Penn
University of Pennsylvania
Artificial Intelligence and Technology Collaboratory for Healthy Aging

PILOT AWARDEES YR3
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https://www.pennaitech.org

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PYRAMES

IMPROVED ALGORITHMS FOR WEARABLE, PASSIVE, NONINVASIVE BLOOD PRESSURE MONITORING FOR OLDER ADULTS

Xina Quan, PhD

Older adults with high blood pressure (BP) are at increased risk of severe health concerns, e.g. heart disease, congestive heart failure, ischemic stroke, cerebral hemorrhage, vascular dementia and Alzheimer's disease. Frequent measurements improve BP control, leading to improved outcomes.

A significant barrier to BP control is obtaining sufficient measurements for effective management. Continuous monitoring with invasive arterial lines is limited to critical care facilities. Periodic cuff measurements through ambulatory BP monitoring provide an indication of BP variation, but devices are cumbersome and uncomfortable, leading to incorrect or insufficient usage.

A more convenient, cost-effective BP monitoring method providing passive measurements and actionable information potentially leads to reduced risk from cardiovascular disease.

PyrAmes has developed a comfortable, easy-to-use sensor band to monitor BP, enabling long-term, personalized BP management. It is soft, flexible, and lightweight, and has been validated for use with patients with fragile skin. Our innovative approach uses patented capacitive sensors to capture pulse waveform data, which is processed on a connected mobile device with neural networks to accurately determine BP values and provide detailed information about cardiovascular health.

Our first device, Boppli®, was FDA-cleared in 2023 for continuously monitoring the BP of critically-ill neonates. Our adult monitor uses identical sensors and validated software infrastructure and has shown initial feasibility. This project accelerates development for the older adult population, leading to FDA clearance and commercialization.

Our technology has the potential to become as ubiquitous for BP measurement as pulse oximeters are today, due to its accuracy, convenience, and ease of use.

https://pyrameshealth.com/

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PennState

TASK-ORIENTED MULTIMODAL CONVERSATIONAL AI FOR ASSISTING SENIORS WITH DAILY TASKS

Rui Zhang, PhD

With a global population of over 1 billion people aged 60 and above, there is a rapidly increasing need for innovative age tech solutions to improve the quality of life of older adults. Conversational assistants, powered by cutting-edge technologies in Artificial Intelligence (AI), Natural Language Processing (NLP), and Large Language Models (LLM), are permeating into home care, assisted living, and nursing facilities for smart elderly care. One type of conversational assistant is task-oriented, which can significantly enhance the life experience for senior people by helping them with real-world complex daily tasks. A task-oriented virtual assistant facilitates daily tasks spanning diverse scenarios such as calling for help in response to emergencies, helping with online grocery shopping, recommending cooking recipes, managing smart home devices, and providing financial education and decision-making. It greatly promotes the life quality of older adults by improving their well-being, efficiency, safety, and independence. In this proposal, we design, develop, and deploy a task-oriented multimodal conversational assistant to help older adults with daily tasks. The innovation of this proposal lies in the fact that we will employ a human-centered participatory approach by emphasizing collaboration between designers and end-users through interviewing, prototyping, and testing to address their unique needs and preferences to improve their daily lives.

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BIDMC
NEUROLOGY

MOBILE TECHNOLOGY AS A COGNITIVE BIOMARKER OF ALZHEIMER'S DISEASE

Chun Lim, MD, PhD

Alzheimer disease's hallmark is insidious memory loss often accompanied by a lack of awareness of the deficit. Its diagnosis requires evidence of cognitive impairment and remains reliant on clinical assessments, primarily traditional pen and paper cognitive tasks, which, with its many limitations results in only one-half of patients ever diagnosed by physicians. Thus, a simple, inexpensive, and at-home method to capture more of these patients earlier in their disease process could facilitate earlier therapy and planning.

