YEARBOOK

2024

institut
cognition

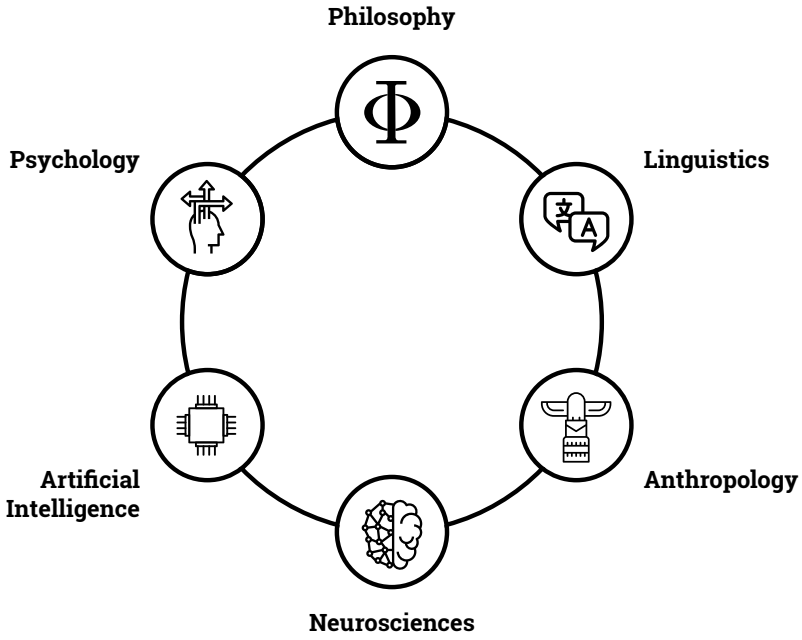
INSTITUT CARNOT cognition

2025 EDITION

Summary

YEARBOOK

2024



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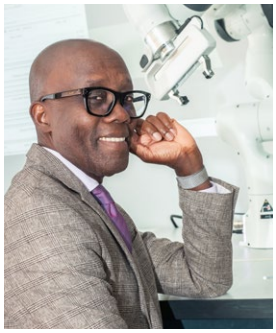
ÉDITION 2025

EDITO

2016-2024: an initial assessment of the Carnot Cognition Institute partnership



Célestin SEDOGBO

Director
of the Carnot Cognition Institute

We are pleased to present the 2024 edition of the Yearbook from the Carnot Cognition Institute, created in 2016. Eight years of intense activity have enabled the Institute to achieve remarkable results in many areas:

- The largest (and undoubtedly the first) structure in France, Europe and internationally on the theme of cognition.
- A federation of 21 multidisciplinary laboratories that cover the thematic field of cognition in a cross-disciplinary manner.
- An interdisciplinary approach to cognition: a network of nearly 2,000 researchers who communicate with each other and meet at scientific conferences (one or two per year) and the Research & Technology Day (a trade fair held every two years). More than 100 scientific resource projects led by at least two of the Institute's laboratories and funded by the ANR.
- A quality process based on knowledge of the contractual procedures of the 21 laboratories and 26 supervisory bodies, with an annual management review.
- A tentative breakthrough for cognition as a strategic issue for businesses, even if there is still a long way to go.

This 2024 Yearbook presents a non-exhaustive overview of the work carried out by our laboratories, which may serve as a source of inspiration for competitive innovation in businesses.

4 distinctive scientific areas for interdisciplinary synergies

The Cognition Institute is based on a distinctive scientific programme structured around four areas:

- Cognitive augmentation technologies
- Cognitive behavioural assessments
- Collective cognition
- Cognition and language

Artificial intelligence is a cross-cutting theme for all big data analyses, particularly those related to cognitive and behavioural markers, and therefore does not appear here as a specific area (it should be noted, however, that the fourth area is a component of AI).

The Institute is characterised by an original approach to interdisciplinarity through calls for expressions of interest drawn up by companies (formalising their needs and expectations) and eliciting responses involving at least two laboratories. A structured offering of technical platforms and a technology portfolio (resources) complete this system. Through its dual national and interdisciplinary network, the Cognition Institute offers opportunities for strong and relevant **cross-disciplinary interactions** that, to our knowledge, are unparalleled anywhere else in the world.

Coordinated by the CNRS, the Carnot Cognition Institute brings together 21 research units located throughout France (SCALAB, Lille - LISN, Orsay and Paris-Saclay - CHArt, IJN, LSP, LSCP, ENSAD-Lab, Paris - Centre BORELLI, Paris Saclay - LaPEA, Boulogne Billancourt - COSTECH, Compiègne - LEAD, Dijon; Gipsa-Lab, LIG, LPNC, Grenoble - IMS, Bordeaux - CeRCA, Poitiers - IRIT, CRCA, Toulouse - LIA, Avignon - LPL, Aix-Marseille - RPNC, Marseille). The CNRS and Bordeaux INP have set up a joint internal unit to manage the Institut Carnot Cognition, known as UAR 2203 CNRS, which is responsible for the operational management of the support team and the operating budget.

Revenue from partnership research with companies

The cumulative revenue (invoiced) from contractual research from 2016 to 2024 for the Carnot Cognition Institute amounts to **€26,134,950, an average of €2.6 million per year**, with around 90 partner companies, representing approximately 770 contracts, ranging in value from €10,000 (supervised Master's internships) to €500,000 (industrial chairs).

High-quality collaborative research for business innovation

To organise its local, national and international positioning and establish itself as the single portal and natural point of contact for French companies across the entire spectrum of cognitive issues, the Cognition Institute offers:

- An approach driven by socio-economic needs, in line with the scientific and technological capabilities of its laboratories. This approach enables us to offer a comprehensive response covering all of a company's needs by combining the methodological skills and expertise in specific cognitive functions of several laboratories.
- Structured coordination of contractual research activities implemented by the supervisory bodies of the Cognition Institute's founding laboratories, ensured through the governance of the Institute, its Director and an Operational Office. To this end, each laboratory involved in this joint action mobilises the contract management resources (SATT for IP management, commercialisation departments, management structures, etc.) currently engaged in this area.
- Pooling of the platforms, equipment and research resources of the Cognition Institute's laboratories for contractual research.

On behalf of the 21 directors of the laboratories that make up the Carnot Cognition Institute and on my own behalf, I hope you enjoy reading this publication.

Collective cognition

To study natural and artificial interactions in different contexts (emotional, cultural, etc.) in order to understand the underlying processes (cognition, communication, etc.), social, belief and emotional regulations in individual and social contexts, stereotypes, effect of the social context on cognition and human- human/animal/virtual agent/ robot interactions.

Célestin SEDOGBO - Scientific Coordinator

Psychological underpinning of household food waste management

Frédérique AUTIN and Emilie GUICHARD (CeRCA)

Scientific background

In the face of increasing waste, a large body of research has investigated the psychological determinants of waste management behavior. These determinants are articulated in different theoretical models such as the theory of planned behavior or the norm activation model. Based on meta-analytical findings, we propose an integrative model of the main determinants of waste management behavior. This model integrates situational, normative, attitudinal and self-related influences. We have tested the predictive value of this model for understanding behavioral habits and intentions towards two overlooked behaviors: food waste sorting and deposit at disposal centers.

Method

A questionnaire was administered to 2,814 participants. It measured the variables we aimed to predict (i.e., habits and intentions to sort food waste and deposit at disposal centers) and their determinants. The latter included situational determinants such as material conditions facilitating or hindering sorting, normative determinants such as the perception of what others do or support, determinants relating to favorable or unfavorable attitudes towards sorting, and self-related determinants such as identification with the environmental cause.

Results

Structural equation modelling revealed a good fit of the integrative model to the data, explaining between 53 and 66% of the variance in sorting intentions and habits.

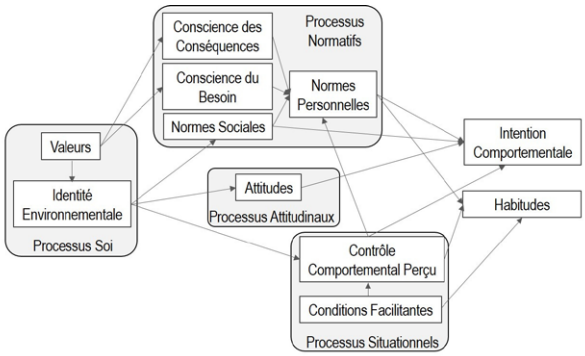


Figure 1 : Integrative model of the main determinants of waste management behavior

General discussion

The four types of determinants (situational, normative, attitudinal, self-related) influence intentions and habits, but two determinants seem particularly preponderant: the feeling of moral obligation to sort, and the feeling of being able to sort. These are two important levers for designing interventions aimed at changing waste management behavior.

Tangible encounters at a distance: support and constraint

Charles LENAY, Florent LEVILLAIN, Vincenzo RAIMONDI and Krystelle GONZALEZ (COSTECH)

Scientific content

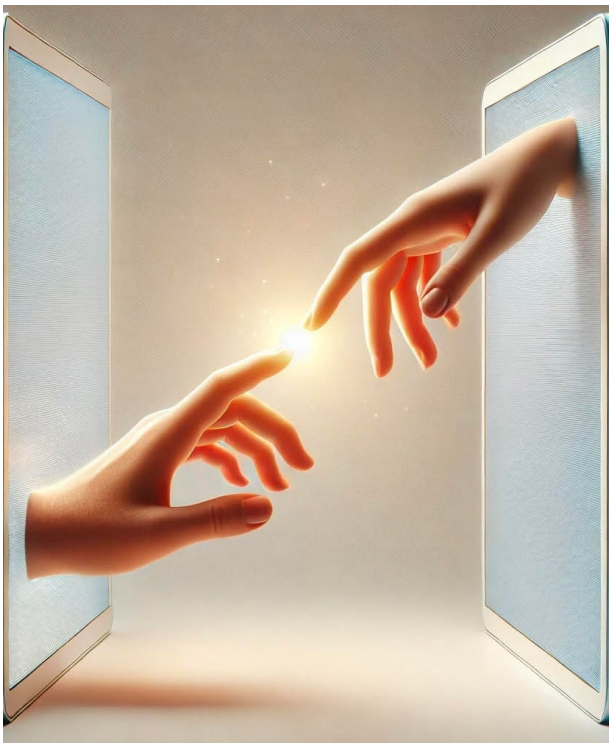
Pseudo-haptic perception is not only the result of stimulation of skin receptors associated with exploratory movements, it is also associated with the encounter with a tangible object that blocks or guides the exploratory gesture. In the case of interpersonal interaction, the mutual encounter of tangible bodies should directly convey emotional values, whether positive or negative. To understand the specificity of this type of interaction, we work in a minimalist environment where interactions are mediated by technical interfaces. The aim is to identify the conditions that give the perception of encountering others as an obstacle, even though the interactions take place at a distance. To do this, we use the principle of pseudo-haptic perception, which we network.

Tools/methods

The tactile communication interfaces developed at UTC (Intersubjectivity team - COSTECH laboratory) enable fundamental study of perceptual interaction mechanisms: coupling of tactile (piezoelectric) boxes with exploratory gestures, networking, recording of perceptual trajectories, etc.

Principle demonstrated

We propose a minimalist experimental study on the ability of pairs of subjects to recognize that they are obstructing each other when they meet at a distance in a digital environment. The emotional effects are evaluated.



Application examples

Guiding principles for designing interfaces that convey positive emotional values (support/guidance).

Virtual reality and creativity

Todd LUBART, Jiayin LIU and Samira BOURGEOIS-BOUGRINE (LaPEA)

Scientific content

Our research on virtual reality and creativity has demonstrated the impact of an optimized environment on creative performance. Both the characteristics of the “room” and the avatars influence creative output. We are studying the nature of these effects, the psychological drivers, and the ways to optimize the system.

Tools/methods

Using a virtual reality platform, we place participants in a virtual environment designed to foster creativity. Avatars are also configured to reflect the creative selves of participants. We have developed idea generation techniques that are tailored to this environment.

Proven principle

Thanks to the effects of virtual reality on cognition, creativity can be enhanced and the production of original ideas benefits as a result. The virtual environment can support creativity thanks to its imaginary nature, different from the real world, and the transformed and relatively anonymous nature of the avatars that represent participants.

Examples of application

It is possible to hold brainstorming meetings in a virtual room. These creative meetings can be organized in companies or schools. Participants can be present in person or remotely.

Cognition and language

Taking language-related cognitive processes into account in natural language processing to improve human-machine interaction (speech and language processing, learning, multimodality, gestuality, multilingualism, assisted translation, affect, language and speaker identification, conversational agents).

Didier SCHWAB (LIG) - Scientific Coordinator

Vocabulary and Reading Comprehension in 7 to 10 Year olds

Emilie DUJARDIN (CeRCA)

Scientific background

Understanding what we read is a central skill in modern society. Reading comprehension is regarded as key skill for academic success. Reading comprehension relied on related language skills such as listening comprehension and word reading. Increasingly, researchers are exploring the role of vocabulary in reading comprehension. We need to have enough vocabulary to understand what we read, to know what words mean, how to use them, to be able to define them, etc. We therefore examined the links between vocabulary, oral comprehension, word reading and reading comprehension in French-speaking children aged 7 to 10.

Method

The study included 237 children from second to fifth grade. The children completed short computer-based tasks assessing their reading comprehension (reading a text and answering written questions); listening comprehension skills (listening to a text and answering oral questions); word reading skills (deciding whether words are spelled the same, pronounced the same or belong to the same semantic field); and vocabulary (answering vocabulary questions about various words).

Main results

Vocabulary, word reading and listening comprehension are distinct language skills that influence reading comprehension (see Figure). The results show that vocabulary has a positive and direct relationship with word reading and listening comprehension, and a positive and indirect relationship with reading comprehension, via word reading and listening comprehension. Word reading had a greater effect on reading comprehension than listening comprehension.

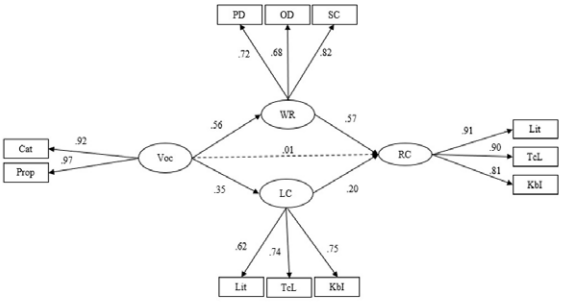


Figure 1 : Graphical representation of the relationships between vocabulary (Voc), word reading (WR), language comprehension (LC) and reading comprehension (RC).

Discussion

Reading comprehension is a complex activity, involving different language skills, in this study listening comprehension, vocabulary and word reading. Word reading plays an important role in understanding a text. This underlines the importance of developing both vocabulary and word reading skills to support reading comprehension from an early age, as they are interconnected.

The Artificial Boothmate: a multilingual interpreting assistant in virtual reality

Leïla CHERROUK and Geoffrey TISSIER (CHArt)

Scientific content

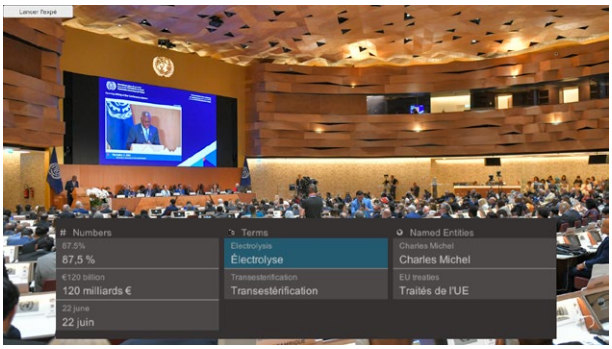
Simultaneous interpreting, or real-time oral speech translation, is one of the most complex cognitive activities that the human brain can perform. It requires the parallel execution of numerous high-level processes. Due to the inherent difficulty of this task, professional interpreters are often pushed to the limits of their abilities, as they constantly balance linguistic, thematic, and cultural demands that vary from one context to another.
To support interpreters in decision-making and to refine the definition of competence through the lens of situated cognition, we have developed an innovative pedagogical tool in virtual reality.

