Research Achievement Report

Trilateral AI Research

Research projects in the field of Artificial Intelligence
coordinated by Japan, France and Germany

Research Period: FY2020 – FY2023

June 2024

Contents

1. Overview of Trilateral AI Research Program and Selected Research Programs

"Trilateral AI Research" is Research project in the field of Artificial Intelligence coordinated by Japan, France and Germany

- Based on agreements, JST (Japan Science and Technology Agency), ANR (Agence Nationale de la Recherche = French National Research Agency) and DFG (Deutsche Forschungsgemeinschaft = German Research Foundation) proceed with research projects among the three countries in the field of Artificial Intelligence.

Fig. 1.
On April 16, 2019, President Michinari Hamaguchi (JST) signed a letter of intent (LOI) for research collaboration in the field of artificial intelligence (AI) with President Peter Strohschneider of the German Research Foundation (DFG) and French Ambassador Laurent Pic on behalf of the French National Research Agency (ANR) at the Embassy of the Federal Republic of Germany in Tokyo.

- **9 research teams** have been selected, and now they are working on research as scheduled from FY2020 to FY2023. Due to the Covid-19 and other reasons, research period of a port of the PIs will be extended to FY2024.

(1) **AI-Cog** AI for Aging societies: From Basic Concepts to Practical Tools for AI-Facilitated Cognitive Training

	Name	Affiliation	Direct Cost
Japanese PI	Mihoko Otake	Center for Advanced Intelligence Project, RIKEN	21,923K JPY
German PI	Tonio Ball	Department of Neurosurgery, University of Freiburg	250,000 Euros
French PI	Alexandre Gramfort	INRIA Saclay Ile de France Research Centre	245,160 Euros

Affiliation and Direct Cost are when selected.

(2) **AI4HRI** Artificial Intelligence for Human-Robot Interaction

	Name	Affiliation	Direct Cost
Japanese PI	Takayuki Kanda	Graduate School of Informatics, Kyoto University	36,000K JPY
German PI	Michael Beetz	Institute of Artificial Intelligence, Bremen University	296,500 Euros
French PI	Aurélie Clodic	LAAS, CNRS	296,579 Euros

Affiliation and Direct Cost are when selected.

(3) **LeCycl** Learning Cyclotron

	Name	Affiliation	Direct Cost
Japanese PI	Koichi Kise	Graduate School of Engineering, Osaka Prefecture University	30,000K JPY
German PI	Andreas Dengel	German Research Center for Artificial Intelligence	260,958 Euros
French PI	Laurence Devillers	Sorbonne University / LIMSI, CNRS	254,115 Euros

Affiliation and Direct Cost are when selected.

(4) **RECOMP** Research on Real Time Compliance Mechanism for AI

	Name	Affiliation	Direct Cost
Japanese PI	Ken Satoh	Principles of Informatics Research Division, National Institute of Informatics	46,900K JPY
German PI	Adrian Paschke	The Institute of Applied Informatics	300,000 Euros
French PI	Jean-Gabriel Ganascia	LIP6, Sorbonne University	251,200 Euros

Affiliation and Direct Cost are when selected.

(5) **EDDA** Enhanced Data Stream Analysis: combining the signature method and machine learning algorithms

	Name	Affiliation	Direct Cost
Japanese PI	Nozomi Sugiura	Global Ocean Observation Research Center, Japan Agency for Marine-Earth Science and Technology	35,450K JPY
German PI	Joscha Diehl	Institute for mathematics and computer science, University of Greifswald	159,000 Euros
French PI	Marianne Clausel	Institut Élie Cartan de Lorraine, University of Lorraine	300,000 Euros

Affiliation and Direct Cost are when selected.

(6) **PANORAMA** Adaptive Artificial Intelligence for Human Computer Interaction

	Name	Affiliation	Direct Cost
Japanese PI	Yukiko Nakano	Department of Computer and Information Science, Seikei University	29,410K JPY
German PI	Elisabeth André	Faculty of Applied Informatics, University of Augsburg	238,847 Euros
French PI	Jean-Claude Martin	LIMSI, CNRS / Université Paris Saclay	254,579 Euros

Affiliation and Direct Cost are when selected.

(7) **TOSAI** Understanding and Creating Dynamic 3D Worlds towards Safer AI

	Name	Affiliation	Direct Cost
Japanese PI	Ko Nishino	Graduate School of Informatics, Kyoto University	30,000K JPY
German PI	Carsten Rother	IWR, University Heidelberg	249,900 Euros
French PI	David Picard	IMAGINE, Ecole des Ponts ParisTech	249,632 Euros

Affiliation and Direct Cost are when selected.

(8) **CHIRON** AI empowered general purpose assistive robotic system for dexterous object manipulation through embodied teleoperation and shared control

	Name	Affiliation	Direct Cost
Japanese PI	Yasuhisa Hasegawa	Graduate School of Engineering, Nagoya University	29,936K JPY
German PI	Jan Reinhard Peters	Computer Science Department, Technical University of Darmstadt	369,768 Euros
French PI	Liming Chen	Department of Mathematics and Informatics, Ecole Centrale de Lyon	313,404 Euros

Affiliation and Direct Cost are when selected.

(9) **KEEPHA** Knowledge-enhanced information extraction across languages for pharmacovigilance

	Name	Affiliation	Direct Cost
Japanese PI	Yuji Matsumoto	Center for Advanced Intelligence Project, RIKEN	31,400K JPY
German PI	Sebastian Möller	German Research Center for Artificial Intelligence	254,831 Euros
French PI	Pierre Zweigenbaum	LIMSI, CNRS	248,477 Euros

Affiliation and Direct Cost are when selected.

2. Final Report from each research team

Final Report of Research Achievement from each Research Team are in the following pages.

(1)	**AI-Cog**	AI for Aging societies: From Basic Concepts to Practical Tools for AI-Facilitated Cognitive Training
(2)	**AI4HRI**	Artificial Intelligence for Human-Robot Interaction
(3)	**LeCycl**	Learning Cyclotron
(4)	**RECOMP**	Research on Real Time Compliance Mechanism for AI
(5)	**EDDA**	Enhanced Data Stream Analysis: combining the signature method and machine learning algorithms
(6)	**PANORAMA**	Adaptive Artificial Intelligence for Human Computer Interaction
(7)	**TOSAI**	Understanding and Creating Dynamic 3D Worlds towards Safer AI
(8)	**CHIRON**	AI empowered general purpose assistive robotic system for dexterous object manipulation through embodied teleoperation and shared control
(9)	**KEEPHA**	Knowledge-enhanced information extraction across languages for pharmacovigilance

- *Final Report of Research Achievement from 9 teams*

  6-8 pages x 9 teams = around 70 pages
  The first page of each Final Report will be linked from the text in the previous page.
  One Research document of TOSAI was added as a reference.

Published

Trilateral AI Research

Research projects in the field of Artificial Intelligence
coordinated by Japan, Germany, and France

Final Report

Research Subject: *AI for Aging Societies: From Basic Concepts to Practical Tools for AI-Facilitated Cognitive Training*

Team AI-Cog

Japanese PI: Mihoko OTAKE-MATSUURA
RIKEN AIP, Team Leader
German PI: Tonio BALL
Freiburg University, Professor MD
French PI: Thomas MOREAU
INRIA, Ph.D.

Research Period: December 2020 – March 2024

Website of the project :
https://dementia.bci-lab.info/projects/jp-de-fr-trilateral-ai-cog

Ref. No. ANR: ANR-20-IADJ-0002 DFG: BA 4695/4-1
JST: JPMJCR20G1

§1 Outline of research implementation

(1) Research Summary

People live longer than ever, most now living beyond their sixties. Aging societies bring significant social, economic, and healthcare challenges. Japan (#1), France (#3), and Germany (#4) are among the top five countries worldwide, with the highest proportion of people over 65. Health conditions in older age include depression, dementia, and long-term disability after stroke. About 50 million people worldwide suffer from dementia, with almost 10 million new cases yearly. According to WHO, there is a new case of dementia every three seconds globally.

Aging populations and age-related brain disorders are a global concern, particularly in Japan, France, and Germany. This project aimed to improve healthy aging by utilizing artificial intelligence (AI) to study machine-learning-driven biomarkers, developing dedicated ML methods for the human brain, and creating an open-source reference software package. The project's scientific objectives included optimizing understandable information about the brain's functional state, identifying biomarkers for cognitive impairments, and guiding AI-facilitated cognitive training.

Despite the challenges of conducting EEG experiments and cognitive interventions during COVID-19 lockdowns in Japan, three research groups from Germany, France, and Japan have redirected their focus towards developing AI-related neuro-biomarkers from pre-existing datasets and exploring the ethical and societal implications of AI in the context of aging. This project has brought together complementary expertise from these groups, including technologies for interventions, EEG measurements, and statistical machine learning algorithms for data analysis.

The Japanese team focused on analyzing data from pre-pandemic experiments conducted by the CBAT Team at RIKEN AIP. They utilized machine learning approaches based on supervised learning principles with features drawn from EEG signal complexity (detrended fluctuation analysis, network neuroscience, and topological data analysis). The experimental paradigms developed and conducted by the CBAT team resulted in encouraging results on a still limited sample size due to pandemic restrictions, reaching the middle ninety percent. The latest results also allowed the team to employ unsupervised learning approaches, which was one of the primary targets of the trilateral project. The Japanese team also started a new experimental session in Japan and, in collaboration with Nicolaus Copernicus University in Poland, collected a new database of combined EEG, eye-tracking (ET), and fNIRS datasets for the no-cost extension of the project. The Japanese team conducted a series of public outreach events to promote using neurotechnology to detect dementia biomarkers. These events included online BCI Spring Schools, which had significant participation from people in various countries worldwide. The 2023 edition had 15,787 attendees from 113 countries (https://www.gtec.at/spring-school-2023/), the 2022 edition had 5,309 attendees from 107 countries (https://www.gtec.at/spring-school-2022/), and the 2021 edition had 4,025 attendees (https://www.gtec.at/spring-school-2021/). Additionally, they co-organized the Neuro-diversity Change Tomorrow Takeshiba 2023 event, with over 100 participants visiting their EEG demonstration booth (https://www.change-tomorrow-takeshiba.com/).

The German team conducted a broad study to attack a question of the brain-age prediction from EEG for a possible neuro-biomarker. The study [4] achieved state-of-the-art results in age decoding, with a mean absolute error of 6.6 years. The researchers found that the model underestimated the age of both non-pathological and pathological subjects by -1 and -5 years, respectively. However, there were no significant differences in the average brain age gap between the two groups, whether they underwent single or repeated examinations. These results contradict previous studies that supported the brain age hypothesis. Therefore, the brain age gap biomarker cannot be used to indicate pathological EEG in

different datasets. A group of researchers from Germany conducted a study to investigate the relationship between the acquisition or recovery of pathology and the brain age gap in other datasets. The results of their research indicate that the trait hypothesis is more likely than the state hypothesis for brain age estimates derived from EEG, as no significant change was observed in the brain age gap. As a result, the initial publication [3] by the French and German teams focused on training supervised machine learning models to estimate subject age from brainwaves, which was not helpful for the dementia neuro-biomarker application. The French team participated in the BIOMAG 2022 Competition on Dementia Screening and emerged as the winner. Their approach to feature extraction based on power densities and covariance tangent vectors was quite impressive. It led to excellent results, placing them at the top of the MEG dataset in the challenge (https://biomag2020.org/awards/data-analysis-competitions/).

(2) Remarkable Research Achievements
<Results as excellent basic research>

1. Summary Description of the first result:

   A team of Japanese researchers and colleagues from Nicolaus Copernicus University in Poland studied emotional responses and cognitive decline in a cross-cultural setting. The study was conducted in Poland, where experimental restrictions due to the pandemic were less severe. This enabled the team to reproduce pre-pandemic emotional faces and interior paradigms. The study utilized EEG complexity features and topological data analysis measures to classify MCI and regress MoCA scores. The results have been published in [1, 2]. These outcomes have demonstrated that EEG-based neuro-biomarkers could be used as feasible predictors of age-related cognitive decline. To share new datasets among all project members without previous ethical restrictions, subsequent more extensive studies are planned during the project no-cost extension.

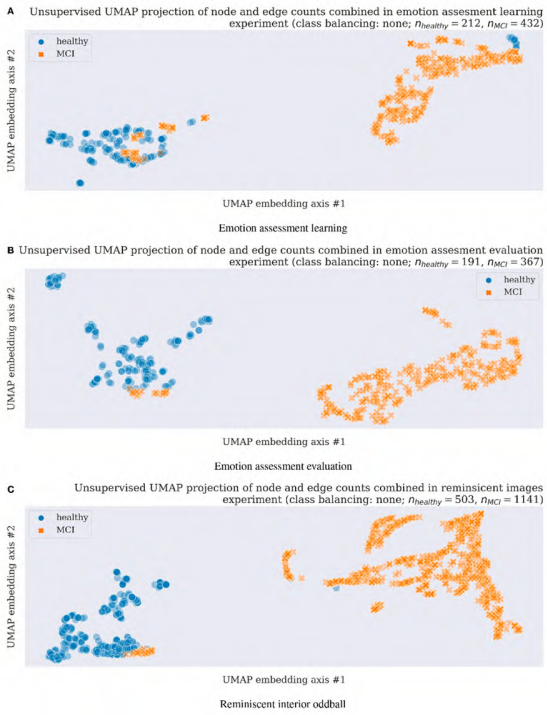

Figure 1. Three unsupervised clustering (machine learning training without class labels) scatter plots using UMAP in three experimental tasks were published in [1] (CC BY 4.0 DEED). They showed clear EEG feature separability of healthy versus MCI subjects.

2. Summary Description of the second result:

The French team made an essential contribution by winning the BIOMAG 2022 Competition on Dementia Screening [3]. They demonstrated a successful application of MEG power densities and covariance tangent vectors to predict the onset of dementia, which was quite impressive. This impressive and meaningful outcome was a clever workaround for the experimental restrictions caused by the pandemic, which significantly impacted our trilateral project. The French colleagues have shown that applying AI tools to publicly available datasets can lead to a competitive and successful approach, resulting in a top score.

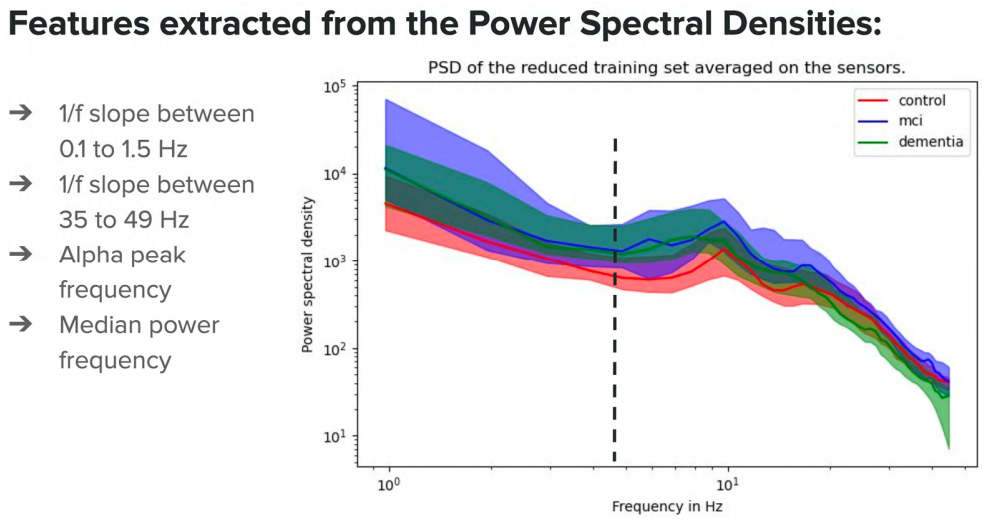

Figure 2. MEG data features were extracted from healthy, MCI, and dementia subjects in the BIOMAG 2022 Competition on Dementia Screening dataset [3], which was won by a French team. The features allowed for further classification of the dementia stages of the subjects.

3. Summary Description of the third result:

In a study published in [4], French and German researchers demonstrated that they could predict a person's brain age with a small margin of error using brainwave data. However, a subsequent thorough investigation led by German colleagues and reported in [5] showed that a brain age gap biomarker was unreliable for indicating pathological EEG across different datasets. This finding significantly impacted the M/EEG scientific community, as it demonstrated that using AI techniques to predict a person's age from brainwave recordings would not lead to a diagnosis of dementia or brain pathological atrophy. With their negative findings, the German team made a solid and impactful contribution to neurotechnology and neuroscience in general.

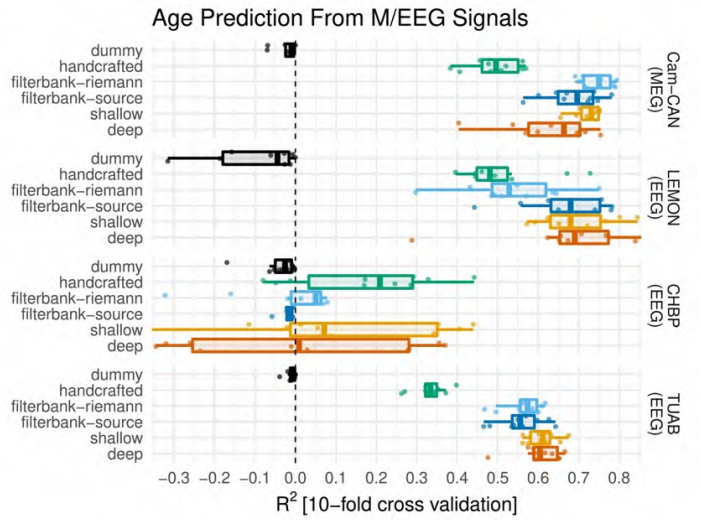

Figure 3. Age prediction benchmarks across M/EEG datasets (R2 score) published in [4] (CC BY 4.0 DEED) show a possibility of inferring the biological brain aging process from the brainwave time series.

<Achievements that significantly contribute to science and technology innovation>

1. Summary Description of the first result:
   Japanese researchers and colleagues from Nicolaus Copernicus University in Poland conducted a cross-cultural study on emotional responses and cognitive decline [1,2]. The study utilized advanced techniques such as EEG complexity features and topological data analysis measures to classify MCI and regress MoCA scores. The results suggest that EEG-based neuro-biomarkers could predict age-related cognitive decline, which could have significant implications for neurology and diagnostic tools. The team's ability to reproduce pre-pandemic emotional faces and interior paradigms when experimental restrictions were severe and their commitment to open science and collaboration demonstrate their innovative approach.

2. Summary Description for the second result:
   The win of the French team in the BIOMAG 2022 Competition for Dementia Screening was an impressive achievement [3]. Despite the restrictions caused by the pandemic, they cleverly adapted by utilizing an online database provided by the competition organizers. They could make accurate predictions by using MEG power densities and covariance tangent vectors in a novel way. Their use of AI tools on publicly available data showcases their innovative approach. Their top score is a testament to their expertise in this field.

3. Summary Description for the third result:
   A recent study by researchers from France and Germany has made significant progress in predicting a person's brain age using brainwave data [4]. However, further investigation led by German colleagues revealed that relying on a brain age gap biomarker was unreliable for indicating pathological EEG across different datasets [5]. Despite this setback, the German team's findings have contributed significantly to neurotechnology and neuroscience, highlighting the importance of continued research and innovation. Their negative results have

paved the way for further advancements and have helped researchers better understand the limitations of using AI techniques to predict a person's age from brainwave recordings, ultimately leading to a better understanding of dementia and brain pathological atrophy.

