AI for personalized dementia prevention and care

K. Kumagai, N. P. Miyake, M. Otake-Matsuura (Conveners)

Participants*:* S. Stock (Germany), H. Ozono (Japan), H. Horie (Japan), S.Saiki (Japan), and K. Kumagai (Germany/Japan). **ISSUE** The increasing number of people with dementia has become a global issue. Dementia is a disease in which brain function begins to decline before the onset of symptoms, but is diagnosed when it interferes with daily life (Hansson et al., 2021). Therefore, the timing of noticing the problem may be delayed, or the areas of daily life in which problems occur vary, depending not only on the individual's living environment and habits, but also on their unique personality and characteristics. In such a background, while many technologies for preventing and supporting people with dementia are moving toward practical application, there is also a growing need for technologies that give more personalized prevention and care. AI (artificial intelligence) technology and ICT (information and communication technology) are attracting attention as tools to realize personalized care. **CONTENT** This symposium invites researchers who are developing systems including AI and ICT related to preventing dementia and maintaining and improving cognitive function. The speakers are both conducting research in countries where the increasing number of dementia patients is an issue: Japan or Germany. This symposium covers technologies that can be used at home: the platform for analyzing drawing-based neuropsychological assessments, a dialogue system with a virtual agent (VA) and robot, and applications that allows such systems to feel more familiar for users. **STRUCTURE** Ozono will talk about a system that integrates a VA listening system with a user's information, health data, a dialogue manager, and sensor data to enable the support and monitoring of elderly individuals at home. Horie will share about the developed "Reminiscence Conversation Service" (Omoide-Kaiwa service), to provide opportunities for daily conversation among elderly people without burdening caregivers. The images searched and displayed by the services are interesting for the person and encourage conversation. Saiki will present EVIDENT, a system platform for analyzing drawing-based neuropsychological assessments. Kumagai will propose a robot system that is the basis for generating a method for effective communication with dementia patients and caregivers regarding dementia based on the aggregated diagnostic and living data of dementia patients. Stock will introduce an E-Health Platform developed to aim to make personalized treatment strategies. **CONCLUSION** The systems reported on during this symposium are currently being researched for practical use. Their efficacy and usefulness have also been verified through user studies. With the realization of digitalized cognitive function tests, data management systems using applications, and support and encouragement systems based on interaction with agents, it is expected that more people will receive personalized prevention and care. The challenge is to conduct and verify user studies on a broader scale. This symposium will also include discussions aimed at solving problems for the next steps in this field.

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Implementing "PC-Mei" system for assisting and monitoring elderly people at home

H. Ozono, S. Chen, M. Nakamura, K. Yasuda

Purpose Currently, an aging population is a global trend, with Japan in particular experiencing the highest rate of aging worldwide. This has led to a societal issue in the form of a shortage of caregiving facilities and personnel. As there are limitations to human-based support, there is considerable expectation for technology-assisted aid (Song et al. 2019). Our research group is investigating and developing systems that support self-help and mutual aid among elderly individuals living at home. One such system is a Virtual Agent (VA) Listening Service (Sakakibara et al. 2017). The VA Listening Service, where a voice dialogue agent listens to the elderly, aims to sense the inner feelings that cannot be observed by sensors. The purpose of this chapter is to implement a system that supports and monitors elderly individuals at home. As an approach, we will improve the VA Listening Service. Our key idea is that by adding features to the VA Listening Service that address P1: information disparity, P2: health issues, P3: communication issues, and P4: monitoring issues, we can enable support and monitoring of elderly individuals at home. **Method** In this study, we focused on four features to address the issues faced by the elderly population: F1: Voice Execution Service, F2: Health Management Service, F3: Casual Conversation Service, and F4: Monitoring Service (Figure 1(a)). For F1, we implemented the You-ID service as a user information management service. For F2, we implemented the Stress Sensing Service (SSS), a service that retrieves and manages health data from Garmin devices. For F3, we configured three dialogue modes in PC-Mei: (1) Listening mode: A mode that returns random responses to user utterances. (2) Silent mode: A mode that doesn't return any responses to user utterances. (3) Casual conversation mode: A mode that returns natural responses to user utterances to enhance conversational continuity. For F4, we implemented a mechanism that initiates a question corresponding to the time when the sensor reacts. **Results and Discussion** In the implementation environment of this study, we used MMDAgent (Mei-Chan) as the spoken dialogue agent, Google Chrome as the web browser, Phidget Motion Sensor as the sensor, Garmin vívosmart 4 as the wearable device, JavaScript and Node.js for the VA Listening Service and Tweet Diary Service, Java and SpringBoot for the You-ID Service and Stress Sensing Service, mebo for the Casual AI, and MongoDB for the database. We mainly implemented a new service called PC-Mei by adding F1-F4 to the VA Listening Service in particular (see Figure 1(b)). On the other hand, while the target of this system is elderly individuals at home and their families, as a future task, we will verify what kind of impact PC-Mei has on elderly individuals at home and their caregivers.

