Sensors In-home for Elder Wellbeing (SINEW) Project – SMU and Sengkang General Hospital partner to support Ageing-in-place

Factsheet

A) The Science of SINEW project

Clinicians and scientists can now support seniors living alone, using advanced devices that capture and transmit digital signals related to their daily activities, such as sleep patterns, physical movement and signs of forgetfulness. This study provides a detailed picture of each senior's cognitive health status over time, enabling early detection and intervention before the condition worsens.

This Sensors In-home for Elder Wellbeing (SINEW)[1] project is a large-scale study led by Associate Professor Iris Rawtaer, Head & Senior Consultant, Department of Psychiatry and Director of Research at Sengkang General Hospital, and Professor of Computer Science Tan Ah Hwee from Singapore Management University.

A first in Asia, it is a longitudinal study that aims to detect Mild Cognitive Impairment (MCI) early before it progresses to dementia. Leveraging ambient intelligent devices in a home environment and artificial intelligence (AI), the team non-intrusively monitors common human daily activities to assess cognitive and functional health. Since 2020, the project has recruited over 200 seniors undergoing comprehensive cognitive assessment, with their activity and behavioural data continually captured and transmitted to a central cloud-based data server for analysis.

Technical Novelty: Compared with our pilot study first announced in 2020[2] which ran for two months and achieved an accuracy rate of around 70%, the current project employs an advanced Machine Learning-based AI model, designed to handle noisy and missing sensor data collected in a real-world environment. Validated with sensor data collected over a period of 13 months, the project trained the model with data from 63 seniors. The noise-resilient predictive model achieved over 90% accuracy in detecting MCI, which is more than a 20% improvement from the previously obtained performance. Also, this AI model is "explainable" – it can explain why a participant is predicted to have normal cognition (NC) or is experiencing MCI based on a set of interpretable rules, which can characterise NC and MCI cases with distinctive activity-based biomarker features.

Sensor Network Set Up: Each participant in the SINEW study lives alone and has either normal cognition (NC) or mild cognitive impairment (MCI). Each of them also has nine sensors – including a wearable one – installed in their homes to passively track their daily behaviours, including movement, room transitions, sleep and medication-taking behaviour. Participants also have a wearable device to measure steps and heart rate. The clinical research team conducts yearly assessments of cognitive function, mental well-being, and physical health. These comprehensive evaluations determine each participant's cognitive status – normal, MCI or dementia – providing the benchmark against which the Machine Learning (ML) models are tested. The SINEW study found that ML predictive models can identify MCI cases with 90% accuracy.

Biomarker Feature Extraction: The SINEW project team developed a dashboard that monitors the sensor status and tracks their digital biomarker values for each participant over time. In the future, healthcare staff and caregivers can track various biomarkers related to physical status, including movement and heart rate, their activities such as their movement from room to room, daily functioning and sleep patterns (for example, direction and the number of interruptions). All the participants' identities are anonymised and only the research team has access to the data. (See Figure 1 below)

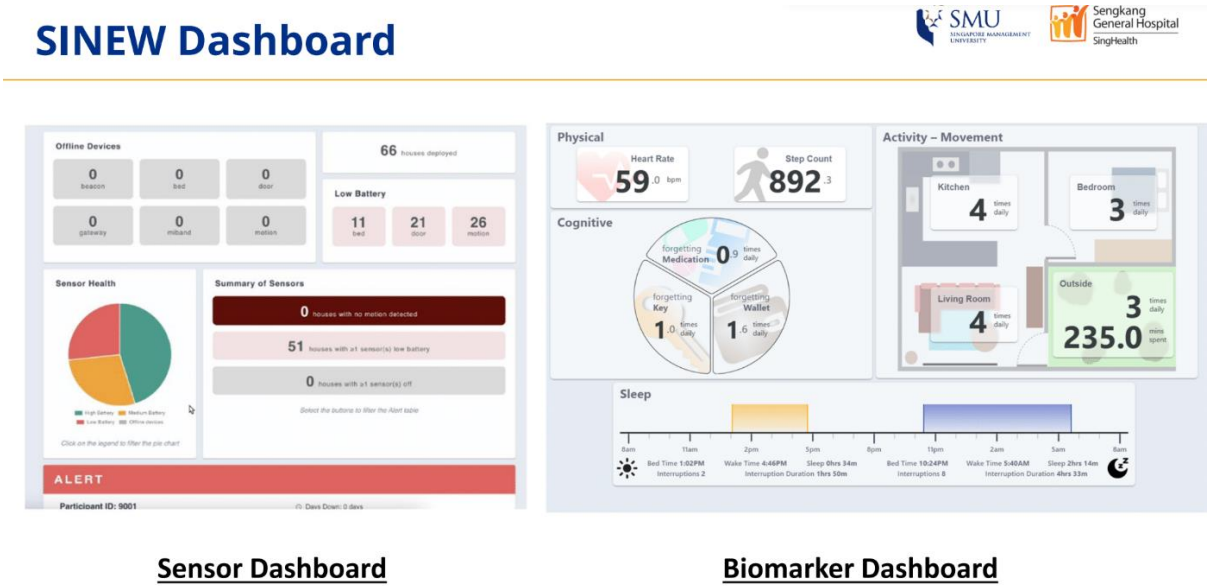

Figure 1: The SINEW Dashboard displaying (left) the overall status of the sensors deployed and (right) and the Biomarker Dashboard for a participant.