<Representative Papers>

1. Rutkowski TM, Abe MS, Komendzinski T, Sugimoto H, Narebski S, Otake-Matsuura M. Machine Learning Approach for Early Onset Dementia Neurobiomarker Using EEG Network Topology Features. Frontiers in Human Neuroscience; 17:262.

   Summary Description: The Japanese team's research paper published in Frontiers in Human Neuroscience [1] focused on utilizing machine learning algorithms to improve the well-being of individuals with disabilities in the "AI for social good" domain. We explored cognitive-behavioral intervention management and digital non-pharmacological therapies for early-onset dementia neuro-biomarkers. Our pilot study in Poland provided findings for cognitive decline prediction. The proposed three experimental tasks in the current pilot study showcased the vital role of artificial intelligence in predicting early-onset dementia in older adults.

2. Gemein LA, Schirrmeister RT, Boedecker J, Ball T. Brain Age Revisited: Investigating the State vs. Trait Hypotheses of EEG-derived Brain-Age Dynamics with Deep Learning. arXiv preprint arXiv:231007029. 2023.

   Summary Description: The difference between biological and chronological brain age has been disputed. A recent study concluded that the difference is stable and not subject to significant changes in neurological disorders. However, a German team using clinical EEG recordings found evidence to the contrary [5]. Brain age is a trait that remains stable over time. Further research on brain age using different imaging modalities is required. An expanded dataset is needed for more nuanced investigations of brain age. This dataset should ideally include non-binary pathology scores compiled by multiple reliable experts and accurate, anonymized age information.

3. Engemann DA, Mellot A, Hoechenberger R, Banville H, Sabbagh D, Gemein L, et al. A reusable benchmark of brain-age prediction from M/EEG resting-state signals. Neuroimage. 2022;262:119521.

   Summary Description: Machine learning on brain images can create measurable indicators for individual aging, known as brain age. MEG and EEG can evaluate brain health on a larger scale, but further research is needed to handle the complexity and diversity of M/EEG signals in various situations. French and German researchers developed reusable benchmarks for machine learning approaches in brain age modeling based on M/EEG adaptations of the BIDS standard [4]. The best performance was achieved by pipelines and architectures incorporating spatially aware representations of the M/EEG signals. These benchmarks come with open-source software and high-level Python scripts, making them reusable for modeling specific cognitive variables or clinical endpoints.

References

1. Rutkowski TM, Abe MS, Komendzinski T, Sugimoto H, Narebski S, Otake-Matsuura M. Machine Learning Approach for Early Onset Dementia Neurobiomarker Using EEG Network Topology Features. Frontiers in Human Neuroscience;17:262.

2. Rutkowski TM, Komendzinski T, Otake-Matsuura M. Mild Cognitive Impairment Prediction and Cognitive Score Regression in the Elderly using EEG Topological Data Analysis and Machine Learning with Awareness Assessed in Affective Reminiscent Paradigm. Frontiers in Aging Neuroscience;15:1294139.
3. Mellot, A., Malezieux, B., and Allain, C. Challenge Biomag 2022: dementia screening, 2022. https://github.com/apmellot/Dementia_screening_challenge_biomag_2022
4. Engemann DA, Mellot A, Hoechenberger R, Banville H, Sabbagh D, Gemein L, et al. A reusable benchmark of brain-age prediction from M/EEG resting-state signals. Neuroimage. 2022;262:119521.
5. Gemein LA, Schirrmeister RT, Boedecker J, Ball T. Brain Age Revisited: Investigating the State vs. Trait Hypotheses of EEG-derived Brain-Age Dynamics with Deep Learning. arXiv preprint arXiv:231007029. 2023.

§2 Research Implementation Organization

(1) PIs and Co-PIs from the Japanese, German, and French research teams and the structure

WP	Team	Country	PI or Co-PI
1	University of Freiburg	Germany	Prof. Tonio BALL
2	INRIA	France	Dr. Alexandre GRAMFORT and Dr. Thomas MOREAU
3	INRIA	France	Dr. Alexandre GRAMFORT and Dr. Thomas MOREAU
4	RIKEN AIP	Japan	Dr. Mihoko OTAKE-MATSUURA
5	University of Freiburg	Germany	Prof. Tonio BALL

(2) Research Network Formation through Collaboration with Researchers and Companies other than this Research Team

*Networking among the Japanese, German, and French research teams

-We have organized regular online meetings several times a year.
Following is the list of online meetings.
September 20, 2023
July 20, 2023
June 13, 2023
May 9, 2023
October 6, 2022
June 2, 2022
March 9, 2022
January 26, 2022
December 10, 2021
November 19, 2021
November 17, 2020 (First time)

-We have organized visits among researchers.

Visit of Dr. Alexandra Wolf (Japanese side young scientist) to Prof. Tonio Ball (German side) and his graduate student (young scientist), Ms. Maryna Kapitonova on September 29, 2023

- We have organized several workshops, organized session with trilateral members.

2022 Joint 12th International Conference on Soft Computing and Intelligent Systems and 23rd International Symposium on Advanced Intelligent Systems (SCIS&ISIS) was held in Ise-Shima, Mie, Japan, on November 29 - December 2, 2022. SCIS&ISIS 2022 is the flagship international conference of Soft Computing in Asia, that attracts several hundred participants all over the world. Dr. Tomasz M. Rutkowski of Japanese side proposed the organized session, “Neurotechnology Advances in Machine Learning Applications for Dementia Neuro-biomarker Development, Cognitive Load Elucidation, and Brain-computer Interfaces” which was accepted. Researcher from German side, Prof. Tonio Ball and Ms.

Maryna Kapitonova participated in the session on site.

First International Workshop on Complex Systems Science & Health Neuroscience was held on Nov. 28, 2022, at Mukokukan, Doshisha University.
A young scientist of Japanese side, Prof. Masato S. Abe, Dr. Tomasz M. Rutkowski, and German PI, Prof. Tonio Ball, and Prof. Tomasz Komendzinski with Nicolaus Copernicus University, Poland, organized the workshop.
Researcher from German side, Prof. Tonio Ball and Ms. Maryna Kapitonova, as well as Japanese side, Dr. Mihoko Otake, Dr. Tomasz M. Rutkowski, Dr. Kornkanok Tripanpitak, Dr. Alexandra Wolf, participated in the workshop.

Japanese-German-Polish Workshop on AI Applications for Dementia – Machine Learning, Robotics and Health Neuroscience Approaches for Aging Societies was held on Dec. 2, 2022, at RIKEN AIP in Nihonbashi, Tokyo.
Japanese PI, Dr. Mihoko Otake, and German PI, Prof. Tonio Ball, and Prof. Tomasz Komendzinski with Nicolaus Copernicus University, Poland, organized the workshop.
Researcher from German side, Prof. Tonio Ball and Ms. Maryna Kapitonova, as well as Japanese side, Dr. Mihoko Otake, Dr. Tomasz M. Rutkowski, Dr. Kornkanok Tripanpitak, Dr. Alexandra Wolf, participated in the workshop.

*Networking other than trilateral group members
The RIKEN AIP Japanese team, while searching for possibilities to conduct EEG experiments during pandemic restrictions, formed a new collaboration with Nicolaus Copernicus in Torun, Poland, where experiments with the elderly were already performed, resulting in published journal papers [1,2]. We also signed a research contract with Nicolaus Copernicus in Torun, Poland, to continue research and data collection initiated during the current trilateral project. As a starting industry partnership, the Japanese team started a project with Shika Holdings Inc. in Hokkaido to develop home-based EEG experiments. The result of the collaboration has already been presented as a poster at the IEEE EMBC 2023 Conference in Sydney, Australia.

- Japanese PI and young scientist in her group invited to give talks in the workshop.

Japanese PI participated and presented on-site at the trilateral symposium held in Tokyo in October 2022. At the AI for Health session, Japanese PI Dr. Mihoko Otake-Matsuura and another presenter from Karlsruhe Institute of Technology (KIT), Prof. Simon Stock, got to know each other and found the potential synergy of their works. Mihoko invited Simon to the above-mentioned Japanese-German-Polish Workshop in Tokyo in December 2022. Simon proposed university funding for organizing the workshop, and Mihoko and a young scientist in her team, Dr. Kazumi Kumagai, were invited to present at the workshop held in KIT in June 2023. International German-Japanese Workshop on Digital Dementia Intervention and Prevention Strategies in the Age of AI was held on June 26th and 27th, 2023, at the Karlsruhe Institute of Technology, Karlsruhe, Germany. Through the workshop, Mihoko, Simon, and his colleagues started planning and developing for further collaboration.

- We have organized workshops with Polish researchers.

The Second International Workshop on Complex Systems Science and Health Neuroscience was held on September 25, 2023, at Nicolaus Copernicus University, Toruń, Poland, and online.
Dr. Alexandra Wolf, a young scientist on the Japanese side, co-chaired the workshop with a Polish young scientist, Dr. Ewa Ratajczak. A young scientist on the Japanese side hired by this trilateral project, Dr. Kornkanok Tripanpitak, participated in both workshops and extended her network.

RIKEN AIP and NCU Joint Workshop on Mathematical Foundations of Machine Learning was held on

September 26, 2023, at Nicolaus Copernicus University, Toruń, Poland, and online.

(2) Team AI4HRI

Published

Trilateral AI Research

Research projects in the field of Artificial Intelligence
coordinated by Japan, Germany, and France

Final Report

Research Subject:
Artificial Intelligence for Human-Robot Interaction

Team AI4HRI

Japanese PI: Prof. Takayuki KANDA
Graduate School of Informatics, Kyoto University
German PI: Prof. Michael BEETZ
Institute of Artificial Intelligence, Bremen University
French PI: Dr. Aurélie CLODIC
LAAS CNRS, Toulouse

Research Period: December 2020 – March 2024

Website of the project: ai4hri.org

(JST) - Grant number JPMJCR20G2
(DFG) - Project number 442588247
(ANR) - ANR-20-IADJ-0006

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1 OUTLINE OF RESEARCH IMPLEMENTATION

1.1 RESEARCH SUMMARY

Europe and Japan both face problems of shrinking and aging population. This raises several issues, like missing workforce, and robots are often seen as a possible way for alleviating them. However, that would require that the robots are introduced into human societies and work in direct contact with people.

The field of Human-Robot Interaction (HRI) is concerned with the ways in which robots should interact with people in the social world. It aims to realize robots that will be present nearby us, humans, and collaborate with us, support us or entertain us. But dealing with humans is notoriously difficult, and bringing this vision into reality proved to be a huge challenge. At the same time, nowadays there are many successful applications of Artificial Intelligence (AI) techniques to increasingly complex tasks. Regardless of that, the field of HRI has largely not yet taken benefit from advanced AI techniques. Conversely, HRI can be considered as a very motivating challenge for AI, where the human is physically and mentally in the loop.

The goal of the AI4HRI project is to develop and tightly integrate several crucial AI technologies that will allow social robots to appropriately and skillfully deal with humans around them.

The first skill that we aim to apply to HRI are knowledge management methods and models, as well as knowledge reasoning abilities that can be used by a robot interacting with humans. These abilities have already been developed for situations where robots act alone and without humans around. In the scope of AI4HRI we explore which necessary scientific advances would be needed to enable interaction with humans. We ask these fundamental questions: what needs to be implemented successfully in the knowledge management system, which kind of models of the humans the robot should build, and which kind of reasoning abilities the robot should have regarding itself and the human it interacts with.

Building upon this knowledge, a second skill that we study is how a robot needs to socially interact with a human. Explicit manual programming of the interaction behaviors that the robot should execute is what is often done in HRI, but it is very difficult to create interactions that are robust to all variations of environment or human behavior. Therefore we use machine learning techniques to learn the interaction patterns that humans use in interactions with other humans and copy them to a human-robot interaction context.

A third skill that is essential for socially interacting robots but still not well developed at this point is to be able to cooperatively work with a human on the same task. We thus work on appropriate techniques for the planning and execution of joint actions, and in particular by taking advantage of the knowledge management and reasoning abilities described above.

Figure 1: Example of AI-enabled HRI: a competent robot-shopkeeper that has knowledge about the store (*left*), and collaborates closely with a human shopkeeper and interacts with customers (*right*)

The main example that we use in the project is a robot-shopkeeper in a retail store (Figure 1). We envision the robot to be working during business hours in the store together with a human shopkeeper and helping with many of the shopkeeper duties – keeping the store running, but also assisting customers in various ways. For example, the robot should: a) know the shop and items in it, so that it is e.g. able to detect changes like missing items and replenish the shelves; b) be able to socially interact with customers in a way that feels natural to them, including greeting them, giving information about the store, guiding them to desired items, etc.; c) be able to coordinate its actions with other shopkeepers, for example to attend to customers when other shopkeepers are busy.

1.2 Remarkable Research Achievements

1.2.1 Results as excellent basic research

Learning about social interactions

Figure 2: Example customer reaction to an unresponsive robot (in HRI data from [6]).

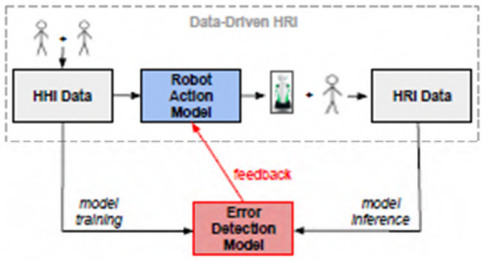

Figure 3: The proposed error detection model (red) in the context of the data-driven HRI framework.

Based on interviews with multiple store employees and collection of two unique human-to-human interaction datasets in a newly prepared sensor network environment, we were able to obtain insights into three-way interactions between store clerk 1, store clerk 2, and customers. We learned what kind of work store employees do and how they collaborate with other store employees to run the store. Based on this, we designed a basic system for learning robot interaction behavior from human-human data. Additionally, data-driven approaches to learning robot interaction behaviors have been refined to include other modalities such as gestures, and progress has been made to better handle errors during interactions (Figs. 2 and 3).

Knowledge representation and reasoning for HRI Everyone of us has to some extend his or her own understanding of the world which is influenced by what we believe. When engaging in interactions with one another, we further have expectations about what the other person knows, believes or what the person can do well. This in turn influences our decision making in this interaction. A robot with a similar skill would not only need to be able to imagine the physical scene from the perspective of the human, but it would further need to interpret the scene with respect to the state of mind of this person. We therefore extended our existing infrastructure KnowRob such that it can maintain multiple knowledge bases that encode the meaning of a scene from the perspective of different agents. The robot can now make a guess about what the human could have inferred from what the robot thinks that the human knows. Interactions between perspectives are considered at the level of the querying language in KnowRob which we extended through modal operators that are indexed by an agent id. Through these extensions, KnowRob can maintain the Know-Me and Know-You knowledge bases as separate graphs, and provides means of accessing the knowledge encoded in the different graphs through modal operators that can embed conjunctive queries in their higher order arguments.

Human-robot joint action planning and execution
The original cognitive robot abstract machine (CRAM) allows to parameterize general actions to execute specific task variations, on different robots and in changing environment. CRAM has been extended to consider not only individual robot action but also interaction with humans, this has led to the creation of CRAM-HRI. It enables the overall interaction execution by the robot taking the human into account, for example by inserting monitoring and communication. This work still needs some developments to be used on the overall retail store scenario but it is a promising first step and an interesting collaboration between UniHB and LAAS .
We have also made a first proof of concept regarding mutual expectation management using the notion of commitment (Fig. 4) that we plan to extend. The central role of commitment is not only functional, in the sense that it helps and/or facilitates coordination between individuals but also, it motivates a set of communicative tools that helps individuals to know what to expect from each other in relation to a joint action.

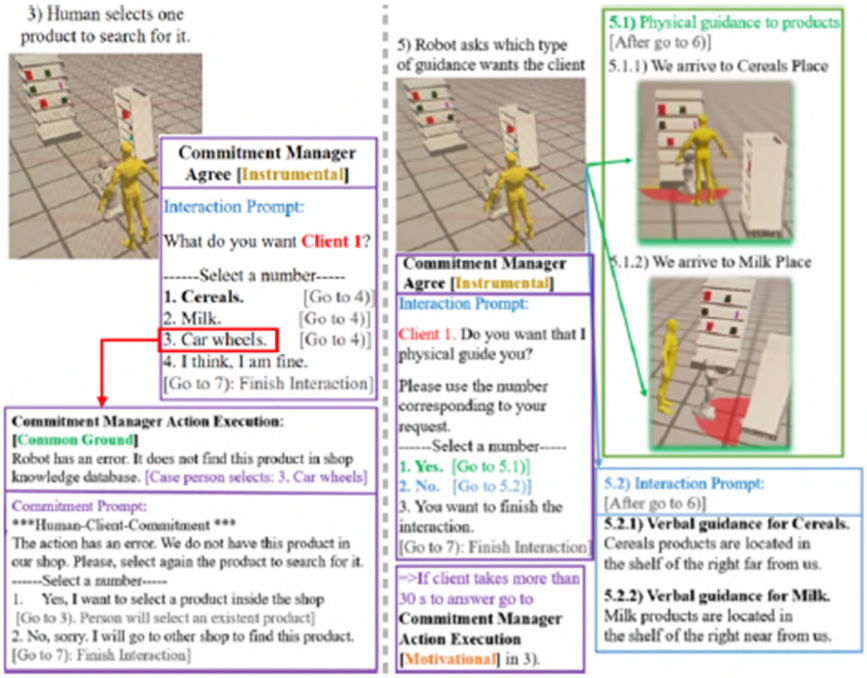

Figure 4: Examples of commitment interactions handled in our proof of concept

We have also questioned our development in face of the arrival of Large Language Models. While we think we need to use these tools with care in the context of a human-robot interaction (considering the possible insertion of bias, hallucination or errors, etc), we are conscious they became unavoidable.
We are currently in the process to complete the supervision and the planning system to consider the overall context envisioned in the project and to be able to run a complete retail store scenario. That will complete the overall architecture that has been build along the project. Indeed, thanks to the project, we are now equipped with situation assessment and knowledge based systems with perspective taking abilities, with action recognition abilities, with social context and expectation management, with social interaction learning abilities, etc, that's to say all the needed building blocks to make it happens.

1.2.2 Achievements that greatly contribute to science and technology innovation

Building inter-lab relationships

We have built close cooperative relationships between partners in Japan, Germany and France, freely sharing and utilizing each other's knowledge and tools (software [Ontologenius, Overworld, CRAM+commitments, navigation, CRAM-HRI, task planner with LLM], datasets, etc.), and developing human resources through regular meetings of young researchers. Furthermore, we have shared the data we are currently collecting and the architecture and software we have developed with other researchers to encourage broader research into AI for robot interaction. We are also taking advantage of the strengths of each partner, e.g. by processing data collected at KyotoU using software and know-how from LAAS , or by adapting CRAM from UniHB to interaction management with LAAS .

International workshops and outreach

Workshops were held among others at two international conferences (Robophilosophy 2022 and IROS 2023) and one european (European Robotics Forum 2023). We were able to share our project results and strengthen our ties with the research community as well as industrials. We also plan to make the collected datasets and

the project's architecture and software available to other researchers, which we believe will have a beneficial impact on research and applications of robot social interaction.

1.2.3 Representative Papers

We present here a selection of our publications.

UniHB We have introduced the simulation framework for Human-robot interaction **UAivatar** where the model of human agent is tightly integrated into the AI software and control architecture of the operating robot [2]. This framework equips robots with rich knowledge about humans, provides common ground access to valuable information about human activities, and integrates a diversely controllable and programmable human model into the inner world model of the robot allowing the robot to 'imagine' and simulate humans performing everyday activities. The framework is not only equipped with symbolic knowledge about humans but also makes full use of a Digital Twin World that provides mechanisms for accessing the full joint configuration of our agent models which allows us to simulate HRI on a highly sophisticated level.

