Challenges for the IoT to Support Aging in Place

Ewan Soubutts
University of Bristol
Bristol, UK
e.soubutts@bristol.ac.uk

Aisling Ann O'Kane
University of Bristol
Bristol, UK
a.okane@bristol.ac.uk

Jon Bird
University of Bristol
Bristol, UK
jon.bird@bristol.ac.uk

Rachel Eardley
University of Bristol
Bristol, UK
rachel@racheleardley.net

ABSTRACT

In this paper we describe how an increase in older adult populations worldwide is a problem for the provision of care at home. As global populations are increasing and more adults are living in 'multi-resident' homes (adults of different generations living together in one household); there is a greater demand being placed on non-professional carers to support an aging population. However, there is also an opportunity for IoT technologies to facilitate care and independent living for older adults. We identify challenges in designing IoT to support aging in place, including how multiple household residents have to negotiate how IoT technologies are customised and how to address different Trust, Identity, Privacy and Security (TIPS) issues to ensure these devices facilitate the most effective care.

INTRODUCTION

The world population is becoming increasingly older, with the number of people over 60 expected to double by 2050 and triple by 2100: an increase from 962 million to 3.2 billion globally [11]. This represents "one of the most significant social transformations of the twenty-first century" [10] and presents both opportunities and challenges for the IoT, particularly in the healthcare domain. We first describe how healthcare provision is changing for older people, using UK data as an illustration. This provides the context for a discussion of two of the key challenges when designing IoT to support the health of older people.

Aging in Place

It is estimated that the proportion of the UK population aged over 65 will increase by 19% between 2015 and 2025 (10.4M to 12.4M), a consequence of which is that there will be a 25% more older people living with disability: an additional 560,000 people who will require care, with dementia cases representing the biggest relative increase [7]. Given the financial challenges and staff shortages in the National Health Service (NHS), in order to provide older people with the care they need, the UK, like many other countries is promoting 'aging in place': "The ability to live in one's own home and community safely, independently, and comfortably, regardless of age, income, or ability level" [3]. Typically, the burden of care falls primarily upon other household residents and family members. The NHS recognises that, "Even people with long term conditions, who tend to be heavy users of the health service, are likely to spend less than 1% of their time in contact with health professionals. The rest of the time they, their carers and their families manage on their own" [9].

Given that the primary locus of health care for aging in place is older people's homes, it is important to note that the composition of older people's households is also changing. It is increasingly likely that older people live together with other residents in a household, not only partners but also other family members of different generations. For example, in the United Kingdom in 1997, a 'cohabiting family' (made up of one owner, with four or more dependents) accounted for 1.5 million families. By contrast, in 2017, 2.9 million families cohabited with a single owner or couple, representing a 93% increase. Multi-resident, inter-generational families are now the largest growing household group in the UK [12]. Internationally, there has also been an increase in the number of multi-resident households, most commonly in large cities [5].

People who live with older adults in multi-resident households may participate in important duties related to an older adult's Activities of Daily Living (ADL's), including household tasks e.g. 'washing and cleaning' as well as arranging medical appointments and overseeing the purchase and installation of assistive technologies, included IoT devices [8]. There are clear opportunities for IoT to support these carers and the people they care for, as well as linking the households to medical professionals

e.g sharing health data. However, the ways in which household members in multi-resident homes interact with IoT technology to help perform care duties with older adults is not a well-researched area [14]. Studies conducted in living labs e.g. the CUHTech, GatorTech and LebensPhasenHaus houses, have all provided a variety of data on living in smart home environments. However, while these research homes may include more than one resident, such as couples, the research tends to focus on individual and not take into account other residents living in the household [8, 13].

In order for multi-resident homes to function, who is responsible for different household activities is negotiated between the different household members e.g. household chores, such as cleaning, washing up and preparing meals, being assigned to a particular resident. Multi-resident households also negotiate how and when rooms are used for different activities e.g. a living room may be used for watching television by some residents and for quieter activities by others. Negotiation is also required when an older person is aging in place in a multi-resident home e.g. negotiating who is responsible for different care duties.