Tools and methods

The system offers a wide range of photorealistic interpretation scenarios experienced through a VR headset. Each environment integrates a head-up display with multilingual speech recognition software and real-time automatic translation of proper nouns, numbers, and technical terms.
Behavioral data are recorded during use, enabling learners to receive immediate feedback on their performance.

Demonstrated principle

Designed as a training tool for interpreters, the technology features a multilingual assistant aimed at reducing the cognitive load associated with short-term speech memorization. Our goal is to demonstrate the contribution of virtual reality to interpreter training and to link observed behavioral variations to the development of intercultural communication skills.



Application examples

1. The system can be configured to simulate various virtual environments, such as international organization meetings, courtrooms, or hospitals. Trainers can customize scenarios to create engaging activities that align with specific pedagogical goals.
2. After completing a task, learners can replay and review their own interpretation from the audience's perspective. This shift in viewpoint within the same immersive environment fosters self-regulated learning.
3. The application can also be extended to support second-language acquisition.

Pyannote, Who speaks when?

Hervé BREDIN (IRIT)

Institut de Recherche en Informatique de Toulouse

Scientific content

Speaker diarization in a spontaneous conversation between several people is a complex problem that remains unsolved today.

Tools/methods

The “pyannote” open-source library was developed at CNRS and is now considered to be extremely efficient for the speaker diarization task.

Demonstrated principle

Two “pyannote” demonstrators are proposed: a web version (where the user can upload a recording and get offline speaker diarization) and a mobile version (where the user can obtain a low-latency live prediction).

Application examples

The “pyannote” open-source library is used by a wide range of industry players, from automatic meeting summaries to dubbing audiovisual content and training multimodal LLMs.

FLUIDILI

Erika GODDE (LEAD)

Scientific content

Training reading fluency in the classroom on a regular and frequent basis, while allowing each student to benefit from training adapted to his or her level, is a challenge. We present Fluidili, a reading karaoke application based on the most effective principles of fluency training: repeated and wide reading, modeling and visual cueing. Young readers read in sync with the audio of an expert reader, following the highlighting on the tablet. This karaoke was used intensively with third and fourth grade pupils for 4 weeks. We assessed the impact of this training on the students' fluency skills.

Tools/methods

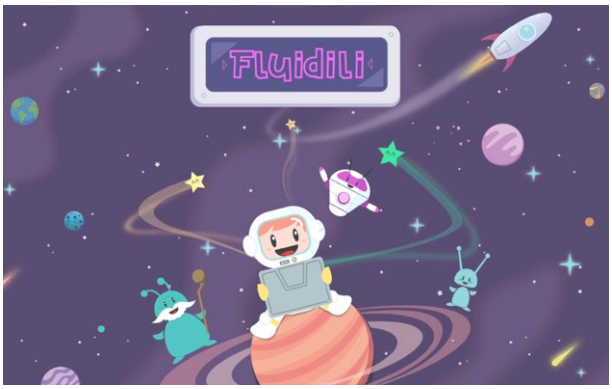
92 third and fourth graders were divided into 3 groups: a control group, two groups with karaoke training: one group with word highlighting and one with breathgroup highlighting. Students in the experimental groups took part in 10 15-minute karaoke sessions 3 times a week over 4 weeks. They practiced 3 texts of increasing complexity. The control group practiced fluency in class with the teacher.
Before and after the training period, all students were assessed for reading fluency on the trained texts and on an unknown text.

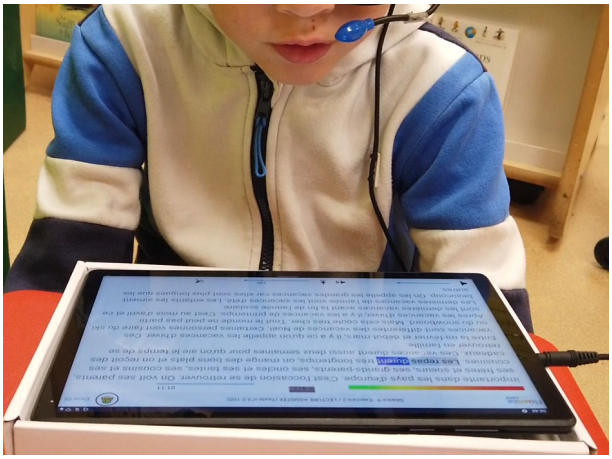
Demonstrated principle

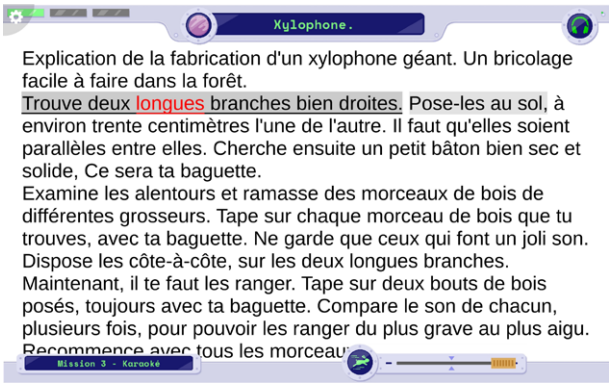
This test demonstrated the positive impact of the application on students' fluency on both trained and untrained texts.

- The 2 experimental groups made greater progress than the control group in expressiveness texts (trained or untrained).
- The group using breathgroup highlighting progressed more in expressivity and phrasing than the other two groups on the complex texts (trained).
- At the end of training, the group using breath-group highlighting had a better level of syntactic awareness.

Training with karaoke therefore improves the expressivity of all students, and allows for better phrasing and expressivity in complex texts thanks to highlighting.







Application examples

Fluidili is the final, classroom-ready version of reading karaoke. This version contains 35 texts at second and third grade level, of increasing complexity, making it possible to produce courses of 30 sessions on 10 texts. This intensive use over a longer period of time should help to anchor the progress made by pupils.
Fluidili has also been scripted, and features a graphic universe to engage students over this long period of time. It can therefore be used in the classroom to enable children to work on fluency on a daily basis, as an independent activity, or as a remedial tool for pupils with reading difficulties.

SUMMSci, a contextualized summarizer of scientific documents at the heart of applications and widgets specialized in research and medicine

Juan-Manuel TORRES (LIA)

Scientific content

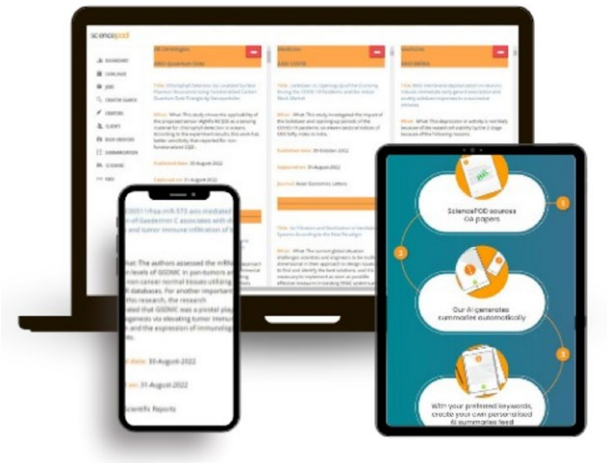
Scientific information is ubiquitous and available in too much quantities for researchers and healthcare professionals to stay systematically informed about their fields. There are simply not enough hours in a day for people working in the knowledge economy field to read and understand the latest scientific publications. One obvious solution is to rely on scientific studies abstracts to provide a relevant overview of each study. In order to avoid any bias (hallucination), the tools developed at LIA are deliberately focused on extractive summarization, which only renders sentences contained in the source documents.

Tools/methods

In partnership with the Irish company SciencePOD, the LIA has provided abstracting solutions that form the engine of the ScioWire solution, a personalized news feed distilling automatic abstracts of the latest scientific studies published in Open Access. Keywords are generated and used to guide the summary. Fast algorithms for PDF analysis and graph centrality to weight relevant chunks of text, as well as contextualization via ontologies, produce relevant summaries. Users can also customize their news feeds to receive only abstracts of scientific studies directly relevant to their research topics (https://magazine.sciencepod.net) and also use the ScioWire concept (https://www.sciowire.com).

Demonstrated principle

We have shown the relevance of contextualized extractive summarization in scientific documents. The aim is not to bias the scientific information in documents (due to hallucinations or irrelevant text).



Application examples

ScioWire's aim is to increase scientific literacy and combat misinformation on the Internet. Automatic summarization of large-scale scientific studies saves researchers and students a considerable amount of time. ScioWire also enables users to monitor the latest studies published in Open Access, and keep them informed of the latest developments. The magazine version (https://magazine.sciencepod.net) currently under development is designed to attract a highly targeted audience of healthcare professionals by optimizing SEO on specific pages linked to key therapeutic areas, to serve as their information platform of reference in specific therapeutic areas. A widget version will be integrated into third-party sites, thanks to a few lines of code, to disseminate information in Internet communities where specialists in scientific and medical fields are gathered.

Visualization and explicability of contextual neural translation models for translators

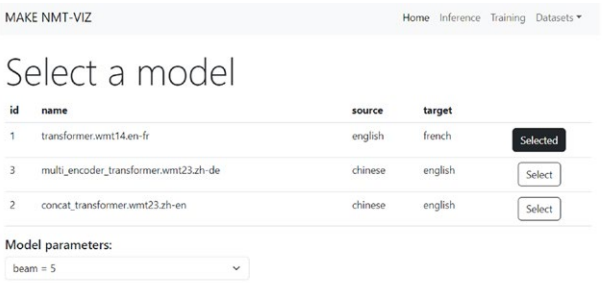
Gabriela GONZALEZ (LIG)

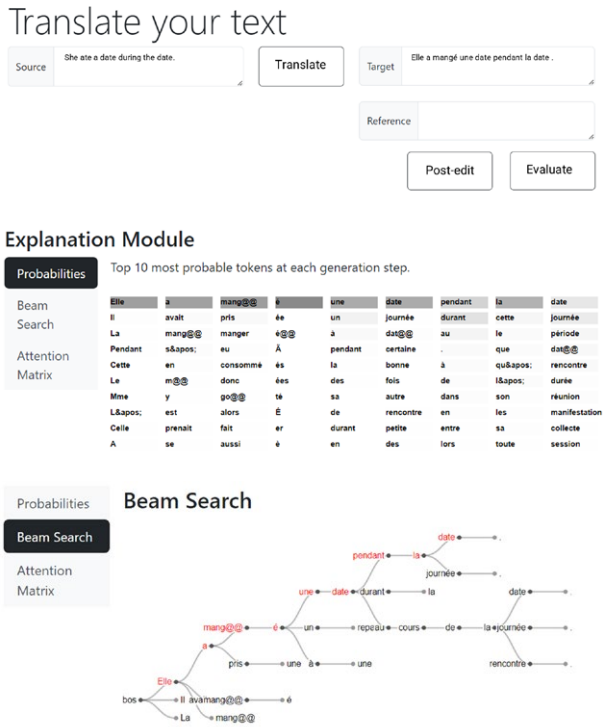
Scientific content

In their meta-analysis, Doran et al. (2017) distinguish between opaque, interpretable and comprehensible systems in various fields. Neural Machine Translation (NMT) is classified as a comprehensible system, if a suitable visualization system is in place. They state that “confidence in an interpretable machine learning system depends on the user’s ability to understand the machine’s input/output mapping behavior”.
Following Phillips’ (2021) four principles of explainable AI, we have developed a platform offering meaningful, accurate and knowledge-bounded explanations: a clear visualization for translators, data from the internal workings of the NMT, and limits shown by quality metrics.

Tools/methods

The visualizer includes translation and analysis modules. The translation module generates the translated text and stores internal data on system operation (e.g., attention weights, generation probabilities). Once the translation is complete, the analysis module explains how the NMT model arrives at this translation. The explanation is divided into three parts: input, process and output, guiding the user through each step of the generation process.
The input analysis focuses on its representation and sub-tokenization. The process describes the operation of the model and its interaction with the input, linking the model’s internal data and characteristics to the output. Finally, the output presents the generated alternatives and explains the choice of the final translation.





Demonstrated principle

MAKE NMTVis system is a visualization tool aimed at making Neural Machine Translation models explicable by following the principles of explicable artificial intelligence (XAI) defined by Phillips et al. (2021): meaningful, accurate and knowledge-bounded explanations. This project brings together the main players in the development of machine translation, fostering collaboration between researchers and professional translators.
It takes into account their needs and preferences, while aiming to improve machine translation culture. By combining research and practice, MAKE NMTVis aims to enhance understanding of translation systems, while offering tools adapted to users’ expertise.

Application examples

This platform provides translators with meaningful, accurate and knowledge-limited explanations of NMT systems. With our tool, translators can translate, post-edit and evaluate texts while simultaneously analyzing and explaining the results of NMT models. In this way, it goes beyond the complex algorithms of artificial intelligence and promotes a better human understanding of translation.

Prototype graphic editor for sign language content

Michael FILHOL (LISN)

Scientific content

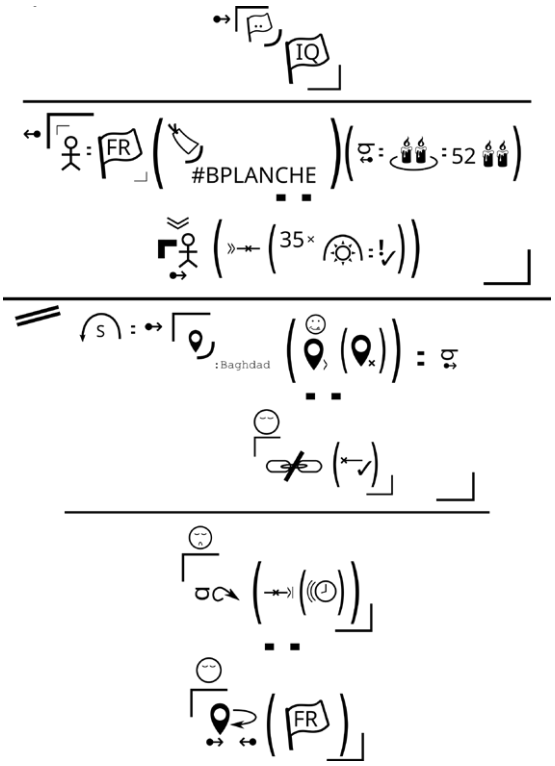
We present a prototype editor for a graphical representation of sign language utterances, capable of determining the (gestural) forms to be articulated. The result is a rendering of the utterance in the form of a 3D animation synthesized by an avatar.

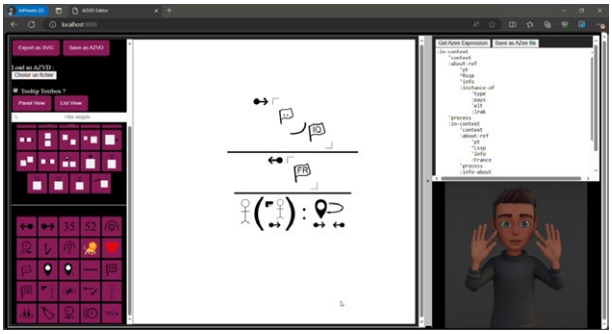
Tools/methods

The graphic system is built on two complementary foundations. Firstly, the AZee model, which allows formal representation of signed utterances, even covering many iconic structures particular to sign languages. Secondly, the study of spontaneous graphic representations that native speakers and language professionals (e.g., translators) produce to put their language on paper.

