 (Oct. 2021)
- Website : ~170.000 page views / year
- Downloads : ~6.000 downloads/year
  ~ 90k total (since 2009)
- Forum members : ~1.000 users
- Forum posts : ~6.500 posts
- Citations : ~600+ citations
  (OpenViBE paper, google scholar)
- Manpower : ~40 year.men
- Code : ~300k lines (C++)

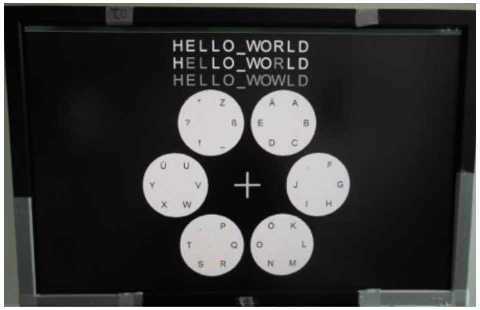


made with OpenViBE

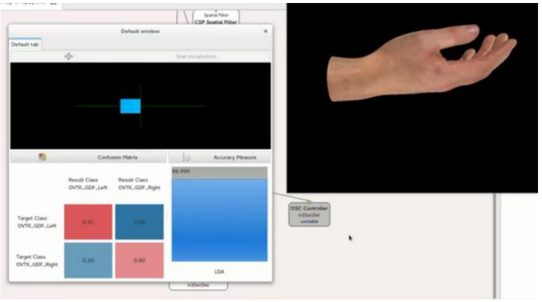


GIPSA - NAO robot control

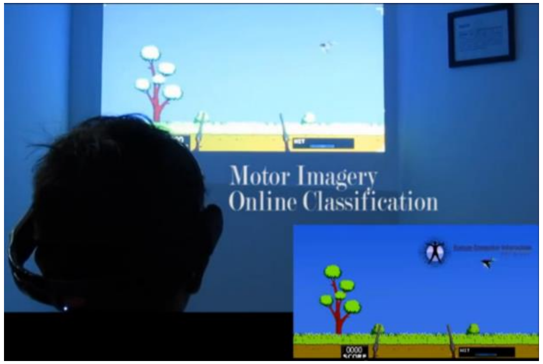
Thymio - Robotics



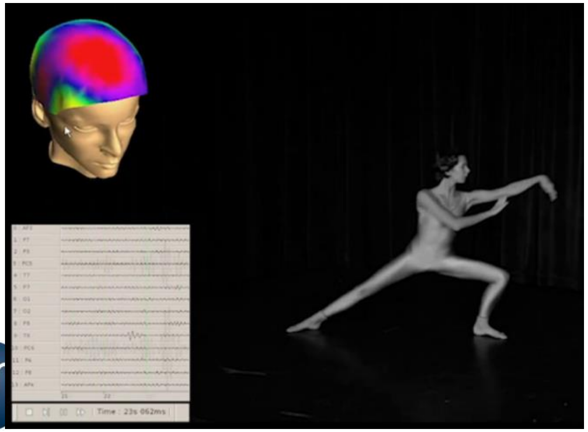
Pieter Jan Kindermans, Ghent University, Unsupervised P300



Ozan Caglayan, Galatasaray University, virtual hand feedback control



Universidad Tecnológica de Pereira, Colombia, BCI Duck Hunt game



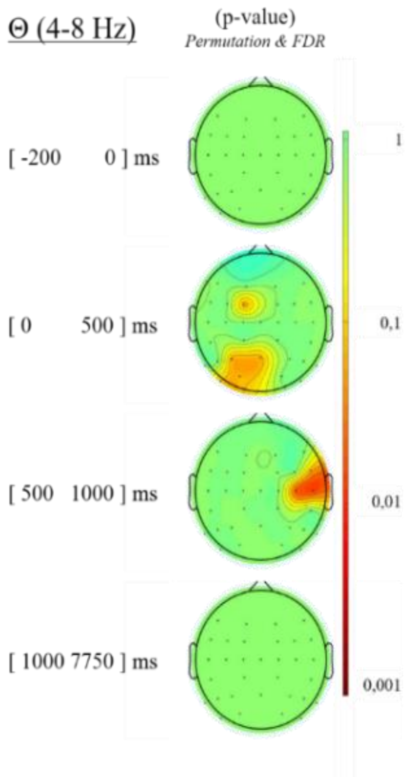
µARTs@Work - Sofia´s Brain Waves Genesis

Nicoletta Caramia, University of Pavia, Motor control studies

John Paul II Catholic University of Lublin, Psycho-Neuro-Physiological Lab - Motor imagery

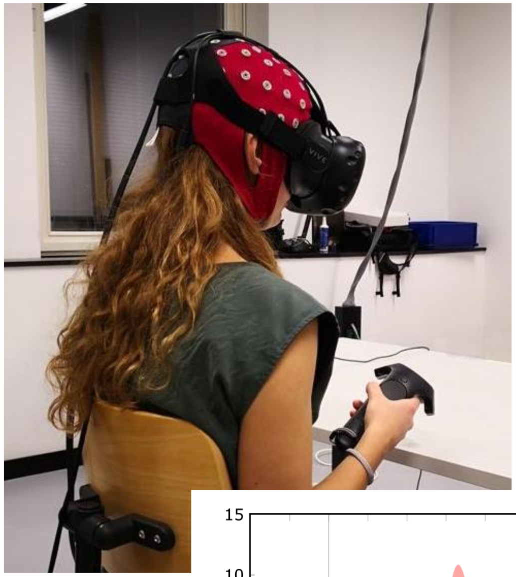
Illustrative results

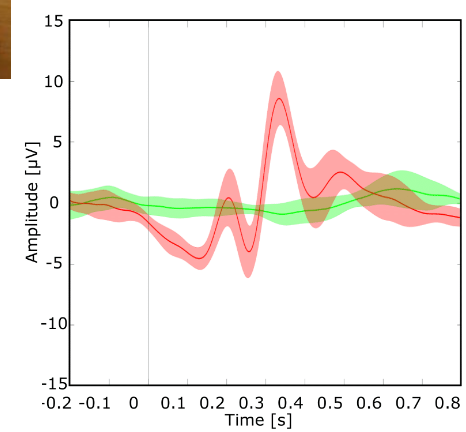
Characterizing Neuromarkers in VR: Neuromarkers of Virtual Embodiment & Agency