Similarly, designers of IoT technologies for aging in place in multi-resident homes must take into consideration that they impact not just the primary recipient of care but also other household members. IoT devices such as Alexa may be used in different ways by different household members e.g. to help a person with a cognitive difficulty follow a set of instructions to iron clothes and by another resident to create to a shopping list. The negotiation of care in multi-resident smart homes results in socio-technical challenges, which must be addressed when designing IoT technologies that support both care and other activities for residents in a multi-resident home.

CHALLENGES FOR USING SMART HOME CARE IOT IN THE HOUSEHOLD

We focus on two major challenges which may impact the effectiveness of smart home IoT technology that aims to support aging in place in multi-resident homes.

Challenge One: Trust, Identity, Privacy and Security (TIPS)

Within multi-resident households, Trust, Identity, Privacy and Security (TIPS) issues are key considerations because other residents are involved in the care of another and their TIPS requirements may differ or even be in conflict. For example, an older adult who is aging in place could record personal information on a device like an Amazon Alexa, such as how frequently they take their medication. They place trust in the device to keep that information secure and they must also trust other members of the household who have access to the device to respect their privacy [6]. Conflicts can arise when recipients of care do not want other members of their household to access their health data, and carers need to access these data to ensure that they are fulfilling their caring duties. For recipients of care with cognitive decline, it may be that the carers' needs are given precedence over the desires of the primary recipient of care. Trust between carers and recipients of care can also change over time

e.g. if the condition of a parent with dementia deteriorates then sensors may be fitted into a front door to track whether a they have left the house.

If confidentiality is breached or not respected, then trust in both IoT technology and other residents may be compromised. For example, should the child of an older adult discover from a smart home device that their older parent had not taken their medication or performed their required health tasks, they may be inclined to confront their older parent on this issue, which in turn could lead to conflict or shame [8]. This in turn may result in the recipient of care wishing for greater privacy.

In addition to these concerns around data privacy within the household, it may also be useful for those outside of the household to access this health data e.g. clinicians, if permission is given to them. While a wide variety of medical data are stored on smart home devices [2], at present, these data are under-utilised by clinicians, even though it could improve quality of care [1]. While this presents a security and interoperability challenge for networking and IoT design, the sharing of medical data in real-time with clinicians, appears to be a significant opportunity for multi-resident smart home IoT.

Identity describes how we represent ourselves to others e.g. the data we choose to share via social media technologies shape our online identities [4]. Issues around identity may also arise in multi-resident households where a person is being cared for. The medicalisation of the home, that is when it is viewed primarily as a centre for health care, may contribute to changes in how residents perceive their own and other residents' identities.

Some residents of a household may wish to distance themselves from an assistive technology, so that they are not linked with a household identity that is associated with healthcare. An example of this may be children of older adults in care, inviting friends over to the household and not wanting them to see healthcare devices lying around the household. While older adults may consider their shared home space to be focussed primarily on their care, different generations may still consider this space their family home and one which should also be able to be used for non-care purposes.

Challenge Two: Customisation

Customisation describes the ability of people to tailor the technology they use according to their own preferences e.g. user interfaces on mobile devices being set to 'dark mode' to prevent eye strain [2]. Within the context of smart home IoT technologies, customisation may take place within a device e.g. choosing the style of voice of a virtual assistant that suits the household.

IoT technologies used in multi-resident homes may potentially be used for both health and non-health purposes by different household members. e.g. an Alexa providing health reminders for the person in care as well as providing music streaming. It is therefore important to consider how IoT technologies used to support care in these contexts should be customisable with multiple residents in mind - not only for the person in care.

While it is important that smart home technology supports the person in care and is customisable by them, the involvement of the whole household in the customisation of care technologies needs to be considered. A multi-resident approach to customisation could enable the co-operative design of smart home technology, which not only facilitates care, but also helps to maintain a good quality of life for the whole household and does not negatively impact residents' privacy, boundaries or lifestyles.