We propose to modernize the clinical diagnosis of Alzheimer's disease by taking advantage of smartphones to collect multiple streams of behavioral information including active data such as reaction/response time to cognitive tasks and games as well as data captured passively on the smartphone such as movement, location, and typing speed. Using advanced analytical tools, we propose to develop a new smartphone-based app for use in the home environment that detect signs and symptoms of early cognitive impairment and to continuously monitor for progression by capturing passive, real-world information, and active data.

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DreamFace Technologies LLC

BUILDING DEEP DIGITAL TWINS FOR PREDICTION OF AD/ADR/MCI IN OLDER ADULTS

Mohammad H. Mahoor, PhD

The Alzheimer's Association predicts that the number of Americans aged 65 and older with Alzheimer's disease-related dementia (ADRD) will reach over 12 million people by 2050. ADRD often stars with mild cognitive impairment (MCI), which is characterized by challenges in memory, language, and thinking skills. Early MCI detection is vital for identifying those at risk of dementia, offering support, advice, and ongoing monitoring. Currently, older adults with MCI are diagnosed clinically; however, their daily challenges are often not noticeable to those whom they encounter irregularly. Artificial Intelligence (AI) holds promise for early cognitive impairment detection, with many AI studies focusing on expensive clinical assessments and medical scans like positron emission tomography (PET) and MRI. There is a pressing need for additional research to advance innovative, cost-effective, and accessible approaches for early detection and prediction of AD and MCI. Human digital twins are at the forefront of aging and longevity research, aiming to create personalized AI models that comprehensively simulate an individual's behavioral, biological, physical, mental, and socio-emotional attributes using health and medical records. These models hold the potential to revolutionize our understanding, prediction, and management of the aging process, offering personalized healthcare solutions. This pilot project aims to investigate AI techniques that leverage multi-modal audio-visual data, along with other available data modalities, to develop human digital twins for research in aging and, more specifically, for predicting MCI and the early onset of AD/ADRD. We design and implement a Deep Digital Twins (DDT) model using Conditional Variational Autoencoders (CVAEs) suitable for heterogeneous multi-modal data including speech, transcribed speech, and facial videos. We then evaluate the efficacy of the proposed model using publicly available datasets such as the I-CONECT and ADReSS datasets, which contain multi-modal data and other metadata suitable for our project. We hypothesize that DDTs trained using multi-modal comprehensive data can predict MCI/AD with high fidelity and accuracy compared to uni-modal data. We compare our proposed DDT with state-of-the-art models in the literature. We assess the models' performance, taking into account the impact of diverse data to ensure they remain unbiased. The expected outcome of this research are knowledge and prototyped Deep Digital Twins capable of assessing and predicting MCI/AD conditions in older adults. It is expected that the DDTs generate the longitudinal trajectories sampled from the data as well as predict the subject's future condition.

https://dreamfacetech.com/

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ALIVIADO

ALIVIADO DEMENTIA CARE MACHINE LEARNING ALGORITHM DEVELOPMENT FOR CAREGIVING

Ab Brody, PhD, RN, FAAN

Care partners (CP) of persons living with dementia (PLWD) provide crucial support and find significant meaning in the care they provide. They show compassion to those they are caring for, and resilience in the face of adversity. Yet, many CP lack high-quality, evidence-based guidance for addressing care needs of PLWD. One key area that is often challenging to CP, yet where they have little support, is in addressing neuropsychiatric symptoms (NPS) such as agitation or wandering. Most PLWD experience more than one NPS at a time and thus not only do CP lack support in managing these symptoms, they don't know which symptom to focus on first to reduce their burden and improve the quality of life of the PLWD. This is particularly true in underserved and marginalized communities who are less likely to have access to comprehensive dementia care or supportive services. Higher NPS, particularly in marginalized CP, greatly increases the risk of CP burden, physical and mental health challenges. To help CP make decisions about what NPS to prioritize, we will use artificial intelligence/machine learning (AI/ML) to develop a precision clinical decision support algorithm to assist CP in prioritizing which NPS to treat. The algorithm will be inserted into a user-friendly smartphone application which CP can download through the iOS or Android app store. The app will increase access to high-quality dementia support, empower CP to better manage NPS and improve the quality of life for both themselves and the PLWD.