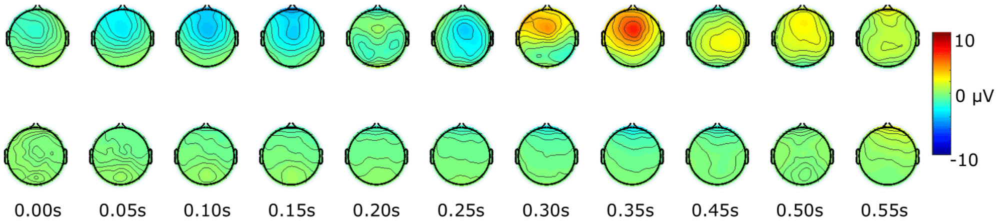
C. Jeunet, L. Albert, F. Argelaguet, A. Lécuyer, *"'Do you feel in control?': Towards Novel Approaches to Characterise, Manipulate and Measure the Sense of Agency in Virtual Environments"*, IEEE Transactions in Visualization and Computer Graphics, vol 24, issue 4, pp. 1486-1495, 2018

Characterizing Neuromarkers in VR: Detection of Error Potentials





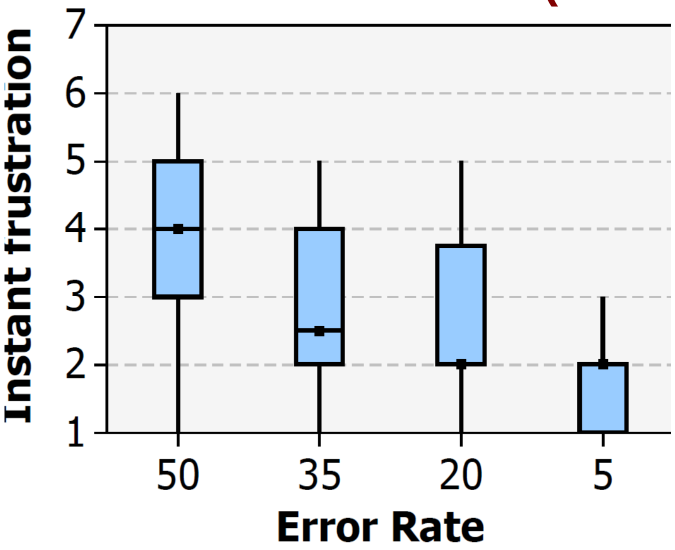
H. Si-Mohammed et al., « *Detecting System Errors in Virtual Reality Using EEG Through Error-Related Potentials* », IEEE Virtual Reality 2020, *(Best paper award)*



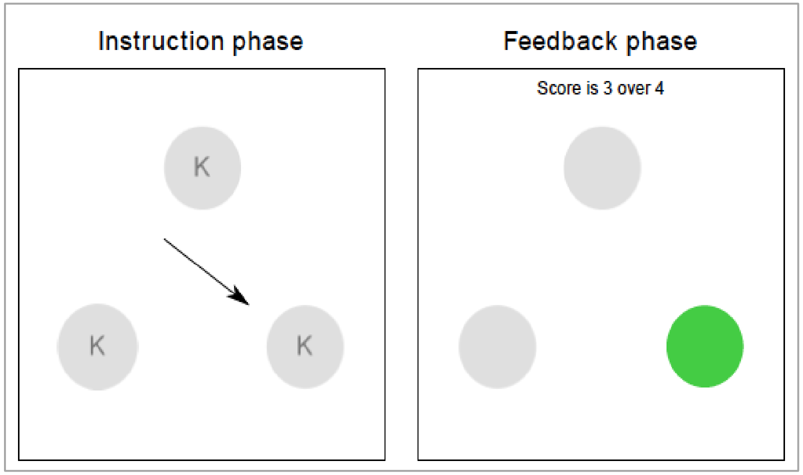
BCI User Experience

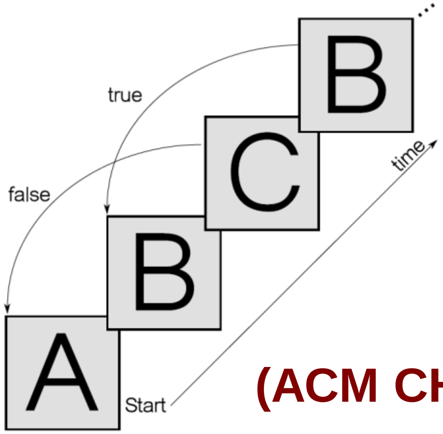
>> frustration ?

(AVI 2016)



>> cognitive load ?





(ACM CHI 2017)