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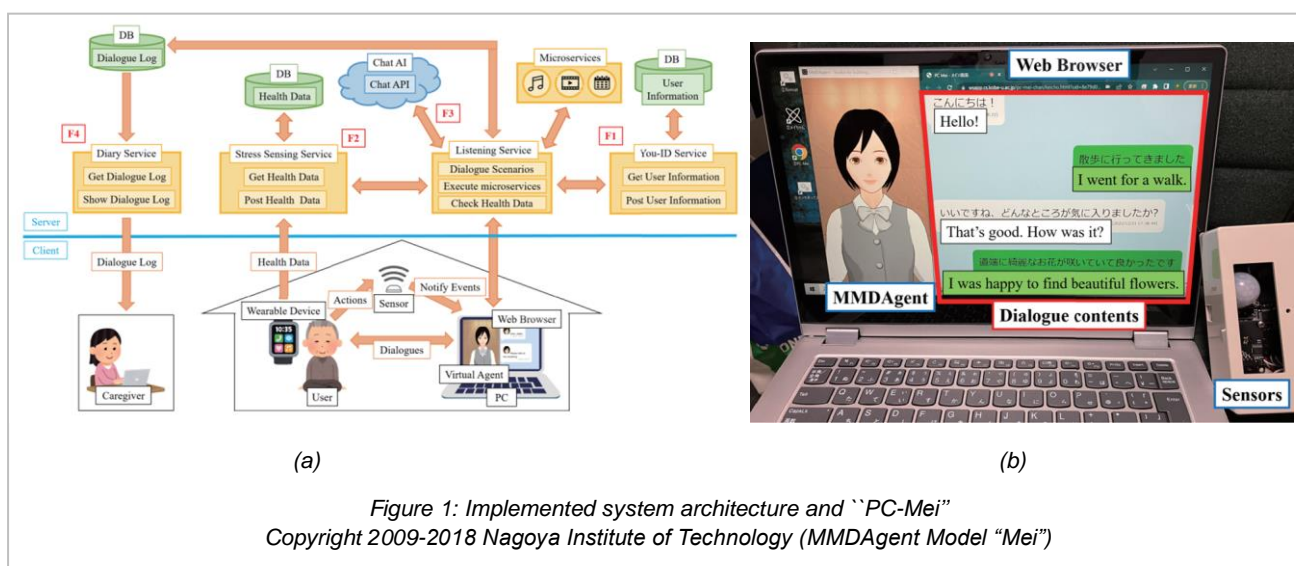
(a)   *(b)*

Figure 1: Implemented system architecture and ``PC-Mei''
Copyright 2009-2018 Nagoya Institute of Technology (MMDAgent Model "Mei")

Developing reminiscence conversation service using spoken dialogue agent and interesting images

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Purpose Talking is an important activity for elderly people and people with dementia to maintain healthy daily living. The reminiscence therapy (Cotelli et al., 2012) and the co-imagination method (Otake et al., 2011) are practical approaches to dementia through conversation. However, since organizing these methods requires considerable manpower and time, it is not realistic to use them on a daily basis. Thus, the practice of daily conversation depends largely on the self-help of elderly themselves and the efforts of family caregivers. The purpose of this study is to provide opportunities of daily conversation for elderly people at home without burdening family caregivers. **Method** The "Reminiscence Conversation Service" (Omoide-Kaiwa Service) was developed, in which an elderly person talks to a spoken dialogue agent "Mei-chan" about his/her memorable events, favorite things, and hobbies, using interesting images. Our research group has been developing the "Mei-chan" system (PC-Mei) for years, which monitors and supports elderly people at home (Ozono et al., 2021). Based on conversation scenarios controlled by various microservices, the agent "Mei-chan" talks to an elderly person autonomously, and recognizes what the person said. The proposed Reminiscence Conversation Service was implemented as a microservice of PC-Mei. As shown in Figure 1, the proposed service consists of three features. First, a family caregiver registers memorable photos of an elderly person, and the service stores the photos in the database. Second, the caregiver (or the elderly) registers the personal interests and preferences of the elderly person (favorite things, hobbies, birthplace, etc.), and the service automatically searches relevant images from the Web. When the elderly person initiates the service, the service displays an image and orders PC-Mei to ask a story related to the image. As the elderly person tells the story, PC-Mei generates a response based on conversational AI, as shown in Figure 2. The conversations are stored in the DB in the form of text and voice. Finally, the images and the conversation logs in the DB can be reviewed by the caregiver, to see how the proposed service worked for the elderly person. **Result and Discussion** The proposed service was evaluated by five subjects (80's male, 70's female, 80's female, 50's male,50's female). The result of the experiment was that interesting images encouraged more conversation than irrelevant images. The subsequent interview showed that the proposed service was seen as a way to eliminate loneliness and to make elderly people happy. The experiment also showed that the timing of the agent's response should be fine-tuned so as not to interfere with the recall of the memorable story.