https://aliviado.org/

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foresite HEALTHCARE

AI/ML ANALYSES OF MOBILITY CHANGES AMONG ELDERLY USING CONTINUOUS GAIT DATA

Nicholas Kalaitzandonakes, PhD

Novel pharmacological and non-pharmacological interventions for Alzheimer's Disease (AD) and Alzheimer's Disease and Related Dementias (ADRD) (e.g., physical therapy, occupational therapy, exercise, etc.) can slow the disease progression, but timely diagnosis is necessary for such interventions to be effective. Yet, early diagnosis of the disease remains difficult. Various biomarkers and specialized brain scans are accurate and effective in diagnosing the disease early, but they are expensive, invasive, and difficult to execute in practice.

In previous studies, gait (e.g., walking speed) and motion characteristics (e.g., cadence, stride time and variability, step length, step width, sacrum mediolateral range of motion) have been found to strongly associate with the onset of AD/ADRD and to, often, precede cognitive decline and the presence of other dementia symptoms. As such, it may be possible to use gait and mobility features as diagnostics for AD/ADRD.

In this project, we will identify and develop gait- and motion-related predictive biomarkers for AD/ADRD. For this purpose, we will analyze multiyear gait and motion data from more than 5,000 older adults in assisted living (AL) and memory care (MC) communities around the US. Residents in MC units are all professionally diagnosed with AD/ADRD.

The identified biomarkers will be used as digital diagnostics for early, easy, and inexpensive identification of AD/ADRD, including through passive monitoring of populations in communities with care management and those aging in place (e.g., via passive, physiological, sensors and wearables).

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Beth Israel Lahey Health
Beth Israel Deaconess Medical Center

DEVELOPING A HOME COGNITIVE VITAL SIGN TO DETECT COGNITIVE CHANGES AD

Daniel Press, MD

For the first time, patients with Early Alzheimer's disease (AD) are beginning disease modifying therapies such as lecanemab in large numbers. With the advent of these therapies, there is a critical need to monitor their cognitive function more closely as they are both at risk for acute cognitive decline, caused by amyloid related imaging abnormality (ARIA), and for chronic decline, to accurately measure disease progression. Unfortunately, there are no clinical tools currently in use to monitor cognition daily at home. Such a tool could not only detect acute changes, such as from ARIA or delirium, but might also be able to accurately measure disease progression over longer time scales, to personalize therapies. We have designed a simple spatial working memory test, the SWiM test, a 1-minute task in the form of a "serious game" that can be performed daily at home and potentially measure disease progression. In addition, this test can act as a "cognitive vital sign", allowing patients and their caregivers to monitor attentional ability daily to detect the cognitive changes that presage either symptomatic ARIA or delirium. We intend to assess the feasibility and the utility of the task in its first "at home" use in 25 patients with early AD, most in our Disease-modifying Immunotherapies for Alzheimer's Disease (DiAD) program. Participants and their caregivers will perform the task daily for six months. We are using a combination of standard (Item Response Theory) analytics and advanced machine learning algorithms to assess patient performance.

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University of Missouri

MOTOR FUNCTION ASSESSMENT FOR MILD COGNITIVE IMPAIRMENT, FRAILTY, AND FALL RISK

Trent M. Guess, PhD

Fall risk, mild cognitive impairment (MCI), and frailty are three interrelated health conditions that diminish quality of life for older adults and put them at higher risk for adverse outcomes, including hospitalization, disability, and death. A common characteristic shared by these conditions is a decline in motor function, most often manifested by degradation in balance and gait performance. Comprehensive early detection of motor declines may offer our best chance of addressing these geriatric conditions. While there is growing interest in using sensors to measure movement and balance, currently available technologies are prohibitively expensive or do not capture multiple aspects of movement. As a solution, we have developed the Mizzou Point-of-Care Assessment System (MPASS), which integrates measurements from multiple sensors to provide an objective, comprehensive dataset of human movement and cognitive performance. The total cost of the testing platform is under $1,500 and MPASS motor function assessments typically take less than 15 minutes. Our goal is to integrate the MPASS with artificial intelligence (AI) approaches to translate the system into a clinically effective tool that quickly, affordably, and accurately assesses risk for falling, MCI, and frailty, in real-world clinical and community settings. Specifically, we will collect data on MPASS motor function, cognitive testing, fall history, and frailty for 30 persons with MCI and 50 community dwelling adults. We will then employ AI to develop prediction algorithms that distinguish persons with MCI, fall risk, and frailty. Finally, we will develop clinically usable outputs based on the prediction algorithms.