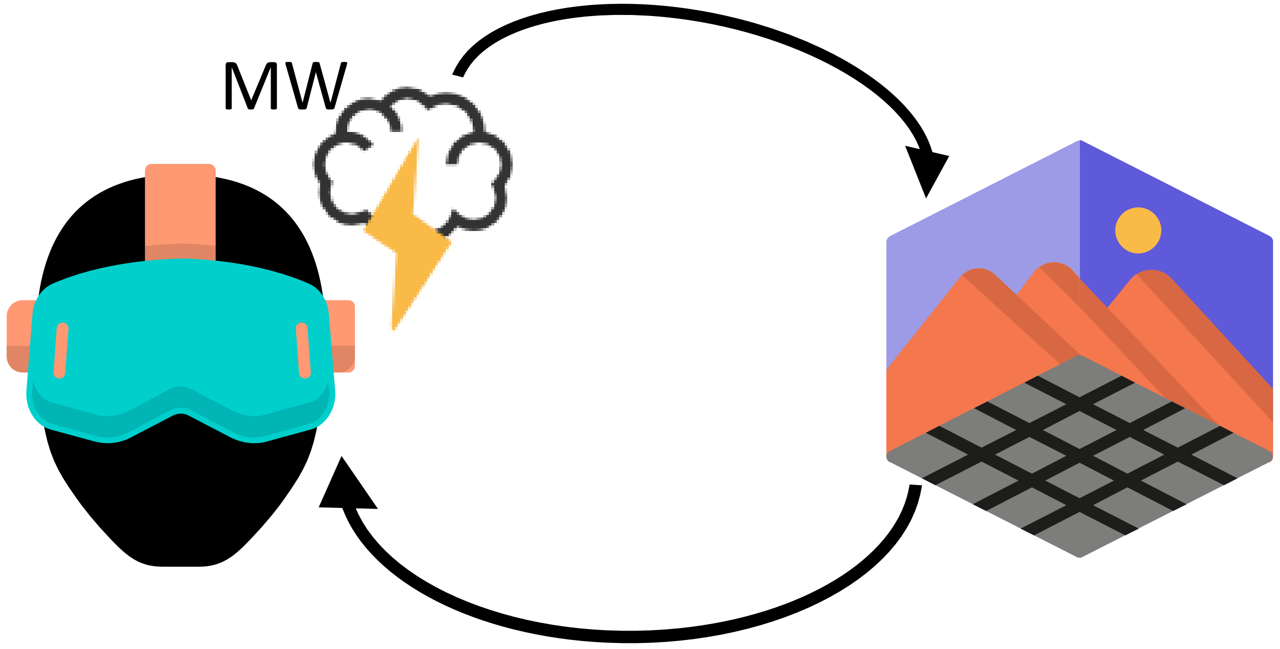
TOWARDS THE EXPLOITATION OF MENTAL WORKLOAD IN VIRTUAL REALITY SYSTEMS

Tiffany Luong

PhD Defense
February 10, 2021

PhD Advisors: Anatole Lécuyer, Guillaume Jégou, Ferran Argelaguet, Nicolas Martin

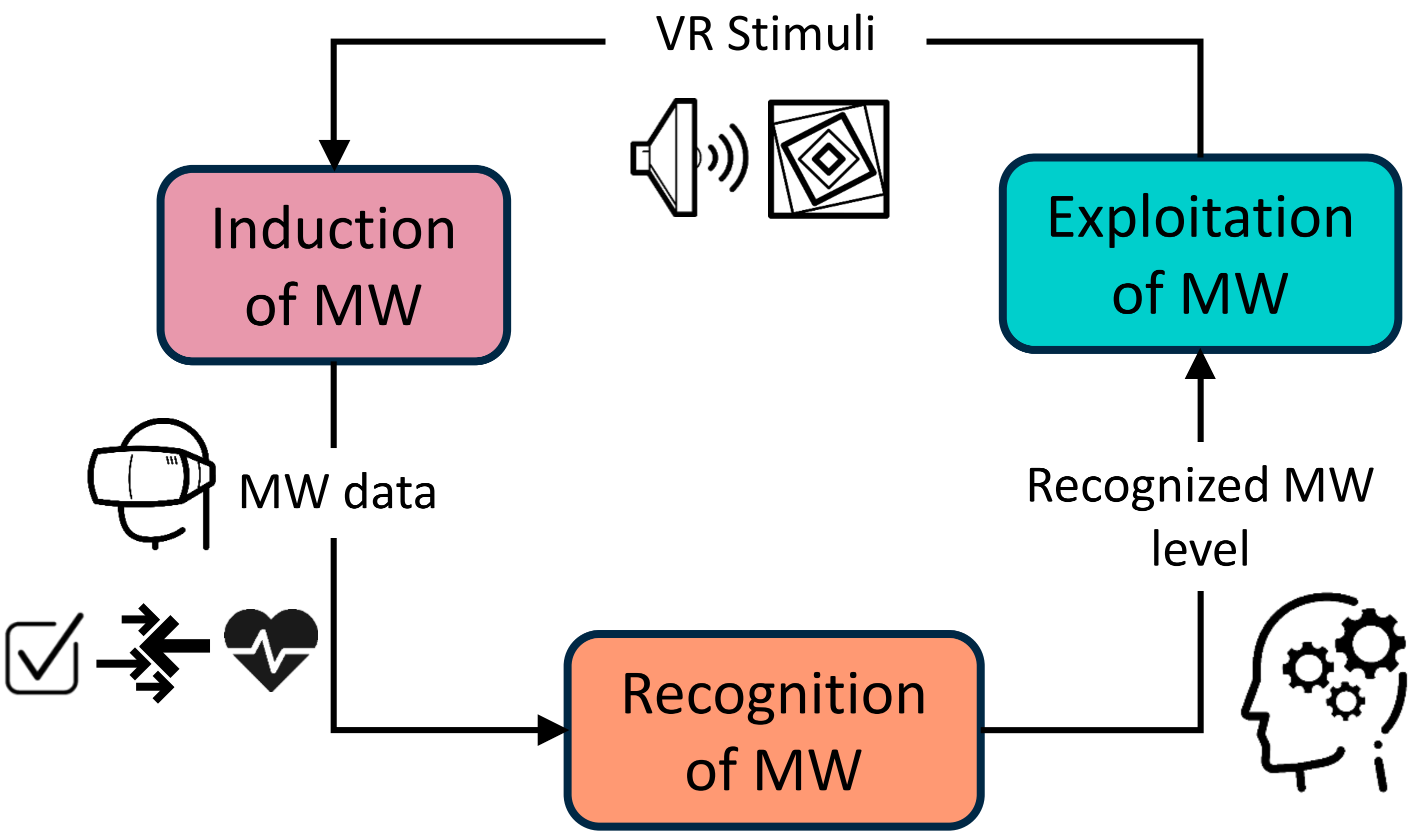
Objective



Objective: Towards the exploitation of Mental Workload (MW) measures in VR.

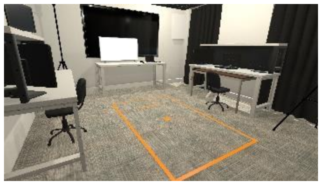
Research Axes

- **Objective:** Going towards the exploitation of MW measures in VR.



Objective: Towards the exploitation of MW measures in VR.

