AI, Robotics, and Clinical Research for Innovative Dementia Interventions: A Japanese-German Collaboration

Simon Stock[1], Mihoko Otake [2,*], Ingo Kilimann [3,*], Markus Schinle [4,*],
Kazumi Kumagai [2,*], Sascha Weimar [1,*], Marius Gerdes[1], Florian Mazura[1], Wilhelm Stork [1,4]

[1] Karlsruhe Institute of Technology, Germany
[2] RIKEN CB-AT, Tokyo, Japan
[3] Deutsches Zentrum für Neurodegenerative Erkrankungen (DZNE) Rostock/Greifswald, Rostock, Germany
[4] FZI Research Center for Information Technology, Karlsruhe, Germany
[*] Invited Speaker

After a successful international workshop in Karlsruhe, Germany in June 2023, transformative initiative is underway involving major institutions: the RIKEN Cognitive Behavioral Assistive Technology (CB-AT) Team in Japan, the Deutsches Zentrum für Neurodegenerative Erkrankungen (DZNE) Rostock/Greifswald, Rostock, the Forschungszentrum Informatik (FZI) and the Karlsruhe Institute of Technology, Institute for Information Processing Technology as well as the Institute for Entrepreneurship, Technology Management and Innovation. The unique strengths of these institutions unite in an interdisciplinary collaboration focusing on novel dementia interventions. This consortium envisions the future of dementia care and the prevention of its progress – a model that brings together the strengths of AI, robotics, digital platforms, and clinical research, not just targeting patients but considering dyadic interventions that support both patients and caregivers.

The KIT and FZI from Karlsruhe bring to the table expertise in software and AI engineering, and experience in research transfer. Particularly crucial is the role of the METIS platform, which supports multi-stage treatment processes for neurodegenerative diseases in an outpatient setting, integrating modern wearables and AI personalization of treatment strategies. RIKEN CB-AT complements this with robotics and system integration capabilities, including access to robots ready for integration into care regimens. The institute is renowned for its speech intervention strategies in dementia prevention, fostering the idea of using robots to aid caregivers and patients alike. Ultimately, the robots could serve as a base station, actively engaging with caregivers, assessing their stress levels, and providing mitigation strategies while simultaneously collecting crucial data. DZNE Rostock/Greifswald rounds out the partnership with a robust clinical background and access to well-defined clinical cohorts. Their research provides valuable insights into patient needs. Furthermore, their proficiency in qualitative research and dyadic interventions adds an essential layer of complexity to the project. In this alliance, a shared ethos of participatory approach, modern digital and wearable technology adoption, and individualized intervention strategies enable a unified research vision. The potential outcomes are manifold: they include technologies for outpatient measurements of intervention, prevention and care, robots aiding caregivers and patients, digitalization of care pathways, stress mitigation, and more. All partners strive to establish bi-lateral connections between existing technology and new integrations, enabling data insights from a variety of sources, including smartwatches, smartphones, robots, novel technology, and caregiver-patient interactions. These insights can be used for the personalization of intervention and care, medication, early detection of emergency situations, and strategies to empower patients and enhance the resilience of caregivers. Once addressed, the opportunity for transformative early prevention of dementia progression are immense. The expected outcomes span joint research projects, scientific publications, societal impact, and entrepreneurial initiatives. In conclusion, this collaborative venture aspires to make strides in dementia care and intervention through the integrative use of platform-based AI, robotics, and clinical research, fostering an enhanced care ecosystem that values patients and caregivers.

In the following the individual workshop contributions are presented:

A first look at Language Models as Virtual AI Coaches in Dementia Care

Simon Stock
Karlsruhe Institute of Technology, Germany

Exploring the realm of dementia care, this presentation navigates the potentials and challenges of implementing transformer-based machine learning models, specifically large language models (LLMs), as virtual health coaches. LLMs offer a myriad of promising applications including the personalization of patient motivation, the automatic generation of risk-factor-based treatment plans, and efficient communication and summarization tools for healthcare professionals. An interactive demonstration provides a glimpse into a potential real-world application, showcasing the dynamic interaction between the AI coach and a patient.

Simultaneously, the talk highlights crucial hurdles like ethical and regulatory issues that are yet to be overcome. These challenges, coupled with the need for more extensive research on the efficacy and limitations of such models in real-world settings, present a complex landscape.