Principle demonstrated

With the demonstrator, you manipulate a diagram using icons and graphic layouts that you drag and drop onto a graphic area. Each modification to the canvas is automatically reflected by an update of the AZee expression, which can be used to animate an avatar. Only a small subset is available today, but experience shows that it is possible, without knowing any code or programming language, to control sign language synthesis with a readable and semantically interpretable graphic system.





Examples of applications

At the very least, such software enables content to be edited in sign language and rendered anonymous, without the need for a video recording, which leads to speaker identification. Furthermore, if sign language speakers adopt it, for example as a writing proxy, it could make it possible to publish content, comment on videos and exchange e-mails in an economical, anonymous and indexable form, unlike video.

CquAE, or how to answer questions in French?

Anne VILNAT and Thomas GÉRALD (LISN)

Scientific content

We present a CQuAE corpus built to create a virtual assistant system for answering questions on documents or course material. In order to be useful to both teachers and students, it is important to consider complex questions and to be able to justify answers on validated equipment. We will also present the different stages in its creation, with a current phase of data enhancement. Finally, we present several experiments to evaluate the use of the corpus as part of an automatic question-and-answer system.

Tools/methods

We tested several language models for their ability to generate expected responses using the collected corpus.

Principle demonstrated

There are few corpora in French devoted to the educational field, and we show the difficulty of inserting oneself into this field where not only must answers be verified, but also adapted to a specific context.
We also show the limitations of the current corpus, which takes into account only the text and not the images that accompany the courses, though they are often very complementary, and indispensable for producing correct answers.

Application examples

The first area of application is education, but the results could be extended to any field where reliable data is scarce.

RTS, Rising Tongue System

Thierry LEGOU and Lise CHARRIER (LPL)

Scientific content

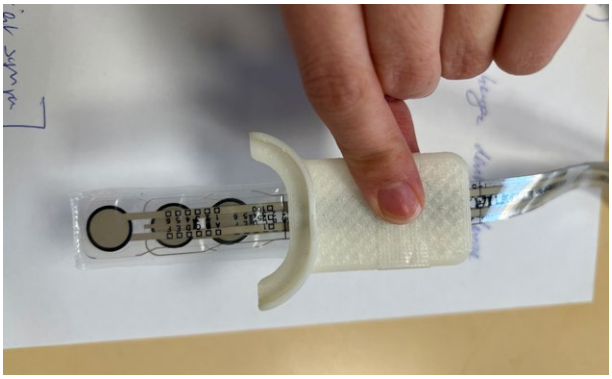
With your mouth closed, can you describe where your tongue is and how it rests on the palate? Difficult, which is why the Rising Tongue System (RTS) is particularly relevant in speech therapy for swallowing disorders (where this question predominates). The interest of biofeedback in functional rehabilitation is well established. For lingual gestures, the biofeedback provided by RTS improves the precision of the lingual gesture and makes the patient more autonomous in his treatment.
In the healthcare field, rehabilitation can be based on regular independent (but guided) practice of tasks proposed by specialists. During these autonomous sessions, biofeedback gives the patient rapid, objective feedback on the gesture performed.

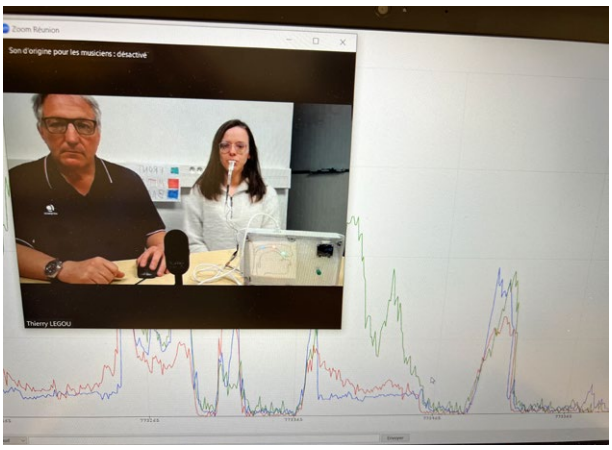
Tools/methods

The RTS device uses contact force sensors to measure the forces at which the tongue forces on the palate at various points. Thanks to a 3D-printed sensor support to stabilize the device, the recordings of these contact forces (called palatograms) enable longitudinal monitoring of speech therapy during the treatment of swallowing disorders. This impartial method empowers the patient and provides the speech therapist with information in an ecological situation.

Demonstrated principle

- The demonstrated principle is the use of biofeedback to improve the performance of an expected gesture (the lingual gesture in our case).
- The use of historical recordings for longitudinal monitoring of rehabilitation, in order to validate or modify the exercises proposed to the patient during rehabilitation in the consulting room and at home.





Application examples

- Rehabilitation of swallowing disorders (dysphagia and dysfunctional swallowing);
- Automation of a physiological resting lingual position with a rebalancing of the orofacial sphere;
- Energize the lingual gesture through the use of precision and/or speed games;
- Improved perception of the location of tongue contacts on the palate after glossectomy or partial palate reconstruction;
- Fine (analog) control of an actuator using lingual supports.

COMON system

Deirdre BOLGER and Thierry LEGOU (LPL)

Scientific content

During an oral interaction between two people, many elements come into play during the exchange. Verbal content is important, of course, but so are coverbal gestures (gestures “attached” to speech), as well as the physiological and neurophysiological aspects of each speaker. Measuring these physiological parameters provides information on the way in which we prepare, experience (and sometimes undergo) a speech utterance, or the possible synchronization or convergence with our interlocutor.

Tools/methods

Breathing measurement measures the moment when the speaker inhales in preparation for speaking. Breathing prior to speaking is sometimes preceded by a look or gesture to signal the speaker’s intention to speak. Systems for measuring gestures or facial expression complement the information gathered for the study of verbal communication.
Measuring the electrodermal response of each interlocutor can also provide information on the emotions felt during the exchange. Electrodermal response is modulated by the autonomic nervous system (ANS), which is involved in the “management” of emotions.
Measuring the frequency composition of brain activity (EEG) enables to understand the level of information being processed (lexical or sub-lexical) or evaluate temporal alignment and convergence between the speakers.

Demonstrated principle

The demonstrated principle is the interest of considering several natures of information to better understand the mechanisms of oral communication by considering physiological and neurophysiological parameters.

Application examples

- Improve oral communication
- Better understand your own constraints and those of others during oral interaction.
- Access indicators to evaluate oral communication, how it is prepared and “lived”.

A multimodal model for predicting the position and type of feedback during a conversation

Auriane BOUDIN, Roxane BERTRAND, Stéphane RAUZY, Magalie OCHS and Philippe BLACHE (LPL)

Scientific background

During a conversation, it is very common to produce reactions such as “mh mh”, nodding or smiling. These reactions, known as feedbacks, play an essential role in the development of dialogue, as they enable the speaker to demonstrate understanding and interest. Despite numerous studies showing the importance of feedbacks, it remains difficult to predict precisely when and how these reactions occur. The aim of this project is to acquire a better understanding of the context in which feedbacks occur, by developing a machine learning model capable of predicting their position and type during a conversation.

Method

The model we have developed predicts when a listener will give feedback based on the verbal, vocal and gestural elements of the main speaker.
It analyzes the evolution of this information for one participant over time and learns to predict when the other participant will produce feedback. We can then identify the patterns and elements that favor the production of feedback.

Main results

Our results show that the production of feedback is often favored by the combination of several informative elements (e.g., rising intonation, laughter or smile, adverb, adjective, etc.). It is therefore crucial to consider verbal, vocal and gestural cues together, in order to predict the timing and type of feedback produced by the speaker.

Figure 1 : A screenshot of a conversation from the “Cheese!” corpus (Priego-Valverde et al., 2020) that was used to build the model.

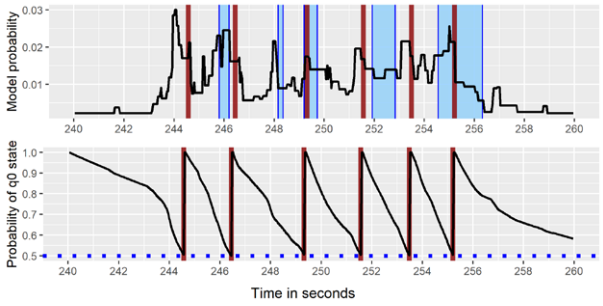


Figure 2 :The model calculates the probability of feedback (represented by the black curve in the top panel) and predicts feedback when this probability exceeds a specific threshold (indicated by the vertical red line). The predicted feedback is compared with the observed feedback (represented by the blue areas) to assess the model’s performance.

Discussion

Feedbacks are essential for developing quality conversations. In addition to a better understanding of these phenomena, our results will eventually enable feedback to be generated automatically in artificial systems, such as conversational agents or video game characters.

Fluence, 4 educational digital apps for learning to read in French and developing listening comprehension in English as a second language

Marie-Line BOSSE and Cynthia BOGGIO (LPNC)

Scientific content

Four evidence-based digital applications, known as “the Fluence package”, have been developed and scientifically validated to facilitate learning of fundamental knowledges. They are the result of research and a partnership with two companies (Editions Hatier and HumansMatter). Their development was co-funded by the e-FRAN (Fluence project) and e-FRAN-vague3 (Trans3 project) programs. These applications aim to improve performance in reading (EVASION, ECRIMO and FLUIDILI) and listening comprehension in English as a Second Language (FIREFLY).

Method

The effectiveness of these 4 applications was evaluated in large-scale, randomized, controlled, longitudinal experiments. A pre-test (measurement of initial level) - training (experimental group vs. control group) - post-test (measurement of final level) protocol was systematically used. Training lasted 10 weeks, on tablets in a real classroom context.

Main results

The results of recent experiments show that training with EVASION in first grade improves the visual attention skills involved in reading. ECRIMO enables pupils at the start of their reading training to improve their encoding skills. Lastly, second graders trained with FLUIDILI improve their expressive reading skills. As for FIREFLY, pupils who have used it perform better in oral English comprehension.

Cognitive behavioral assessments

Cognitive behavioral assessments are the methodological basis of cognitive sciences enabling the observation, study, understanding, characterization and, where appropriate, simulation of the mechanisms underlying the mental functioning of humans in interaction with their environment. Cognitive behavioral assessments are based on a body of knowledge, experimental methods, measurements (quantitative and qualitative) and instruments from a variety of disciplines: psychology, biology, neurosciences, medicine, mathematics, computer science, signal processing, linguistics, communication sciences, educational sciences, cognitive anthropology, philosophy, etc.

Measurement methodologies include subjective, behavioral (e.g. performance measures, non-verbal and verbal measures, etc.), psychophysical, eye tracking, as well as peripheral physiology (ECG, electrodermal activity, EMG, EOG, ...) and brain imaging (EEG, NIRS, fMRI, MEG, electrophysiology, ...). In addition to these measurement tools, other signal processing, modeling and advanced statistical methodologies (classifications, machine learning, etc.) are used.

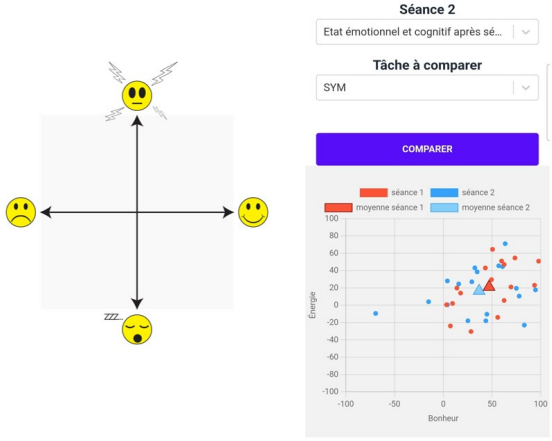
Nathalie GUYADER (GIPSA Lab) et Liliana GARCIA-AUDOUIN (IMS) - Scientific Coordinators

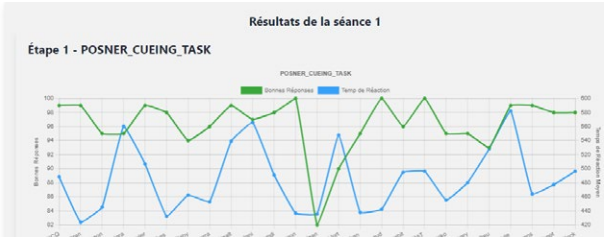
A platform for sustainable performance: combine well-being and results

Nicolas EPINOUX (CeRCA)

Scientific content

Psychosocial skills (PSS) are becoming increasingly important in international public discourse, whether in education and training policies (Morlaix & Nohu, 2019; Morlaix & Tavant, 2021), in the world of work (Faure and Cucchi, 2020), and in health policy in general and mental health policy in particular (Public Health France report (2022)). The issue of athletes' long-term success and mental health also raises questions about the role of PSCs (Gustafsson et al. (2008); Isoard-Gautheur (Gustafsson et al. (2008); Isoard-Gautheur et al. (2016)). The Public Health France report (2022) defines the contours of these CPS. The project is part of an international research initiative on intervention sciences and more specifically within the field of social developmental psychology. Our ambition is to highlight the role of these psychosocial capacities or resources in the success of individuals in real-life situations in a variety of contexts (more or less demanding emotionally, physically, cognitively, and socially). Lochbaum et al. (2022) in their review of the literature in the field of sports show that these resources impact performance (or success), with one difficulty: the complexity of evaluating actual performance.
With this in mind, we are developing a system for collecting performance data in a real-world context based on the collection of global measurements and image analysis via AI, but also in a virtual context (VR headset). This booth will present a platform for collecting various scientific data (qualitative and quantitative tests) on psychosocial resources (cognitive, emotional, and social dimensions) as well as performance data. This platform offers a decision-making support process based on this data collection. At this booth, we will illustrate the link between cognitive tests and performance measurements in a VR headset and heart rate measurement.





Tools/methods

The tool used is a data centralization platform, a VR headset, and a heart rate sensor.

Principle demonstrated

The principle we are seeking to demonstrate is the link between isolated measurements of executive functions and instantaneous mood and results in an immersive and emotionally "hot" context.

Examples of application

One possible example is in the context of sports, where clubs need to recruit, support, and predict upward or downward performance trends, limiting psychosocial risks or supporting the resumption of cognitive-emotional training after an injury. This ambition is based on the possibility of measuring the cognitive-emotional and positional (social) state of subjects and groups.

Simulating sensory-motor aging: a valuable tool for better understanding senior citizens

Jeremy VILLATTE (CeRCA)

Scientific content

Normal aging is characterized by both sensory-motor impairments (e.g., decreased visual and hearing acuity, muscle loss, and loss of balance) and a number of cognitive changes that can lead to complaints (e.g., memory problems, needing more time to understand a problem). The link between sensory-motor function and cognition in aging has been studied for several years now, and several findings indicate a relationship between sensory-motor and cognitive abilities (Baltes & Lindenberger, 1997; Li et al., 1998). It thus appears that sensorimotor disorders can predict the performance of seniors on tasks involving reasoning, memory, processing speed, or general knowledge. Studying the sensorimotor disorders that characterize normal aging could therefore provide a better understanding of the cognitive changes that accompany it. Aging simulators have been developed to reproduce in young adults the sensorimotor difficulties faced by older adults. They can thus be used to determine whether peripheral impairments influence the performance of cognitive tasks.
In addition, by putting young individuals “in the shoes” of older individuals, they can be useful for studying the psychosocial factors that may influence their cognitive performance.