- M Abdel-Keream, M Beetz. Imagine a human! UAivatar - Simulation Framework for Human-Robot Interaction. Workshop on Artificial Intelligence for Social Robots Interacting with Humans in the Real World (intellect4hri), 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2022), October 2022.

  Designing reliable, effective, and safe robotics systems for Human-Robot Interaction (HRI) remains still a major challenge due to the non-symmetrical nature of HRI and the absence of a comprehensive human model. For a meaningful interaction is suggested that both participants must have knowledge of one another. To achieve this an adequate representation of the other's belief, intentions, goals, actions, etc. is necessary. We introduce in this paper the UAivatar simulation framework that allows for the simulation of various HRI scenario. It includes a cognitive control for a human character and a knowledge-based human model that is integrated into the AI software and control architecture of the operating robot. Our framework, therefore, extends the robots inner world model with rich knowledge about humans allowing the robot to 'imagine' and simulate humans performing everyday activities.

KyotoU We propose a zero-shot error detection method for data-driven social imitation learning in human-robot interaction. Instead of relying on labeled data, our approach leverages normal human behavior models to detect abnormal reactions to robot errors, treating it as a novelty detection task. By applying this method, we achieved an average precision of 0.497 for error detection, outperforming supervised and unsupervised baselines, even with limited training data.

- J Ravishankar, M Doering, T Kanda. Zero-Shot Learning to Enable Error Awareness in Data-Driven HRI. 19th ACM/IEEE International Conference on Human-Robot Interaction (HRI 2024). March 2024.

  Data-driven social imitation learning is a minimally-supervised approach to generating robot behaviors for human-robot interaction (HRI). However, this type of learning-based approach is error-prone. Existing error detection methods for HRI rely on data labeling, rendering them inappropriate for the data-driven paradigm. We present a zero-shot error detection strategy that requires no labeled data. We use human interaction data to learn models of normal human behavior, then use these models to extract features that help discriminate abnormal human reactions to robot errors. In this feature space, we frame error detection as a novelty detection task, utilizing human interaction data to learn a model of non-erroneous interactions in an unsupervised fashion. Then, we apply the fitted novelty detector to HRI data to identify erroneous robot behavior. We show that our method obtains an average precision of 0.497 on errors, outperforming unsupervised baselines and supervised approaches with limited training data.

LAAS We propose that social robotics may benefit from developing and designing commitment-based approaches to human-robot interaction. In particular, by modelling and taking advantage of situated expectations. It is an original contribution to the field and it has lead to one conference paper and one book chapter.

- Victor Fernández Castro, Amandine Mayima, Kathleen Belhassein, and Aurélie Clodic (in press, 01/2024) "The Role of Commitments in Socially Appropriate Robotics" In Gransche, M. Nerurkar, J. Bellon, S. Nähr-Wagener (eds) Technology Socialization? Social appropriateness for computer-based systems. Springer.

  In this chapter, we explore theoretically how commitments may be a fundamental element in human-robot joint actions and in the design of socially appropriate robots. We sketch a particular framework of how a robotic architecture for commitment may capture the two aspects and how they can be modelled. We conclude with some remarks regarding the long-range consequences and considerations of introducing the notion of commitment in the research on social robotics and its role concerning sociality and social appropriateness.

- Ely Repiso, Guillaume Sarthou and Aurelie Clodic. Towards a system that allows robots to use commitments in joint action with humans. 2023 IEEE International Conference on Robot and Human Interactive Communication (RO-MAN 2023), August 2023.

  In this paper, we present an implemented proof of concept system using commitments in human-robot interaction management. It focuses on reducing normative expectations that can be of three types: motivational, instrumental and common ground. We have applied these theories in a simulated Human-robot interaction. The robot has two possible plans, greetings and helping the human to search for a product in the shop. In this interaction, there are several examples of our commitment types to be handled, like knowing if the person is motivated to start, continue the interaction or finish it; solving uncertainties about how to execute an action like verbal or physical guidance; and solving uncertainties about common knowledge of the product availability in the shop.

1.3 Results obtained through the division of roles between Japan, Germany, and France

We have achieved various results through collaboration between labs.

As a result of collaboration between Kyoto University and LAAS, researchers at LAAS are working on extracting semantic information from the human-human interaction dataset collected at Kyoto University. This semantic information extraction will yield information extracted from the data, such as customer and shopkeeper's line of sight, which is beyond the original abilities the data abstraction techniques used in social behavior learning. This data will be used to train a robot shopkeeper, which has abilities beyond the previous state of the art robots trained via data-driven HRI (data-driven imitation learning).

As a result of another collaboration between Kyoto University and LAAS, we have combined elements of the database learning approach of Kyoto University [4] with a system employing Large Language Models, designed at LAAS, to create two systems. One system can automatically verify the correctness of information given by human shopkeepers during conversation. The second system can recognize images of products and answer customers questions about them. A joint publication has been submitted for this work.

As a result of a collaboration between LAAS and Bremen University, we achieved to link CRAM to LAAS DACOBOT architecture and dedicated software to manage not only the robot knowledge but also the human knowledge and to consider perspective taking. The resulting software, named CRAM-HRI, extends CRAM (which was mostly used for now on robot scenario) to human-robot collaborative scenario. For now, the system is running on a benchmark task that has been developed at LAAS [7] but will be extended to the AI4HRI scenario in the following months. A joint publication is in preparation on this work.

2 Research Implementation Organization

2.1 PIs and Co-PIs of the Japan, Germany, France research teams and the structure

WP	Team	Country	PI or Co PI
WP1 Architecture	UniHB	Germany	Michael BEETZ
WP2 Knowledge representation and reasoning	UniHB	Germany	Michael BEETZ
WP3 Learning social interactions	KyotoU	Japan	Takayuki KANDA
WP4 Joint action planning and execution	LAAS	France	Aurélie CLODIC
WP5 Integration, data collection, user studies	KyotoU	Japan	Takayuki KANDA
WP6 Dissemination	LAAS	France	Aurélie CLODIC

2.2 Research Network Formation through Collaboration with Researchers and Companies other than this Research Team

We listed table 1, the complete list of the workshops we organised. Besides the meeting and discussion with other researchers, these workshops help us to strengthen and develop our network in several directions:

- with companies, such as PAL robotics[1] in Spain (ERF and HRI2024 workshop) with Francesco Ferro, Severin Lemaignan; and Blue Frog Robotics[2] for the ERF workshop,
- with technical committee such as IEEE TC committee on social robotics,
- with other research communities, such as philosophers and psychologists (Robophilosophy workshop) to which it was valuable to share our needs and issues. That way we gain also contact with Transor network [3] via Johanna Seibt and with the WASP program [4] via Virginia Dignum.

Thanks to all the workshops organized, we have a network of researchers to establish future collaborations in projects or workshops: Dr. Luis Merino, Dr. Raja Chatila (Sorbonne University), Dr. Kerstin Fischer (SDU), Dr. Maja Matarić (USC), Dr. Adriana Tapus (ENSTA), Dr. Yukie Nagai (University of Tokyo), Dr. Serena Ivaldi (INRIA), Dr. Séverin Lemaignan (PAL Robotics), and Dr. Koen Hindriks (Vrije Universiteit), Dr. Alessandra Sciutti (IIT), Dr. Yiannis Demiris (Imperial College), Dr. Cynthia Matuszel (Univ. of Maryland), Dr. Matthias Scheutz (Tufts University), Dr. Dorsa Sadigh (Stanford University), Dr. Yutaka Nakamura (RIKEN), Dr. Luca Iocchi (Sapienza University of Rome), Dr. Ingar Brinck (Lunds university), Dr. Raul Hakli (Helsinki University), so on. In particular, since these workshops were mostly organised by the project post-docs and phd students, it is very valuable for them at the beginning of their career.

The Bremen group contributed to a Delphi study on *Robots in Care and Everyday Life: Future, Ethics, Social Acceptance* conducted by the social sciences expert Uwe Engel. AI4HRI researcher Mona Abdel Keream authored a chapter on *Ethical Challenges of Assistive Robotics in the Elderly Care* [1] in a book featuring the main results of this study [5], and Bremen PI Michael Beetz is co-author of another chapter [3] in the same book.

The *International Workshop on Ontologies for Autonomous Robotics (ROBONTICS) 2023*[5] which addressed topics closely connected to AI4HRI WP2 was co-organized by the Bremen group as well as the *International Workshop on Ontologies and Standards for Robotics and Automation*[6] (WOSRA 2023 at ICRA 2023). Both workshops had a special focus on HRI in 2023.

[1] https://pal-robotics.com/
[2] http://www.bluefrogrobotics.com/
[3] https://cas.au.dk/en/robophilosophy/transor
[4] https://wasp-sweden.org/
[5] https://robontics.github.io/
[6] http://www.wikicfp.com/cfp/servlet/event.showcfp?eventid=172280&copyownerid=180080

Workshops						
Date	Status	Workshop Title & Website	Attendees from Team AI4HRI	Conference Name	Speakers	Organizers
October 2022	Accepted	Artificial Intelligence for Social Robots Interacting with Humans in the Real World [intellect4hri]. Website: https://intellect4hri.sciencesconf.org/	In person: Takayuki Kanda, Dražen Brščić, Malcolm Doering, Ely Repiso. Online: Aurélie Clodic, Adrian Vigne, Guillaume Sarthou, Mona Abdel-Keream.	2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2022)	Dr. Alessandra Sciutti, Dr. Yiannis Demiris, Dr. Cynthia Matuszel, Dr. Matthias Scheutz, Dr. Dorsa Sadigh, Dr. Yukata Nakamura, Dr. Luca Iocchi. Starting talk for AI4HRI: Dr. Ely Repiso	All partners of AI4HRI project. Main Organizers: Ely Repiso and Malcolm Doering.
March 2023	Accepted	Companion robots: when?. Website: https://erf2023.sdu.dk/timetable/event/companion-robots-when/	In person: Aurelie Clodic. Online: Takayuki Kanda, Michael Beetz, Ely Repsiso, Mona Abdel-Keream.	European Robotics Forum (ERF2023)	Aurélie Clodic, Michael Beetz, Luis Merino, Raja Chatila, Kerstin Fisher, PAL Robotics, Blue Frogs robotics	Aurélie Clodic, Ely Repiso, MonaAbdel-Kercam, Luis Merino.
August 2022	Accepted	Roboticists' Perspective on Social Robots in Social Institutions: How to Design Social Robots That Can Operate in Complex Social Environments?. Website: https://ebooks.iospress.nl/volumearticle/62601	In person: Aurélie Clodic. Online: Takayuki Kanda, Ely Repiso.	Robophilosophy Conference 2022 - Social Robots in Social Institutions	Raul Ingar Brinck, Kerstin Fischer, Takayuki Kanda, Aurelie Clodic.	Aurélie Clodic, Raul Hakli, Ely Repiso, Kathleen Belhassein.

Table 1: Workshops

The EASE Fall school 2023[7] in Bremen and the co-located *9th workshop on Artificial Intelligence and Cognition (AIC 2023)*[8] provided a great opportunity for networking with international experts. It was focussing on cognitive human-robot interaction evidenced by internationally leading researchers in HRI participating as lecturers. They included Jean Oh (CMU), Alessandra Sciutti (IIT), Britta Wrede (Uni Bielefeld), Katharina Rohlfing (Uni Paderborn), Agnieszka Wykowska (IIT), John Laird (University of Michigan), David Vernon (CMU Africa).

Bremen PI Michael Beetz is co-chair of the IEEE RAS technical committee on "Cognitive Robotics" with a strong focus on HRI.

University of Bremen has funded together with University of Bielefeld and University of Paderborn the coAI (cooperative and cognition-enabled AI, https://coai-jrc.de) Joint Research Center. A key activity of this center is a preproposal for an excellence cluster on "co-constructive and cognition-enabled embodied AI" with the title "co-constructing understanding and skills between humans and robots". LAAS-CNRS and Kyoto University are planned to become associated collaboration partners.

LAAS and IAI Bremen became nodes in the European Network of excellence centers in robotics euROBIN[9] and took leading roles in the network. LAAS is leading the science area "Human-centric" focussing on human-robot interaction. Bremen leads the science area "Know" focussing on knowledge representation and reasoning for robots. Both science areas are working closely and synergetically together thanks to the close cooperation and seed activities in AI4HRI.

Ely Repiso Polo is a former member of the Team of Alberto Sanfeliu at Institut the robotica e Informatica Industrial (IRI), Universitat Politècnica de Catalunya (UPC). Thanks to this connexion, we have been able to collaborate on several works related to Human-Robot Collaborative navigation.

Aurélie Clodic, PI from LAAS is responsible of the robotics theme besides Toulouse Artificial Intelligence Institute (ANITI [10]). In this framework, several presentations of the AI4HRI project has been made, in particular, an afterwork has been organized to present the project and a demonstration to researchers and industrials (around 70 people).

Aurélie Clodic has been an expert for several months besides the HUMAINT project ([11]) from the Joint Research Laboratory (JRC) of the European Commission. In this framework, a collaboration has been setup with AI4HRI project. The discussion were about the presentation of the European Commission proposal regarding trustworthy AI and AI explainability as well as personal data management (e.g. when we are gathering data during user study). A workshop has also been organised in Toulouse in coordination with the JRC and ANITI: **Robotics uptake in Industry**: during this workshop industrials and researchers (around 50 people) from Toulouse area where invited to listen Cecile Huet (Head of the Unit "Robotics and Artificial Intelligence Innovation and Excellence" at the European Commission) to present european funding possibilities in robotics and a round table has been handled to gather industrials needs and questions about the development of robotics.

Aurélie Clodic has been recently elected as one of the coordinators of the Artificial Intelligence and Cognition in Robotics (AICoR) Topic Group of EuRobotics [12]. There is around 200 members in this topic group. In this framework, she is involved in the definition of the next european strategic roadmap and she is pushing the AI4HRI topic within the European research and innovation community.

2.3 Specific activities for networking between Japan, Germany, and France

[7] https://ease-crc.org/fall-school-2023/
[8] https://ease-crc.org/aic-2023/
[9] https://www.eurobin-project.eu/
[10] https://aniti.univ-toulouse.fr/
[11] https://ai-watch.ec.europa.eu/humaint/team_en
[12] https://eu-robotics.net/artificial-intelligence-and-cognition-in-robotics-aicor/

2.3.1 Meetings

Since the start of the project, we've had a monthly meeting (the first Friday of each month at around 8:00/15:00, more than 20 meetings). It lasts about an hour and brings together all consortium members. It enables us to share general information, current plan and discuss about next steps. Minutes of the meeting are made available to all the consortium members as well as presentations.

Date	Location	Partners present	Meeting topic
monthly meeting	TelCo	LAAS/UniHB/KyotoU	General discussion
2021/01/27-28	TelCo	LAAS/UniHB/KyotoU	Kick-Off Meeting
2021/03	TelCo	LAAS/UniHB/KyotoU	Scenario Discussion
2021/05	TelCo	LAAS/UniHB/KyotoU	Integration Meeting
2021/11	TelCo	LAAS/UniHB/KyotoU	Bremen avatar presentation
2021/12	TelCo	LAAS/UniHB/KyotoU	Scenario and architecture Discussion
2022/04	TelCo	LAAS/UniHB/KyotoU	Scenario and architecture Discussion
2022/05	TelCo	LAAS/UniHB/KyotoU	Perspective taking
2022/11	TelCo	LAAS/UniHB/KyotoU	Consortium meeting
2023/03	TelCo	LAAS/UniHB/KyotoU	Use of LLM and Action Recognition
2023/03	TelCo	LAAS/UniHB/KyotoU	Use of LLM
2023/04	TelCo	LAAS/UniHB/KyotoU	Kyoto Dataset
2023/06	TelCo	LAAS/UniHB/KyotoU	Integration meeting preparation
2023/10	LAAS	LAAS/KyotoU	Integration meeting
2024/02 (planned)	LAAS/KyotoU	LAAS/KyotoU/UniHB	Integration meeting

A second integration meeting will be held in Kyoto, Japan in early 2024.

2.3.2 Dispatch of students and researchers

We coordinated some stays of students and postdocs in partner's labs to aid in integration and coordination of research activities, as listed in detail in the table below.

Date	Location	Personnel	Activity
2022/09	UniHB	Adrien Vigné (LAAS)	OpenEase Fall School
2022/10	KyotoU	Ely Repiso (LAAS)	Database and software sharing
2023/03-2023/05	LAAS	Mona Abdel-Keream (UniHB)	Setup of CRAM, VR system, first implementation of CRAM-HRI
2023/10	LAAS	Malcolm Doering (KyotoU)	System integration

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[2] Abdel-Keream, M. and Beetz, M. (2022). Imagine a human! uaivatar - simulation framework for human-robot interaction. In *IROS2022 Workshop: Artificial Intelligence for Social Robots Interacting with Humans in the Real World [intellect4hri]*.

[3] Beetz, M., Engel, U., and Langer, H. (2023). Cognition-enabled robots assist in care and everyday life: Perspectives, challenges, and current views and insights. *Robots in Care and Everyday Life*, page 103.

[4] Doering, M., Brščić, D., and Kanda, T. (2021). Data-driven imitation learning for a shopkeeper robot with periodically changing product information. *ACM Transactions on Human-Robot Interaction (THRI)*, 10(4):1–20.

[5] Engel, U. (2023). *Robots in Care and Everyday Life: Future, Ethics, Social Acceptance*. Springer Nature.

[6] Liu, P., Glas, D. F., Kanda, T., and Ishiguro, H. (2016). Data-driven hri: Learning social behaviors by example from human–human interaction. *IEEE Transactions on Robotics*, 32(4):988–1008.

[7] Sarthou, G., Mayima, A., Buisan, G., Belhassein, K., and Clodic, A. (2021). The Director Task: a psychology-inspired task to assess cognitive and interactive robot architectures. In *IEEE RO-MAN*.

(3) Team LeCycl

Published

Trilateral AI Research

Research projects in the field of Artificial Intelligence
coordinated by Japan, Germany, and France

Final Report

Research Subject: Learning Cyclotron

Team LeCycl

Japanese PI: Koichi Kise
Osaka Metropolitan University, Professor
German PI: Andreas Dengel
German Research Center for AI, Executive Director
French PI: Laurence Devillers
LISN-CNRS / Sorbonne University, Professor

Research Period: December 2020 – March 2024

Website of the project : https://opu-imp.github.io/lecycl/

Ref. No.
ANR: ANR-20-IADJ-0007
DFG: Project Number 442581111
JST: JPMJCR20G3

§1 Outline of research implementation

(1) Research Summary

Learning Cyclotron is a mechanism to support human learning by three functions, "Perceiving", "Mastering", and "Transferring". "Perceiving" is intelligent sensing technologies for learners' internal and knowledge states. "Mastering" is an AI-assisted learning to acquire knowledge and skills effectively and efficiently. "Transferring" is an intelligent framework of "learning-by-teaching", and its fundamental technologies. We also develop "nudging strategies for all three functions.

The Japanese team has a background of learning augmentation worked with the German team, with a special focus on "Learning English as a second language." The German team, in addition, has its own advantage of analyzing the process of learning programming. The French team consists of specialists of speech and language analysis. Thus, we assign the following tasks to each team. The Japanese team works on English learning focusing on visual modality with the German team, and speech modality with the French team. The German team is focusing on the analysis of programming learning with visual modality. The French team works mainly on speech modality of English learning together with the Japanese team.

