Employing in-home sensor technology to explore elderly's social needs: implications on personalising community elder care

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Introduction

Ageing-in-place, the ability to age holistically in the community, is increasingly gaining recognition as an effective solution for the labour intensive and costly institutionalised elderly care system [1-4]. It gives freedom for the elderly to live in their own homes in their golden years and enjoy better quality of life as they could pursue what they like and stay in close contact with their loved ones. However, effective community elderly care models may require a personalised and an all-encompassing approach to caregiving. A successful community care model may require the synergy of various stakeholders; ranging from caregivers, healthcare providers, technology providers to policy makers for care management of older people living in the community.

In this research, we combine data gathered through: (i) non-obtrusive in-home sensors, (ii) subjective surveys and (iii) attendance in social activities and apply AI methods to explore how we can early identify elderly in need of interventions through synthesising technology and community care. Twenty-one seniors who are members of Lions Befrienders Service Association, a leading befriending service agency in Singapore, and assessed to be at risk or socially isolated were selected for the study. We use a qualitative approach to (a) cluster elderly based on the factors associated with social wellbing and (b) identify inter-cluster and intra-cluster relationships to understand the different cirumstances of seniors to provide value-added elder care planning.

Data collection

Sensor-data: Sensor data was gathered from 21 sensor enabled homes over a period of 3 months, from Jan-2016 to Mar-2016. Each home is equipped with a set of motion sensors and a door contact sensor. As shown in Figure 1, motion sensors are installed in each room of the house - namely the living room, bedroom, kitchen and toilet - to detect in-home living patterns of elderly. The motion sensors function by firing a signal at 10 min intervals to indicate whether a motion is detected or not. A door contact sensor, installed on the main door, has two parts: one is attached to the main door and the other to the frame. It is magnatic and fires a signal when the two magnets are apart.
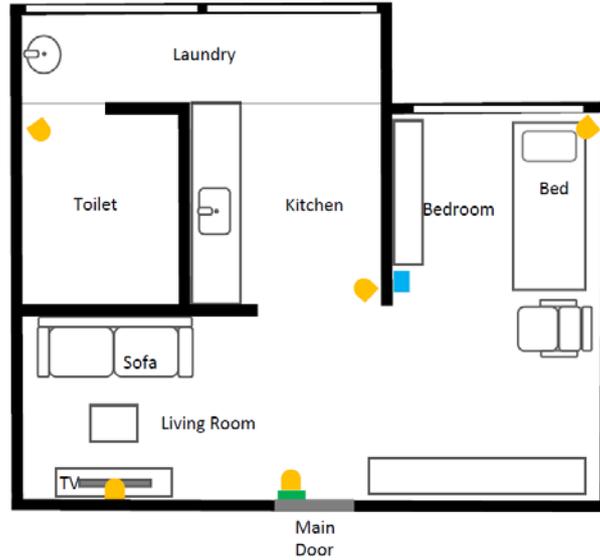
Figure 1: Layout of the sensor-based elderly monitoring system