Tools/methods

There are many devices that simulate aging, but they all have the same goal: to mimic as closely as possible the sensory-motor changes associated with advancing age. To do this, they generally incorporate four types of modules: the head module (vision, hearing, and neck motor skills), torso (spinal movements), arms (touch, joint movements, and fine motor skills), and legs (walking and gross motor skills). However, it is important to note that certain sensory declines, particularly taste and smell, are difficult to simulate.

Figure 1 : Illustration of some simulator models (a) Gerontological Test Suit (GERT), (b) The Aged Simulation Set LM-060, (c) Age Gain Now Empathy System (AGNES), (d) Genworth R70i and (e) Sakamoto Model M176.

Demonstrated principle

We seek to determine whether simulating the sensorimotor impairments characteristic of normal aging can result in patterns of cognitive impairment comparable to those observed in older adults.

Examples of application

Ageing simulators enable young subjects to perceive and move around in conditions that are closer to those experienced by older adults. When young adults wear the simulator while performing cognitive tasks that are usually difficult for older adults, this could provide a better understanding of the extent to which these difficulties are caused by their sensory or motor impairments. It is also possible to use ageing simulators as tools to enable young It is also possible to use aging simulators as tools to help young adults better understand the reality of the sensory-motor impairments that characterize aging, which could be useful in reducing negative stereotypes about older adults.

The smart mattress, a non-intrusive device for measuring physiological signals

Claude Elvire KENGOUM (CHArt)

Scientific background

Since its discovery in 1877, ballistocardiography (BCG), which measures body movements generated by blood ejection, has proven effective for non-intrusive monitoring of cardiorespiratory activity. Thanks to technological advancements, it has evolved into intelligent, precise, and robust systems. The device developed in this project transforms a mattress into an innovative medical tool, with precision comparable to current clinical devices. The integrated sensors convert movements transmitted to the bed surface into actionable information, such as heart and respiratory rates. This system enables discreet, contactless monitoring, with promising applications in research, medicine, telemedicine, and sports.

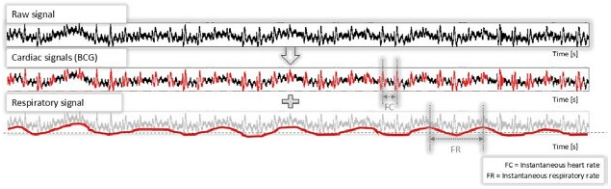


Figure 1 : Processing of physiological signals from a smart mattress. The raw signal captured is broken down into cardiac (BCG) and respiratory signals, allowing real-time extraction of physiological parameters such as heart rate (HR) and respiratory rate (RR).

Method

A four-step mechanical approach was implemented to ensure the device's accuracy and robustness under various stresses (in diverse contexts). The first step involved characterizing the mattress's mechanical properties through compression and indentation tests, revealing its visco-hyperelastic nature. Then, behavioral laws were established, using Maxwell's model for viscous properties and Ogden's model for hyperelastic properties, with parameters adjusted to the material. The second step measured body movements using transmitters and receivers based on microphones. The third step used these data to simulate mattress deformations caused by cardiac impacts via ANSYS software. Finally, real-life tests on over 1000 participants of various sizes and ages validated these simulations.

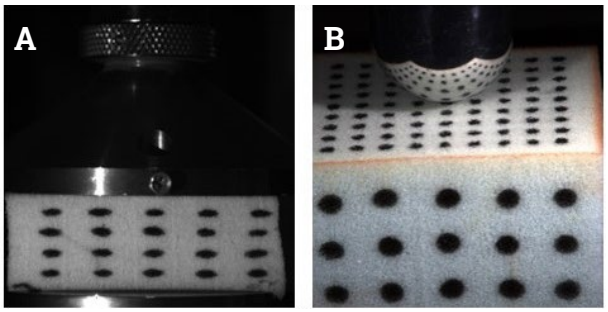


Figure 2 : Tests conducted on mattress samples used in the device. (A) Uniaxial compression using a flat plate, and (B) Indentation test to characterize the visco-hyperelastic properties of the material.

Results

We validated the feasibility of the device across a large population with a reliable protocol. The prototype, ready for clinical trials, allows for the visualization of cardiac signals, motion detection, and extraction of heart and respiratory parameters.

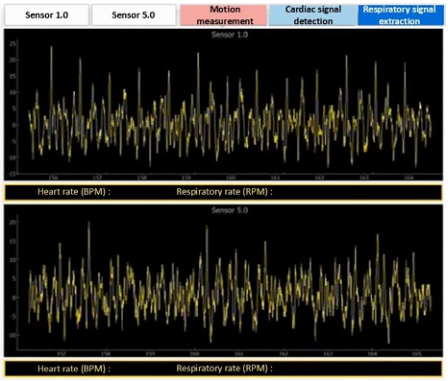


Figure 3 : Visualization of the interface showing various options, such as visualizing cardiac and respiratory signals extracted from sensors 1.0 and 5.0, motion detection, and cardiac event detection. The interface also displays physiological parameters, including heart rate (BPM) and respiratory rate (RPM).

Discussion

The validation of the device across a large population demonstrates its potential for non-intrusive cardiorespiratory monitoring in various contexts. The precision and robustness of the prototype make it a promising candidate for clinical trials. However, further studies, particularly longitudinal ones, are necessary to assess its long-term performance in diverse environments, such as hospitals and homes. The integration of this technology in telemedicine opens up new opportunities for remote monitoring but requires specific validations. Lastly, continuous improvement of algorithms, particularly through artificial intelligence, could further refine the detection of cardiac and respiratory parameters, expanding its applications in the prevention and monitoring of chronic diseases.

Virtual reality learning in a forest ecosystem

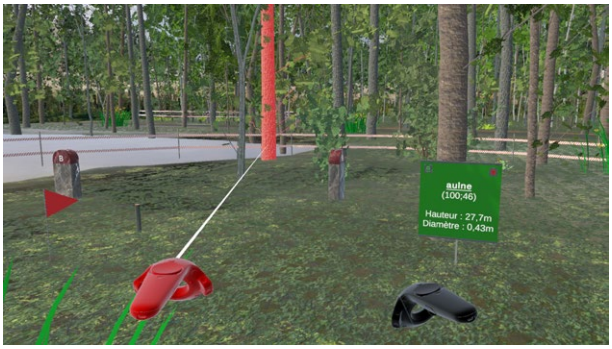
Noé MONSAINGEON and Jean-Michel BOUCHEIX (LEAD)

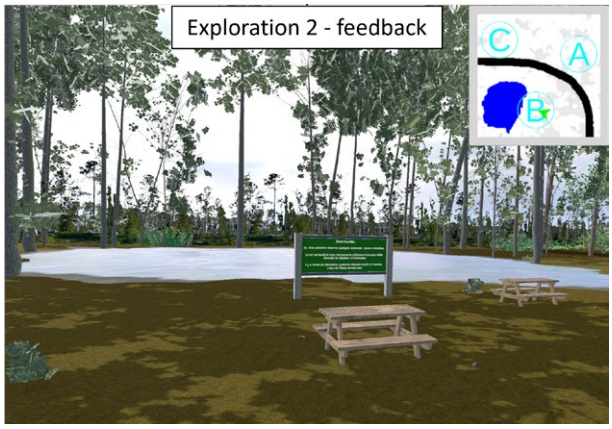
Scientific content

Immersive virtual reality allows learners to be placed in three-dimensional learning material, enabling them to see and hear things that could not be perceived in reality. However, learning in IVR is not always equivalent to conventional media (Coban et al., 2022). Several factors may explain these differences, such as the amount of visual stimuli, the level of task control, or the degree of immersion (Makransky et al., 2019). In order to improve the ergonomics of virtual environments in a learning context, a field of research is developing and evaluating principles derived from studies on multimedia learning (Albus et al., 2021, 2023; Makransky, 2021). These principles advocate adapting virtual environments to the limitations of the human cognitive system. The present demonstrator made it possible to test the effect of multimodality, visual guidance, and feedback on learners' learning and eye behavior.

Tools/methods

Two virtual reality applications are presented. The first application offers a multimodal and interactive lesson on competition for light between a beech tree and an oak tree in a forest environment. A virtual forest was represented with the two trees placed in the middle of a surrounding forest. Learners had the opportunity to move around and look at 360 degrees to observe the evolution of the trees. The second application allows learners' attention to be guided and enables them to visualize the effect of their actions over a time scale of around ten years. It offers a task dedicated to forestry students, which consisted of exploring forest areas and determining the most suitable location for welcoming visitors. Users can move around, consult information on the elements surrounding them, such as trees, herbaceous plants, and the presence of animals, and then visualize the effect of visitors' passage over 10 years. In both applications, eye movements over elements of the environment are measured to assess what learners are paying attention to. In particular, this method makes it possible to assess whether students are paying attention to elements that are relevant or irrelevant to learning.





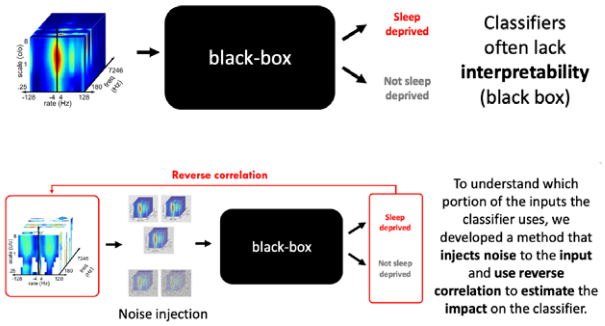
Proven principle

These applications make it possible to evaluate principles for using immersive virtual reality in the context of learning. They help us understand the usefulness of promoting auditory modalities in addition to visual modalities in a virtual environment. They also help us understand how to guide learners' attention by pointing out relevant elements. Finally, they demonstrate the need to show students projections of the future in virtual reality.
Today, these applications are used in the context of forest ecosystems, but virtual reality learning is also used in other sectors, such as industry and nuclear power.
The principles established for the proper use of VR can be applied to other sectors.

Automatic extraction of biomarkers through AI explainability

Etienne THORET and Daniel PRESSNITZER (LSP)

Laboratoire des Systèmes Perceptifs



Scientific content

Machine learning methods are increasingly being used to identify predictive biomarkers in various medical fields. However, the complexity of models, particularly deep neural networks, poses a challenge in terms of interpretability, making it difficult to clinically validate the identified biomarkers. In this context, the integration of explainability techniques helps overcome these limitations by providing explanations of how models learn and use data characteristics to predict clinical outcomes. This project aims to develop automatic biomarkers using machine learning algorithms combined with explainability techniques such as the bubble method and the reverse correlation method. By combining these methods, we can identify the most relevant features for prediction. This approach ensures a better understanding of the models, improves clinician confidence, and facilitates the adoption of biomarkers in clinical settings. The results show that the use of these techniques allows for robust and interpretable biomarkers.

Tools/methods

To develop automatic and interpretable biomarkers, we have implemented an approach combining machine learning algorithms and explainability techniques that we have developed based on the bubble method and reverse correlation. The bubble method and the reverse correlation method consist of randomly disrupting the input data locally in order to measure the impact on the model's prediction. These techniques make it possible to visualize areas of interest in the data in terms of "AI black boxes" by highlighting the characteristics that are most influential for the final decision. It is particularly useful for interpreting complex neural networks by providing clear visual explanations of the contributing factors . By combining these two approaches, we were able to develop a robust explainability strategy that not only enables the creation of automatic biomarkers, but also provides accurate and visual explanations to clinicians, thus facilitating the interpretation of results and their clinical validation. The analyses are performed on a variety of clinical data sets, and the results demonstrate the relevance and robustness of the biomarkers generated using these explainability methods.

Proven principle

The integration of explainability methods into the process of automatic biomarker creation makes it possible to overcome the traditional limitations of machine learning models in terms of interpretation and clinical validation. By applying the bubble method, for example, to EEG data from sleeping individuals, we have demonstrated that the areas of interest identified by the model coincide with the clinical characteristics recognized by experts in the field, thus validating the relevance of the generated biomarkers. In addition, the reverse correlation method revealed complex relationships between different variables, highlighting non-trivial interactions that might have been overlooked with more traditional techniques for identifying markers of fatigue in the voice. These approaches were tested on several clinical data sets. The results showed that the biomarkers produced were both robust and interpretable, paving the way for wider adoption in real-world medical settings. By providing a better understanding of the prediction mechanisms, these methods increase practitioner confidence and facilitate clinical decision-making, while reducing the risk of interpretation errors.

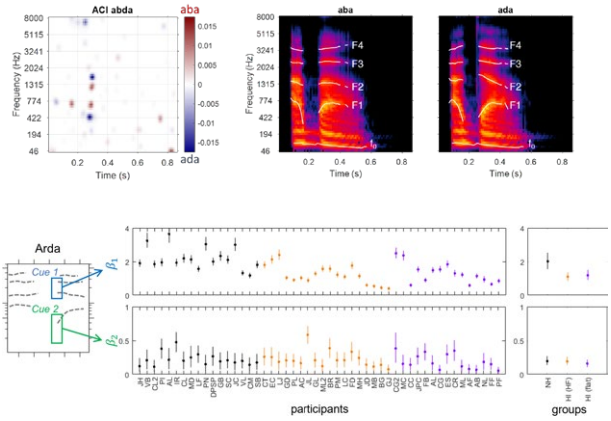
Application examples

The explainability methods developed have been applied to various fields, illustrating their versatility and effectiveness. In the diagnosis of vocal fatigue, they have made it possible to identify specific vocal characteristics (such as variations in timbre and prosody) that change with the state of fatigue. This information is essential for creating reliable biomarkers that can detect fatigue from short vocal sequences. For the diagnosis of attention disorders via the voice, reverse correlation was used to identify anomalies in vocal patterns that could indicate concentration problems, such as hesitations or irregular variations in speech rate. This approach helped to identify biomarkers related to individuals' attention abilities. In the context of vocal characterization of the effects of cognitive behavioral therapy (CBT) on insomnia, explainability techniques revealed subtle changes in the modulation and fluency of patients' voices before and after treatment.

Exploring listening strategies for people with hearing loss who use hearing aids

Léo VARNET (LSP)

Laboratoire des Systèmes Perceptifs



Scientific content

Understanding speech relies on the brain's ability to decode speech sounds into a series of phonemes. To do this, our auditory system extracts certain very specific pieces of information from the sound, known as acoustic cues. People with hearing loss are no longer able to correctly perceive all of the acoustic cues available in sound, which compromises their ability to communicate on a daily basis. Hearing aids are currently the preferred solution for hearing impairment. Unfortunately, this approach does not always restore completely normal hearing perception: sounds that are once again audible sometimes remain unintelligible. The development of new, more effective hearing aid systems, as well as more sophisticated diagnostic tools, necessarily requires a detailed study of individual listening strategies in people with hearing loss.

Tools/methods

The Auditory Classification Images (ACI) method allows for direct and highly detailed visualization of a participant's listening strategy. The basic principle of this approach is based on the study of comprehension errors made by the participant. The Auditory Classification Image obtained corresponds to a time-frequency map of the sound elements on which the listener relies to understand. ACI is therefore a new purely behavioral imaging technique for auditory perception. By allowing the sound information on which the participant focuses their attention to be visualized, the method offers a form of "ear-tracking" with unprecedented accuracy, opening up new perspectives for understanding and improving hearing aids. The implementation of studies is simplified by the open access fastACI toolbox, which automates the performance of ACI experiments and the analysis of the data collected.