C1 Studying the Mental Effort in Virtual Versus in Real Environments

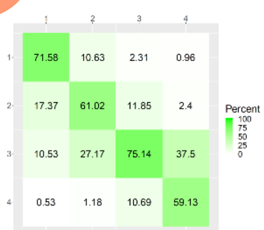


Wearing a VR HMD has a limited effect on Users’ Mental Efforts. Interactions and difference in representations should be controlled.

C2 Introducing MW Assessment in the Design of VR Training Scenarios

The methodology managed to induce the expected MW progression overtime.

C3 Towards Real-Time Recognition of Users’ MW Using Physio Sensors Integrated Into a VR HMD.



The solution we proposed allowed to recognize users’ MW in VR in real-time. We gave insight on the effect of different setups on MW recognition accuracy.

Related Work

Recognition of MW in VR

Self-report

- NASA-TLX [Hart and Staveland, 1988]
- SWAT [Reid and Nygren, 1988]
- ISA [Tattersall and Foord, 1996]
- RSME [Zijlstra, 1993]
- Etc.

Tasks performances

- Accuracy
- Response time
- Reaction time

[O'Donnell & Eggemeier, 1986]

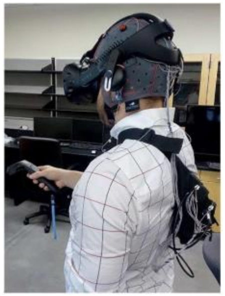
Observational measures

- Facial expression
- Body gesture
- Eye behaviour

[Coral, 2016]

Psychophysiological measures

EEG



[Tremmel et al., 2019]

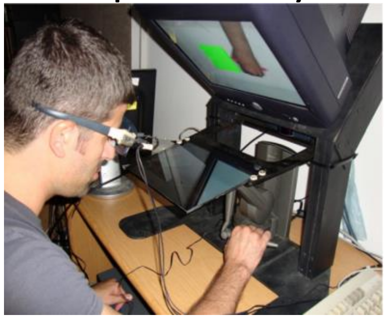
fNIRS

[Putze et al., 2019]

EDA & Heart rate

[Collins et al., 2019]

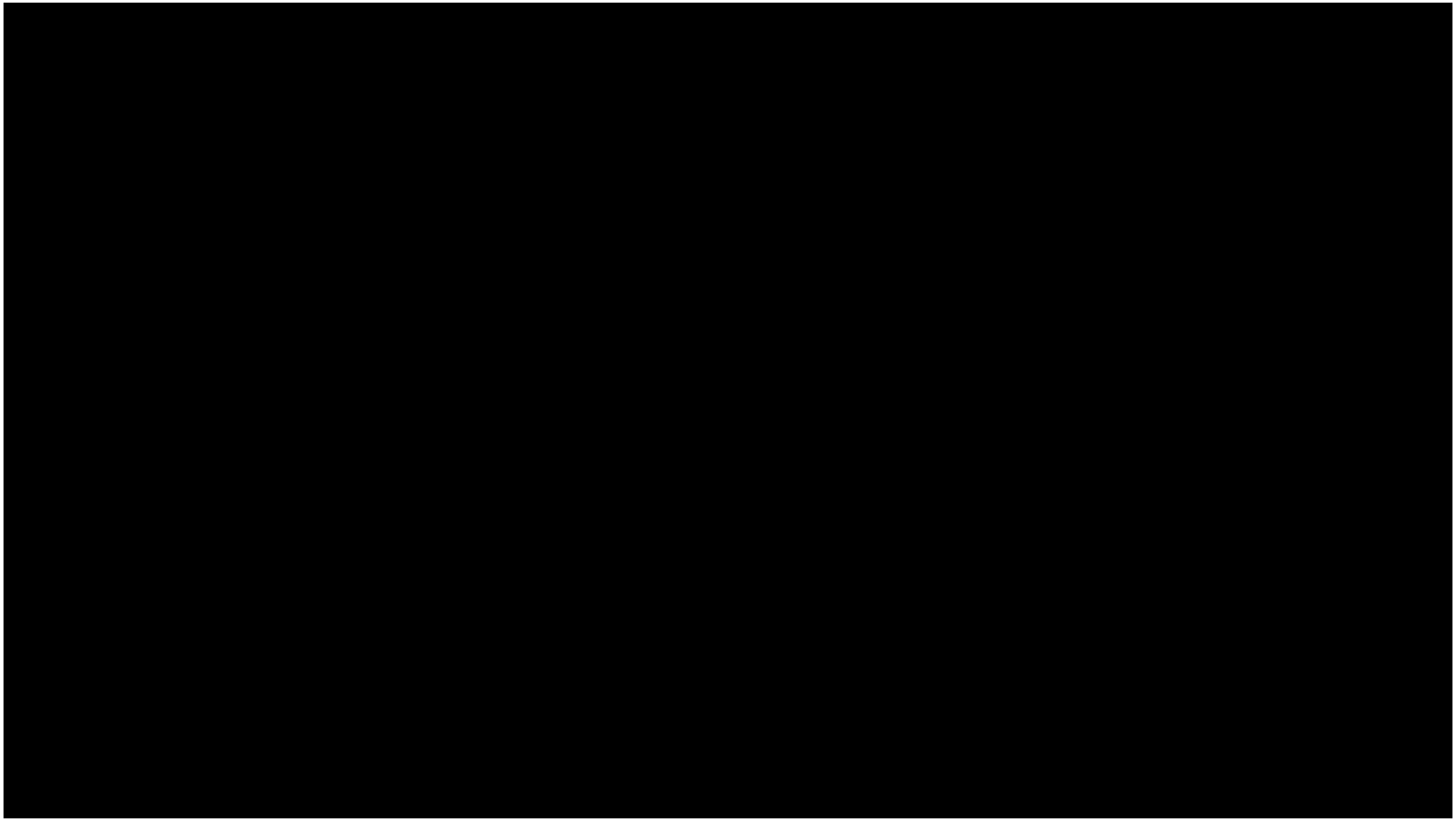
Pupillometry



[Reiner and Gelfeld, 2014]

Protocol and Tasks

C2



Objective

C3

- Propose an « all-in-one » approach for the real-time recognition of users' MW in VR using physiological sensors integrated into an HMD.
- Compare different supervised learning setups on MW recognition accuracy.