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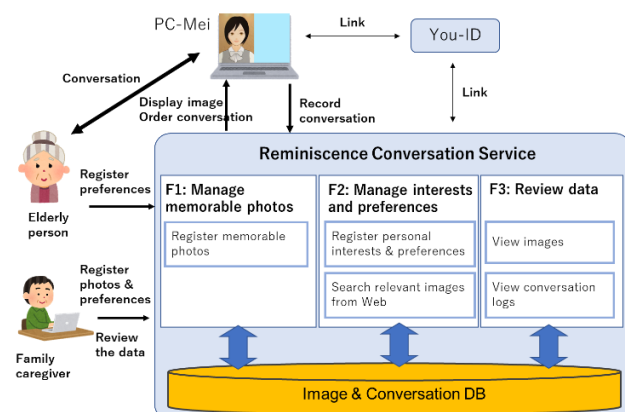
Figure1: System architecture of the proposed service

Figure2: Reminiscence conversation with PC-Mei

SP: DEMENTIA & TECHNOLOGY

EVIDENT: A comprehensive platform for digitizing drawing-based neuropsychological assessments

S. Saiki, R. Sekimoto, N. Kodama, A. Sato, M. Nakamura

Purpose Neuropsychological drawing assessments, including the clock drawing test and the cube drawing test, are acknowledged for their substantial efficacy in the early identification of dementia. These evaluations are administered under the supervision of healthcare professionals. Nonetheless, Japan faces a significant challenge in routinely implementing these tests due to its super-aged society and the critical shortage of medical staff. Typically, these drawing tests are evaluated and interpreted by examining the finished illustrations. An alternative approach to avoid the shortage problem involves transmitting only the results of the drawings to medical experts for analysis. However, this method encounters numerous obstacles in regular application, such as the complexities involved in the transfer and management of test data. Furthermore, it is posited that the drawing process itself harbors extensive insights (Müller et al., 2017). For instance, prior research indicates that details from the drawing procedure, like the duration of contemplation before completion and the sequence of execution, are intricately linked to cognitive functions. Consequently, evaluations based solely on the final artwork might neglect critical diagnostic information. **Method** In this research, we introduce EVIDENT (Extraction and Visualization Interface of Drawing Execution in Neuropsychological Tests), a sophisticated platform for analyzing drawing-based neuropsychological assessments. Figure 1 shows the architecture of the proposed system. This system leverages pen-input devices, such as Apple's iPad, to facilitate the administration of standard drawing tests. EVIDENT is designed with functionalities that allow for the execution of routine drawing evaluations via a tablet, subsequent verification of the outcomes by medical practitioners, and the elucidation and examination of various aspects of the drawing process shown in Figure 2. Furthermore, the platform can generate time-series data in a numerical format, which can subsequently be subjected to analysis employing artificial intelligence, specifically through techniques such as machine learning. This innovative approach not only streamlines the assessment process but also enhances the depth and breadth of cognitive function analysis, potentially offering a more comprehensive understanding of the neuropsychological state of individuals. **Results and Discussion** In our evaluation of the EVIDENT platform, we engaged elderly individuals, healthcare professionals, and care managers at day-care facilities, conducting both clock-drawing and cube-copying tests. The cohort of elderly participants comprised 18 individuals, aged between 69 and 95 years. Regarding the usability of the system, a few participants required assistance from caregivers to interact with the tablet. Nevertheless, 17 of them successfully completed the drawing tests independently. One participant opted out, requesting to discontinue because they found the test tasks overly challenging. Furthermore, all healthcare professionals involved in the study were able to efficiently store the drawing data and access the visualized outcomes, encountering no technical issues with the system. These observations indicate that EVIDENT is proficient in facilitating comprehensive management of patient information, administering drawing tests—which include recording the drawing process—and in the subsequent visualization and analysis of that process. The system's utility in a real-world healthcare setting demonstrates its potential to enhance the assessment of cognitive functions through technologically advanced, yet user-friendly, methodologies.