There are several aspects of an elderly's daily living that can be inferred using an in-home sensor-based monitoring system. For example; sleeping, going-out behavior, toileting etc. In this study, we focus on the elderly's going-out pattern to identify elderly who are at risk of social and emotional wellbeing declines. Going-out/away patterns are particularly important for elderly living alone who may possess a limited social network of friends and relatives. Further, past research have shown that elderly who go out more often tend to show lower loneliness levels, feel less isolated and possess high cognitive functions. We have designed an algorithm to derive the going-out pattern of elderly based on the door contact sensor and in-home motion sensors. Figure 2 illustrates the process of detecting away durations.
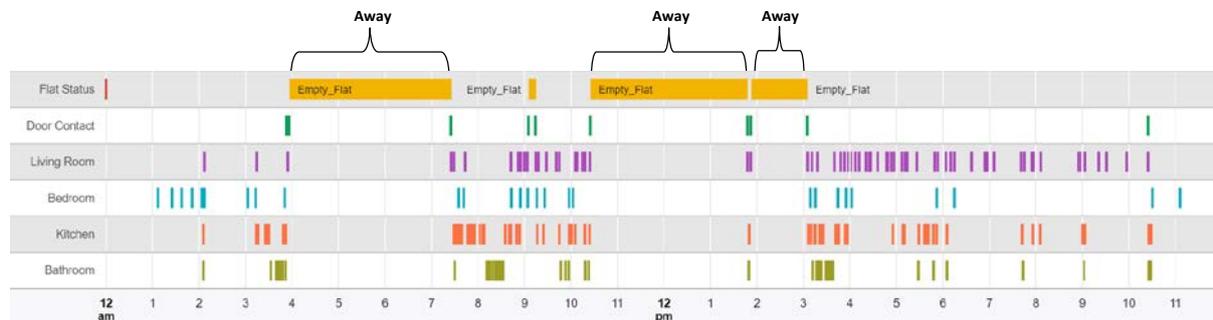

Figure 2: Raw sensor readings and empty flat status. (i.e., empty flat statuses longer than 30 mins are identified as away durations)

Survey data : a baseline survey was conducted in Feb 2016 to gather information pertaining to demographics and wellbeing of the elderly. The survey comprised questions to assess

participants in terms of their physical and social health wellbeing. The main aspects of the survey include: demographic characteristics, loneliness, social network and the physical health status. The presence of a social network was measured using the Lubben Social Network Scale [5] to evaluate the family and friendship network of the elderly. Perceived loneliness was measured using the De Jong Gierveld Loneliness Scale [6]. All items were measured using a five-point likert-scale with anchors from 'strongly disagree' to 'strongly agree'.

Attendance in Senior Activity Center : all elderly are members of the Lions Befrienders Service Association (LBSA) in Singapore. The LBSA provides an array of activities at their Senior Activity Centre (SAC) to help seniors to stay physically and mentally alert, and keep them integrated in the society. The elderly's weekly attendance in activities between Jan-2016 to Mar-2016 was extracted through attendance logs maintained by the organisation.

Results and discussion

The following table shows the demographic characteristics of participants:

Category	Demographic Characteristic	Number of elderly
Age group	60 – 64	0
	65 – 74	5
	75 – 84	12
	85 and above	4
Gender	Female	9
	Male	12
Race	Chinese	20
	Malay	1
	Indian	0
	Others	0
Education	No formal qualifications	18
	Primary (PSLE)	1
	Secondary	2
	Junior College	0
Marital Status	Single (never married)	15
	Currently married	0
	Separated	0
	Divorced	2
	Widowed	4
Work Status	Working part-time	0
	Looking for work, Unemployed	2
	Retired	19

Venturing out of home: Our results showed a weak-positive relationship between elderly's going-out frequency and attendance in the Senior Activity Center (SAC) activities. We observed two categories of elderly based on their going-out habits: 1) elderly who go out more often than the community average and 2) elderly who go out less often than the community average. Elderly in category 1 showed a higher level of participation in SAC activities.