Demonstrated principle

The audio files provided demonstrate the principle of the "microscopic noise effect" that underpins the ACI approach. A particular noise recording can induce a systematic noise bias in favor of a particular interpretation of the sound. Here, for example, a succession of sounds is presented in white noise, selected to maximize the microscopic effect.
This microscopic noise effect is the fundamental principle of ACI. By exposing participants to a large number of random noises, it then becomes possible to analyze those that led to response errors in order to identify the spectro-temporal regions associated with the relevant acoustic cues.

Examples of application

The Auditory Classification Images method offers unparalleled accuracy compared to previous psycholinguistic approaches for exploring the listening strategies of hearing-impaired people who use hearing aids. Thus, in a recent study, we demonstrated that hearing-impaired listeners with hearing aids did not combine high-frequency and low-frequency acoustic cues in the same way as normal-hearing listeners. These results highlight the need to develop personalized approaches to improve the effectiveness of hearing aids, taking into account the cognitive and auditory specificities of each user.

How does physical activity support memory?

Séverine FAYET and Ilona MOUTOUSSAMY (CeRCA)

Scientific background

Aging is often accompanied by a decline in memory capacity, partly explained by a decrease in executive functions with age. These functions—such as the ability to ignore irrelevant information, switch between tasks, and update information in real time—are essential for learning and retrieving information from memory. It is well established that physical activity protects against memory decline associated with aging, although these benefits vary depending on the task. Those who engage in more physical activity maintain better memory performance despite aging, especially in complex tasks. These tasks rely more on executive functions, which are themselves enhanced by physical activity. One of the main challenges is to better understand how physical activity improves memory in order to better guide future interventions for older adults. We propose that physical activity enhances executive functions, which in turn improves memory.

Method

Adults aged 20 to 40 and 60 to 85 participated in the study. Their physical activity over the past 12 months was assessed based on the intensity, frequency, and duration of their sports and leisure activities. Participants learned a list of words following this procedure (see Figure 1): they first memorized a series of numbers and letters (e.g., 5B6J9) before each word, then recalled this series after the word was presented. Subsequently, the first three letters of each learned word were shown to facilitate word retrieval, and participants had to indicate whether the word was old (learned) or new (unlearned). Finally, various tests were administered to assess the participants' executive functions.

Results

Statistical analyses highlighted two key points. On one hand, physical activity protects against age-related decline in memory and executive functions. On the other hand, the effects of physical activity on memory appear to be explained by the preservation of executive functions in older adults.

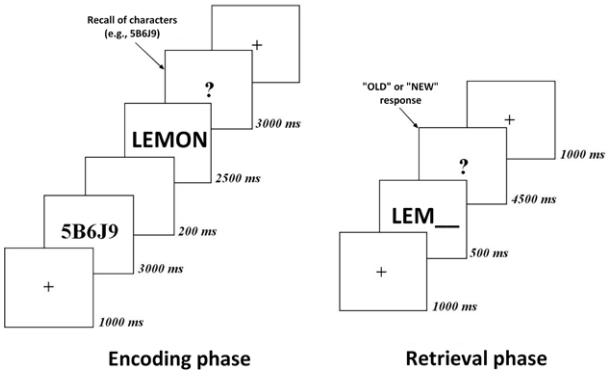


Figure 1 : Representation of the Word Encoding and Retrieval Procedure.

Discussion

The study highlights a crucial aspect of the benefits of physical activity on the memory of older adults. Specifically, engaging in physical activity appears to enhance executive function, which in turn supports memory. This understanding will help better assess the advantages of physical activity in care programs for older adults. Consequently, it may guide recommendations to incorporate physical activity as a key component in interventions aimed at maintaining and improving cognitive health in older adults.

Artificial intelligence

Developing “human-centric” AI is one of the pillars to overcome the limits of current systems. One of the keys is the fundamental alliance between computer science, human sciences and life sciences. ChatGPT reveals the progress and challenges of AI, illustrating the latest advances in natural language processing programs. However, experts agree that it is not yet capable of completely replacing human analysis.

Interactive discovery of recurring patterns in time series

Thibaut GERMAIN and Christophe LABOURDETTE (Centre BORELLI)

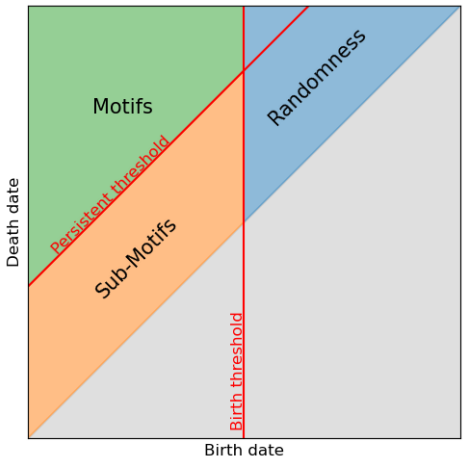
Scientific content

The analysis of time series based on their recurring patterns is a relevant approach in many fields. However, existing algorithms for pattern discovery are generally difficult to parameterize and require business expertise, leading to trial-and-error parameterization. To overcome this ambiguity, we propose an application based on topological data analysis tools to facilitate pattern discovery from visual and aggregated representations of a time series. Applicable in many contexts such as physiology and neuroscience, this application is aimed at engineers and researchers wishing to better understand the nature of high-dimensional time series.

Tools/methods

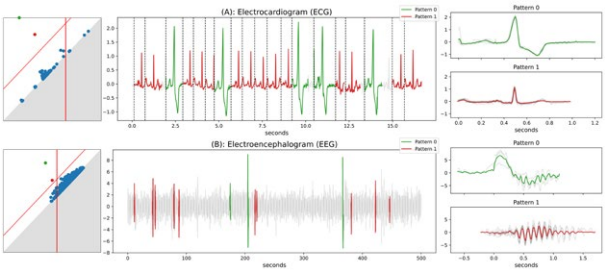
The application is based on a motif discovery algorithm [Germain, T., Truong, C., & Oudre, L. (2024). Persistence-based motif discovery in time series. IEEE Transactions on Knowledge and Data Engineering] which:

1. Transforms a time series into a graph where nodes are subsequences and edges are weighted by a distance between subsequences.
2. Summarizes the graph by persistent homology into a diagram from which it is possible to identify sub-graphs associated with recurring patterns.
3. Merges adjacent subsequences of subgraphs for sets of recurring patterns.



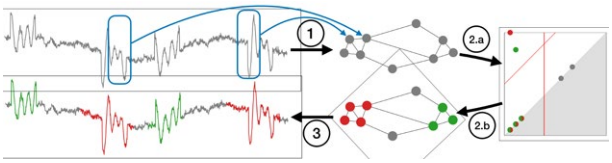
Principle demonstrated

On the persistence diagram of a time series, the sets corresponding to recurring patterns are in a specific region (top left). Simply set two thresholds to isolate this region and deduce the patterns very quickly (linear in time series size). Moreover, the readability of the diagram can be improved by adjusting the distance parameters. Given the interpretability and speed of the algorithm, the persistence diagram becomes a central pillar for understanding the structure of the time series and deducing its patterns.



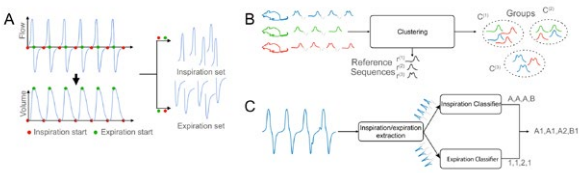
Application examples

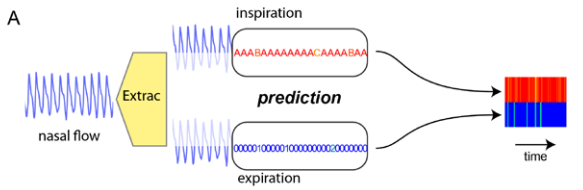
This method is illustrated on electrocardiograms, where it can be used to find patterns indicating cardiovascular pathology. Similarly, on encephalograms of a sleeping subject, it is possible to detect patterns indicative of phase-two sleep, typically K-complexes and sleep spindles.

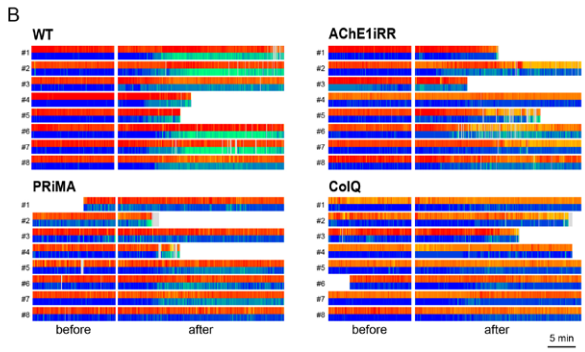


Ventilation analysis using plethysmography signals

Thibaut GERMAIN and Christophe LABOURDETTE (Centre BORELLI)







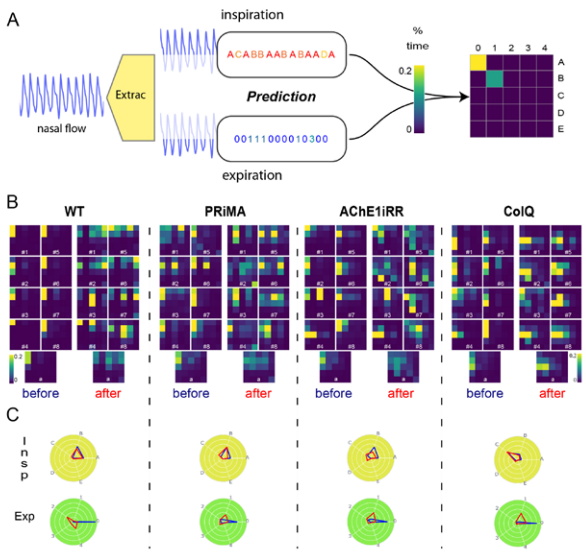
Scientific content

Ventilation is a simple physiological function that ensures the vital supply of oxygen and the elimination of CO2. This function is generally evaluated using plethysmographic signals. Today, this analysis is based on simple descriptors of the respiratory cycle (inspiration/expiration) such as its duration, and these are often aggregated over time. Unfortunately, this methodology only captures part of the dynamics of respiratory exchanges. The proposed application offers a new classification of respiratory cycles that captures the diversity and dynamics of respiratory exchanges. It also makes it easier to understand the signals recorded on a cohort, thanks to global and visual representations.

Tools/methods

This method is composed of three parts [Germain, T., Truong, C., Oudre, L., & Krejci, E. (2023). Unsupervised classification of plethysmography signals with advanced visual representations. Frontiers in Physiology, 14, 1154328].:

1. Detection and segmentation of respiratory cycles into sequences of inspirations and expirations.
2. Unsupervised learning of prototype inspirations and expirations with a time series-specific clustering algorithm.
3. Symbolization of plethysmography signals from prototype inspirations and expirations.

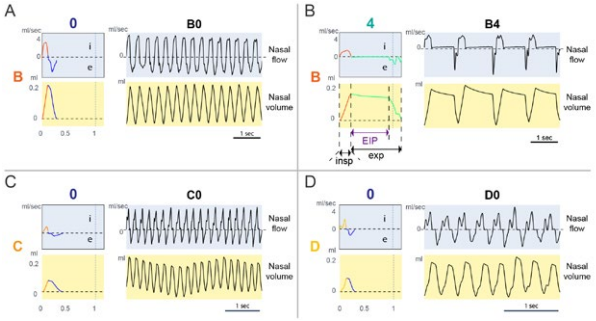


Demonstrated principle

This method makes it possible to characterize respiratory modalities that are indistinguishable from conventional descriptors of respiratory cycles, and which, moreover, are characteristic of different genotypes and exposure to toxic drugs that alter respiration. Similarly, the symbolic representation of a plethysmographic signal provides a global and local view of a mouse's respiratory dynamics.

Application examples

The method is illustrated on a dataset containing plethysmography signals from 32 mice of 4 different genotypes. All mice are exposed to a respiration-altering drug after 20 minutes of recording. The figures illustrate the differences between genotypes as well as the evolution of respiration after drug injection.



SmartDetector, a new tool for action observation studies

Christel BIDET-ILDEI (CeRCA)

Scientific background

Observation and recognition of actions play a significant role in daily life and have been the subject of extensive research. Over the past four decades, an intriguing methodology known as the point-light display (PLD) paradigm has been developed to study action observation. This method involves using animated sequences that represent the main joints of a moving actor. PLDs have proven valuable for understanding the mechanisms involved in action observation, particularly in learning and rehabilitation contexts. However, traditional PLD generation methods, such as motion capture, are costly and challenging to apply in real-world situations like patient care or sports activities. Consequently, there is a need for automated and cost-effective tools to efficiently generate PLDs in real-world settings.

Method

Here, we introduce SmartDetector, an AI-based program for automatic PLD generation and visualization. The system is integrated into an open-access, user-friendly web interface, making it available to novice researchers (https:// plavi mop. prd. fr/ index. php/ en/ automatic- creation- pld). The automatic PLD generation method is illustrated in Fig. 1. First, human posture is detected in recorded RGB video using a convolutional neural network-based approach. Then, human joints are extracted as sequences of 2D coordinates (x, y) within the camera plane. Based on prior psychological research, the 13 most important body parts (right/left shoulders, elbows, wrists, hips, knees, ankles, and nose) are identified in the video frames. The spatial coordinates of the joints are then recorded as animated PLD sequences representing the action in the video. The algorithm also generates CSV files containing the x and y coordinates of each landmark. Notably, all processing steps are performed in real-time. We then assessed the perceptual performance of 126 adults using the PLDs generated by SmartDetector and compared the results with those reported in the literature.

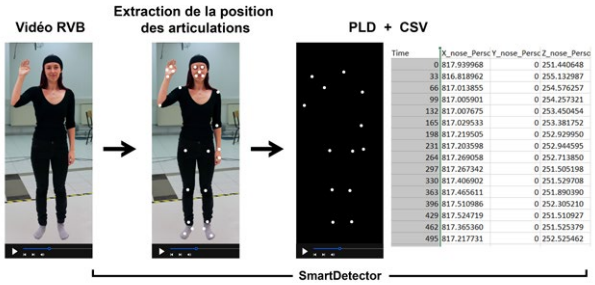


Figure 1 : Proposed method for PLD generation with SmartDetector.

Main results

The results showed that, regardless of the task (detection/ discrimination or recognition of PLD), the PLDs generated by SmartDetector achieved perceptual performance levels equivalent in terms of accuracy and response times to those reported in the literature.

Discussion

The proposed SmartDetector application offers a promising alternative to traditional motion capture, particularly when motion capture is difficult to implement, such as with patients or during sports activities, or when time constraints exist between capture and obtaining usable PLDs. Future developments include creating systems for generating PLDs for fine motor actions and facial expressions, as well as adapting the algorithm to handle multiple actors.