The following important results were obtained by the contributions of each team.

The Japanese team analyzed fundamental aspects of learning in relation to sleep and in-the-wild data acquisition. It also developed mobile and stationary methods of sensing learners' internal states, methods for "mastering" to boost learning with various mechanisms, and edutainment methods with Mangas.

The German team developed two important software systems called "TrackThink" and "EnGauge", which are employed for learning programming and analyzing communication during the "transferring," respectively.

The French team established a protocol for analyzing speech for L2 English learners, and the tool called "Eye-got-it" which allows simultaneous acquisition of speech and eye gaze data.

(2) Remarkable Research Achievements

<Results as excellent basic research>

1. Summary Description for 1st result

In order for the developed technology to be useful under real-world conditions, the original data for technology development must reflect the real-world environment (i.e., data acquired under so-called in-the-wild conditions). In addition to recording data of various modalities in a relevant manner, labels for machine learning are required. For this purpose, the Japanese and German teams developed a data labeling mechanism and a plug-in to obtain web search logs. The French team developed Eye-Got-It, a mechanism for synchronous acquisition of voice and gaze.

2. Summary Description for second result

For learning to be efficient and effective, the environment in which the learning takes place is important. Specifically, the following factors are important: the state of the learner (sleep quality, respiration, exercise, etc.), the environment in which learning takes place (context of learning, other media (context, pictures, sound, etc.) that assist understanding, and relationships with others (peer pressure, etc.)). In this study, we conducted various experiments on these matters and obtained knowledge on what, when, how much, and to whom these factors affect.

3. Summary Description for third results

The most important result mainly achieved by the French team are the design of a multimodal EFL (English as foreign language) protocol, the evaluation involving the development of a multimodal data tool, and finally the acquisition and constitution of a database of 75 speakers. This database enables us to identify and model L2 mastering relevant cues and propose hierarchy

of features and preliminary propositions of cross L2 levels and cross-cultural distinctive features relevant to French and Japanese speakers. We also worked on a comparison between text read with and without nudging strategies such as the use of Manga.

<Achievements that greatly contribute to science and technology innovation>

1. Summary Description for 1st result

One of the features of this research is that we have conducted extensive research to develop the process of "Mastering," which has not been well explored in the past. Specifically, these include confidence estimation during question answering, adaptive generation of questions and materials according to the learner, learning support using smartphone sensors, edutainment using Mangas as learning materials, and gamification. The possibilities for the generation of learner-specific questions and teaching materials have expanded with the advent of generative AI such as ChatGPT. We are currently conducting experiments to evaluate the effectiveness of this technology.

2. Summary Description for second result

Another feature of this research is that it examines knowledge transfer methods and nudging strategies for knowledge transfer. This is a major feature of this study that is not found in other studies. Specifically, we developed the following methods and verified their effectiveness experimentally. (1) DiscussionJocky: a method to intervene in a multi-person conversation to prevent one person from speaking out of turn, (2) EnGauge: a method to read Engagement in dialogue from upper body video data, (3) Analysis of problems in knowledge sharing communities such as Stack Exchange, and (4) interventions using making-it-a-habit and peer pressure. Since many of these methods can be used beyond English and programming learning, they can be expected to be applied to other fields.

3. Summary Description for third result

The main achievements of the French team consist of the conception of an innovative protocol to acquire and further process multimodal data in order to cover 2 out of the 3 objectives of the project: (I) perceiving and (ii) mastering with focus on English as foreign language for native French and Japanese learners. The second main result is the acquisition of a database including 75 speakers.

<Representative Papers>

1. Summary Description

Andrew Vargo, Motoi Iwata, Mathilde Hutin, Sofiya Kobylyanskaya, Ioana Vasilescu, Olivier Augereau, KoWatanabe, Shoya Ishimaru, Benjamin Tag, Tilman Dingler, Koichi Kise, Laurence Devillers and Andreas Dengel. "Learning Cyclotron: An Ecosystem of Knowledge Circulation". In Proceedings of the 2022 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct Publication (UbiComp '22 Adjunct), pp. 308–312, 2022.

The circulation of knowledge is an important function for enriching our social life. Knowledge circulation, which has traditionally been conducted manually, is undergoing a transformation in the age of artificial intelligence. In this paper, we describe our project called "Learning Cyclotron (LeCycl)," which was initiated to accelerate the circulation of knowledge for building a knowledge ecosystem based on artificial intelligence technology. The three functions of sensing, mastering, and transferring knowledge are effectively operated through the power of AI-empowered digital nudging strategies. We outline what has been accomplished to date and summarize future directions for the ultimate goal of LeCycl.

2. Summary Description

Andrew Vargo, Shoya Ishimaru, Md. Rabiul Islam, Benjamin Tag, Koichi Kise, Obtaining Labels for In-the-Wild Studies: Using Visual Cues and Recall, IEEE Pervasive, Vol.21, Issue 1, pp.9-17, 2021.12, DOI: 10.1109/MPRV.2021.3129500

The observer effect challenges laboratory research. In-the-wild studies mitigate this but struggle with accurate data labeling for algorithm training. Manual labeling can be obtrusive, time-intensive, and raise privacy concerns. We introduce a labeling workflow from an in-the-wild study examining cognitive states via eye-gaze in real-world settings. Our method, employing J!NS MEME electrooculography glasses, Narrative Clip 2 cameras, and a unique data tagging software, allows participants to label data swiftly and discreetly. It ensures data quality and privacy, is replicable for field research, and is apt for the pandemic and post-pandemic era.

3. Summary Description

Hutin, M., Kobylyanskaya, S., Devillers, L. : Nudges in technology-mediated knowledge transfer : Two experimental designs. In : Adjunct Proceedings of the 2022 ACM International Joint Conference on Pervasive and Ubiquitous Computing and the 2022 ACM International Symposium on Wearable Computers. pp. 267–273 (2022)

Recent advances in technologies now allow us to learn almost anything in virtual environments, be it via Internet forums or websites, telephone apps, video games, and many more. Such technology-mediated learning can be enhanced with the use of embedded nudges, i.e., devices in the architecture of choice to encourage (nudge) the users towards one choice rather than the other without limiting their freedom of choice. This paper presents an overview of how nudges can help improve knowledge acquisition, as well as a two ongoing projects. Ethical issues are also highlighted.

§2 Research Implementation Organization

(1) PIs and Co-PIs of the Japan, Germany, France research teams and the structure

WP	Team	Country	PI or Co-PI
0 Modification of the plan	Japanese, French, and German teams	Japanese, French, and German teams	Koichi Kise, Andreas Dengel, Laurence Devillers
1 Construction of "Preceive"	Japanese, French, and German teams	Japanese, French, and German teams	Koichi Kise, Andreas Dengel, Laurence Devillers
2 Construction of "Master"	Japanese, French, and German teams	Japan, France, Germany	Koichi Kise, Andreas Dengel, Laurence Devillers
3 Construction of "Transfer"	Japanese, French, and German teams	Japan, France, Germany	Koichi Kise, Andreas Dengel, Laurence Devillers
4 Construction of "Nudging strategies"	Japanese, French, and German teams	Japan, France, Germany	Koichi Kise, Andreas Dengel, Laurence Devillers
5 System construction	Japanese, French, and German teams	Japan, France, Germany	Koichi Kise, Andreas Dengel, Laurence Devillers
6 Evaluation and modification	Japanese, French, and German teams	Japan, France, Germany	Koichi Kise, Andreas Dengel, Laurence Devillers

(2) Research Network Formation through Collaboration with Researchers and Companies other than this Research Team

In the middle of the project, we have decided to work together with the following researchers in Australia, especially for the topic of "nudging strategies": Dr. Tilman Dingler, Dr. Benjamin Tag, both from University of Melbourne, Australia. Now, Dr. Tilman is an associate professor at Delft University of Technology, Netherland, and Dr. Tag is at Monash University, Australia.

For the organization of workshops as satellites of UbiComp, AIED and Interact, we asked the following researchers outside the teams to work with us: Dr. Victoria Abou-Khalil (ETH Zürich, Switzerland), Dr. Michele Magno (ETH Zürich, Switzerland), Dr. Manu Kapur (Professor, ETH Zürich, Switzerland), Dr. Rwitajit Manjoumdar (Associate Professor, Kumamoto University, Japan).

(4) Team RECOMP

Published

Trilateral AI Research

Research projects in the field of Artificial Intelligence
coordinated by Japan, Germany, and France

Final Report

Research Subject: Research on Real-time Compliance Mechanism for AI
Team RECOMP

Japanese PI: Ken Satoh
National Institute of Informatics, Professor
German PI: Adrian Paschke
Institut für Angewandte Informatik, Professor
French PI: Jean-Gabriel Ganascia
Sorbonne University, Professor

Research Period: December 2020 – March 2024

Website of the project : https://research.nii.ac.jp/RECOMP/

Ref. No.
ANR: ANR-20-IADJ-0004
DFG: PA 1820/5-1
JST: JPMJCR20G4

§1 Outline of research implementation

(1) Research Summary

With the rapid evolution and spread of AI technologies in society, we can receive many benefits from AI. However, these same technologies also introduce new risks and negative consequences for individuals or society that threaten legal and ethical principles. Thus, we need to ensure that AI is compliant with these principles and this is a central concern that has become prominent both in public opinion and policy maker's agenda.

In EU, there has been a proposal of "AI ACT" to ban AI systems that have an unacceptably high risk to create a clear threat to society, livelihoods, and rights of people and strongly regulate AI systems that have a high risk to be used in critical infrastructures and systems influencing human rights. Other AI systems are not regulated by this ACT but AI systems in general should be trustworthy, which means they should be lawful (respecting all applicable laws and regulations), ethical (adhering to ethical principles and values), and robust (both technically and considering their social environment). Therefore, technical solutions are needed to achieve this goal, and it is strongly believed that mechanisms addressing these issues must/should/have to be embedded at the core of AI agent architectures. As far as we know, there has been no research combining legal and ethical compliance in AI systems.

In this research, we propose an overall architecture that combines legal and ethical compliance mechanisms to ensure the above conditions of trustworthy AI in the context of AI agent planning in multi-agent systems.

As a use case, we consider the management of personal data. In the domain of the use case, concerns about privacy and protection of personal data have received a lot of attention not only from a philosophical and ethical side (see for instance the aforementioned European guidelines) but also from a legal perspective, with European initiatives such as the GDPR which put companies under close scrutiny of their policy on the subject.

In our framework, we regard legal rules as "hard constraints" which AI must follow and ethical rules as "soft constraints" which play a role to choose the best action sequences among possible action sequences and we have a real-time compliance mechanism to check compliance even if there is a change of environment during the execution of a plan and we can modify the plan to be compliant with the new environment.

In this research project, we develop the following module.

① Planner which can dynamically modify the current plan according to the change of environment (real-time replanning) and generate physically possible plans

② Legal compliance checker which filters illegal plans from output plans from the planner.

③ Ethically best plan selector which chooses ethically best plans among legal plans output from the legal compliance checker.

④ Execution module which performs the first action of one of the legal and ethically best plans.

We iterate this mechanism until the desired goal is obtained. (see Figure 1).

For ①, French team formalized causality which is a theoretical base of planning and Japanese team implemented planner which perform real-time replanning. For ②, German team worked on formal representation of legal knowledge and Japanese team implemented on legal compliance checker. For ③, French team worked on formal representation of ethical knowledge and French team implemented ethically best plan selector in collaboration with Japanese team. For ④, German team worked on multi-agent systems to combine planner, legal compliance checker and ethically best plan selector.

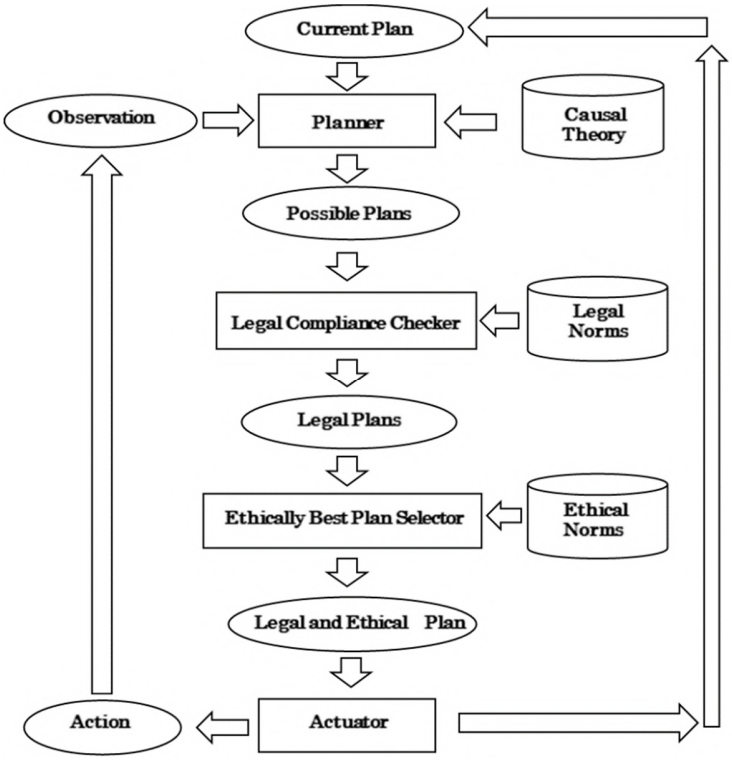


Figure 4 Basic Mechanism

(2) Remarkable Research Achievements

<Results as excellent basic research>

1. Summary Description for first result: **Real-time Compliance Mechanism Implementation**
   All groups have been working on implementation of Real-time Compliance Mechanism. It consists of planning module, legal compliance checker module, ethically best plan selector module and execution module. The planning module is based on HTN (Hierarchical Task Network) planning and has a function of replanning mechanism following results of action and exogenous environmental change from action executor. This is done by updating belief and making alternative plans (see Figure 2). The Legal Checker module receives physically possible plans from the planning module and filters illegal plans. The Japanese team worked on these modules. Then the Ethical Checker selects plans which satisfies ethical rules as much as possible. The French team worked on the Ethical Checker. Then finally we choose a plan among the best plans and execute the first action in the selected plan in the execution module (called Prova Agent) which was developed by the German team (see Figure 3).
2. Summary Description for second result: **AspectOWL Legal Ontology**
   The German LPI's group created an ontology representing legal norms for data privacy. It consists of a formalization of general legal and privacy-related terms and relations extracted from the European General Data Protection Regulation (GDPR), realized using the W3C OWL ontology language. Moreover, the ontology is extended to also capture action language related concepts, such as states and events that trigger state transitions. This allows, for example, the representations of changing obligations and permissions of third parties after the revocation of

consent to processing of data. The representation for this dynamic part is developed using AspectOWL, which is an extension of W3C OWL with multi-dimensional interpretations.

3. Summary Description for third results : **Ethical compliance checking**
   According to the initial architecture, hard constraints represent norms that must not be violated, that are used to identify which plans are allowed or prohibited, soft constraints are used to identify the best allowed plan. Legal norms are modeled as hard constraints to filter out illegal plans. In order to meet these needs we have developed a model based on multiple criteria. These criteria are used for the ordinal assessment of the level of respect to different AI values, in a hierarchical tree-like structure. We make use of voting rules to combine several orders, and our model can take into account the importance and/or superiority of the different criteria used for ethical assessment.
   The main focus in this work is on the proper criteria required to assess the level of respect or promotion of a certain AI value, for which we have drawn inspiration from AI ethics guidelines. In addition to this online checker, we also developed an offline checker based on a causality mechanism to explore different ethical principles and situations with chains of events.

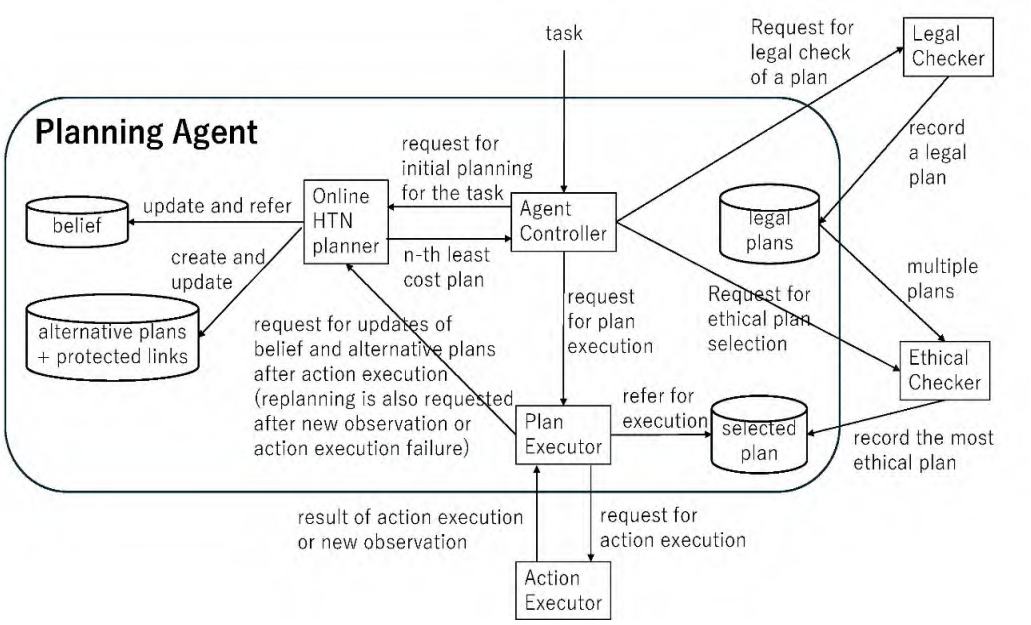


Figure 5 Detail Description of Planning Agent

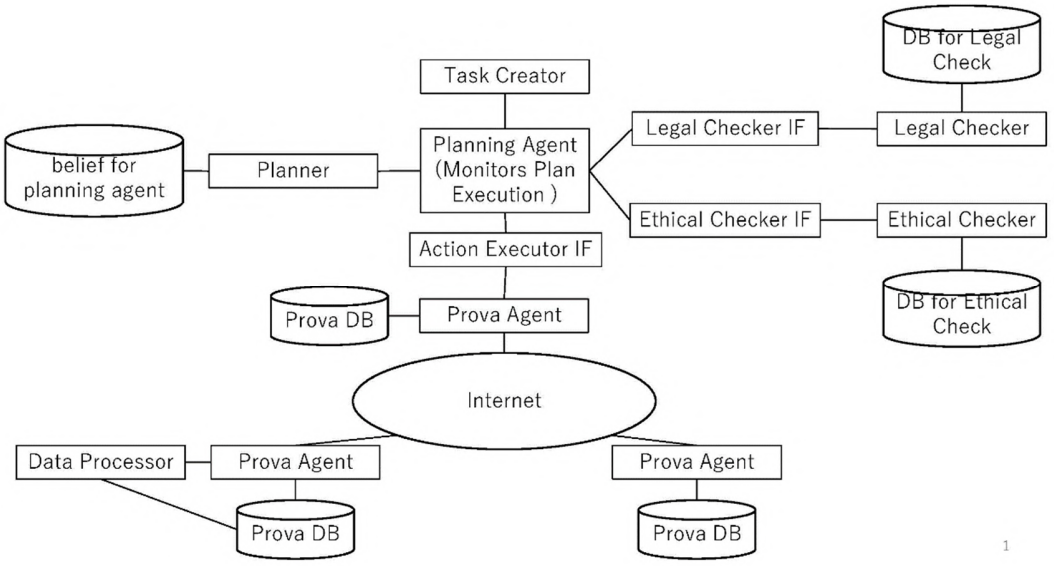


Figure 6 Overall Architecture

<Achievements that greatly contribute to science and technology innovation>

The first result as excellent basic research (real-time compliance mechanism implementation) is expected to be a basis on the future AI compliance mechanisms.