Predictive Modelling: As real-world sensor data captured from the real world can be incomplete and noisy, the SINEW research team has developed predictive models using various machine learning techniques to handle this challenge. Validated against findings of clinical assessment, our experiments show that machine learning-based predictive models can identify MCI cases based on the extracted digital biomarkers with over 90% accuracy. This shows that the sensor-based digital biomarkers are indicative of the users' cognitive health status and may be useful for more general health assessments.

Says Associate Professor Iris Rawtaer, Head & Senior Consultant, Department of Psychiatry and Director, Research at Sengkang General Hospital: "This project represents an important step forward in how we detect and respond to early cognitive decline. By bridging healthcare and computer science expertise, we are not just developing smart tools, but are creating scalable solutions that can identify signs of dementia before they become clinically obvious. Too often, individuals seek help only after a significant decline has occurred, missing the crucial window for intervention and advanced planning. Our goal is to refine our model and set up, so that we may intervene during that critical period, using AI and real-world behavioural data to eventually direct individuals to timely, evidence-based support. With the number of people living with dementia in Singapore reaching 152,000 by 2030 and 187,000 by 2050, the potential impact of SINEW on individuals, families and healthcare providers is substantial."

Observes Professor Tan Ah Hwee of Singapore Management University: "Sensor data from real homes is often messy and incomplete—but our team has shown that with smart modelling, we can

still spot early signs of mild cognitive impairment with up to 90% accuracy. This is the first long-term study using data quietly collected from everyday life at home, and it shows how Human-Computer Interaction can gently support health monitoring without being intrusive. Similarly significant is how we've worked closely with seniors living alone and ensured that the technology fits naturally into their daily routines—easy to use, easy to live with."

Another advantage is that the AI doesn't just make predictions—it explains them, he says. "That means we can understand why it flagged someone as being at risk. For example, the system has learned that people with mild cognitive impairment often move around less at home and are more likely to miss their medication. These kinds of insights help caregivers and doctors step in early, with the right kind of support."

"Looking ahead, this kind of system could be used to quietly support ageing-in-place, especially for seniors living alone or with caregivers. It could help families and healthcare teams catch early warning signs before problems become serious. With more data and wider use, the model could also be tuned to pick up other conditions."

B) Experience of two elderly participants in the SINEW study

They have been supported by the Lions Befrienders Active Ageing Centre, which offers holistic active ageing programmes, befriending services, and social and health support, as well as the Thye Hua Kwan Active Ageing Centre, a social hub that helps seniors build strong connections in the community, respectively.

Julie, 97 years old

Julie feels secure with the sensors in place, confident that someone will be alerted in the event of a fall. While she values the added safety, she noted a minor inconvenience—changing clothes in the bathroom for privacy, as she is concerned about being seen through the sensors. Additionally, she has a separate camera installed by her god-daughter's son for extra safety, which provides excellent resolution. Although Julie expressed concern about the cameras capturing clear images, she was reassured that the sensors do not offer such high visibility. Julie believes the sensors could be beneficial for other elderly individuals living independently at home.

Julie also won the Lions Befrienders' Gin Rummy competition in April last year, competing against 40 participants from 10 centres.
Note: Julie may not fully recall the project's aim to study data on activity, sleep, and cognitive decline. The focus for patient interviews/quotes in the SINEW story will centre on the sensors being unobtrusive and easy to use.

Rosnah, 76 years old

Rosnah stays active by delivering food to neighbours and participating in activities at the Thye Hwa Kuan Centre, where she makes friends and stay active. She feels that the sensors and alarms in her home provide safety, particularly as she lives alone. The sensors light up when she moves during the night, offering her peace of mind.
Rosnah believes that the installation of sensors in other seniors' homes would enhance their safety, and she is reassured knowing that SKH will be alerted if any issues arise. She likens the sensors to a "secret friend" looking out for her, and feels comfortable with the sensors.

Rosnah appreciates the regular visits from the research coordinator for assessments and is thankful for the ongoing support.

C) References:

[1]Tan, A.-H., Ying, W.-Y., Subagdja, B., Huang, A., Shanthoshigaa, D., Tay, T. C.-I., & Rawtaer, I. (2024). Predicting mild cognitive impairment through ambient sensing and artificial intelligence. *Proceedings of the 2024 IEEE Conference on Artificial Intelligence (CAI)*, 1101–1108. https://doi.org/10.1109/CAI59869.2024.00198

[2]Tan, Theresa. (2020, July 1). Smart sensors to test seniors' cognitive functions. *The Straits Times*. Retrieved from https://www.straitstimes.com/singapore/smart-sensors-to-test-seniors-cognitive-functions

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