CHAWA, Chatbots With Attitude: demonstrating chatbots with distinct, engaging personalities

Fabrice LEFÈVRE (LIA)

Scientific content

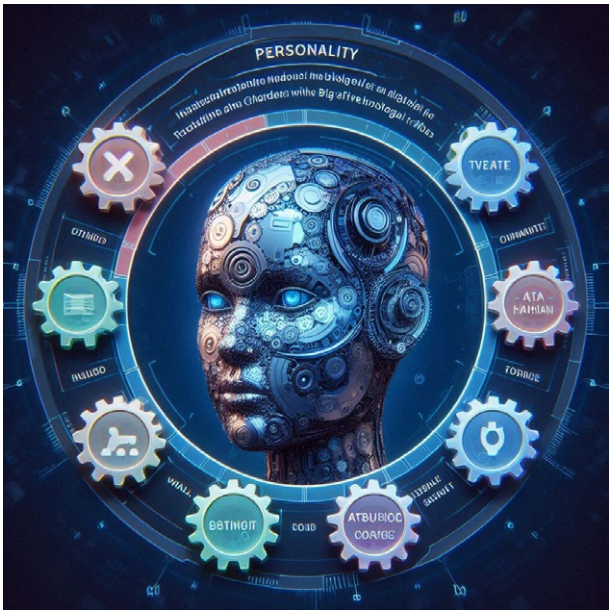
These chatbots are designed using a sophisticated architecture that combines large language models (LLM) and information retrieval techniques (RAG), enabling them to perform specific tasks while embodying a predefined personality. Leveraging the generative power of LLMs, we aim to test whether they are capable of generating natural, coherent and adaptive dialogues, even in open-domain environments, while remaining guided by the simulated personality of the conversational agent.

Tools/methods

Based on an architecture combining LLM (open-source) and RAG, chatbots are built to perform their task while expressing a specific pre-defined personality.

Demonstrated principle

Ability of LLMs to generate natural, consistent dialogues in an open domain, guided by a simulated personality of the conversational agent. Objective and subjective evaluation measures to assess the accuracy of the modeling chosen and its impact on the nature of the dialogues generated with humans.



Application examples

Voice coache (psychological and medical support, training for teleoperators, etc.).

Cognitive enhancement technologies

« Cognitive enhancement » is a cross-cutting field of research at the frontier between human-computer interaction, psychology, ergonomics and neuroscience. It aims to create innovative interactions that help, supplement, or increase the capacities for human processing of information. The creation of such interactions comes from the ability to measure in real time human information processing and the cognitive states of users.

The development of new interactions makes it possible, for example, to design innovative uses, « affective » conversational agents or adaptive interfaces according to a user's profile or behavior.

Philippe TRUILLET - Scientific Coordinator

Robotic assistance for learning and relearning motor gestures: optimizing human-robot interaction

Victor FRANCISCO, Christel BIDET-ILDEI and Arnaud DECATOIRE (CERCA)

Scientific background

The use of robotic assistance in rehabilitation presents promising opportunities, but it is crucial that robotic guidance is well designed to enable the patient to learn without the robot taking full charge of the movement. Most existing systems act more as assistive devices than learning devices, which may limit the transfer of learning to everyday life. What sets this study apart is the use of an innovative device to simultaneously learn trajectory and motion dynamics. To optimize learning of a complex movement, we explored two frequencies for presenting visual feedback on the movement.

Method

The learning protocol took place over two days: on the first day, participants performed six blocks of 15 trials. The task was to reproduce a couple-movement profile following a reference model, with constant visual feedback for the Limited Control group and decreasing frequency for the Fading group (100% to 0% over the six blocks of trials). On the second day, all participants first performed a block without feedback (transfer test), then with feedback (retention test).

Results

The results showed that the Fading group performed better in the transfer test (without visual feedback) compared with the group that always had access to visual feedback on the torque actually produced compared with the required torque (i.e., RMSE).

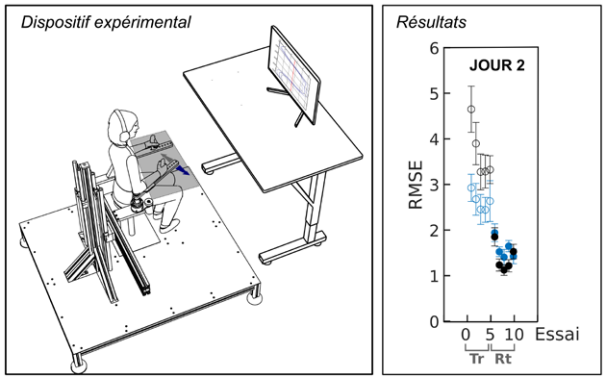


Figure 1 : A) Experimental set-up. Participants were taught to produce a complex torque vs. motion profile. A screen was used to display (or not, depending on the trial) continuous visual feedback of desired vs. produced torque. B) Results. Root-mean-square error (RMSE) between desired torque and produced torque as a function of group (Control: black; Fading: blue) and feedback availability (Open circle: No feedback; Closed circle: Visual feedback). Tr: Transfer test; Ret: Retention test). Error bars correspond to standard errors.

Discussion

Robotic devices are commonly used to aid body movement learning, but typically focus on trajectory learning without including task dynamics. In this study, we examined whether participants could learn a torque-movement profile with admittance control. The results showed that participants made significant errors at the start of practice, as the dynamics of the task were not yet integrated by the central nervous system. The robot's assistance prompted participants to adjust their motor commands, thereby improving their performance. However, the Fading group, which received less and less visual feedback, performed better on the transfer test (Day 2) than the Control group, suggesting that gradually reducing visual feedback promotes more robust long-term learning by reducing dependence on feedback. These results underline the importance of a balance between visual feedback and the use of proprioceptive cues for learning complex movements.

Little robot, my friend

Valentina CARAVETTA (CHArt)

Scientific content

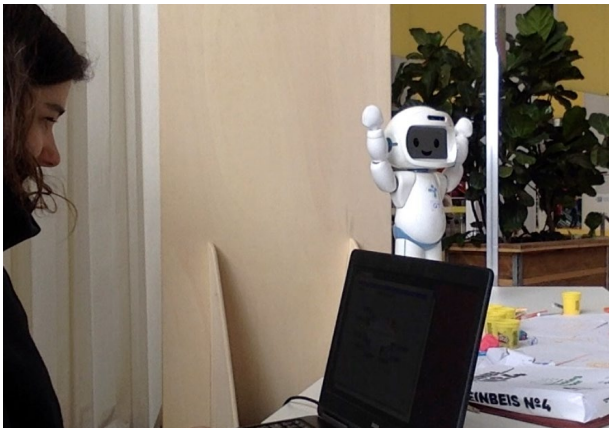
Social robotics represent a new aid for the treatment of childhood neurodevelopmental disorders (CND): robots can produce clear, easy-to-understand verbal and non-verbal social signals, and maintain engagement in children generally resistant to treatment with a human therapist. They reduce the stress of therapy and improve learning and concentration in young patients.
Studies, still in their early stages, are moving towards the use of technologies in hospital and school settings, and are aimed primarily at the treatment of autism and learning disabilities. Recent research has also shifted the focus to home-based intervention.

Tools/methods

The aim of the study was to explore the feasibility of the "child-robot-caregiver" system. The following technological tools were used as aids to the development of the "Child-Robot-Caregiver" system: the QTrobot, controlled via Wizard of Oz, and the Rehabilitation Robotic Companion for Children and Caregivers (R2C3) interface.
To build the activities, we drew on existing training programs in the literature and theories of play in child psychology. The interaction activities involve the child, the robot and the caregivers. The experimental protocol was customized with the help of the team from the Child and Adolescent Psychiatry Department of the Pitié-Salpêtrière Medical Hospital, to suit the difficulties and resources of children with neurodevelopmental disorders.

Demonstrated principle

By integrating the technological resource of a social robot into the treatment, the proposed rehabilitation can help to improve the development of the child's cognitive and emotional capacities, by offering training and learning where the child is in difficulty, and by reinforcing the capacities already present.
This kind of rehabilitation is not standardized, but tailored to the needs and particularities of each individual, adding a playful dimension to hospital care that is particularly useful for its intensity.
Interaction with a robot companion, and the balance between entertainment and clinical intent (easily concealed), can effectively accelerate the development of a child's skills.



Application examples

The study provides an innovative use of technology in the treatment of various forms of childhood neurodevelopmental disorders. The interactive child-robot-caregiver activities can be carried out both in hospital and at home. The program comprises three categories of play activities:

1. motor rehabilitation exercises ;
2. emotional expression activities;
3. social skills development activities.

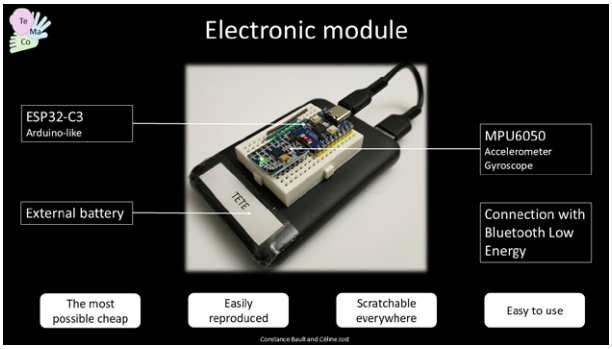
The robot has been programmed to provide feedback to the young participant during games shared with caregivers. In particular, the robot can provide encouraging feedback to the child's every step forward, reinforcing the skills acquired.

Portable digital device to make functional rehabilitation more fun

Céline JOST (CHArt)

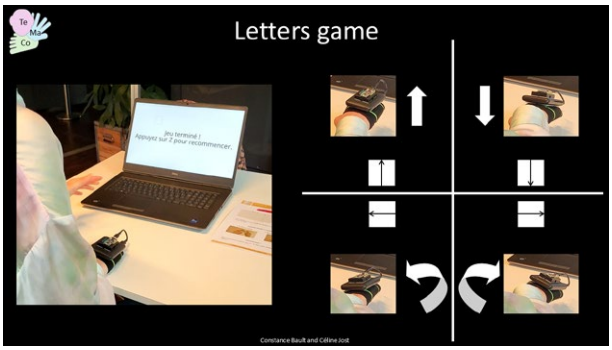
Scientific content

As part of rehabilitation protocols, patients are often subjected to intensive, repetitive exercises designed to optimize the recovery of their motor or cognitive functions. However, occupational therapists frequently observe lassitude and reduced motivation, which have an impact on rehabilitation. The TeMaCo project proposes to address this issue by designing a portable digital device designed to capture and analyze patients' movements, with the aim of providing feedback on a screen. Initially, the aim is to explore the acceptability and usability of such a technology, both in the general population and among occupational therapists. This multidisciplinary project brings together researchers specializing in computer science, electronics, occupational therapy and ergonomics. The ultimate aim will be to identify and explore the levers likely to encourage active and lasting involvement of patients throughout their rehabilitation process.



Tools/methods

To carry out this feasibility study, the project followed a user-centered approach: (1) a needs study carried out with 31 occupational therapists confirmed the interest in such a tool, (2) an evaluation of the device was carried out with 13 students from the Master Technologie et Handicap at Université Paris 8, (3) games were developed and then tested at 4 research or general public events, and improved with each feedback, (4) once all feedback had been taken into account, feedback was collected from 101 visitors to the Cité des Sciences et de l'Industrie in Paris, (5) an acceptability and usability assessment was carried out with 35 healthcare professionals in 5 regions of France (27 occupational therapists and 8 physiotherapists).



Principle demonstrated

A survey of the general public at a science popularization event at the Cité des Sciences et de l'Industrie in Paris involved 101 people (51 women and 50 men) aged between 5 and 75 (mean: 20 years; standard deviation: 15.60). The majority of people preferred TeMaCo (compared with a computer) for playing games (56.4%), exercising (90.1%) and learning lessons (62.4%). Participants were almost unanimous in their desire to use TeMaCo again (97%).
An evaluation with professionals involved 27 occupational therapists and 8 physiotherapists (24 women and 11 men) aged between 22 and 64 (mean: 40.6 years; standard deviation 12). TeMaCo achieved an F-SUS acceptability score of "excellent" (87.4). The majority of occupational therapists thought TeMaCo would be useful in their work (82.86%), and expressed their intention to use the system (77.14%). Finally, 97.14% of professionals thought the system was fun to use.

Examples of applications

According to the general public, TeMaCo can be used for learning purposes, for example to develop gross and fine motor skills, or to learn to concentrate. TeMaCo can also have applications in rehabilitation centers, where it can be used to work on both motor and cognitive functions. In particular, it can be used to propose dual tasks.
The occupational therapists we interviewed see numerous applications for TeMaCo in activities of daily living, and see great potential in geriatrics and pediatrics.
TeMaCo can also be used for home self-education. According to healthcare professionals, it would be important to pursue the project in this direction.

A mini skateboard to stimulate the motor development of very preterm infants

Joëlle PROVASI and Marianne BARBU-ROTH (CHArt)

Scientific background

Children born very prematurely, with or without brain damage, are at risk of motor and locomotor problems during development. However, early motor and locomotor training, at a time when the brain and body are highly plastic, could have positive consequences on the motor and locomotor development of these children. The objective of this study is to evaluate the effects of eight weeks of quadrupedal walking training on a mini skateboard, starting as soon as the children leave the neonatal unit and return to their parents' home, on the motor and general development of very premature infants during their first year of life.

Method

A mini skateboard was designed, patented in 2016, and has been marketed internationally and in France since January 2024. The child is placed face down on the board, so that their head and torso are raised and their arms are free to move, allowing them to propel themselves independently using their arms and legs (a propulsion method known as quadrupedal walking). A group of prematurely born children (the "Crawli" group) were trained by a professional at their parents' home for 5 minutes a day for 8 weeks on the skateboard, starting at term age (Figure 1). The motor and general developmental performance of these children up to 12 months of age was compared to the performance of two control groups: a group of premature children positioned on their stomachs on a mat without a mini skateboard for 5 minutes a day for 8 weeks, by a professional ("Mat" group) and a group of premature infants receiving standard care ("Control" group).

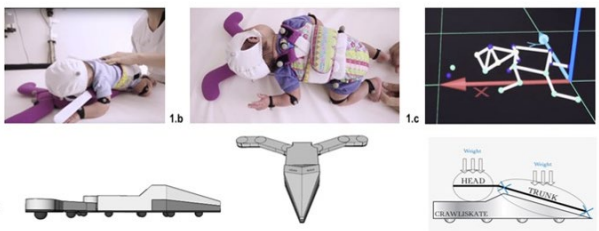


Figure 1 - 1a. Typical 2-day-old newborn lying flat on its stomach and wrapped in the Crawli; 1b. Stimulation of quadrupedal propulsion on the Crawli; 1c. 3D reconstruction of quadrupedal walking on the Crawli; 1d. Structure of the Crawli.

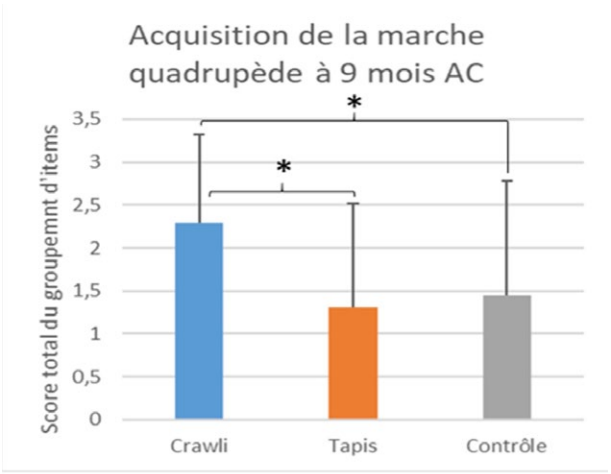


Figure 2 : Graphical representation of raw scores for grouped items on the Bayley scales reflecting the acquisition of quadrupedal walking at 9 months of corrected age. Statistical analyses were performed using Kruskal-Wallis tests. * for $p < 0.05$.