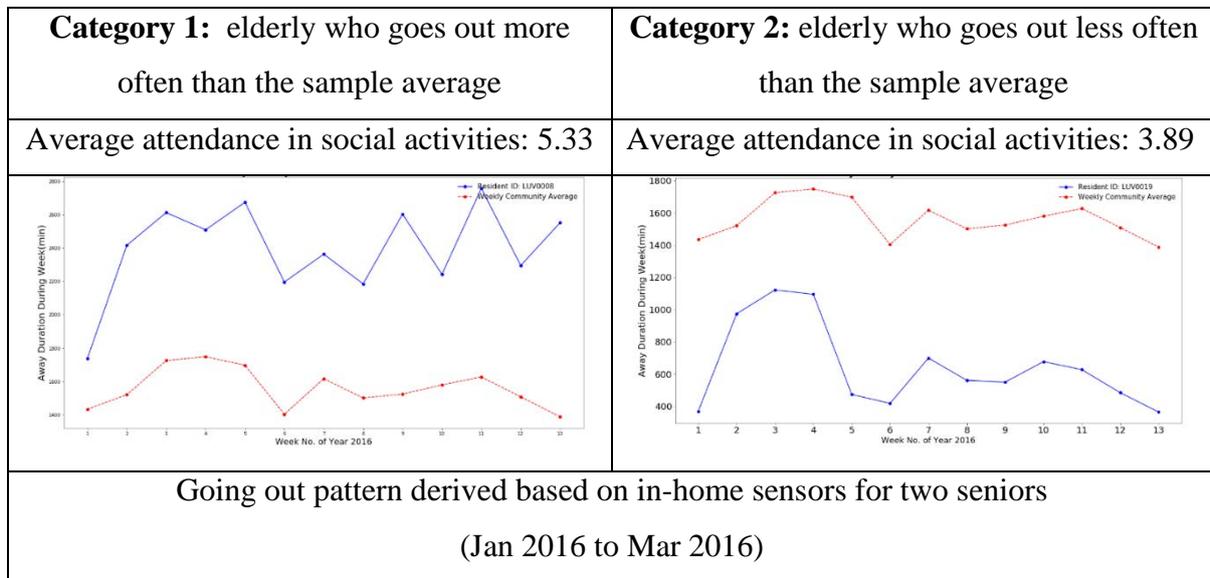| **Category 1:** elderly who goes out more often than the sample average	**Category 2:** elderly who goes out less often than the sample average
Average attendance in social activities: 5.33	Average attendance in social activities: 3.89
Going out pattern derived based on in-home sensors for two seniors (Jan 2016 to Mar 2016)	

Figure 3 shows the probability of elderly being out at a given hour of the day, as detected by the sensor-based monitoring system. Accordingly, there is a high probability that the elderly is out of home between 8am and 10am during both weekdays and weekends. We observed a second peak in their going out pattern during the weekdays between 12 noon to 4 pm. This going out pattern, as detected by the sensors, is consistent with the SAC's activity schedule, which usually comprises two sessions, one in the morning and one after lunch.
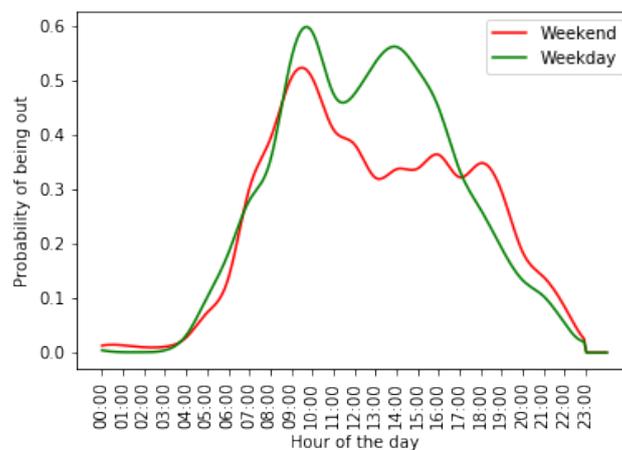