Different objective measures	Sensors in HMD vs commercial grade sensors	Different signal normalization methods
 Cardiac (PPG), EDA, Ocular, Task Perf.	 vs. 	Normalization by subtraction of baseline features; Normalization by adding baseline features in features map; Min-Max normalization

Data Acquisition Protocol

C3

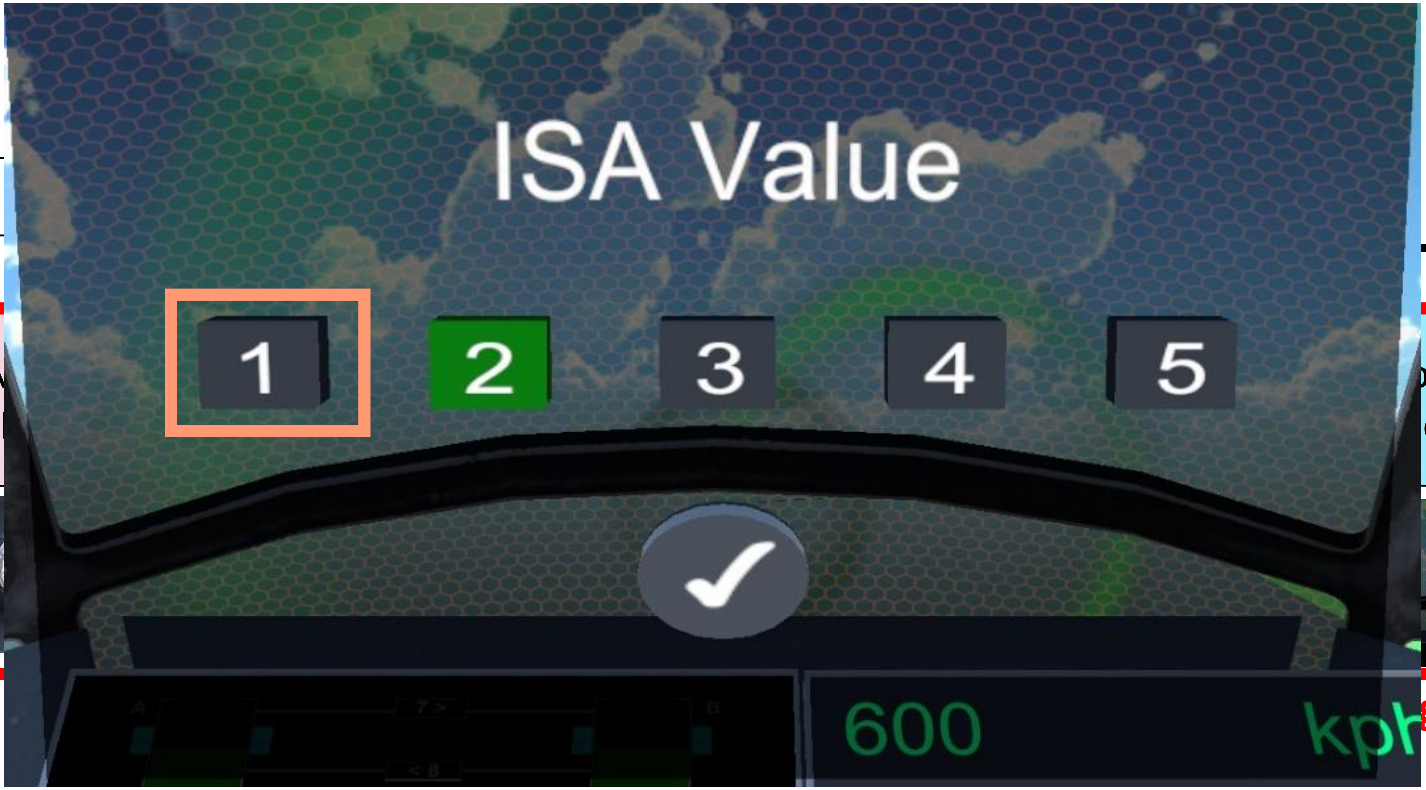
- **Collected Data**

=75 38 37

Ages: 18-64 (M=38.69)

HM

ojective MW
core (1-5)