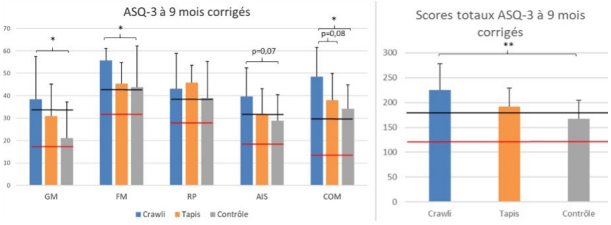


Figure 3 : The black line represents the threshold for an emerging risk score and the red line represents the threshold for a confirmed risk score. The maximum score for each domain is 60, and the maximum overall score is 300. AC stands for age-adjusted, GM for gross motor skills, FM for fine motor skills, PR for problem solving, IS for individual and social skills, and COM for communication. * for $p < 0.05$; ** for $p < 0.01$

Results

Our results show not only the feasibility of our intervention, but above all that daily stimulation of quadrupedal walking in premature infants from term age onwards has beneficial effects on the development of their crawling at 9 months of age (Figure 2), as well as on their gross motor skills and overall development (Figure 3).

Discussion

These positive results encouraged us to propose a new study (currently underway) targeting very premature infants at high risk of neuromotor disorders with 10 minutes of training per day at home, this time carried out by parents under professional supervision for eight weeks after discharge from the neonatal unit. In addition to motor and general follow-up until the age of 12 months, these children are monitored using neuroimaging (EEG and MRI) to assess the effects of training on their brain development before and after the training period. These results will be compared with those of a control group receiving standard care.

A dosimeter to protect your hearing

Arnaud NORENA (CRPN)

CRPN
CENTRE DE RECHERCHE EN PSYCHOLOGIE & NEUROSCIENCES

Scientific content

It is well known that exposure to loud sounds (>80 dB) for a sufficiently long period of time (noise overexposure) can impact the auditory system, and in particular cause cochlear damage and aggravate auditory perception disorders such as tinnitus and hyperacusis. It is difficult to avoid overexposure to sound because sounds are often "painless." In fact, the opposite is sometimes true: loud sounds are sought after because they "cut off" the world (listening to headphones or earbuds) and/or produce pleasure (concerts). Furthermore, symptoms that are aggravated by overexposure to sound sometimes appear several hours after overexposure, making it difficult to establish a correlation between overexposure and the worsening of symptoms and therefore more difficult to anticipate.

Tools/methods

The innovation is a prevention app that allows users to 1) monitor their sound environment (measure accumulated sound exposure) and 2) collect data on the severity of their symptoms directly from a smartphone. The app then provides guidance on the behavior to adopt in a given sound situation, namely reducing the sound level if possible or avoiding sound environments that are potentially harmful (noisy public places, public transport, etc.) to the auditory system and/or auditory symptoms.

Principle demonstrated

We have demonstrated the usefulness and ease of use of the solution. We have also developed a "hard" prototype that allows us to bypass the characteristics of the smartphone's sound card.

NoisyWorld

Tinnitus Hyperacusis

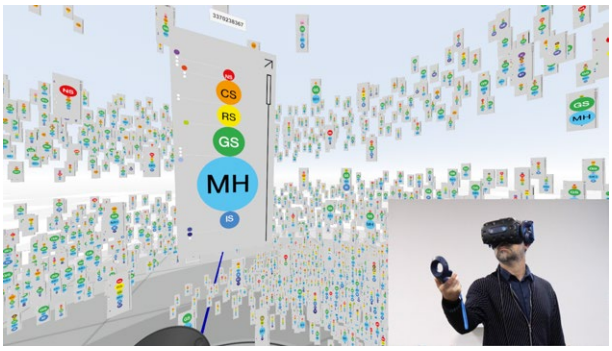
Examples of application

The auditory system has no mechanism for measuring the accumulated dose of sound, alerting the subject to impending hearing loss (by means of a painful signal, for example), and therefore protecting the auditory system from overexposure to noise and preserving hearing. By measuring the cumulative dose of sound to which the subject is exposed, the solution informs the subject of the risks involved in a given sound environment. In addition, the application establishes a correlation between sound exposure and the worsening of the subject's symptoms, which are specific to them. By being informed of their personal limits in terms of noise tolerance, subjects can have a certain amount of leeway in how they live in relation to their sound environment.

Dr Cloud, a tool to stimulate research hypotheses on genetic diseases

EnsadLab

François GARNIER, Nicolas GARCELON and Dionysios ZAMPLARAS (ENSADLab)



Scientific content

The Dr Cloud project seeks to rebuild a subjective and sensitive relationship between researchers and clinicians from the Imagine-Necker team and their clinical and genetic data. We want to recreate a sensory, visual, and tactile proximity with large bodies of dematerialized data in order to reactivate cognitive abilities that are inseparable from emotion and the body in action, in activities involving intuitive analysis of complex systems.
This heuristic approach to Big Data offers an alternative to keyword-based screen searches, combining the perceptual qualities of VR immersion (embodiment, presence, flow) with the analytical capabilities of artificial intelligence (indexing, image recognition, clustering). It places the user in a new paradigm conducive to free exploration, stimulating serendipity and spatial memory, subjective analysis, and the production of hypotheses through fortuitous association.

Tools/methods

The Dr Cloud project combines the Tamed-Cloud virtual reality system developed by EnsadLab with the Dr Warehouse medical database developed by the Imagine Institute.
Raw hospital data is transformed into a synthetic representation of clinical cases in the form of a phenotype avatar. The phenotype avatars are then spatially organized around the clinician according to specific configurations (clustering). The clinician can interact with the data thanks to a “natural user interface” design.
The Dr Cloud project is led by the Imagine Institute, EnsadLab, and ENS-DEC as part of the Vulnerabilities and Capabilities Chair and is supported by PSL Valorisation and the Carnot Cognition Institute.

Proven principle

In this immersive experience, users interact through their movements, gestures, and voice with a cloud of living, malleable images, similar to a flock of birds. They can spatially organize the data around them, grasp its mass, select groups, consult data, and memorize it.
This tool allows researchers and clinicians from the Imagine-Necker team to immerse themselves in a corpus of clinical cases structured spatially according to criteria such as proximity or relevance, in order to search, identify, and associate cases.

Application examples

The Tamed Cloud concept can be applied in many fields, including digital humanities, communication, research, and healthcare. We are developing use cases in several business studies, including:

- Curation and promotion of cultural collections
- Monitoring and analysis of trends on the web
- Analysis of clinical cases

VIICAD 1.0, Virtual Immersive Interaction for Complex Analysis and Decision

Olivier MARTIN and Pascal BELLEMAIN (GIPSA-Lab)

Scientific content

The VIICAD project is based on the development of interactive virtual environments (IVEs) using virtual, augmented, and mixed realities (VAMR) to generate contextualized interaction scenarios. The coupling of IVEs with sensors for analyzing visual information, decision-making, and adaptive behavior makes it possible to (i) define the simulation parameters of the interaction situation, (ii) identify and characterize the complexities of interaction encountered, in order to (iii) recommend the adaptation of interaction contexts to improve the decisions, behaviors, and solutions to be adopted.
VIICAD is particularly interested in dynamic data flow analysis scenarios for the simulation of humans in motion and the evolution of natural environments.

Tools/Methods

- Virtual, augmented, and mixed reality (VAMR)
- Immersion in natural, high-risk environments
- Face-to-face inter-individual simulation
- First-person interaction
- Immersive disruption protocol
- Behavioral data recording
- Analysis of information processing and decision-making
- Criteria-based evaluation model

Proven principle

VIICAD demonstrates (1) a principle of heuristic fusion of heterogeneous data and (2) its coupling with real or simulated event markers in an interactive VRAM for the study of human behavior in situations involving information processing and decision-making in disruptive environmental contexts and urgent situations requiring action. By combining the flexibility of virtual immersion, the simulation of complex environments, and the analysis of interaction performance based on criteria, the innovative VIICAD project supports multiple data analysis and decision-making strategies in increasingly demanding conditions for professionals in sectors where adaptation to complex interaction situations is crucial.

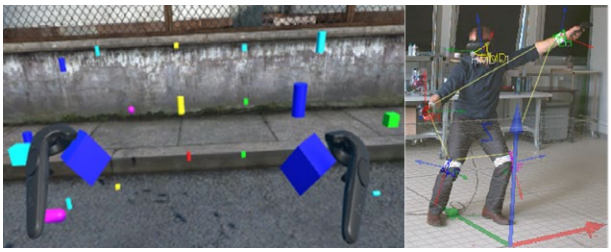


Figure 1 : Example of VIICAD-Human application - analysis of an emergency matching task involving virtual physical objects, subject to constraints of alternative choices and speed-accuracy trade-offs, with real-time recording of behavioral data.

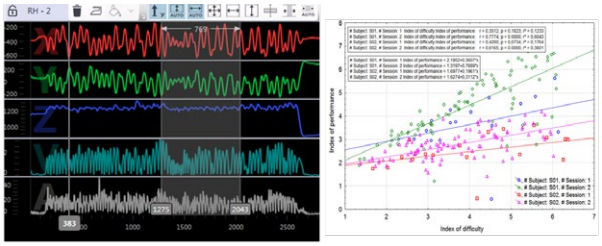


Figure 2 : Characterization of gestures and correlations between task characteristics and behavioral changes, for an assessment of interaction performance.

Application examples

VIICAD is intended for application areas that use VRAM to simulate context-dependent human-environment interaction analysis conditions, such as (1) cognitive ergonomics for task analysis and risk anticipation (GRT-gaz, EDF), (2) in sports performance, through immersion in a parameterized disturbance situation for analysis of the functional determinants for optimizing interaction performance (GEXPER-Sport), (3) in health through therapeutic stimulation (sensorimotor and cognitive) adapted to individualized patient monitoring (PIVVIT-VR), (4) in professional training through individual and collaborative e-learning, and (5) in environmental risk prevention (CPD-RISK).

LODYSEI, dynamic, semantic, and intelligent location tracking

Antonio SERPA (IRIT)

Institut de Recherche en Informatique de Toulouse

Scientific content

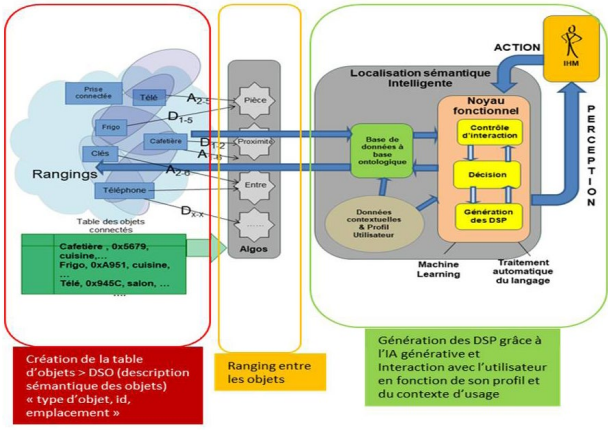
The localization of connected objects in a living environment, in a covered public and/or professional space, is a major obstacle to the deployment of interactive systems that assist in their localization. Designing technologies that assist in object localization addresses important and multi-level challenges:

- Personal safety (risk of falling while searching for objects, medical risks associated with not finding one's pill box, etc.)
- Enhancing independence and enabling dependent individuals to remain in their own homes
- Improving efficiency and quality of life at work in dangerous, complex, and/or repetitive processes
- Improving the user experience (culture, leisure, commerce, etc.)

Tools/methods

LODYSEI is a project combining disciplines from information and communication sciences (IRIT laboratory) and humanities and social sciences (CLLE laboratory).
LODYSEI is based on:

- A detailed analysis of the variability of end-user needs based on object search contexts and user characteristics (cognitive ergonomics, CLLE laboratory).
- ranging tools and methods (Internet of Things, network: RMESS team),
- artificial intelligence tools (LLMs) for generating DSPs (Natural Language Processing (NLP): MELODI team),
- and machine learning tools for adapting DSPs to user profiles and usage contexts (Human-Machine Interaction (HMI: ELIPSE team)



Proven principle

LODYSEI aims to be a groundbreaking project compared to existing approaches by transferring the concept of Semantic Position Description (SPD), which consists of generating the relative location of an object in natural language (e.g., "The keys are in the kitchen near the sink") via identifiable landmarks in the environment. This approach also considers privacy issues, particularly in the context of private homes. We want to demonstrate that this approach to object localization, which is similar to that used by humans and independent of the object's position relative to the user, is more intelligible, intuitive, and easy to remember than the point-to-point guidance approach.

Examples of application

The LODYSEI system has a wide range of potential uses. Thanks to its ability to adapt to the context of use and user profile, the LODYSEI system could be used in a variety of fields, such as enhancing independence at home for people with disabilities and/or the elderly, Industry 4.0 in critical processes such as FOD (Foreign Object Damage) in aeronautics or the nuclear sector, logistics and commerce (optimization of picking, etc.), tourism and culture (navigation in a museum, etc.), etc.

Interactive system for annotation and specific processing of 3D point clouds

Nicolas MELLADO and Loïc BARTHE (IRIT)

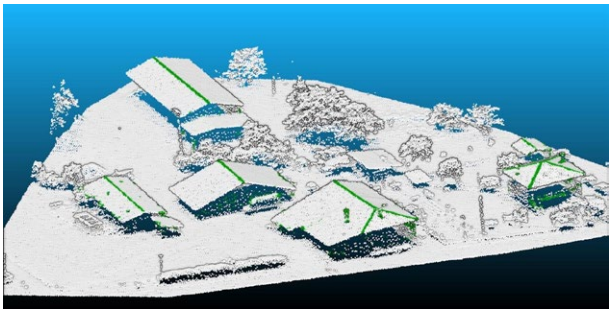
Institut de Recherche en Informatique de Toulouse

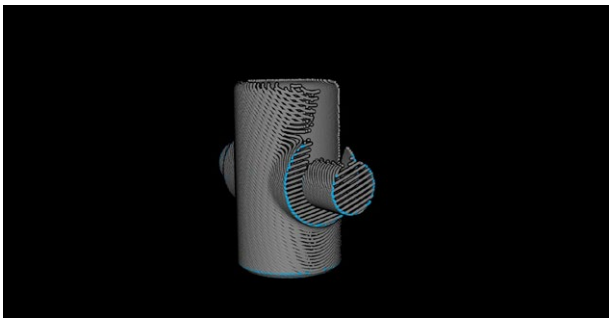
Scientific content

Our demonstrator is based on recent research showing the use of neural networks that can be trained and evaluated interactively on 3D point clouds.
We are interested in three major challenges in the processing of 3D point clouds: (1) the rapid and representative production of annotated data, (2) the rapid training of neural networks, and (3) the rapid and efficient processing of billions of 3D points acquired by manufacturers in a specific business context.
Our innovation is a solution based on specific geometric processing and a specially adapted neural network capable of addressing these three challenges.
In particular, the demonstrator offers an unprecedented capacity for annotation, training, and processing of interactive learning solutions capable of scaling up.

Tools/methods

Our approach requires small volumes of annotated data (a few hundred points may suffice), network training takes only a few seconds or minutes, and we are able to classify clouds of billions of points.





Proven principle

The demonstrator is a tool for visualizing massive 3D point clouds composed of hundreds of millions of points that have been acquired by manufacturers. Users can interactively annotate the data and then launch the network training. Once trained, the network returns the result of the point cloud processing in a matter of seconds. The user can then interactively complete their annotation in order to refine the network training and enter an “annotation/training improvement” loop to get the system to perform the specific processing desired by the user on their own data.
Our approach also makes it possible to automatically produce large quantities of annotated data quickly, which can then be used to train a more complex learning system (deeper network and/or more advanced architecture) capable of performing more complex processing.