<Representative Papers>

1. Japanese Team
   (1) Hisashi Hayashi, Theodoros Mitsikas, Yousef Taheri, Kanae Tsushima, Ralph Schäfermeier, Gauvain Bourgne, Jean-Gabriel Ganascia, Adrian Paschke, and Ken Satoh. 2023. "Multi-Agent Online Planning Architecture for Real-Time Compliance." In *Proceedings of the 17th International Rule Challenge and 7th Doctoral Consortium @ RuleML+RR 2023 Co-Located with 19th Reasoning Web Summer School (RW 2023) and 15th DecisionCAMP 2023 as Part of Declarative AI 2023, Oslo, Norway, 18 - 20 September, 2023*, edited by Jan Vanthienen, Tomás Kliegr, Paul Fodor, Davide Lanti, Dörthe Arndt, Egor V. Kostylev, Theodoros Mitsikas, and Ahmet Soylu. Vol. 3485. CEUR Workshop Proceedings, Vol. 3485 (2023).
   (2) Ken Satoh, Jean-Gabriel Ganascia, Gauvain Bourgne and Adrian Paschke: Overview of RECOMP project. Proc. of International Workshop on Computational Machine Ethics (CME2021) in conjunction with KR 2021, November 5 (2021)
2. German Team
   (1) Ralph Schäfermeier, Theodoros Mitsikas, Adrian Paschke, Modeling a GDPR Compliant Data Wallet Application in Prova and AspectOWL. In: Proceedings of the 16th International Rule Challenge and 6th Doctoral Consortium @ RuleML+RR 2022, 26 - 28 September, 2022. CEUR Workshop proceedings, Vol-3229.
   => Winner of the 16th International Rule Challenge award.
   (2) Theodoros Mitsikas, Ralph Schäfermeier, and Adrian Paschke. 2023. "Modeling Medical Data Access with Prova." In: *Proceedings of the Seventeenth International Workshop on Juris-Informatics 2023 (JURISIN 2023) in association with the 15th JSAI International Symposia on AI (JSAI-isAI 2023), Kumamoto, Japan, 5-6 June, 2023,* edited by Ken Satoh and Katsumi Nitta.

3. French Team
   (1) Gauvain Bourgne, Camilo Sarmiento, Jean-Gabriel Ganascia : "ACE modular framework for computational ethics : dealing with multiple actions, concurrency and omission", *International Workshop on Computational Machine Ethics*, Online event, France (2021)
   (2) Yousef Taheri, Gauvain Bourgne and Jean-Gabriel Ganascia. "Modelling Integration of Responsible AI Values for Ethical Decision Making", *2nd International Workshop on Computational Machine Ethics*, KR2023 Workshop, Rhodes, Greece (2023)
   (3) Camilo Sarmiento, Gauvain Bourgne, Katsumi Inoue and Jean-Gabriel Ganascia. "Action Languages Based Causality in Decision Making Contexts", in *proceedings of PRIMA (Principles and Practice of Multi-Agent Systems)*, pp 243-259 (2022)

§2 Research Implementation Organization

1. PIs and Co-PIs of the Japan, Germany, France research teams and the structure

WP	Team	Country	PI or Co-PI
1	Sorbonne Univ., AIIT	France	PI, co-PI
2	InfAI	Germany	PI
3	NII	Japan	PI
4	Sorbonne Univ., Univ. Paris 8	France	PI, co-PI
5	Sorbonne Univ., Hosei Univ.	France, Japan	PI, co-PI
6	InfAI, AIIT, NII, Sorbonne Univ.	Germany, Japan, France	PIs, co-PI

2. Research Network Formation through Collaboration with Researchers and Companies other than this Research Team

(1) The German research team collaborated with Fraunhofer FOKUS on the RECOMP data wallet use case. Fraunhofer FOKUS developed the basic infrastructure for the Solid PODs based on the W3C Solid community project and the BMBF Panqura project. This was used as a technical basis and extended with the RECOMP GDPR-compliance checking mechanisms. The German research team also closely collaborated with Freie Universität Berlin specifically in the scope of the RuleML standard and the Prova implementation. Collaboration between the German team and the medical department of Leipzig University resulted in the modeling and proof-of-concept implementation of the medical data access scenarios in hospital information systems and clinical trial databases. Another collaboration between the German team and Swansea University resulted in the adaptation of GDPR-related terms for parts of the RECOMP ontology as well as GDPR-specific legal rule sets.

(2) The Japanese PI has been selected as a visiting chair of FFJ (the France-Japan Foundation (FFJ) associated with EHESS (École des hautes études en sciences sociales) in France working on Compliance mechanism of algorithmic law and stayed at Paris from July 2022 – December 2022. This is closely related with the RECOMP project since the compliance mechanism is very similar to the legal checking module. So the Japanese PI simultaneously worked on the RECOMP project with Sorbonne university and collaboration with FFJ.

(3) Jean-Gabriel Ganascia is animating with Grégory Bonnet a new CNRS working group on Computational Ethics (cf. https://gdr-radia.cnrs.fr/), which aims to promote collaboration between the different French teams on different issues of this topic.

(4) A new collaborative project called Thémis involving the French team and two industrial partners has

been accepted. It will start at the end of October 2023. This project inline with the RECOMP project intends to detect fake news and other infringements to current laws, such as illegal hate speech or terrorist content and unlawful discriminatory content, and to automatically take the required actions in order to comply with legal and ethical issues.

(5) The French partner organized in Paris on June 2-3 2022 the first 1st French-German dialogue on Perspectives on Ethics of Artificial Intelligence.

(6) The French team is participating in the the AlgoJust project that is an interdisciplinary project that aims at formalizing legal reasoning in collaboration with different computer science, logic and law teams.

(5) Team EDDA

Published

Trilateral AI Research

Research projects in the field of Artificial Intelligence
coordinated by Japan, Germany, and France

Final Report

Research Subject: EnhanceD Data stream Analysis with the Signature Method

Team EDDA

Japanese PI: Nozomi Sugiura
Japan Agency for Marine-Earth Science and Technology, Dr.
German PI: Joscha Diehl
University of Greifswald, Professor Dr.
French PI: Marianne Clausel
Université de Lorraine, Professor Dr.

Research Period: December 2020 – March 2024

Website of the project: https://sites.google.com/view/project-edda/project-edda

ANR: 20-IADJ-0003.
DFG: 442590525
JST: JPMJCR20G5

§1 Outline of research implementation

(1) Research Summary

The Japanese team has established several methods for applying signatures, which aggregate path information, to Earth Sciences. Specifically, because observational data in Earth Sciences often come in the form of paths, known as profiles, the team demonstrated that converting these profiles into signatures allows for effective time-series analysis, atmospheric state estimation, quality control of ocean profiles, and data assimilation, using real-world data. Through the consideration of practical applications to Earth Sciences, the team was able to jointly obtain insights with other teams on concepts such as the group mean of signatures (Fig. 1), the inverse transformation from signatures back to paths, the consideration of the mean of Brownian motion, and the geodesic distance between signatures.

The French team has investigated applications of the signature method to data stream analysis exploring several research directions. First, the team has worked on the concept of mean of signatures, which is an important building block for further applications in machine learning. Second, clustering methods based on the use of iterated integrals have also been explored. Several practical applications have been tackled : finance, neurosciences and earth sciences. On these two subjects the French team has interacted with the German team which brings its algebraic knowledge and with the Japanese team bringing interesting applications.

The German team has focused on algebraic fundamentals: we have, for the first time, defined and studied multi-parameter sums signatures, have defined, studied and implemented iterated sums over arbitrary commutative semirings, and laid the theoretical foundation for the use of iterated sums in efficient transformer architectures. Moreover we have provided the first python package to use iterated sums for time series classification.

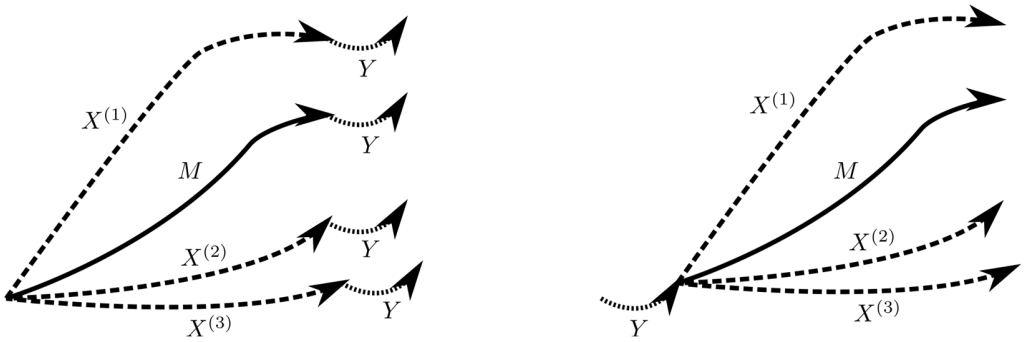


Figure 1 The group mean of signatures has a significant property that it is bi-invariant under concatenation. When S(M) is group mean of signatures {S(X(i))}, then S(Y*M) is the group mean of {S(Y*X(i))} (left panel), while S(M*Y) is the group mean of {S(X(i)*Y)}(right panel), where S(X) is the signature of path X, and * is the concatenation of paths.

(2) Remarkable Research Achievements

<Results as excellent basic research>

1. Summary Description for 1st result

   The signature method has become a powerful tool in the analysis of time series data. Its discrete iterated-sums analogue is particularly useful for the analysis of *discrete* time series data. It has been an open question for a while, whether similar techniques are applicable to multi-parameter objects, like images or videos. In the paper *Two-parameter sums signatures*

and corresponding quasisymmetric functions (Joscha Diehl, Leonard Schmitz, under review at Journal of Algebra) we present a positive answer to this question, thereby opening up an entire new line of research.

2. Summary Description
The classical signature method owes much of its success to the fact that it can be computed efficiently, using Chen's identity. This identity, which essentially says that a two-parameter object can be written in terms of a one-parameter object, has not been used to its full potential though. In unpublished work, we show that Chen's identity can be used in transformer networks to achieve a linear-in-input-size complexity when scanning over *time intervals* (instead of *time points*). The theoretical results are sound, and we are working on a successful implementation.

<Achievements that greatly contribute to science and technology innovation>

1. Summary Description for 1st result
Signatures have been shown to act as a key component in machine learning for Earth sciences. In this field, time series and observational profiles are treated as multidimensional sequential data. By converting these into signatures, we've demonstrated that high-performance prediction can be achieved either with simple machine learning methods or in combination with other techniques. This effectiveness is based on the mathematical principle that signatures can serve as a basis of functions on a set of paths. Strong evidence for these claims is provided in the paper by Sugiura (2022), as well as in papers currently under review [Fujita et al., 2023; Derot et al., 2023].

2. Summary Description for second result
The calculation of the mean is a key step in many machine learning methods. Several works have tackled this question of defining and computing in a proper way the mean of several time series. Unfortunately, in most of the cases, either computation of the average is highly time consuming or heavy assumptions as stationarity are required. In addition, up to our best knowledge, few methods address the multivariate setting. The aim of our work was to propose an approach based on the signature to average multidimensional time series Our contribution was to suggest to take advantage of the Lie group structure to average signatures, using the exp and log operation of the group [Mignot et al. 2022]

<Representative Papers>

1. Summary Description
The barycenter in free nilpotent Lie groups and its application to iterated-integrals signatures (J. Diehl, M. Clausel, R. Mignot, L. Schmitz, N. Sugiura and K. Usevich, arXiv:2305.18996, 2023, under review at SIAM Journal on Applied Algebra and Geometry). Here we established general results on the so-called signature mean, that we previously defined. We first establish the unique existence of the group mean and provide two algorithms, together with an implementation in SageMath and python, for calculating the empirical mean of a collection of time series. Our code is publicly available on https://github.com/Raph-AI/signaturemean

2. Summary Description
Two-parameter sums signatures and corresponding quasisymmetric functions (J. Diehl, L. Schmitz, https://arxiv.org/abs/2210.14247, under review at Journal of Algebra). Here we

expand from the realm of time series analysis by introducing a signature for two-parameter data, extending the applicability to image analysis. These are polynomial features that are invariant under time warping. We show that these two-parameter features are mathematically complete in a specific sense, and we set up the proper Hopf algebraic framework, including a weak form of Chen's identity.

3. Summary Description
The moving frame method for iterated-integrals: orthogonal invariants (Joscha Diehl, Rosa Preiß, Michael Ruddy and Nikolas Tapia, Foundations of Computational Mathematics, 2022) Invariant elements of the signature are the main source of interpretable features, the 'area', which is invariant to rotations, being a prime example. In this work we apply Fels–Olver's moving-frame method (for geometric features) paired with the log-signature transform (for robust features) to construct a set of integral invariants under rigid motions for curves in from the iterated-integrals signature.

§2 Research Implementation Organization

(1) PIs and Co-PIs of the Japan, Germany, France research teams and the structure

Tasks	Team	Country	PI or Co-PI
A, C	EDDA-FR	France	Marianne Clausel
B	EDDA-DE	Germany	Joscha Diehl
D	EDDA-JP	Japan	Nozomi Sugiura

(2) Research Network Formation through Collaboration with Researchers and Companies other than this Research Team

We have settled several new collaborations to disseminate the use of the signature in the machine learning community. First we began to work on the relevant choice of dictionaries to use the signature method with S. Chretien, who is a senior researcher in machine learning, interested in applications in neurosciences.

We also discuss with several senior researchers of the signal processing community. P. Abry (ENS de Lyon), is interested in testing the powerful impact of the signature method from a practical point of view. Patrice Abry has many collaborations with Japan, and is interested in developing his network with Japanese colleagues. We began to work with J.Y. Tourneret (Toulouse) and one of his PhD students on the application of the signature method on anomaly detections with applications to marine monitoring.

We also began to establish a collaboration with E. Robeva (U. British Columbia), on fruitful interaction between the signature method and causality. R. Mignot will pursue a postdoctoral position at UBC next year to explore this new research direction.

We also had interactions with industrial partners, as EDF and Total SA to name a few on this topic who are eager to disseminate the use of the signature method into the industrial community.

Several events will be organized this year and next year to gather the rough path scientific community S. Chretien will organize a workshop on the signature in December 2023 at Pau.

In April 2024 the EDDA team will organize a one-week international conference at Greifswald with a research school on diffusion models and applications to the signature methods on machine learning. This research school will be followed by four day of talks with outstanding researchers of the domain as Terry Lyons, Harald Oberhauser, and Valentin De Bortoli.

(6) Team PANORAMA

Published

Trilateral AI Research

Research projects in the field of Artificial Intelligence
coordinated by Japan, Germany, and France

Final Report

Research Subject: user adaPtive Artificial iNtelligence fOR humAn coMputer interAction

Team PANORAMA

Japanese PI: Yukiko Nakano
Seikei university, Professor
Japanese Co-PI: Shogo Okada
Japan Advanced Institute of Science and Technology, Associate Professor
German PI: Elisabeth André
University of Augsburg, Professor
French PI: Jean-Claude Martin
Laboratoire Interdisciplinaire des Sciences du Numérique (LISN, ex LIMSI), CNRS, Université Paris-Saclay, Professor
French Co-PI: Catherine Pelachaud
CNRS-ISIR, Sorbonne University, Director of Research CNRS

Research Period: December 2020 – March 2024
Website of the project: https://www.panorama-project.org/
Ref. No. ANR: ANR-20-IADJ-0008 DFG: 442607480 JST: JPMJCR20G6

§1 Outline of research implementation

(1) Research Summary

The key concept of this project is “user adaptive AI in the context of human-computer interaction”. When people talk to other people, they change their verbal and nonverbal communication behaviors according to those of the partner. Therefore, to improve user-adaptivity in human-agent interaction, the system needs to recognize human communication signals and generate agent’s behaviors according to the status of the communication. Towards this goal, this project addressed issues of collecting and analyzing corpus, developing conversational agents, and machine learning techniques.

In corpus studies, we collected multi-cultural corpus in two scenarios: Motivational Interviewing (MI) and NoXi. MI is a collaborative goal-oriented communication aiming to strengthen personal motivation for a specific goal. PANORAMA partners collected multi-cultural MI corpus in French, English and Japanese, and annotated the corpora using standard MI coding schemes. The second scenario is NoXi, which collected expert-novice interaction in Germany, French, English, and Japanese. The European NoXi was prepared for an international challenge of human social behavior analysis tasks with gold-standard annotation. We also developed the NOVA tool to support manual annotation processes. We used NOVA as the platform for manual annotation in the PANORAMA project, and the MI and NoXi corpora can be accessed via the NOVA tool.

As the component of conversational agents, we developed methods of recognition and generation of social signals as listed below:

- We investigated interruption mechanisms using the NoXi corpus and developed a generative model for facial expressions and head rotations, exhibited by the interrupter during the interruption phase.
- We investigated effectiveness of 3D face models, and provided a comprehensive analysis of their current capabilities and limitations when compared to state-of-the-art models that rely on 2D face image sequences.
- We participated in the Affective Vocal Bursts Competition in ACII 2022, and in the A-VB Type Task, which aimed to automatically distinguish between different types of vocal bursts, we achieved the first-place position.
- Analyzing MI corpus, we proposed a method for detecting Change Talk, which is a statement by a client revealing consideration of, motivation for, or commitment to change. We also proposed a method that generates facial expression dynamics in MI using conditional diffusion model.

To improve verbal communication with users, we proposed dialogue managers with user-adaptive dialogue strategies. In particular, we focused on exploiting knowledge graph and dialogue generation methods considering semantic representation in interviewing interaction.

In addition to the studies focusing on specific scenarios and domains, we proposed machine learning techniques that can be widely applied to a variety of human behavior data. First, we created a multitask learning algorithm using different kinds of multimodal social signal corpora. We also proposed an efficient transfer learning algorithm for adapting to the user’s multimodal behaviors.

(2) Remarkable Research Achievements

<Results as excellent basic research>

1. Yuan Gao, Longbiao Wang, Jiaxing Liu, Jianwu Dang, and Shogo Okada. Adversarial Domain Generalized Transformer for Cross-Corpus Speech Emotion Recognition, IEEE Transactions on Affective Computing (2023).

We proposed a new model called the Adversarial Domain Generalized Transformer (ADoGT) (see Figure 1) for cross-corpus speech emotion recognition (SER). This model aims to tackle the challenges of domain, individual differences and data scarcity, common issues in current deep learning methods for SER. The ADoGT improves recognition performance by adapting to different domains and removing specific domain information, thereby addressing data sparsity issues. The paper including the research findings, the collective experimental evaluation results have been accepted by IEEE Transactions on Affective Computing.