get variable

Recognition Model Training

C3

Objective measures features

Subjective data

	HR	SDNN	SCL	…	MW_level
0	75	30.7	2.3		3
1	68	32.82	1.5		2
…	…	…	…		…

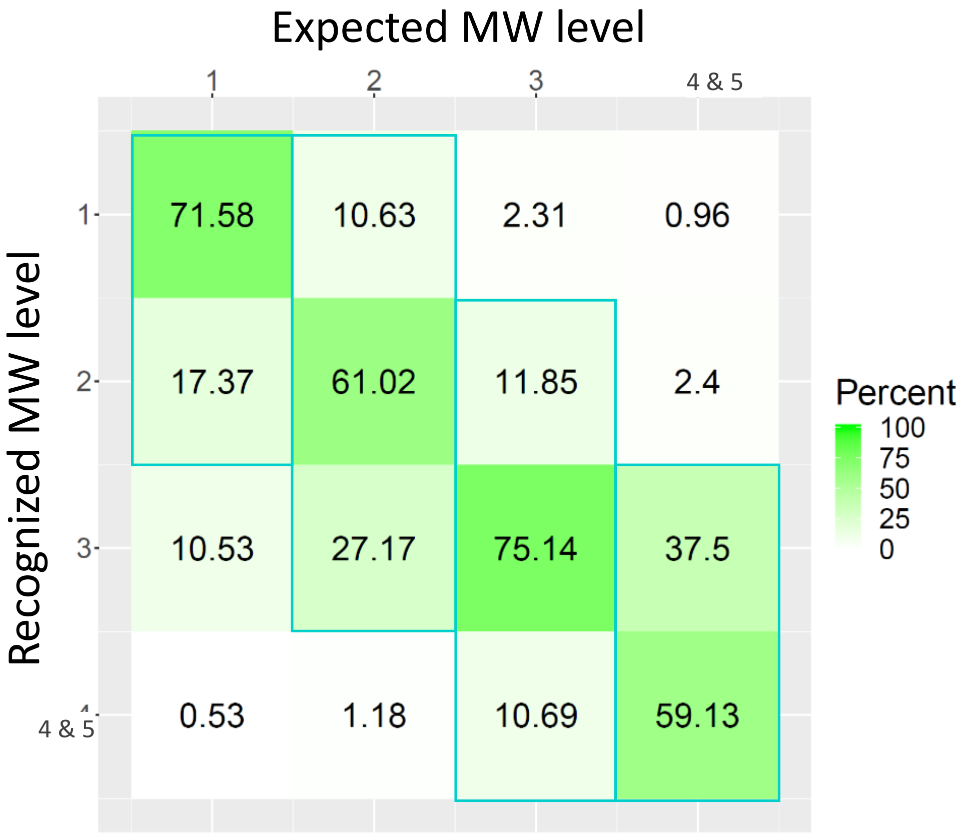
Model training

Random Forest algorithm

MW recognition model

Results

C3



Confusion Matrix using HMD sensors and task performance data

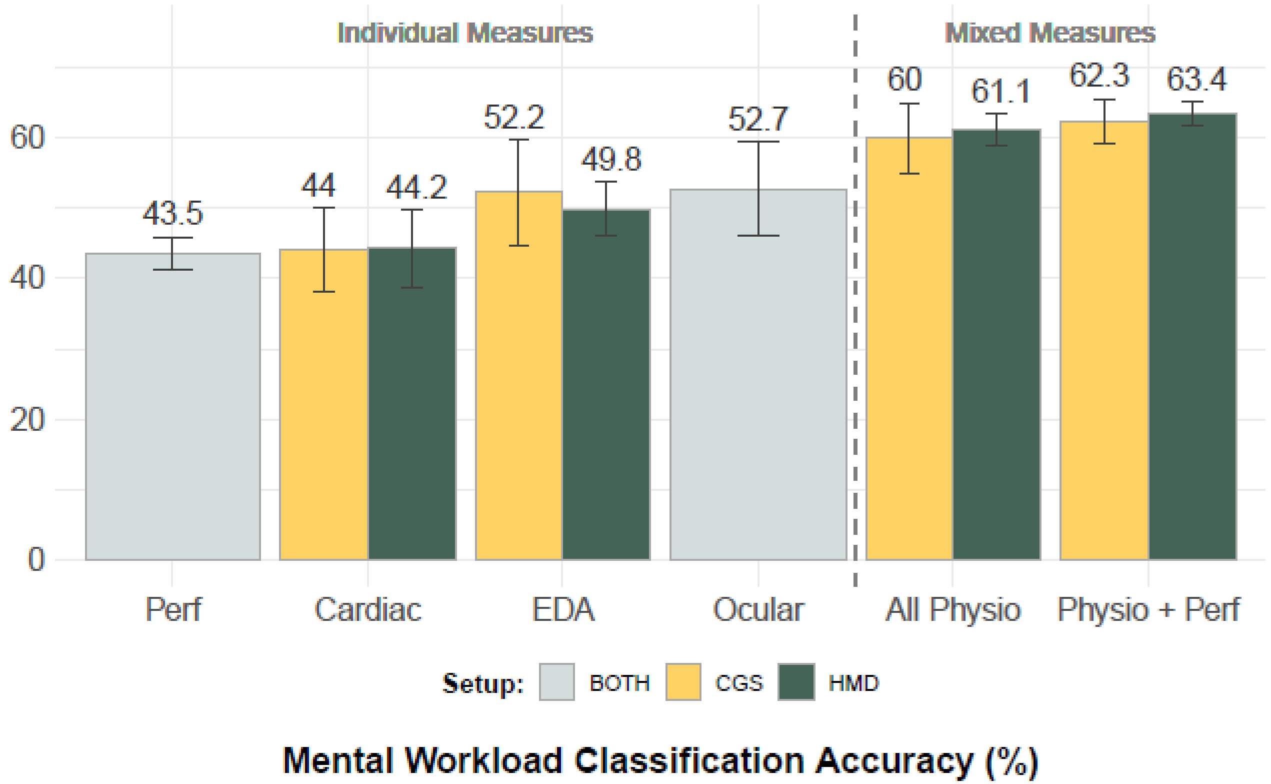