Examples of application

Direct applications include the optimization of digital twins of energy infrastructure (power lines) and buildings, infrastructure monitoring to optimize maintenance and control risks for surveying teams and design offices that make extensive use of 3D data acquisition, the analysis and use of mechanical components to meet the needs of production line robotization in industry, and heritage preservation (recognition of pottery elements, reconstruction of structural elements of buildings, detection of human structures in outdoor acquisitions).

Board games and creativity

Todd LUBART (LAPEA)

Scientific content

The aim is to study the impact of board games on creativity. With the support of Asmodée, as part of the Homo Creativus chair at the Paris Cité University Foundation, we conducted three years of research on this topic.

Tools/methods

Board games (such as Imagine, Dixit, The Big Idea) and measures of creative potential (brainstorming tasks).

Proven principle

We observe that games involving a search for original ideas facilitate the development of creativity in young adults. These effects concern both performance in individual creative production tasks and collective creativity tasks. We interpret the observed effect in terms of priming cognitive flexibility and supporting other resources for creativity.

Examples of application

It is possible to identify board games that can stimulate creativity. These games can be used in educational and professional contexts to help develop creative abilities.

Translation of speech/text into pictograms for communication by people with cognitive disabilities

Didier SCHWAB (LIG)

Scientific content

When a person has difficulty speaking and cannot use traditional channels of communication (speech, gestures, sign language) to express a message, alternative and augmentative communication (AAC) can be used. AAC involves the use of pictograms, images representing a more or less concrete concept. Access to communication by and for all is a major challenge.
Offering a sequence of pictograms based on the voice will enable hospital staff and families to convey a message in pictograms that are easily understandable by AAC users, without any prior knowledge.

Tools/methods

To create a sequence of pictograms from spoken language, several modules are required, each with a specific task in the translation process.
Recent advances in automatic speech recognition now make it possible to transcribe what has been said more accurately. Using this text, we can perform various linguistic processes to produce a coherent sequence of words based on the pictogram bank used.
Finally, the pictograms associated with the words are selected to generate a sequence of pictograms corresponding to the spoken text.

Proven principle

Voice2Picto is free, open-source software that allows users to associate a sequence of pictograms with speech. Voice2Picto facilitates access to communication using pictograms for people who are unfamiliar with or do not use this type of medium. Families and healthcare professionals can thus have an inexpensive and easy-to-implement tool to help people who use pictograms as a means of communication.

Examples of application

A first version of the software is currently available. As the tool is open source, it can be developed further based on user feedback and technological advances.
The possible uses are numerous, even infinite, as they can be applied to many everyday situations, such as communicating a need, a desire, an emotion, telling a story, or asking someone a question.

Frequent alternation between sitting and standing body positions to optimize health, performance, and productivity

Bonnet Cédrick (SCALab)

Scientific content

Prolonged sedentary behavior (> 50% of the day spent sitting) is a societal disease of the 21st century. It affects more than half of the world's population, especially in high-income countries such as France, and causes serious diseases (diabetes, cancer, cardiovascular disease, premature death, etc.). Several countries (USA, Canada, Denmark, etc.) are extensively purchasing sit-stand desks to allow for more standing in offices. France is lagging behind and needs to equip itself extensively, especially since published articles and our research projects at the University of Lille all show that the use of sit-stand desks is beneficial i) for health (physiological, psychological, cognitive) and ii) for performance and productivity at work.
Our research team is currently finalizing and protecting a software application that accurately measures the time spent sitting vs. standing at a desk. This application also helps users achieve optimal sitting/standing use by encouraging frequent alternation between sitting and standing positions (15 min – 45 min). We emphasize the potential of this application at the socio-professional level (for users), socio-economic level (for entrepreneurs), and for research (e.g., participatory research).

Proven principle

On the one hand, it is undeniable that sitting is harmful to health. Indeed, it can cause premature death (Ekelund et al., 2016), type 2 diabetes (Katzmarzyk et al., 2019), cancer (Jones et al., 2019), chronic inflammatory diseases (Levine, 2010), etc. Prolonged sitting is also associated with psychological problems such as anxiety (Stanczykiewicz & al., 2019), depression (Verhavert et al., 2020), demotivation, discomfort (Finch et al., 2017), etc. It even has negative effects on cognitive functions (executive functions, working memory, flexibility, and attention) (Chandrasekaran et al., 2021).
On the other hand, standing is beneficial for improving performance on modified Stroop (short) tasks (Rosenbaum et al., 2017; Smith et al., 2019) and attention (short) tasks (Attention Network Task; Abou Khalil et al., 2023, 2024).
For longer tasks (> 1 hour), alternating between sitting and standing leads to better performance in office tasks than prolonged sitting (Hasegawa et al., 2001; Schwartz et al., 2018, 2019; van Steenbergen et al., 2024).
In general, individuals who use sit/stand desks are more productive at work than those who are always seated (e.g., Colleen et al., 2012; Puig-Ribera et al., 2015).

Examples of application

The first target group most concerned by sit/stand desks are people who work in an office all day (e.g., call center agents, secretaries, public and private administrative staff).
The companies that employ these people therefore should be particularly keen to equip themselves with sit/stand desks.
The second target group is people who work from home one or more days a week.
The third target group is people who work in the evenings and/or on weekends on a computer at home. In this case, individuals themselves should equip their own homes with sit/stand desks.
All of these people—and there are many of them—would benefit in the short, medium, and long term from using sit/stand desks at work and/or at home. More generally, we need to rethink our society to allow certain individuals in lecture halls and/or classrooms and/or meeting rooms to stand up and work standing up. This could be achieved by installing sit-stand desks at the back (in the last row) of these lecture halls and/or classrooms to ensure that sit/stand users do not disturb others in front of them.

FOCUS, your daily ally for a calm and focused mind

Sandrine MEJIAS (SCALab)

Scientific content

FOCUS guides users through cardiorespiratory coherence exercises. It also provides biofeedback on heart rate variability (HRV), allowing users to visualize the impact of breathing on their well-being.
FOCUS is based on solid scientific evidence showing that controlled breathing influences HRV, a key indicator of stress management. An increase in cardiorespiratory coherence through regular exercises is associated with greater emotional resilience and reduced anxiety. FOCUS allows direct intervention on the autonomic nervous system, promoting a state of relaxation and improved psychological well-being.

Tools/methods

FOCUS offers guided breathing exercises, mediated by a light halo whose intensity increases during inhalation and decreases during exhalation. These exercises can be accompanied by vibration, reinforcing the perception of rhythmic breathing. The user places their thumb on an ergonomic sensor that measures HRV.
Biofeedback is provided in real time by a light gauge, which increases as the user improves their HRV, offering a visualization of the progress made.
A mobile app allows users to track long-term progress and calibrate the FOCUS device, ensuring optimal personalization of the exercises.

Proven principle

Scientific studies conducted on children and adults have shown that conscious, guided breathing, combined with real-time HRV biofeedback, reduces physical and mental symptoms related to stress while improving well-being. Based on simple, natural, and effective principles, FOCUS helps users become more aware of their physical and emotional responses to stress. Portable and easy to use, FOCUS helps users reduce their heart rate, stress, and agitation, while improving concentration and emotional resilience.

Exemples d'application

FOCUS can be adapted to various contexts:

- **Professional environment:** Helps manage stress, improve concentration, and prevent burnout.
- **Medical environment:** Supports patients suffering from anxiety, eating disorders (ED), and sleep apnea.
- **Private use:** Promotes screen-free relaxation before bedtime and improves well-being.
- **Education:** Helps children and adults develop emotional self-regulation skills.

Research partnerships with a company

This collection of highlights from the Cognition Institute's scientific research in 2024 would be incomplete without reference to the intense activity of contract research. We have chosen to illustrate the 193 research contracts by presenting a sub-set that does not claim to be either representative or emblematic.

These are just a few examples to illustrate the mobilization of the Institute's 812 permanent and 1381 non-permanent alongside partners from the socio-economic world, thereby contributing to their competitive innovation.

Improving the relationship with a conversational assistant in an industrial context: measuring and optimizing user engagement

Laurent PRÉVOT and Roxane BERTRAND (LPL)

Industrial context

Airudit designs non-embodied conversational assistants (without a body or face) specifically for the workplace. Its technology enables workers to lower their cognitive load and improve tool efficiency by using voice commands instead of going back and forth between workstation and input station. However, this technology is not well accepted by workers, who are reluctant to use it.

Aims

The aim of this thesis is to design a conversational assistant that adapts to user engagement in order to improve its acceptability. Engagement is the process by which two (or more) participants establish, maintain and terminate the perceived connection between them during an interaction. When acceptability is low, like when interacting with a conversational assistant with a monotone voice, the user will tend to disengage from the interaction with the agent and therefore stop using it. This is precisely what a company like Airudit, which designs conversational assistants, wants to avoid. In order to develop a conversational assistant that adapts to user engagement, we are going to conduct various studies that will enable us not only to establish objective measures of user engagement, but also to determine which behaviors of the conversational assistant are most engaging for the user, and how this agent can take user engagement into account. The conversational assistant we use in this thesis will be in Wizard of Oz (sentences produced by the assistant are triggered manually) to simulate an interaction (see Fig.1). In order to provide a professional context for our experiments, we have coupled a Dofbot robotic arm (see Fig.2) to our conversational assistant. It is presented to users as a miniaturized robotic arm from a waste processing plant. It is controlled remotely to guarantee consistent interaction.

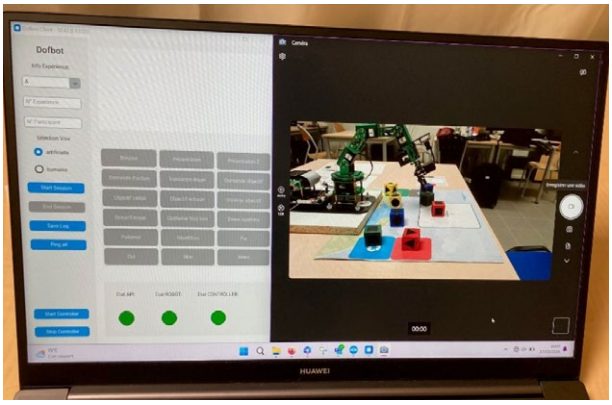


Figure 1 Experimental view. Left: Wizard of Oz software to trigger the phrases emitted by the conversational assistant. Right: View of robotic arm via camera for remote control.

Figure 2 Dofbot robotic arm

Results

The conversational assistant we design will be better accepted by professionals, since it will take user engagement into account and will therefore be used more. The features of this conversational assistant will be integrated with those produced by Airudit to enable greater work comfort and greater concentration on the task in hand.

Rehabilitating motor skills or language using action observation

Victor FRANCISCO, Christel BIDET-ILDEI and Arnaud DECATOIRE (CERCA)

Industrial context

Mélioris-Le Grand Feu is a post-acute care and rehabilitation center, specialized in treating patients requiring continuous medical monitoring. It has 100 full-time hospitalization beds and 23 places in a day hospital for patients from Niort and the surrounding areas. The center stands out with its two medical departments: Neurology and Locomotor/Burns, with specialized teams focused on functional rehabilitation. The physicians, experts in physical medicine, assist patients suffering from various pathologies, with a focus on improving motor and cognitive functions to promote autonomy.

Aims

The project focuses on the integration of action observation (AO) in the rehabilitation of locomotor disorders and language impairments, such as aphasia. Traditionally, motor rehabilitation is provided by a multidisciplinary team and primarily focuses on increasing joint range of motion, muscle activation, and strengthening. Language rehabilitation, on the other hand, is managed by speech therapists who adapt a wide variety of protocols based on the patient's response, often using static visual aids. However, recent studies suggest that incorporating AO may improve clinical and functional outcomes for both language and motor skills. This is due to the close links between the perception, understanding, and production of an action. The project has two main goals: first, to understand and evaluate the impact of observing point-light displays (PLD) showing human actions on gait recovery after total knee arthroplasty; second, to compare AO with a conventional method of verbal rehabilitation in aphasic patients. To achieve this, we rely, among other techniques, on motion capture technology, which allows us to record the kinematics of an action and obtain the spatial coordinates of the joints of interest and their temporal evolution, as shown by the example in Figure 1 of walking. From this data, we can generate a visual stimulus for action observation (PLD), or conduct a quantitative analysis of the action's kinematics. The main challenge is to enhance rehabilitation protocols to optimize both the functional recovery and communication skills of the patients.

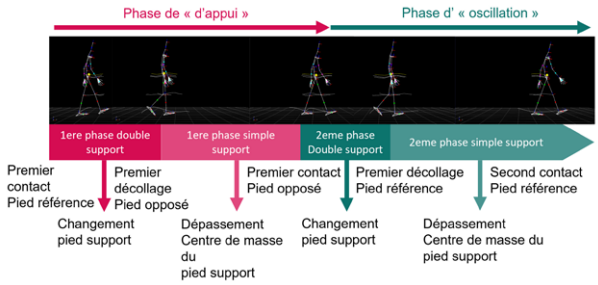
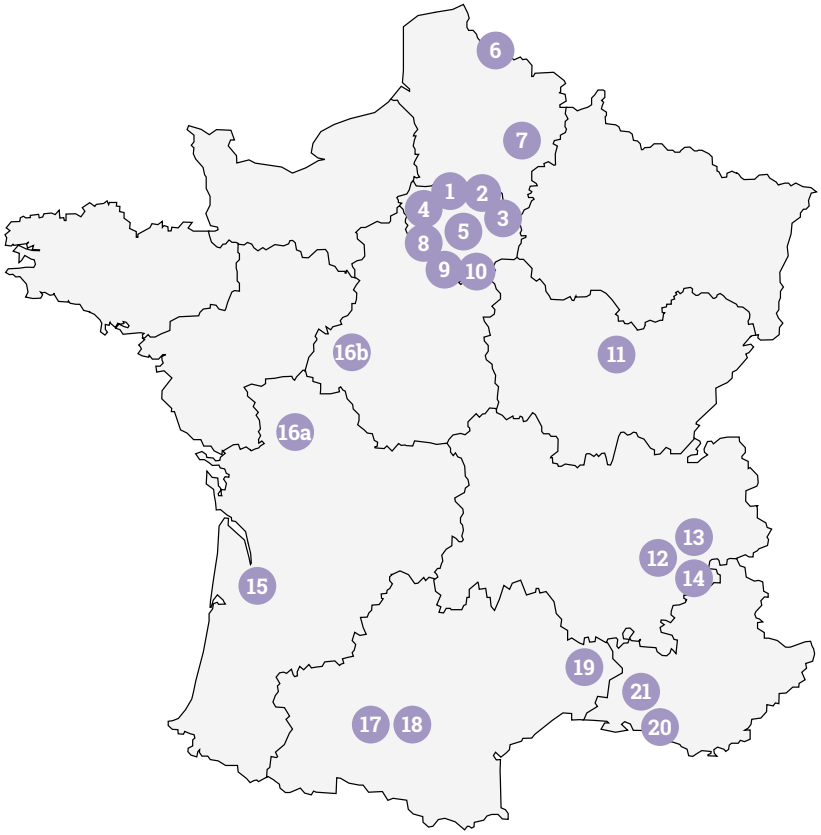


Figure 1 : The different stages of gait analysis, which allow for quantifying gait improvement or creating animated sequences (PLD) representing a walking motion.

Results

In the short term, we aim to better understand the links between action observation and action production, as well as those between action observation and language, in order to exploit them within rehabilitation protocols. In the medium term, through ongoing clinical trials, we seek to demonstrate that PLDs can be an effective and adaptable tool for managing patients with motor or language disorders. In the long term, we envision creating an AO-based tool that could serve as a support for learning and relearning motor skills and language.

OUR LABORATORIES



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