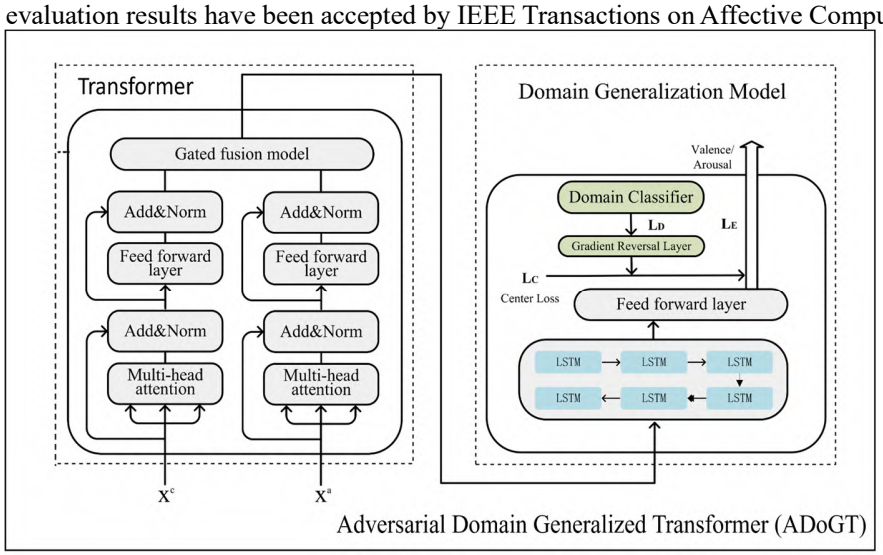


Figure 1: Overview of ADoGT referred from the paper (1.)

2. Liu Yang, Catherine Achard, Catherine Pelachaud. Multimodal classification of interruptions in humans' interaction. Proceedings of the 2022 International Conference on Multimodal Interaction. ICMI, 2022.

   We developed a multimodal classification model of interruptions using acoustic features, facial expression, head movement, and gaze direction from both interlocutors. The classification model learns from the sequential information to automatically identify interruption types. Then we developed a predictive model for when interruptions may occur during the conversation using multimodal features only from the speaker. We proposed a behavior generative model to compute the nonverbal behavior before an interruption (see Figure 2). To assess these models' accuracy, we conducted objective and perceptual studies where we compared different timings and different agent's behaviors (ground truth or randomly chosen or predicted by our models).

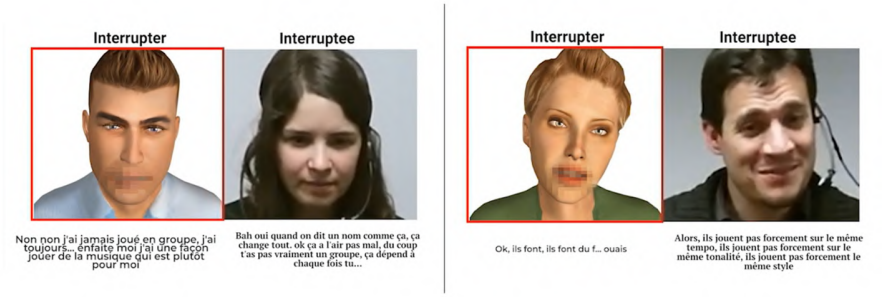


Figure 2: Frames extracted from videos used from the perceptual studies of our behavior generative model. They illustrate the agent interrupting human users. The mouth region is blurred as we have focused only on upper facial expressions and head movements.

3. Philipp Müller, Michal Balazia, Tobias Baur, Michael Dietz, Alexander Heimerl, Dominik Schiller, Mohammed Guermal, Dominike Thomas, François Brémond, Jan Alexandersson, Elisabeth André, Andreas Bulling: MultiMediate'23: Engagement Estimation and Bodily Behaviour Recognition in Social Interactions. ACM Multimedia 2023. CoRR abs/2308.08256 (2023)

   We prepared the NoXi dataset (see Figure. 3) containing data from different European cultures for an International Challenge organized in conjunction with ACM Multimedia 2023. To this end, we designed various human social behavior analysis tasks including engagement estimation and bodily behavior recognition in social interactions. We furthermore developed baselines consisting of well-established features for each modality as well as a fusion of all of them. MultiMediate 2023 (Multi-modal Group Behaviour Analysis for Artificial Mediation) represents the first challenge on engagement estimation and the recognition of bodily behaviors in social interaction.

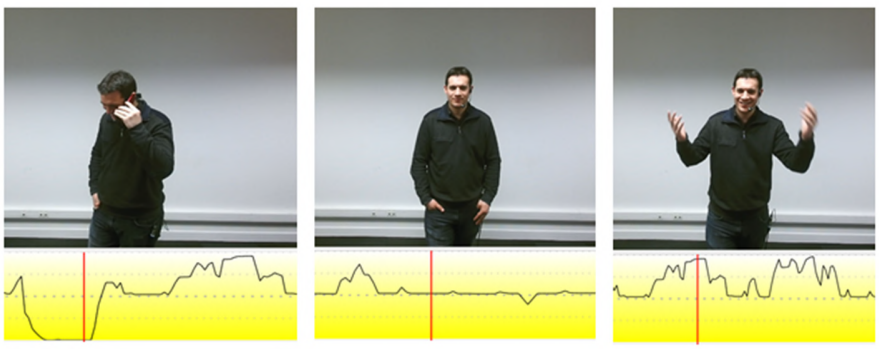


Figure. 3: Snapshots of scenes of a participant in the NOXI corpus being disengaged (left), neutral (center) and highly engaged (right).

<Achievements that greatly contribute to science and technology innovation>

1. NOVA Annotation tool: https://github.com/hcmlab/nova
   Tobias Hallmen, Silvan Mertes, Dominik Schiller, Florian Lingenfelser, Elisabeth André: Phoneme-Based Multi-task Assessment of Affective Vocal Bursts. DeLTA 2023: 209-222

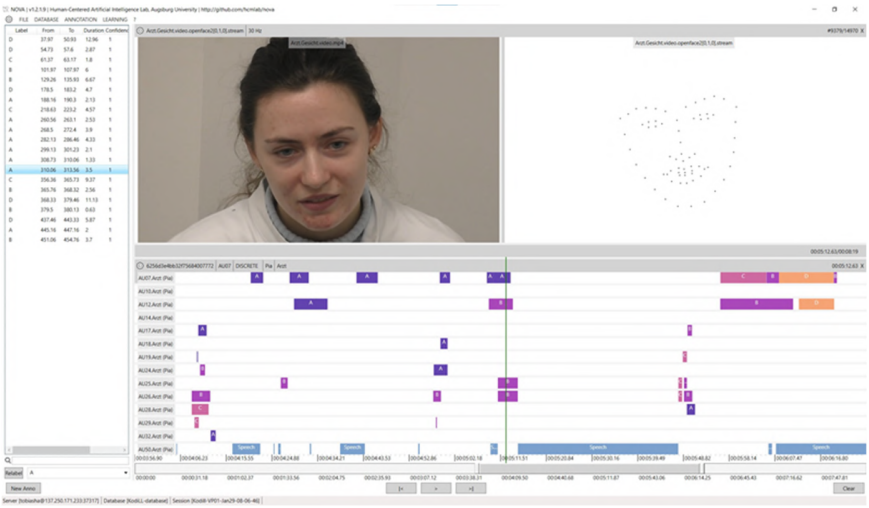


Figure.4: Screenshot of the NOVA tool taken from a training scenario for future medical doctors

The NOVA tool (see Figure. 4) has undergone significant enhancements. These improvements encompass state-of-the-art XAI techniques as well as advanced tools for cooperative annotation tasks (see WP2 description). Additionally, Panorama has introduced fresh innovations, such as a method for detecting vocal affect bursts. In a competition, the team achieved a first place with a 59% accuracy rate compared to the baseline performance of 42% UAR. NOVA has evolved into a highly utilized tool, boasting more than 4,260 downloads from GitHub (including pre-built releases), and the repo has been starred over 164 times. It finds application across diverse institutions, including universities and businesses.

2. Jie Zeng and Yukiko I. Nakano and Tatsuya Sakato, Question Generation to Elicit Users' Food Preferences by Considering the Semantic Content, SIGDIAL2023.

   Acquiring user model is indispensable to develop user adaptive systems. Toward this goal, this study proposes a semantics-aware GPT-3 fine-tuning model that generates interviews to acquire users' food preferences. The model was trained using dialogue history and semantic representation constructed from the communicative function and semantic content of the utterance (see Figure. 5). Using two baseline models: zero-shot ChatGPT and fine-tuned GPT-3, we conducted a user study for subjective evaluations alongside automatic objective evaluations. In the user study, in impression rating, the outputs of the proposed model were superior to those of baseline models and comparable to real human interviews in terms of eliciting the interviewees' food preferences.

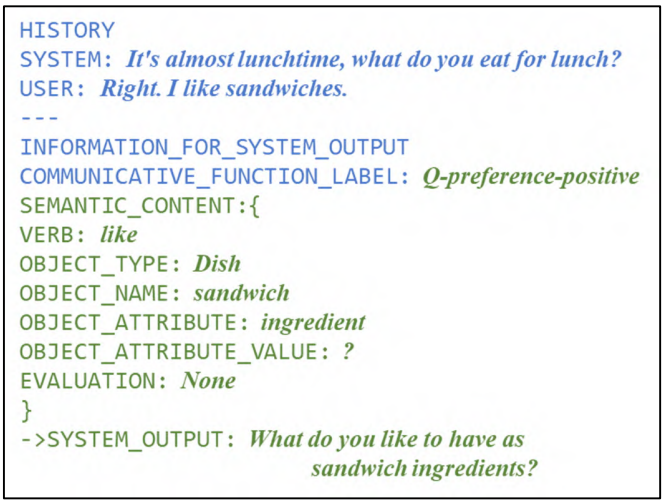


Figure. 5: Prompt and completion pairs in GPT-3 fine-tuning

3. **Corpora**. Available corpora of dyadic interactions in various settings are few. Multiple corpora were created or extended by the PANORAMA partners (JAMI, MICA, NOXI, AnnoMI). These corpora cover dyadic interactions in several settings (motivational interviewing and expert/novice interactions; French, English and Japanese; pedagogical videos vs. real interviews). They include videos and multi-level annotations that support the study of dyadic interactions at the levels of signals, behaviors and dialog acts.

<Representative Papers>

1. Yukiko I. Nakano, Eri Hirose, Tatsuya Sakato, Shogo Okada, and Jean-Claude Martin. 2022. Detecting Change Talk in Motivational Interviewing using Verbal and Facial Information. In Proceedings of the 2022 International Conference on Multimodal Interaction (ICMI '22). Association for Computing Machinery, New York, NY, USA, 5–14. https://doi.org/10.1145/3536221.3556607 [Best Paper Award Runner-up]

   This study focused on Motivational Interviewing (MI), which is collaborative communication aimed at eliciting the client's own reasons for behavior change (see Figure. 6). To investigate the effectiveness of facial information in modeling MI, we collected an MI encounter corpus with speech and video data in the nutrition and fitness domains and annotated client utterances using the Manual for the Motivational Interviewing Skill Code (MISC). We then proposed LSTM-based multimodal models to detect Change Talk. Our experiment showed that the best performing model was a multimodal BiLSTM model that fused language and client facial information, and our best model reached F1-score of 0.65 for Change Talk detection.

Speaker	Category	Utterance
Client	FN	I eat instant food once a day
Client	FN	I like it, and, one day later
Client	FN	I can eat it. This is my rule, and I've been living like that for a long time.
Client	CT	So, I tend to reach for those things easily, and that's not good. Change Talk
Client	ST	I'm already aware of that, but it's hard to stop.
Counselor	Reflect	Potato chips is a kind of vegetable in your life.
Client	FN	It's not an exaggeration to say that they're already a part of my life, and I've been eating them since I was a child.
Counselor	Facilitate	Um

Figure.6: Example of Motivational Interviewing

§2 Research Implementation Organization

(1) PIs and Co-PIs of the Japan, Germany, France research teams and the structure

WP	Team	Country	PI or Co-PI
1	LISN U of Augsburg	France Germany	Jean-Claude Martin Elisabeth André
2	U of Augsburg LISN ISIR JAIST Seikei	Germany France France Japan Japan	Elisabeth André Jean-Claude Martin Catherine Pelachaud Shogo Okada Yukiko Nakano
3	JAIST Seikei U of Augsburg	Japan Japan Germany	Shogo Okada Yukiko Nakano Elisabeth André
4	ISIR LISN U of Augsburg Seikei	France France Germany Japan	Catherine Pelachaud Jean-Claude Martin Elisabeth André Yukiko Nakano
5	Seikei ISIR	Japan France	Yukiko Nakano Catherine Pelachaud

(2) Research Network Formation through Collaboration with Researchers and Companies other than this Research Team

- We are currently working on integrating results from the TAPAS project into the Panorama project: ISIR and LISN are part of the ANR-JST CREST TAPAS Project. With Professor Nakamura of NAIST, partner of the TAPAS Project, a model is being developed to select the next best counselor's action. The counselor's action is represented by the MISC category of the produced utterance. Based on the user's multimodal input, a reinforcement learning algorithm selects the next counselor action that will maximize the number of change talks produced by the patient. We are working on integrating this model by using the category predicted as an additional input for the LLM model and also semantic information extraction from the LLM generated utterances. This way, the flow of the dialogue can be both more controlled and personalized to the user. This can also help the LLM model to produce more diverse utterances that are still relevant to the flow of the dialogue. At the same time, we will generate a counselor's nonverbal behavior in real time based on the behavior of both parties in the conversation as an auxiliary expression to make the conversation more natural. It ensures that the conversation is imbued with nonverbal cues to align with effective communication.

(7) Team TOSAI

Published

Trilateral AI Research

Research projects in the field of Artificial Intelligence coordinated by Japan, Germany, and France

Final Report

Research Subject: Understanding and Creating Dynamic 3D Worlds Towards Safer AI

Team TOSAI

Japanese PI: Ko Nishino
Kyoto University, Professor

German PI: Carsten Rother
University Heidelberg, Professor

French PI: David Picard
École des Ponts ParisTech, Senior Research Scientist

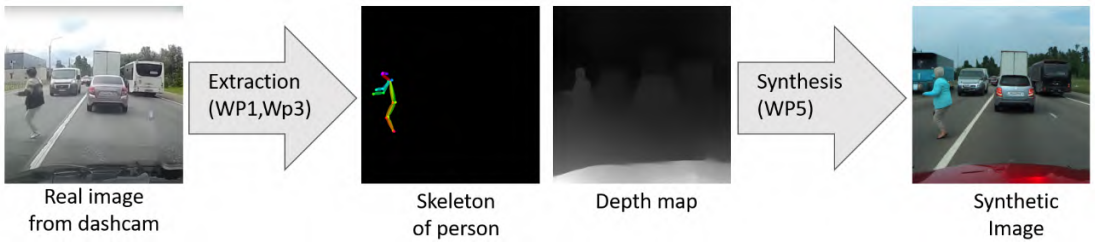
Research Period: December 2020 – March 2024
Website of the project: https://tosai-project.github.io

Ref. No.
ANR: 20-IADJ-0009
DFG: RO 4804/3-1
JST: JPMJCR20G7

§1 Outline of research implementation

(1) Research Summary

The goal of this work is to build tools that, firstly understand a dynamic 3D world and secondly use this understanding to synthesize new scenes. In this way scenes of dangerous scenarios, e.g. for autonomous driving, can be created. The figure below shows such an example. On the left we have a real image from a dashcam, that depicts a dangerous scene, where a person is crossing a road with cars approach fast. We can extract a 3D skeleton of the person crossing the road (WP3), additionally with a depth map (WP1). With this we can generate new dangerous scenes, with different conditions such as lighting, whether, etc. Will an autonomous vehicle still recognize this dangerous scene with respect to all these new conditions? This is obviously a fundamental question for making autonomous systems safer.



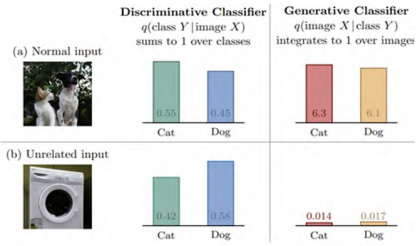
To achieve this result, we have worked on the two research fronts: information extraction (WP1-3) and image synthesis (WP4). These work packages nicely go hand-in-hand to generate the above result. Besides this outcome we have achieved more results in the individual work packages, which will ultimate help to generate synthetic images with higher fidelity and more variability. This includes a way to detect blind spots for driving, in order to automatically find dangerous scenes in e.g. dashcam footage. It also includes a detailed analysis of image, such as: reflectance properties extraction; the estimation of the 6D pose of objects present in the scene; and detection of detailed skeletons of people where hands and feet are accurately modeled.

(2) Remarkable Research Achievements
<Results as excellent basic research>

1. Summary Description for 1st result

We realized multimodal material segmentation, the recognition of material categories at each pixel in images of different modalities, i.e., RGB, near-infrared, and polarization, captured from the same vantage point (e.g., car-mounted camera). For this, we introduced the first dataset of multimodal material images (MCubeS dataset) and derived a novel deep architecture (MCubeSNet) to learn to recognize per-pixel materials. The network leverages a novel filter selection scheme called region-guided filter selection (RGFS) that enables "dynamic" selection of filters (i.e., combinations of imaging modalities) tailored to different potential materials underlying different object categories without significant computational overhead.

2. Summary Description for second result



With the maturing of deep learning systems, trustworthiness is becoming increasingly important for model assessment. We understand trustworthiness as the combination of explainability and robustness. Generative classifiers are a promising class of models that are said to naturally accomplish these qualities. However, this has mostly been demonstrated on simple datasets such as MNIST and CIFAR in the past. In this work, we firstly develop an architecture and training scheme that allows Generative classifiers to operate on a more relevant level of complexity for practical computer vision, namely the ImageNet challenge. Secondly, we demonstrate the immense potential of Generative classifiers for trustworthy image classification. Explainability and some aspects of robustness are vastly improved compared to feed-forward models, even when the Generative classifiers are just applied naively. While not all trustworthiness problems are solved completely, we observe that GCs are a highly promising basis for further algorithms and modifications.

3. Summary Description for third results

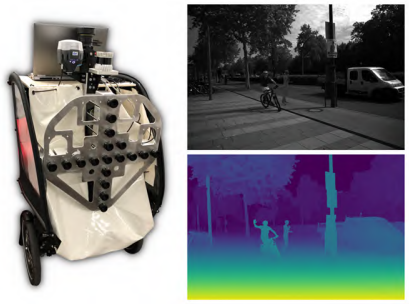
Image generation is a booming field at the core of the project and yet the behavior of current models is not well understood. In particular, it is unknown how they encode relevant information into a latent space and what structure such latent space has. In recent work, we show that generative models tend to discover semantics by specializing regions of the latent space to specific semantic content. In the case of encoding-decoding architectures (like the ones found in VAE or in diffusion models), by letting the model decide which latent vector to associate to each region, we observe specialization of some latent vectors on semantically consistent regions (like the shoes on the image above), which hints at a well-structured latent space.

<Achievements that greatly contribute to science and technology innovation>

1. Summary Description for 1st result

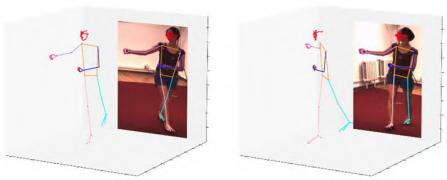
We realized automatic blind spot detection on the road. By automatically detecting road regions that are occluded from the vehicle's vantage point, we can proactively alert a manual driver or a self-driving system to potential causes of accidents (e.g., draw attention to a road region from which a child may spring out). We achieve this by introducing a self-supervised learning method that generates ground-truth blind spot training data for arbitrary driving videos by leveraging monocular depth estimation, semantic segmentation, and SLAM and then learns to fully automatically estimate frame-wise blind spot probability maps for arbitrary driving videos.