Figure 3: Probability of being away at a given hour of the day

Physical health: The analysis of the physical health of the elderly yield interesting results. On average, an elderly suffers from four chronic health conditions. Though plagued by more chronic conditions, a category of elderly (C4, Figure 4) showed higher going-out levels and SAC attendance than the corresponding average going out and SAC attendance of all elderly in the study. Futher investigation of this category of elderly showed that they perceived relatively low loneliness levels (i.e. combined score of both social and emotional loneliness) compared to the rest of the elderly. On the other hand, another cluster of elderly who had similar number of chronic conditions (C3, Figure 4) showed low levels of going out and SAC attendance. Moreover, this category of elderly also perceived moderately high loneliness levels. The timely identification of this cluster of elderly is particularly important as they might be at risk of being socially isolated and forgotten, due to their low attendance in SAC activities and prolonged stay at home.
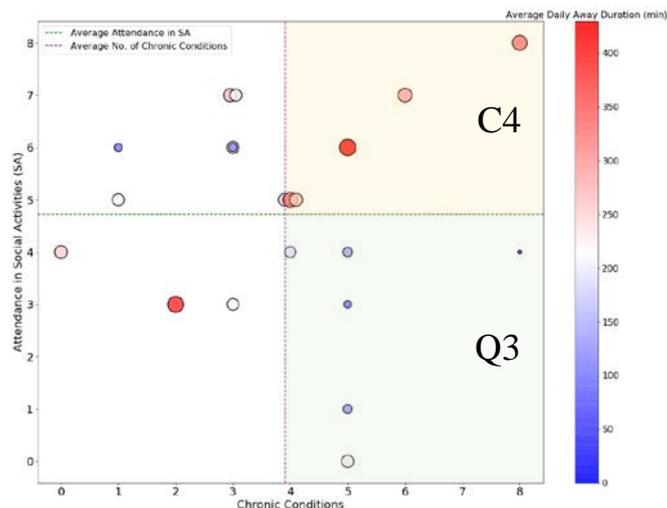

Figure 4: Attendance in social activities and going out levels vs
number of chronic conditions

Effective socialising: We found a negative correlation between social networking and perceived social loneliness, i.e., elderly with better social networks have low perceived social loneliness levels. In particular, we observed a cluster of elderly with moderate going-out levels, having a good social network and perveiving low social loneliness levels (C1, Figure 6).

In contrast, the relationship between emotional loneliness and social networking was not significant. Our results revealed a cluster of elderly (C4, Figure 5) who possess better social networks and higher going out levels with higher emotional loneliness levels. This may indicate that despite going out more and having a better social network, the elderly may still be emotionally lonely due to the stigma associated with sharing their personal struggles with their

peers. In fact, a majority of the elderly in this cluster have higher than average attendance levels at SAC activities – which may make the higher emotional loneliness less apparent.
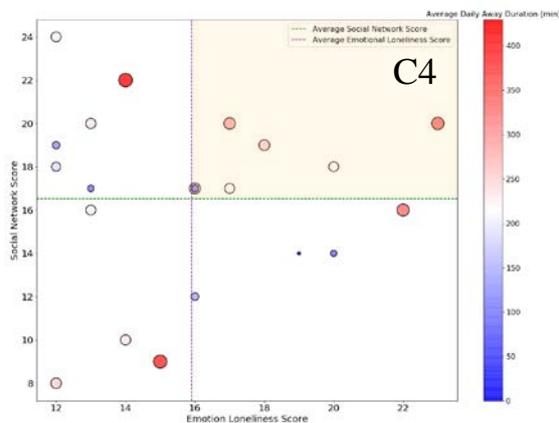

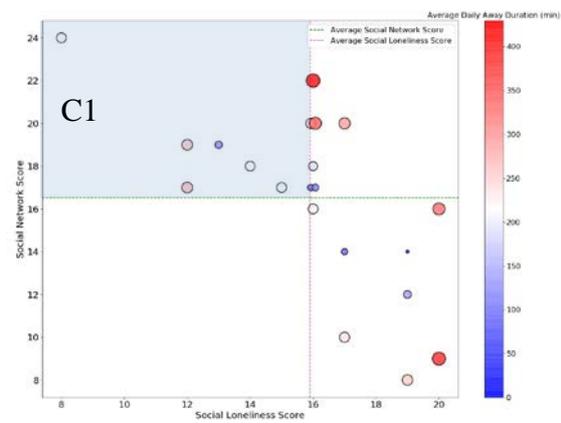Figure 5: social network vs emotional loneliness

