

Measurement Systems for Cognitive/Well-Being Assessment within Smart Homes

We are all experiencing the evolution of Sensors and increasing levels of automation enabled by Smart Homes connected to cloud intelligence. These can provide convenience (automatic lights) and efficiency (lower thermostat at night) in our day to day lives. These technologies are now being applied to solutions that go well beyond convenience to now proactively support the independence of individuals as they age. This requires sensors and sensor processing methods to measure and assess meaningful attributes of well-being. There are a number of activities that older adults perform that would be worth measuring, a number of sensors and sensor combinations that would be appropriate to do the measuring, and then different data analytic techniques to produce useable information.

This special edition explores these issues in a little more depth. The potential for technology to directly address the needs and challenges aging adults face in their day to day lives is also leading to the formation of multi-disciplinary teams that bring together the skills and expertise of clinicians and care providers with engineers and data scientists. This is demonstrated by the numerous physician and medical co-authors within the papers as they bring their insights and expertise to focus the technology on solutions that directly help people.

This special issue offers an overview of the evolution of these technologies starting from new applications of sensors and sensor processing for novel measurements of well being through to holistic systems of sensors that monitor the complete residence and even a vehicle.

The first group of papers addresses older adult functioning. The first activity domain important to older adults is mobility. "On the Assessment and Reliability of Assistive Technology: The Case of Falls and Postural Sway Monitoring" by Andò *et al.* discusses how technology can be used to measure fall risk. While detecting falls has merit, preventing falls through early intervention could be even better.

There are a number of papers that address the next geriatric giant, namely cognition. "Measuring Cognitive Status from Speech in a Smart Home Environment" by Fraser and Komeili discusses an emerging new sensor and processing method for speech assessment. Changes in cognition can affect speech patterns, and again early detection of these changes could lead to early intervention.

The paper "DTCoach: Your Digital Twin Coach on the Edge During COVID-19 and Beyond" by Díaz *et al.* discusses how smart phones can provide a platform for activity analysis. Similar to changes in speech, changes in executive functioning could be detected in smart phone use and coaching feedback could be provided to improve activity and actions.

The next paper looks at other cognitive domains that can be affected by normal or pathologic aging. "Predicting Engagement in Older Adults With and Without Dementia While Playing Mobile Games" by Miguel-Cruz *et al.* shows how so-called serious games are emerging as an assessment method. In addition to providing enjoyment, electronic games can also provide ongoing assessment of cognitive dimensions like processing speed. One of the benefits of serious games is that they can continue to be used in more advanced forms of cognitive decline.

Finally, the paper "Smart Home Technologies for Cognitive Assessment in Healthcare" by Lombardo discusses how smart home systems can be applied and the systems adapted for the challenge of in-home ambient cognitive assessment.

The next group of papers looks at the integration of sensors and data analytic techniques.

The paper "Human Activity Recognition with Device-Free Sensors for Well-Being Assessment in Smart Homes" by Raeis, Kazemi and Shirmohammadi discusses the potential for the recognition of activity through the fusion and analysis of information sensors placed throughout the residence.

The paper "Assessment of Domestic Well-Being: From Perception to Measurement" by Casaccia *et al.* discusses the potential and challenges from ambient home monitoring systems as many measures are only an indirect measure of activity and behavior and this leads to a need for fusion of sensors to determine activity.

The paper "Home-Based Assessment of Cognition and Health Measures: The Collaborative Aging Research Using Technology (CART) Initiative and International Collaborations" by Thomas *et al.* discusses a multi-nation project that brings together home, vehicle and wearable sensors on a common platform.

The paper "The Assessment of Cognitive and Physical Well-Being through Ambient Sensor Measures of Movement

Towards Longitudinal Monitoring of Activities of Daily Living” by Bennett *et al.* discusses how well-being assessment builds in layers from specific sensors and knowledge through to holistic views of an individual through the fusion of many sensor systems.

We end on a cautionary note. While we believe the future of home and ambient sensing is bright, we need to be careful of the limitations. “Wearable Devices and Diagnostic Apps: Beyond the Borders of Traditional Medicine, But What About Their Accuracy and Reliability?” by Cosoli *et al.* discusses the

potential measurement challenges associated with novel assessments such as wearables.

We hope that this special issue has shown the potential for sensors and smart home technology to move from convenience to proactively supportive systems that can truly enable independence for many individuals whether that be to support declines in function related to aging. These systems have the potential to directly improve the lives of older adults, and also support care partners and care professionals, to ultimately allow people to age in place.