2. Summary Description for second result



We have been working on depth estimation from so-called light field cameras for a long period of time. A light field camera consists of many small cameras in a physically closed space (see example on the right). In the context of this project we studied an outstanding issue in depth estimation: to predict for each pixel not only a single depth value, but a multitude of depth values. Such scenarios happen in reality quite frequently, such as: specular surfaces, windows, fine structure such as trees, ect. We are proud that, based on the work in our lab, a start-up spin out: https://rabbitai.de/ with now 12 employees. One goal of the start-up is identical to this project, i.e. the creation of dangerous scenes for autonomous driving. However, in contrast to rabbit.ai we tackle this problem without having an accurate 3D reconstruction up-front. This is much more challenging, but opens the avenue for large-scale, fully automated image generation.

2. Summary Description for third result



We have developed an entire framework for 3D whole-body human pose estimation that enables estimating the pose of the hands and the detailed face expression in addition to the global pose of the body. Having the pose of the hands and the face in 3D is key additional information to better understand and predict the behavior of humans in a video stream. For example, a pedestrian reading on a phone and not paying attention to their surroundings can be better identified by having the hands and head information. In addition to releasing data to train 3D whole-body pose estimation models, we also release pretrained models enabling downstream tasks (https://github.com/wholebody3d/wholebody3d).

<Representative Papers>

1. Summary Description

"Camera Pose from Object Appearance," Kohei Yamashita, Vincent Lepetit, Ko Nishino, in preparation, 2023. We are preparing a submission to a leading computer vision international conference that summarizes our collaborative research (JP-FR) on camera pose estimation. Accurate knowledge of viewpoint plays a critical role in any visual understanding task. Its estimation becomes particularly challenging when objects in sight are textureless and shiny, such as cars on the road. In this work, we have derived a novel method that leverages the reflected surrounding scene on the object surface to estimate relative camera motion between pairs of images. This research project started in PI Lepetit's one-month stay in PI Nishino's lab in Japan.

2. Summary Description

The field of image synthesis has made tremendous strides forward in the last years. Besides controlling the output image with prompts, an intuitive approach is to utilize a guidance image, e.g. in forms of a depth map. In this work we propose a new neural architecture that gives outstanding results, and has at the same time only a fraction of parameters, in contrast to competitive models. We call our model controlnet-XS:https://vislearn.github.io/ControlNet-XS/

3. Summary Description

"Templates for 3D Object Pose Estimation Revisited: Generalization to New Objects and Robustness to Occlusions; Van Nguyen Nguyen, Yinlin Hu, Yang Xiao, Mathieu Salzmann, and Vincent Lepetit, CVPR 2022."

This work proposes an approach that can recognize new objects and estimate their 3D pose in RGB images even under partial occlusions. The method requires neither a training phase on these objects nor real images depicting them, only their CAD models. It relies on a small set of training objects to learn local object representations, which allow us to locally match the input image to a set of "templates", rendered images of the CAD models for the new objects. In contrast with the state-of-the-art methods, the new objects on which our method is applied can be very different from the training objects. As a result, we are the first to show generalization without retraining on the LINEMOD and Occlusion-LINEMOD datasets. Our analysis of the failure modes of previous template-based approaches further confirms the benefits of local features for template matching. We outperform the state-of-the-art template matching methods on the LINEMOD, Occlusion-LINEMOD and T-LESS datasets.

§2 Research Implementation Organization

(1) PIs and Co-PIs of the Japan, Germany, France research teams and the structure

WP	Team	Country	PI or Co-PI
1 Appearance Modeling	Kohei Yamashita, Tomoki Ichikawa, Ryosuke Wakaki, Ko Nishino, Shohei Nobuhara Titus Leistner, Carsten Rother	Japan, Germany, France	PI: Nishino (Jp) Co-PI: Lepetit (Fr) Co-PI: Rother (De) Co-PI: Nobuhara (Jp)
2 Geometric Modeling	Nguyen VanNguyen, Antoine Guédon, Vincent Lepetit, Carsten Rother	France, Germany	PI: Lepetit (Fr) Co-PI: Rother (De)
3 Dynamic People Modelling	David Picard, Vincent Lepetit, Shu Nakamura, Soma Nonaka, Shohei Nobuhara, Ko Nishino, Nermin Samet, Nicolas Dufour	France, Japan	Pi: Picard (Fr) Co-PI: Lepetit (Fr) Co-PI: Nobuhara (Jp)
4 Uncertainty Modeling as Case Study for Safety	Titus Leistner, Jens Muller, Radek Mackowiak, Lynton Ardizzone, Carsten Rother	Germany	PI: Rother (De) Co-PI: Kothe (De)
5 Image Synthesis for Data Augmentation	Denis Zavadski Phillip, Grassal, Malte Prinzle, Carsten Rother, Taichi Fukuda, Kotaro Hasegawa, Shin'ya Ishizaki, Shohei Nobuhara, Ko Nishino, Nicolas Dufour, David Picard	Germany, Japan, France	PI: Rother (De) Co-PI: Nishino (Jp) Co-PI: Picard (Fr)
6 Software Development	Shu Nakamura, Shohei Nobuhara, Ko Nishino, David Picard, Carsten Rother	Japan, Germany, France	PI: Nishino (Jp) Co-PI: Picard (Fr) Co-PI: Rother (De)
7 Communication	All	France, Germany, Japan	PI: Picard (Fr) Co-PI: Rother (De) Co-PI: Nishino (Jp)

(2) Research Network Formation through Collaboration with Researchers and Companies other than this Research Team

In addition to the online communications within the three teams of this research program as well as the two workshops (one virtual and one in-person) that consisted of talks and discussions among the team members including students, we also have had research visits (notably by PI Lepetit in Japan for a month) and plan to have PhD student exchanges in 2024 post COVID19 pandemic. Furthermore, we have extensively collaborated researchers outside the three research teams. The Rother lab (DE) worked within the team of Prof. Niessner and Prof. Justus Thies at TUM (Munich/Germany) on the topic of new view synthesis with neural networks (so called neural rendering). The Nishino lab (JP) worked closely with Prof. Kristin Dana at Rutgers University (USA) on the topic of 3D reconstruction using polarization cameras. This collaboration has resulted in a top-tier international conference paper. The team at Ecole des Ponts in France worked on 3D pose estimation with the company Ergonova for assessing ergonomics at workplaces, and the project also sparked a collaboration with the automotive company Valeo which

aims at developing the 3D pose estimation framework for in-car monitoring purposes. The supervision of the PhD student working on image manipulation at Ecole des Ponts is done in collaboration with Vicky Kalogeiton at Ecole Polytechnique and this collaboration is expected to expand into more co-supervision in the future.

(8) Team CHIRON

Published

Trilateral AI Research

Research projects in the field of Artificial Intelligence
coordinated by Japan, Germany, and France

Final Report

Research Subject: AI empowered general purpose assistive robotiC system for dexterous object manipulation tHrough embodIed teleopeRation and shared cONtrol

Team CHIRON

Japanese PI: Yasuhisa Hasegawa
Nagoya University, Professor

German PI: Jan Peters
Technische Universität Darmstadt, Professor

French PI: Liming Chen
Ecole Centrale de Lyon, Professor

Research Period: December 2020 – March 2024

Website of the project: https://chiron.website/

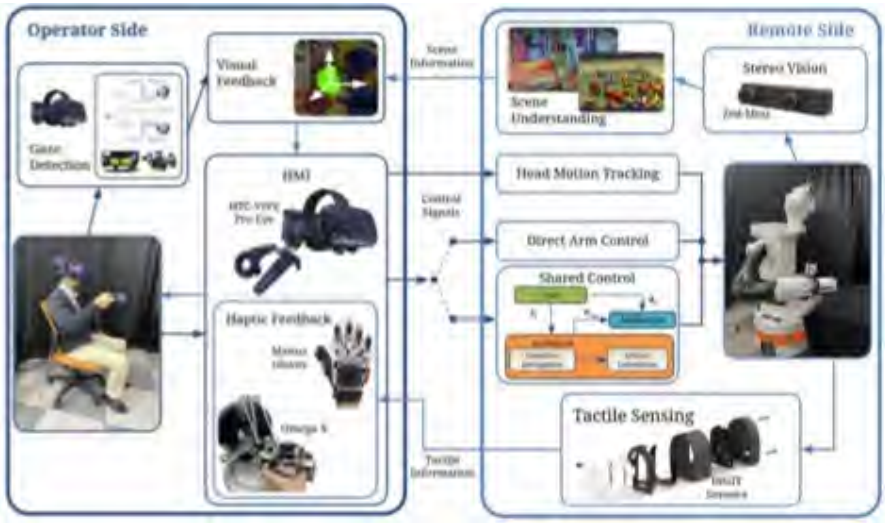
JST JPMJCR20G8 / DFG PE2315/8-1 /ANR-20-IADJ-0001-01

§1 Outline of research implementation

(1) Research Summary

Dexterous manipulation of objects is a core task in robotics. Because of the design complexity needed for robot controllers even for simple manipulation tasks, robots currently in use are mostly limited to specific tasks within a known environment. Within the CHIRON project, we aim to develop an **AI empowered general purpose robotic system for dexterous manipulation** of complex and unknown objects in rapidly changing, dynamic and unpredictable real-world environments. This will be achieved through intuitive embodied **robotic teleoperation under optimized shared-control** between the human operator enhanced with an intuitive haptic interface and the **robot controller empowered with AI-based vision and learning skills**. The privileged use case of such a system is assistance for "stick-to-bed" patients or elders with limited physical ability in their daily life object manipulation tasks, *e.g.*, fetching a bottle of water and pouring it into a glass, through an intuitive and embodied robot tele-operated by themself. Such object manipulations would be otherwise not possible for them. To make possible such an embodied tele-operated robotic system for dexterous manipulation, thus without any assumption about the object to be manipulated and the operating environment, the CHIRON project features **unique innovations simultaneously on different AI applied domains: robotics, computer vision and machine learning**.

(2) Remarkable Research Achievements

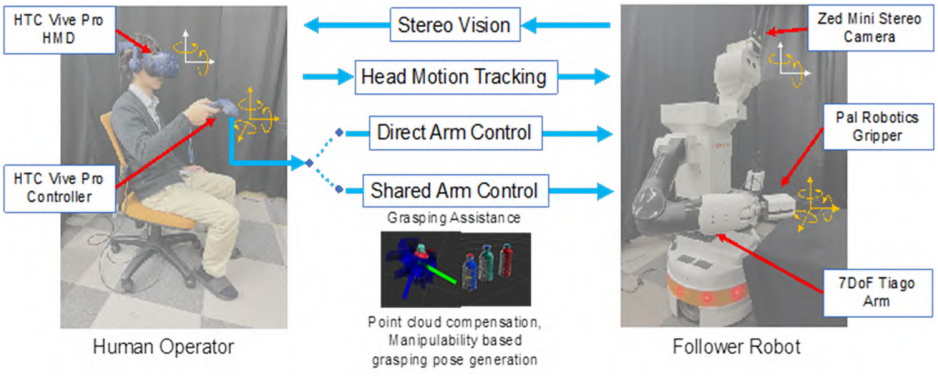


<Results as excellent basic research>

1. Yaonan Zhu, Bingheng Jiang, Qibin Chen, Tadayoshi Aoyama and Yasuhisa Hasegawa, "A Shared Control Framework for Enhanced Grasping Performance in Teleoperation," in IEEE Access, vol. 11, pp. 69204-69215, 2023, doi: 10.1109/ACCESS.2023.3292410.

   Remote teleoperation has seen notable progress since its inception in the 1940s. Recently, shared control methods, where robots aid operators, have become prominent, especially in tasks such as object grasping. This project develops a shared control framework to improve teleoperated grasping using a virtual reality-based system. Our approach uses template matching for pose generation and selects grasp candidates based on joint constraints. The

operational assistance is finalized with trajectory blending. Experimental evaluations demonstrate our framework's efficacy in enhancing grasping efficiency and reducing workload.



Shared control framework for enhanced teleoperation

2. Kay Hansel, Janosch Moos, Hany Abdulsamad, Svenja Stark, Debora Clever, Jan Peters. 2023. “Robust reinforcement learning: A review of foundations and recent advances”. Machine Learning and Knowledge Extraction (MAKE), 4(1), 276-315.

   In robotics, the use of reinforcement learning (RL) assuming a Markov decision process has been very successful. However, ensuring the robustness of RL solutions in real-world and complex environments has emerged as a critical challenge. Uncertainty, disturbances, and environmental changes often impede the performance of current RL algorithms. We conducted a comprehensive survey of robust approaches to RL, classifying them into four categories: (i) Transition robust designs account for uncertainties in the system dynamics; (ii) Disturbance robust designs leverage external forces; (iii) Action robust designs redirect transitions of the system by corrupting an agent’s output; (iv) Observation robust designs distort the perceived system state. Moreover, we addressed the correlation between robustness, risk-based and entropy-regularized RL. The survey provides a novel and comprehensive overview of the core concepts underpinning robust RL and their recent advancements.

3. Lingkun Luo, Liming Chen, Shiqiang Hu. “Attention Regularized Laplace Graph for Domain Adaptation”, IEEE Transactions on Image Processing, Online 28-Oct-2022: https://doi.org/10.1109/TIP.2022.3216781

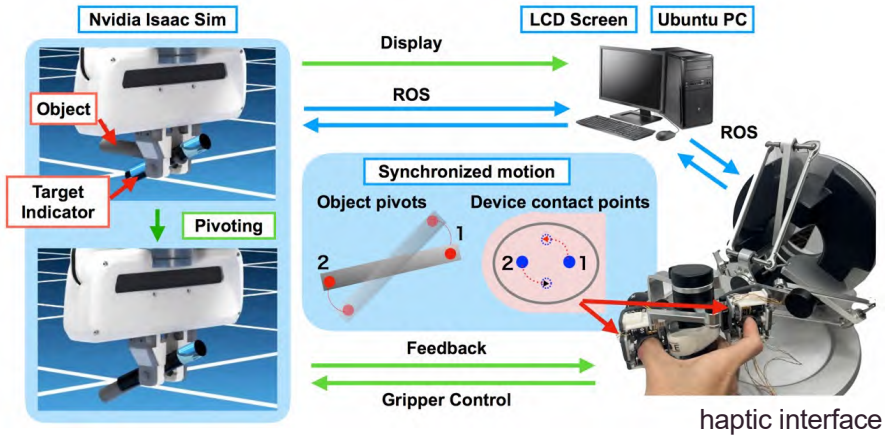
   Robot learning relies more and more upon simulation data. But the learned models need to run in the real world despite the gap between simulated and real data. In this work, we have proposed a novel unsupervised DA method, namely Attention Regularized Laplace Graph-based Domain Adaptation (ARG-DA). Specifically, by weighting the importance across different sub-domain adaptation tasks, we propose the Attention Regularized Laplace Graph for class aware DA, thereby generating the attention regularized DA. Furthermore, using a specifically designed FEEL strategy, our approach dynamically unifies alignment of the manifold structures across different feature/label spaces, thus leading to comprehensive manifold learning.

<Achievements that greatly contribute to science and technology innovation>

1. Yaonan Zhu, Jacinto Colan, Tadayoshi Aoyama and Yasuhisa Hasegawa, "Cutaneous Feedback

Interface for Teleoperated In-Hand Manipulation," 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Kyoto, Japan, 2022, pp. 605-611.

In-hand pivoting is an important robot manipulation skill for addressing environmental uncertainties and motion inaccuracies. While mathematical and learning-based solutions have been explored, challenges remain as open problems. Humans, however, excel in such tasks due to their intrinsic skills. This project develops a cutaneous feedback interface, aiming to leverage human dexterity in teleoperation. The device is designed using a five-bar link mechanism, the



Haptic interface for dexterous in-hand teleoperation

interface offers feedback on the index finger and thumb. When integrated with a haptic device, it can feedback normal forces and object poses through cutaneous sensation. The effectiveness of this interface is evaluated through passive pivoting tasks in the Isaac Sim simulator.

2. Kay Hansel, Julan Urain, Jan Peters, Georgia Chalvatzaki. 2023. “Hierarchical policy blending as inference for reactive robot control”. In 2023 IEEE International Conference on Robotics and Automation (ICRA) (pp. 10181-10188).
An Thai Le, Kay Hansel, Jan Peters, Georgia Chalvatzaki. 2023. “Hierarchical Policy Blending As Optimal Transport”. In Learning for Dynamics and Control Conference (pp. 797-812). PMLR.

Motion generation in complex and dynamic environments is a central topic in robotics, rendered as a multi-objective decision-making problem. Balancing safety and performance, state-of-the-art methods trade-off between reactive policies and planning-based motion generation. To combine the benefits of reactive policies and planning, we introduced two novel hierarchical motion generation methods: Hierarchical Policy Blending as Inference (HiPBI) and Hierarchical Policy Blending as Optimal Transport (HiPBOT). Both techniques combine stochastic, reactive expert policies with planning, dynamically computing optimal weights over the task horizon. HiPBI employs probabilistic inference, framing policy blending as sampling-based stochastic optimization, while HiPBOT formulates it as deterministic entropic-regularized linear programming. Our methods effectively evade local optima, facilitating feasible reactive plans for navigating challenging dynamic environments.

3. Guillaume Duret, Nicolas Cazin, Mahmoud Ali, Florence Zara, Emmanuel Dellandréa, Jan Peters, Liming Chen, "PickSim: a dynamically configurable Gazebo pipeline for robotic manipulation", Advancing Robot Manipulation Through Open-Source Ecosystems-2023 IEEE International Conference on Robotics and Automation (ICRA) Conference Workshop **Internationally Co-authored paper.**

   We have developed and released PickSim: A dynamically configurable Gazebo pipeline for robotic manipulation learning. Specifically, we propose a new plugin and pipeline, based on the well known open source robot software Gazebo. Rich and perfect annotations (e.g., object masks, poses, occlusions, etc.) are automatically generated and enable the learning and evaluation of computer vision models over a number of varying factors. PickSim unlocks multi-task robot manipulation learning when a robot model and physics engine are integrated into it, and thereby paves the way to the generation of large-scale robot manipulation data as required in general-purpose robot manipulation learning.

<Representative Papers>

1. **Best paper award, Internationally Co-authored paper.**
   Yaonan Zhu, Shukrullo Nazirjonov, Bingheng Jiang, Jacinto Colan, Tadayoshi Aoyama, Yasuhisa Hasegawa, Boris Belousov, Kay Hansel, and Jan Peters, "Visual Tactile Sensor Based Force Estimation for Position-Force Teleoperation," 2022 IEEE International Conference on Cyborg and Bionic Systems (CBS), Wuhan, China, 2023, pp. 49-52, doi: 10.1109/CBS55922.2023.10115342.

   Vision-based tactile sensors are becoming prominent in robotics for their ability to derive contact or haptic information during manipulations. This project introduces a contact force estimation method using the tactile sensor DIGIT, integrating it into a position-force teleoperation setup. The process involves creating a depth map of the DIGIT gel's deformation and employing a regression algorithm to link depth and force data. The setup includes a leader haptic device and a follower robot gripper equipped with the DIGIT sensor for contact force measurement. Research outcomes indicate the potential of affordable vision-based sensors in force feedback applications.

2. **Internationally Co-authored paper.**
   Qibin Chen, Yaonan Zhu, Kay Hansel, Tadayoshi Aoyama, and Yasuhisa Hasegawa. 2023. "Human Preferences and Robot Constraints Aware Shared Control for Smooth Follower Motion Execution." In 2023 IEEE International Symposium on Micro-Nano Mechatronics and Human Science (MHS), (2023).