However, the inherent scalability and adaptability of LLMs offer promising opportunities for their integration into a comprehensive platform approach towards dementia intervention strategies. This opens the doors for a new era in dementia care, underlining the transformative potential of AI in health interventions.

AI for cognitive intervention and prediction of cognitive decline

Mihoko Otake
RIKEN CB-AT, Tokyo, Japan

AI nurturing or complementing human intelligence is becoming more important than ever. Simultaneously, the number of people with dementia is rising rapidly. The goal of the Cognitive Behavioral Assistive Technology (CBAT), advocated by the author since 2017, is to develop technology assisting cognition and behavior of human with and without disabilities. We focus on AI which promotes cognitive health for preventing cognitive decline and dementia among older adults. In this talk, we introduce two major achievements:

1) novel technologies which enable cognitive intervention through social activities in older adults with evidence;

2) novel technologies to predict cognitive functions from different modalities of behavioral and/or physiological data.

Early involvement of users of digital assistance using examples from the dementia ecosystem

Ingo Kilimann
Deutsches Zentrum für Neurodegenerative Erkrankungen (DZNE) Rostock/Greifswald, Rostock, Germany

The involvement of future users is highly relevant for the success of an application. However, involvement of people with cognitive impairment and their ecosystem consisting of the patient, family caregivers, treatment providers and others arises special challenges. The user-centered design is a key requirement for successful AU development and testing cannot be underestimated.

This talk will present recent projects of user-centered design of AI supported application for people with dementia at the DZNE Rostock/Greifswald with varying user involvement. The PARTbeirat advisory board of the University Medical Center Rostock, which is currently being established, will involve people with lived experience already in the study planning phase. In the GAIN study the comprehensibility of the examination instrument and the usability of digital devices were improved together with family caregivers. Specific characteristics and limitations of the evaluation of digital applications with people with dementia are explored in the SAMI and Prospect-AD studies. Overarching aspects of AI are addressed in the ExplAInation study aiming explanatory AI and the European CAIDX framework study focusing on regulatory aspects, implementation strategies, and staff training concerning the use of AI in health care.

Fighting Dementia with data-driven Digital Health Applications

Markus Schinle
FZI Research Center for Information Technology, Karlsruhe, Germany

One third of all dementia cases could be prevented or delayed by timely treatment of specific risk factors. This requires a holistic care concept including medical counseling services. A personalized sequence of steps will therefore be necessary, and digital health applications could provide low-threshold support.

The data collected in this way has the potential to leverage efficiency gains necessary for this. On this basis, new pathways for this clinical picture can be defined to help relieve the burden on the healthcare system. In this context, we have collected findings that will be incorporated into a digital concept for the accompanied implementation of personalized prevention and treatment plans for dementia in the form of a digital platform. Data-intensive processes associated with the user's individual risk profile can be accompanied in everyday life by applications and wearables such as smartwatches. Therefore, the improvement of tools for the digital accompaniment of corresponding treatment processes is pursued as a goal.

Towards a robot system to estimate and encourage older adults' health state through dialogue: study on older adults' reaction to the robot and learning appropriate timing of robot's voice-calls

Kazumi Kumagai
RIKEN CB-AT, Tokyo, Japan

As an attempt to deal with the super-aging society, we have been researching a dialogue system aiming at monitoring, maintaining, and improving health using robot technology.

Robot's actions (mainly talking) to older adults allow the robot to actively detect/estimate the state of the older adults and provide approaches to achieve a better situation.

As the first step towards building such a robot system, we have investigated in detail the responses of older adults to robots during dialogue. We are also studying a method of learning and generating appropriate robot voice-calls. In this presentation, we would like to introduce and discuss our studies.

Unveiling Regulatory Pathways for Digital Health Startups: Insights from a Spin-off's Experience under the Medical Device Regulation

Sascha Weimar
Karlsruhe Institute of Technology, Germany

The medical device regulation (MDR) presents challenges for digital health startups. Based on the research project and spin-off METIS, we outline the essential steps involved in meeting these regulations. These steps include defining the intended use and risk class, establishing a quality management system, and creating a technical documentation. Practical examples highlight successful implementation of MDR requirements by METIS. This presentation provides valuable insights and highlights best practices for achieving compliance in this crucial field, thereby fostering the development of secure and dependable medical software devices.

Acknowledgments