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DREXEL UNIVERSITY
School of
Biomedical Engineering, Science and Health Systems

DETECTING COGNITIVE IMPAIRMENT USING LARGE LANGUAGE MODELS FROM SPEECH

Hasan Ayaz, PhD

Early detection of cognitive decline due to Alzheimer's Disease and Related Dementias (ADRD) in older adults living alone is essential for developing, planning, and initiating interventions and support systems to improve patients' everyday function and quality of life. Conventional, clinic-based methods for early diagnosis are expensive, time-consuming, and impractical for large-scale screening. This project aims to develop and translate an artificial intelligence (AI)-enabled speech-powered dementia screening tool that is cost-effective and user-friendly for early detection of cognitive impairment to inform clinical practice (healthcare, clinical trials). We plan to harness the full potential of the state-of-art large language models (LLMs) for dementia prediction based on speech that will be a low-cost, easy-to-use, scalable approach to detection of AD, thereby holding immense potential for revolutionizing AD prognosis, diagnosis, and clinical research by enabling the earlyEarly detection of cognitive decline due to Alzheimer's Disease and Related Dementias (ADRD) in older adults living alone is essential for developing, planning, and initiating interventions and support systems to improve patients' everyday function and quality of life. Conventional, clinic-based methods for early diagnosis are expensive, time-consuming, and impractical for large-scale screening. This project aims to develop and translate an artificial intelligence (AI)-enabled speech-powered dementia screening tool that is cost-effective and user-friendly for early detection of cognitive impairment to inform clinical practice (healthcare, clinical trials). We plan to harness the full potential of the state-of-art large language models (LLMs) for dementia prediction based on speech that will be a low-cost, easy-to-use, scalable approach to detection of AD, thereby holding immense potential for revolutionizing AD prognosis, diagnosis, and clinical research by enabling the early forecasting of AD risk in longitudinal, unobtrusive monitoring of cognitive health.

https://liang-lab.org/

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THE UNIVERSITY OF TENNESSEE KNOXVILLE

MUSICARE-VR: MUSIC INTERVENTION WITH VIRTUAL REALITY FOR ALZHEIMER'S CARE

Jindong Tan, PhD

MUSICARE-VR is an innovative system that combines the benefits of music intervention with the connective power of virtual reality to improve the well-being of people with Alzheimer's disease and related dementia (PwADRD). By providing engaging music sessions in a virtual environment, MUSICARE-VR aims to enhance cognitive function, physical activity, emotional positivity, and social connectedness among PwADRD, especially those living in isolation. The system will be developed using cutting-edge virtual reality technologies. PwADRD will participate in personalized, interactive music activities led by skilled music therapists, fostering a sense of achievement and encouraging repeated engagement. A key feature of MUSICARE-VR is the integration of artificial intelligence (AI), which will adapt music interventions in real-time based on users' emotional and physiological responses, ensuring an engaging and effective experience. AI-powered virtual agents will also join the sessions, enhancing social interactions and overall engagement. To ensure the system's success, MUSICARE-VR will be developed through a user-centered, iterative design process. The feasibility and acceptance of the system will be evaluated among PwADRD and their caregivers, with a focus on usability, engagement metrics, and participant feedback. By combining music intervention, virtual reality, and AI, MUSICARE-VR promises to be a groundbreaking tool for improving the quality of life of PwADRD and their caregivers.

https://mabe.utk.edu/

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