   In robot teleoperation, shared control is used to reduce the operator's burden. This project introduces a dynamic shared control approach for object grasping that balances the operator's preferences with the constraints of the follower robot. The system seamlessly toggles between manual and automatic modes, allowing the operator's interventions. The point cloud-based grasping pose detection considers both the operator's current hand pose and the robot's manipulability to generate a feasible grasping pose. Experimental results indicate that the new strategy results in smoother trajectory execution during shared control.

3. Luo, Lingkun;Hu, Shiqiang; Chen, Liming; "Discriminative Noise Robust Sparse Orthogonal Label Regression-based Domain Adaptation", International Journal of Computer Vision (IJCV). Online 24-Aug-2023 here. The preprint can be found here: https://arxiv.org/abs/2101.04563;

Robot learning relies more and more upon simulation data. But the learned models need to run in the real world despite the gap between simulated and real data. In this work, We have furthered our previous DA methods and proposed a novel unsupervised DA method, namely Discriminative Noise Robust Sparse Orthogonal Label Regression-based Domain Adaptation (**DOLL-DA**). We carry out comprehensive experiments in comparison with 35 state of the art DA methods using 8 standard DA benchmarks and 49 cross-domain image classification tasks. The proposed DA method demonstrates its effectiveness and consistently outperforms the state-of-the-art DA methods with a margin which reaches 17 points on the CMU PIE dataset.

§2 Research Implementation Organization

(1) PIs and Co-PIs of the Japan, Germany, France research teams and the structure

WP	Team	Country	PI or Co-PI
1. Continuous few shot learning for deep scene understanding	Ecole Centrale de Lyon (ECL)	France	Liming Chen (PI), Emmanuel Dellandréa (Co-PI)
2. Reinforcement learning trajectories estimation/prediction	TU Darmstadt (TUDA)	Germany	Jan Peters (PI)
3. Embodied teleoperation and shared control	Nagoya University (NU)	Japan	Yasuhisa Hasegawa (PI), Yaonan Zhu (Co-PI)
4. Demonstration and benchmark	NU, TUDA, ECL	Japan, Germany, France	Yasuhisa Hasegawa (PI), Yaonan Zhu (Co-PI), Jan Peters (PI), Liming Chen (PI) , Emmanuel Dellandréa (Co-PI)

(2) Research Network Formation through Collaboration with Researchers and Companies other than this Research Team

The cooperative control technology for remote control of robots studied in this project has led to joint research for its applications with researchers and engineers from automobile manufacturers, other universities, and hospitals, including Nagoya University Hospital.

(9) Team KEEPHA

Published

Trilateral AI Research

Research projects in the field of Artificial Intelligence
coordinated by Japan, Germany, and France

Final Report

Research Subject:
Knowledge-enhanced information extraction across languages for pharmacovigilance

Team KEEPHA

Japanese PI: Matsumoto, Yuji
Riken AIP, Team Leader, Dr.Eng.

German PI: Möller, Sebastian
DFKI, Speech and Language Technology Lab, Professor, Dr.-Ing.

French PI: Zweigenbaum, Pierre
Université Paris-Saclay, CNRS, LISN, Senior Researcher, Ph.D.

Research Period: December 2020 – March 2024

Website of the project : https://keepha.lisn.upsaclay.fr

Ref. No.
JST-JPMJCR20G9
DFG-442445488
ANR-20-IADJ-0005-01

1 Outline of research implementation

(1) Research Summary

Nowadays, scientific knowledge can be published digitally within many different forms and sources, such as encyclopedias, scientific papers, and regulatory documents, but also structured knowledge sources like ontologies or knowledge bases. Besides that, news articles, blog posts, forums or social media can contain relevant information and be used for research. All this is published every day in a large number of different languages. The volume and speed of production of digital content have become too fast in some domains for humans to be able to keep up with them and maintain an up-to-date view of current scientific evidence. The present project aimed to design Artificial Intelligence methods that automatically digest these different text sources and jointly extract such knowledge and observations to populate existing knowledge bases. Our project showcases these methods in the domain of pharmacovigilance, which endeavors to maintain up-to-date knowledge of adverse drug reactions (ADRs) for the benefit of public health. We focused on detecting mentions of adverse drug reactions in social media and scientific journals.

An ADR is *an appreciably harmful or unpleasant reaction, resulting from an intervention related to the use of a medicinal product, which predicts hazard from future administration and warrants prevention or specific treatment, or alteration of the dosage regimen, or withdrawal of the product* [?]. From a natural language processing point of view, an ADR is the expression of a causal relation that relates a drug to a medical problem: the latter are two mentions of entities, while the former is a relationship. This calls, therefore, for two information extraction tasks: entity detection and relation extraction.

In our context, few annotated data were available to train information extraction systems. Moreover, since social media users express their views in their own languages, we needed to process text in the relevant languages, i.e., Japanese, German, and French. This set the main goals for the project and led to the achievements below.

A foundational asset jointly created by the three-country team is an annotation schema for adverse drug reactions. This schema was designed iteratively through a series of consortium-wide online meetings, with feedback from each team. It was then used to perform annotations on each language: DFKI led the annotations on German and French, and the Japanese party managed annotation on Japanese, resulting in the KEEPHA tri-lingual annotated corpus.

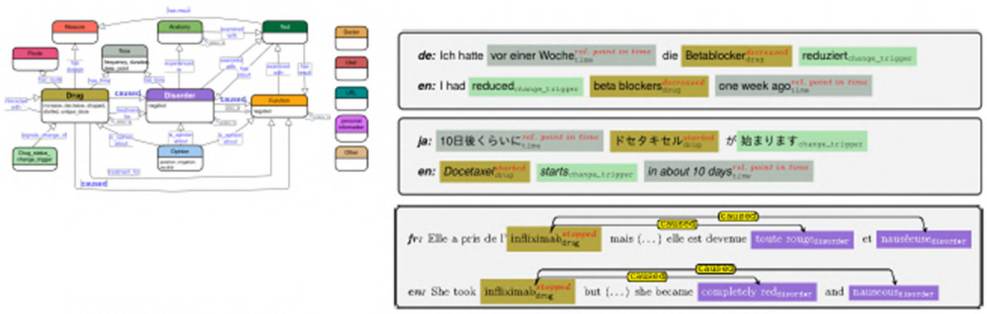
Such annotations provide the basis for training deep neural network systems that analyze text contents. All teams prepared and made available methods and deep learning tools to perform information extraction. The initial experiments were performed on pre-existing biomedical annotated corpora. After the tri-lingual annotated corpus was available, we also started to test our methods on this new corpus. The information extraction methods created by the team include entity detection (all), attribute classification (NAIST, LISN), relation extraction (RIKEN, LISN), as well as discourse dependency parsing (RIKEN). Specific methods were elaborated such as joint detection of entities and relations (RIKEN), cross-language detection (DFKI, LISN), prompt-based relation extraction (LISN), zero-shot relation extraction (RIKEN, LISN) or message classification (DFKI) among others. Additionally, RIKEN created Japanese language models pre-trained for the medical domain: these specific models improve Japanese information extraction in that domain.

To reach out to the wider natural language processing community, NAIST organized a shared task (challenge) on the detection of adverse drug reactions in multilingual text, hosted by the NTCIR conference (2023), prepared together with all KEEPHA partners. This attracted the attention of a large number of teams worldwide, among which eight went all the way to creating ADR detection systems and submitting results to the shared task. We have also planned another shared task, led by LISN and DFKI with contributions by all, that will use the KEEPHA tri-lingual annotated corpus (SMM4H 2024). These shared tasks lead to better dissemination of our work and to better assessment of the current state of the art on tasks of interest to our project.

(2) Remarkable Research Achievements

<Results as excellent basic research>

1. Summary Description
   (joint) KEEPHA multilingual annotation guidelines.
   One of the joint achievements of the KEEPHA team is the creation of annotation guidelines for the German, French, Japanese, and English languages, aimed to be applicable to other languages as well.



(a) Annotation schema (b) Example annotations

Figure 1: Annotation schema and examples

They provide detailed instructions to annotate mentions of medications, medical signs/symptoms, patient opinions, and other medically relevant expressions. Further, the guidelines allow the specialization of these mentions, in particular medication, time, and opinion expressions, by adding attributes for a more fine-grained annotation. In addition, guidelines for annotating relationships between these mentions are provided to capture the occurrence of adverse drug reactions, the timeline of medication intake, or medications prescribed for a specific medical symptom, among others. The guidelines have been developed iteratively with the whole consortium over a period of about two years within many online sessions. Figure 1(a) shows the entities, attributes, and relations in the annotation schema.

2. Summary Description
(joint) KEEPHA multilingual annotated corpus
Based on the above-mentioned guidelines, we collected and annotated data in three languages: German, French, and Japanese. This dataset comprises the first multi-lingual corpus for the detection and extraction of adverse drug reactions across languages, as well as for other medically relevant mentions and relationships. The texts for the corpus are collected so that they represent the perspective of patients, i.e., they originate from social media sources such as Twitter, Q&A fora, and patient fora. The corpus will be made publicly available and contains, at this point (still being extended), 118 German, 100 French, and 619 Japanese documents with detailed annotations. Figure 1(b) shows examples of entity and attribute annotations in German, Japanese, and French, and example relation annotations in French.

3. Summary Description
(joint) NTCIR multilingual annotated corpus
For the Social Media Adverse Drug Event Detection (SM-ADE) subtask of NTCIR'17, the KEEPHA team jointly prepared a multi-lingual parallel corpus in four languages based on synthesized and translated tweets (pseudo-tweets). The SM-ADE subtask aims to identify a set of symptoms caused by a drug within social media texts in Japanese, English, French, and German. The corpus contains about 9,900 pseudo-tweets per language. Each pseudo-tweet is labeled with the symptoms occurring in the text.

<Achievements that greatly contribute to science and technology innovation>

1. Summary Description
(joint) Organization of international shared tasks
NTCIR For this year's NTCIR'17 shared task, the KEEPHA team contributed the Social Media Adverse Drug Event Detection subtask. The subtask aims to identify adverse drug events within social media texts in Japanese, English, French, and German. The competition attracted 26 teams, of which eight submitted official runs for that subtask. We believe this task will be essential to develop core technologies of practical medical applications in the near future.

SMM4H For the Social Media Mining for Health (SMM4H) Shared Task 2024, we provided a part of our tri-lingual ADE dataset and organized the competition "Cross-Lingual Few-Shot Relation

Extraction for Pharmacovigilance in French, German and Japanese" in the first half of 2024. The workshop will be held at the international ACL conference in August 2024.

2. Summary Description
(joint) Top ranks for the detection of drug information (n2c2 shared task) In a team effort, we participated in the international n2c2 2022 contextualized medication event extraction challenge. We designed methods using best practices, ensembling different methods for drug detection, event classification, and context classification. We obtained first place for event classification (was there a change in drug prescription), second place for context classification (what were the properties of the change in prescription), and tenth place at drug detection: our methods represented the state of the art, and we were invited to present our systems orally at the AMIA n2c2 2022 workshop.

3. Summary Description
(all) Methods and tools for the detection of entities and relations
(JA) Japanese Biomedical Language Model We obtained paper abstracts in the medical domain from JST, totalling over 10M sentences. Using this data, we pre-trained RoBERTa language models specialized in the medical domain and made them publicly available as open source models.
(DFKI+LISN) We provide **multilingual methods for the detection of medication mentions** on the KEEPHA multi-lingual corpus, showing that multi-lingual training improves drug detection.
(JA) Zero-shot relation extraction We proposed a model incorporating discriminative embedding learning for both sentences and semantic relations. A self-adaptive comparator network is used to judge whether the relationship between a sentence and a relation is consistent. This method significantly outperforms the state-of-the-art.
(LISN) Prompt-based relation extraction We explored prompting, an efficient method to adapt pre-trained language models to new target tasks. Our contribution is a systematic approach to obtain prompt setups from the dataset automatically, which obtains better performance than conventional training.

<Representative Papers>

1. Summary Description
(joint: all) "NTCIR-17 MedNLP-SC Social Media Adverse Drug Event Detection Subtask Overview" (NTCIR 2023) [Wakamiya et al 2024]
The Social Media Adverse Drug Event Detection (SM-ADE) subtask aims to identify a set of symptoms caused by a drug, referred to as adverse drug event (ADE) detection, within social media texts in multiple languages, including Japanese, English, French, and German. The competition attracted 26 teams, of which eight submitted official runs for the SM-ADE subtask. We believe this task will be essential to develop core technologies of practical medical applications in the near future.

2. Summary Description
(joint: all) "A Dataset for Pharmacovigilance in German, French, and Japanese: Annotating Adverse Drug Reactions across Languages" (accepted at LREC-COLING 2024) [Raithel et al 2024].
This paper summarizes the development of the annotation guidelines and the multi-lingual corpus described above and provides preliminary experiments for the cross- and multi-lingual extraction of medical mentions and classification of relations between these mentions.

3. Summary Description
(joint: DFKI+LISN) "Cross-lingual Approaches for the Detection of Adverse Drug Reactions in German from a Patient's Perspective" (LREC 2022) [Raithel et al 2022]
We present the first corpus for German Adverse Drug Reaction (ADR) detection in patient-generated content. The data consists of 4,169 binary annotated documents from a German patient forum. The class label imbalance and a high topic imbalance make it a very challenging dataset, since often, the same symptom can have several causes and is not always related to a medication intake. We report experiments for binary classification using different methods of zero- and few-shot learning based on a multi-lingual English-German model. We make the dataset and models publicly available for the community.

2 Research Implementation Organization

(1) PIs and Co-PIs of the Japanese, German, and French research teams and the structure

WP	Team	Country	PI or Co-PI
1. Project Coordination and Management	LISN	France	Zweigenbaum
2. Resource Preparation	DFKI	Germany	Möller
3. Acquiring Cross-lingual Structured Knowledge from Text	RIKEN/NAIST/NII	Japan	Matsumoto
4. Using Structured Knowledge to Help Information Extraction	LISN	France	Zweigenbaum
5. Multilingual Methods to Improve Information Extraction	DFKI	Germany	Möller
6. Dissemination	RIKEN/NAIST/NII	Japan	Matsumoto

(2) Research Network Formation through Collaboration with Researchers and Companies other than this Research Team

- We liaised with online patient forum publishers with an aim of obtaining data for the project. DFKI obtained an e-mail-based agreement with the patient forum lifeline.de to download and use their data for the project's corpus. DFKI and LISN prepared a non-disclosure agreement with MeaMedica to explore their data, but this does not so far allow the use of these data in a distributed corpus.
- NAIST collaborated with the organizers of the NTCIR conference and shared tasks to propose and then organize the MedNLP-SC shared task on Medical Natural Language Processing for Social Media, which the other KEEPHA partners contributed to prepare.
- LISN and DFKI collaborated with the organizers of the SMM4H workshop and shared tasks (Cedars-Sinai Medical Center, California) to propose a KEEPHA shared task at SMM4H 2024, with contributions by all partners.
- DFKI is in contact with a company that offers a platform for patients to interact in French and German (and other languages) to acquire more relevant data for the joint corpus potentially. First data (in English) were exchanged, and our models were applied to them to extract information on ADRs.
- NAIST started a collaboration with Sanofi for drug information extraction from social media (2022–2024).
- RIKEN started a collaboration with RIKEN Bioresource Research Center on constructing ontologies for course information on drugs and diseases (2023–).
- After submitting the KEEPHA proposal, LISN collaborated with the CRESS epidemiology team in Paris to detect drug and other treatment information in Covid-19 clinical trials from around the world (Covid-NMA).
- Since the start of KEEPHA, LISN launched a collaboration with two French hospitals (Groupe Hospitalier Paris Saint-Joseph, and Lille University Hospital) and another academic team (LS2N, Nantes Université) to design clinical information extraction methods that extract, among other things, information on drug prescription and signs and symptoms from clinical text in cardiology (ANR funding, PREDHIC project, 2022–2025).

3. Opinion and Comment from Each Funding Agency

(1) ANR

After the signature of a collaboration agreement between the French, German and Japanese research funding agencies in April 2019 in Tokyo (Japan), the decision to run a joint call involving the three countries was taken with the objective to foster research collaborations in Artificial Intelligence. The primary objective of the call was the emergence of high-quality level projects addressing fundamental research as well as applications of Artificial Intelligence in various domains of engineering, life sciences or social sciences. Additionally, this call targets the establishment of persistent collaborations between researchers issued from the three countries.

In 2019, a joint evaluation committee composed of valuable researchers from the three countries has selected nine research projects spanning on different topics among which knowledge extraction, representation and reasoning and machine learning can be mentioned. In 2023, all the projects presented their work and shared their results during a one-day workshop organized in Bonn (Germany). The scientific achievements of these projects showed actual advances in the state of the art in different areas like computer vision or natural language and speech processing. Moreover, this workshop highlighted the high level of collaboration reached by the partners of each project issued from the three countries.

Beyond its satisfaction with the results and achievements of each project funded by this trilateral call involving France, Germany and Japan, ANR would like to highlight the above-mentioned high level of collaboration achieved by each of these projects. ANR would also like to mention that this call made it possible to strengthen its collaborative relations with the German (DFG) and Japanese (JST) research funding agencies. Last, ANR thanks both the researchers for their contributions as well as the members of the DFG and of the JST for their permanent responsiveness and for their continuous involvement in the monitoring of the selected projects.

(2) DFG

DFG would like to express sincere gratitude to their partner organizations, the Agence nationale de la recherche (ANR) and the Japan Science and Technology Agency (JST) for the continuing excellent cooperation. This “TRILATERAL CALL FOR PROPOSALS ON ARTIFICIAL INTELLIGENCE (AI) 2019” is taking place in an intercultural format which brings together perspectives from France, Japan and Germany on how basic research on new technologies can contribute to solutions for global challenges. The funded projects are characterized by their broad range of applications and deep

technical basis. We see the lively exchange between the projects and the networking as a further strength of this activity. The current developments, particularly in the field of machine learning and generative AI, are impressive. Public attention has increasingly turned to these areas and brought a necessary debate on opportunities and risks. This call has therefore come at a right and important time because it has focused on aspects such as trust, transparency and fairness. In these times of political instability and global challenges, trusted collaborations between like-minded partners are becoming ever more crucial. Therefore, the invaluable relations cultivated between France, Japan and Germany through joint activities like these serve as a cornerstone for our shared future endeavors.

(3) JST

The Trilateral (Japan-German-France) AI research, which was launched based on the agreement at the government level between Japan, Germany, and France in April 2019. Due to the impact of the Covid-19 and other unforeseen circumstances, the start of research period has been moved from April 2020 to December 2020 with the postponement of the implementation schedule of a joint panel for adoption, and extension of research periods for some teams, however, we were able to smoothly carry out the research activities of the nine teams thanks to flexible responses from DFG, ANR, and JST, in particular, the application selection process and the public kick-off meeting in November 2020 (ANR in charge), the preparation and submission instructions for the public interim reporting in October 2022 (JST in charge), and the final workshop in November 2023 (DFG in charge). We believe that we were able to successfully implement the project by the work between the three Funding Agencies. In addition, we have established a format in which application documents and follow-up reports are prepared by the Japanese, German, and French PIs and submitted to each FA, which is considered to be applicable to other international collaboration programs. I hope it will be continuously and widely used in the future.

In this program, we would like to thank all evaluators for selection, advice for each research activity, and evaluation at the research end, and the nine (9) research teams including PIs, Co-PIs, and researchers from Japan, Germany, and France who were involved in their respective research theme, and achieved excellent research results. Finally, we would also like to thank everyone at DFG and ANR for their persistent cooperation in operating this program.

In the end, we would expect the development and success of the Research Activity.

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