Figure 6: social network vs social loneliness

Furthermore, elderly who have attended SAC activities more often reported that they have a better social network (C4, Figure 7). SACs are drop-in centres for many vulnerable seniors in Singapore. Such centres provide the opportunity for elderly living alone in the neighbourhood to interact and support each other. Attendance in activities organized by the centres is an important means for social integration for these community dwelling elderly.
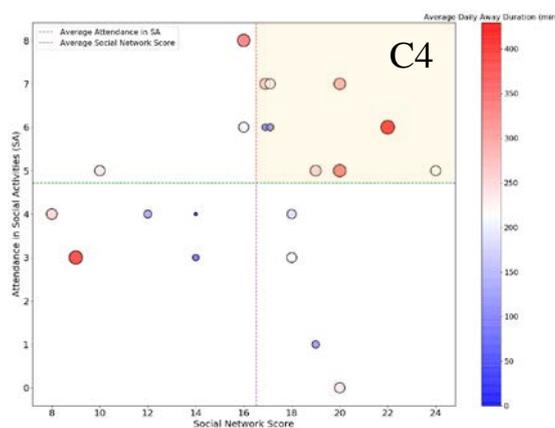

Figure 7: Social network vs attendance in social activities

In this study, we examined different clusters of elderly identified based on their going-out pattern, attendance in activities organized by the Senior Activity Centre and subjective wellbeing. We examined each identified cluster in-depth to understand common circumstances

of elderly in order to provide recommendations for Voluntary Welfare Organisations to cater community caregiving efforts to maximise the effect on elderly's overall wellbeing.

One major limitation in the social care sector is that data collection and analysis for community care is primarily done via pen and paper. Therefore, there is no holistic approach to combine data gathered through various means for decision making and to identify high risk elderly for early interventions. This can be a key bottleneck in the social service sector, where manpower and resources are scarce. Our research is an initial attempt towards a techno-centric all-inclusive care and response protocol aimed at improving the social and emotional wellbeing of the community dwelling elderly. In collaboration with the Lions Befrienders Services Association, we have identified elderly who are at risk and taken initial steps for personalised interventions. Figure 8 illustrates our overall research framework.
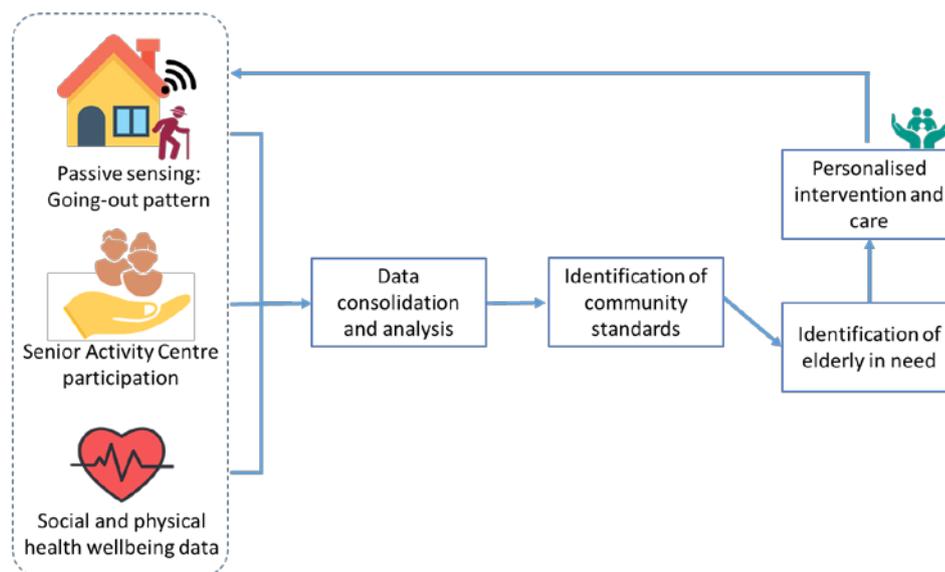

Figure 8: Research framework

Future work will be carried out to extend this study to a larger audience and to study the effect of personalised interventions in improving elderly's social and emotional wellbeing.

References

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