Recognition accuracy: 65%

10-fold cross validation

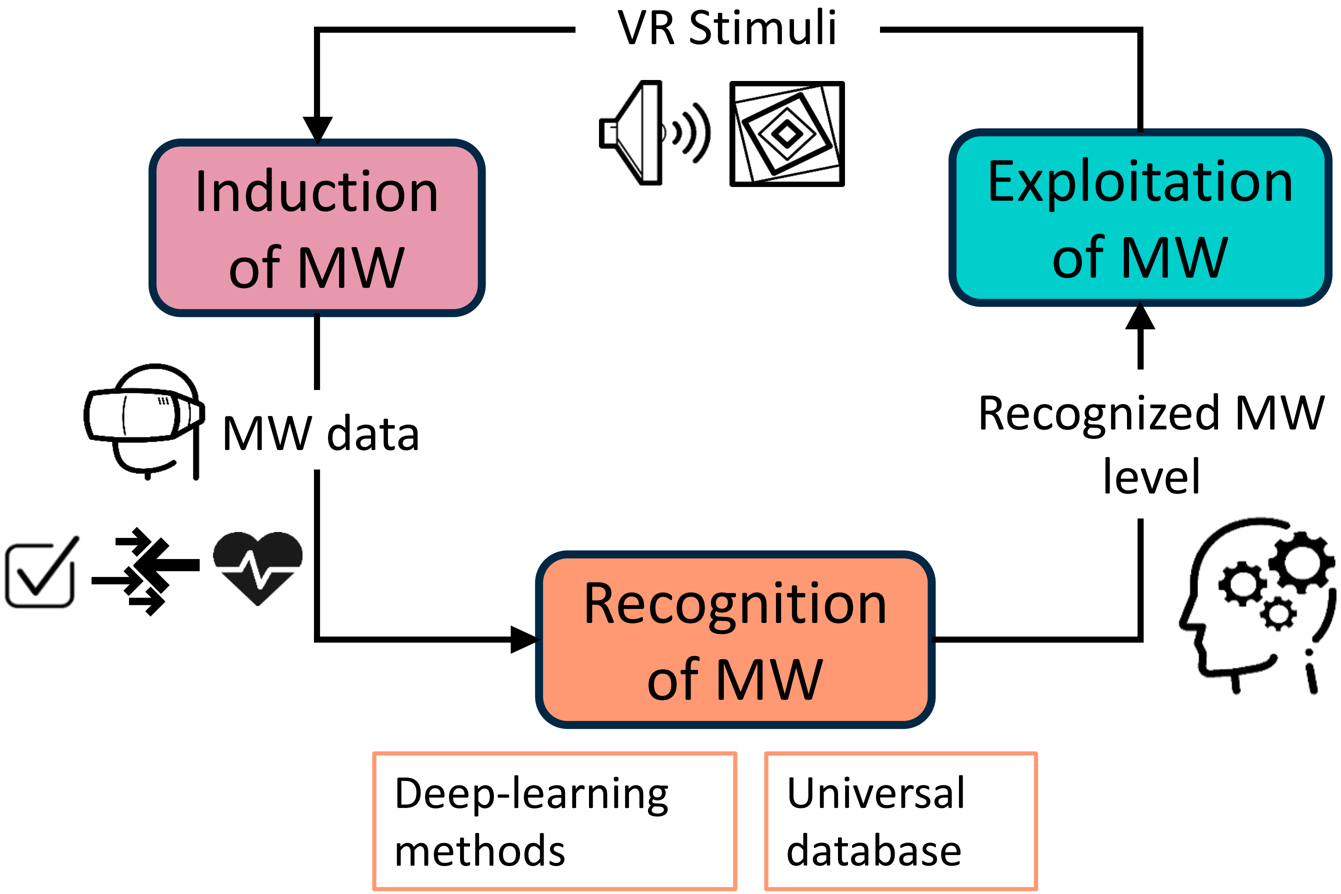
Results

C3

- Comparison of the sensors on MW recognition accuracy

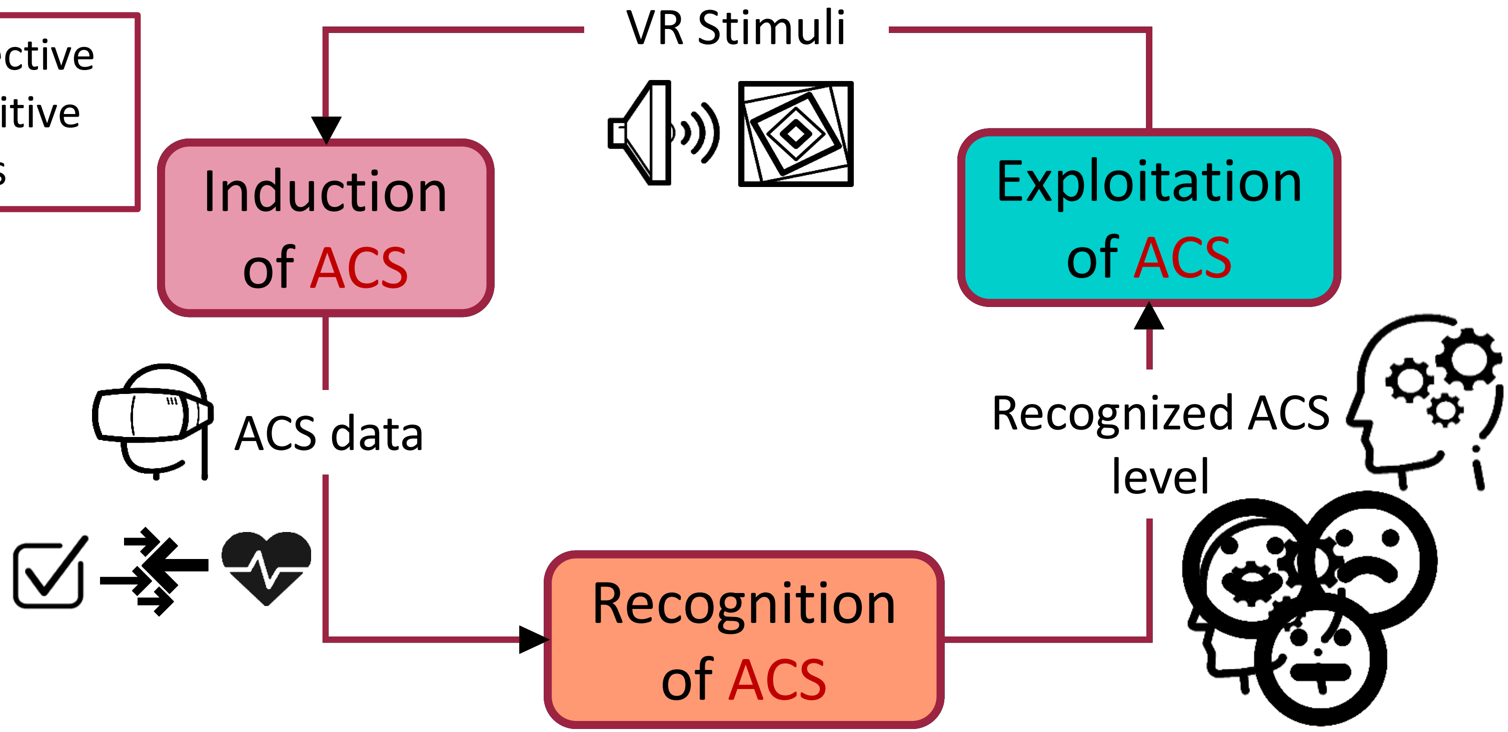


Long-Term Perspectives



Long-Term Perspectives

ACS = Affective and Cognitive States



Extend the approach to other Affective and Cognitive states?