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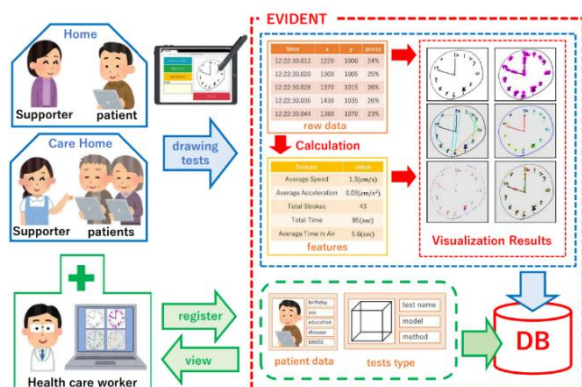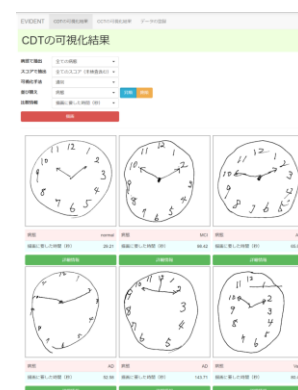
Figure 1: Architecture of EVIDENT

Figure 2: Results of Drawing Visualizations

Development of dialogue and voice-call robot system for personalized dementia prevention and care
K. Kumagai, S. Stock, N. P. Miyake, M. Otake-Matsuura, W. Stork

Purpose The looming challenge of dementia, exacerbated by demographic shifts and an aging global population, places immense strain on society and our healthcare infrastructure. It is desirable for societies around the world to conquer this problem by developing effective care technologies for dementia patients and caregivers, as well as providing strategies for dementia prevention. In this project, we propose a robot system that is the basis for generating a method for effective communication with dementia patients and caregivers regarding dementia based on the aggregated diagnostic and living data of dementia patients. **Method** The system aims to integrate diagnostic and daily living data and the use of a robot. The output is a dialogue that is effective for helping the user to care about their health status. The data analysis/processing methods are constructed in two steps. In the first step, a table of effective robot dialogues for each user's diagnostic and living data is created in advance. Using the METIS Platform (Stock, 2022), we are able to integrate biometric data from wearable devices within the Internet of Medical Things (IoMT) along with supplementary patient-reported information, data-driven capabilities. In this study, as a method for establishing the needed dialogue capabilities, a scenario-based dialogue (Kumagai et al., 2022) has been adapted. In a scenario-based dialogue, the robot's utterances are designed so that a conversation can be established, regardless of the content of the user's responses. To create the lookup table, an appropriate dialogue theme depending on the user's state is determined in advance. This table allows the robot to generate simple utterances that are tailored to the user's status. In the second step, the robot conversation content is generated based on the user's data (diagnosis data and biometric data) by Chat GPT. Even if two users' states are the same, from the perspective of getting the user to accept the robot's voice, the appropriate contents of the robot's utterances are assumed to differ depending on the individual user. For example, it may be necessary to consider how to directly point out the user's status, or whether to indirectly recommend appropriate actions. In our previous research, we used neural networks and reinforcement learning techniques to develop systems that individualize the parameterized robot's behavior by adjusting the parameters to individual users (Kumagai et al., 2018). In this project, we will use a similar approach to generate personalized robot dialogues for each user, based on both generalized knowledge and individual data. Feedback on the user's affective reactions to the robot's speech is thought to help personalize the way of the robot's speech. **Results and Discussion** This presentation will show the results of a simple survey to examine the robot's speech generated by the system we have built and the impressions of users' dialogues with the robot. We also discuss challenges in connecting to robots.

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SP: DEMENTIA & TECHNOLOGY

A data-driven approach towards an e-health platform for dementia intervention

S. Stock, M. Schinle, M. Gerdes, W. Stork

Purpose Globally, only 20-50% of dementia cases are diagnosed, indicating a major gap in the identification and treatment of this neurological disorder. Despite this, there is widespread agreement among both doctors and patients (Schinle et al., 2022) on the value of early diagnosis to adjust care and daily routines effectively. To address this issue, the German federal government launched a national dementia strategy in 2020. Current research (Livingston et al., 2020), suggests that early treatment of certain risk factors could prevent or slow down one-third of dementia cases. The METIS project is based on the understanding that dementia is caused by complex processes which are linked to individual risk profiles and aims to make personalized treatment strategies for neurodegenerative diseases more accessible through an e-health platform. **Method** METIS employs digital technology to offer a step-by-step treatment process through a mobile app, enhancing patient support. This includes using AI to tailor treatments based on specific patient risk profiles and diagnostic information. It also enables direct communication with healthcare professionals and coaching, supported by AI chatbots. Additionally, the use of wearable technology for continuous biometric data collection improves the accuracy of the patient's health profile and treatment plan. **Results and Discussion** Preliminary results suggest the potential for addressing the healthcare challenges presented by dementia. The current focus is on the platform's usability and its effectiveness in providing personalized prevention and treatment strategies for dementia. By integrating everyday technology, like smartwatches, with data-driven processes that consider individual risk profiles, METIS is developing digital tools for managing dementia. This approach will improve patient care and offer new solutions for reducing the impact of dementia on the healthcare system through personalized interventions.

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