DISCUSSION AND CONCLUSIONS

We have examined two socio-technical challenges that complicate the design of IoT health technologies for multi-resident environments. There is a need for further investigation of multi-resident households to gain an understanding of how best to design IoT that facilitates aging in place.

We argue that to design useful IoT health technologies for multi-resident households it is necessary to consider the variety of residents who are impacted by the introduction of technology, not just the primary recipient of care. In particular, households have to negotiate how IoT technologies are customised to address different TIPS issues and to ensure the devices facilitate the most effective care.

REFERENCES

[1] DanaKai Bradford and Qing Zhang. 2016. How to save a life: Could real-time sensor data have saved Mrs Elle?. In *Proceedings of the 2016 CHI conference extended abstracts on human factors in computing systems*. ACM, 910–920.

[2] Alison Burrows, David Coyle, and Rachael Gooberman-Hill. 2018. Privacy, boundaries and smart homes for health: An ethnographic study. *Health & place* 50 (2018), 112–118.

[3] CDC. 2017. Centre for Disease Control and Prevention. (2017). https://www.cdc.gov/aging/index.html

[4] Rachna Dhamija and Lisa Dusseault. 2008. The seven flaws of identity management: Usability and security challenges. *IEEE Security & Privacy* 6, 2 (2008), 24–29.

[5] Eurostat. 2017. Eurostat - Statistics Explained. (2017). https://ec.europa.eu/eurostat/statistics-explained/index.php/People_in_the_EU_-_statistics_on_household_and_family_structures#Other_types_of_household

[6] Michael Friedewald, Elena Vildjiounaite, Yves Punie, and David Wright. 2006. The brave new world of ambient intelligence: An analysis of scenarios regarding privacy, identity and security issues. In *International Conference on Security in Pervasive Computing*. Springer, 119–133.

[7] Maria Guzman-Castillo, Sara Ahmadi-Abhari, Piotr Bandosz, Simon Capewell, Andrew Steptoe, Archana Singh-Manoux, Mika Kivimaki, Martin J Shipley, Eric J Brunner, and Martin O'Flaherty. 2017. Forecasted trends in disability and life expectancy in England and Wales up to 2025: a modelling study. *The Lancet Public Health* 2, 7 (2017), e307–e313.

[8] Amanda Lazar, Hilaire J Thompson, Shih-Yin Lin, and George Demiris. 2018. Negotiating Relation Work with Telehealth Home Care Companionship Technologies that Support Aging in Place. *Proceedings of the ACM on Human-Computer Interaction* 2, CSCW (2018), 103.

[9] NHS England National Health Service. 2014. Centre for Disease Control and Prevention. (2014). https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf

[10] United Nations. 2017. United Nations, Aging Department. *United Nations, Department of Economic and Social Affairs, Population Division, 2017, Working Paper No. ESA/P/WP/248* (2017). http://www.un.org/en/sections/issues-depth/ageing/

[11] United Nations. 2017. World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. *United Nations, Department of Economic and Social Affairs, Population Division, 2017, Working Paper No. ESA/P/WP/248* (2017). https://esa.un.org/unpd/wpp/publications/files/wpp2017_keyfindings.pdf

[12] UK Office for National Statistics. 2017. Office for National Statistics. (2017). https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/bulletins/familiesandhouseholds/2017#number-of-families-in-the-uk-continues-to-grow-with-cohabiting-couple-families-growing-the-fastest

[13] Julie M Robillard, Aaron W Li, Shilpa Jacob, Dan Wang, Xin Zou, and Jesse Hoey. 2017. Co-Creating Emotionally Aligned Smart Homes Using Social Psychological Modeling. In *Proceedings of the 4th international Workshop on Sensor-based Activity Recognition and Interaction*. ACM, 8.

[14] Matteo Zallio and Niccolò Casiddu. 2016. Lifelong housing design: user feedback evaluation of smart objects and accessible houses for healthy ageing. In *Proceedings of the 9th ACM International Conference on PErvasive Technologies Related to Assistive Environments*. ACM, 70.