Machine learning in ongoing projects

GENESIS

leveraGing nEuromarkers for Next-gEneration immerSIve Systems

chist-era

Neurosciences :
Neuromarkers (EEG) -> Cybersickness / Presence…

HCI : Mitigate cybersickness

VR : Use case applications with VR-BCI

Signal processing & Machine learning :
EEG processing
Neuromarker detections

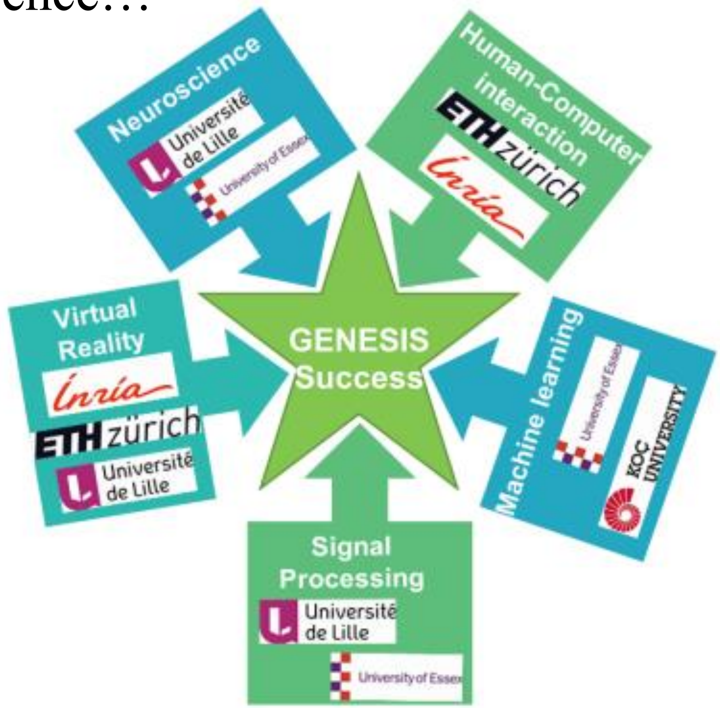


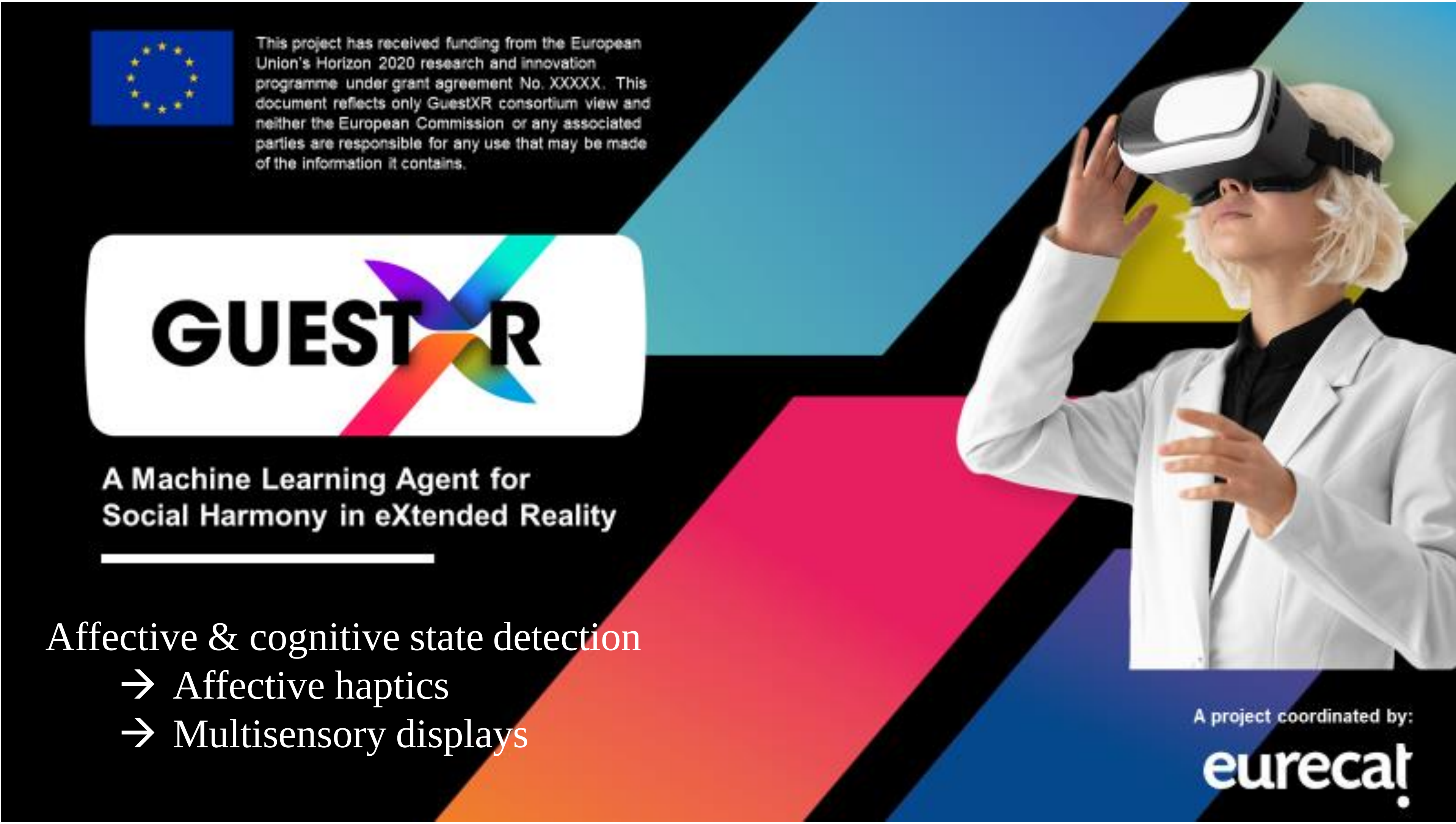
Figure 2: GENESIS multi-actor and transdisciplinary

cnrs

IRISA

Inria

GUEST-XR



Affective & cognitive state detection

→ Affective haptics

→ Multisensory displays

?

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