IoT-Enabled Community Care for Sustainable Ageing-in-Place

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About the SMU-TCS iCity Lab

The iCity lab was established in Aug 2011 to explore and pursue new research areas in **Smart Cities** to provide long-term competitive advantage to TCS

- **i = {intelligent, integrated, inclusive, innovative}**
- Leverages TCS’s and SMU’s strength in IT and management

In view of the successful partnership in the last 6 years, TCS has **committed funding to extend the relationship** for a further 3 years (Aug 2017 – July 2020) to take the iCity lab to greater heights
The iCity team

Steering Committee

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Elderly who live alone are at risk!

Source: The Straits Times, 18 Dec 2015

1.7X
MORE LIKELY TO DIE PREMATURELY

2X
MORE LIKELY TO FEEL DEPRESSED
Technology Pilots & Services

Pull-cord alert alarm system (AAS) @ home

Response from staff/community

~23,000 elderly homes

AN INITIATIVE

Source: The Straits Times, 26 Apr 2015

Photo: ST
Technology Pilots & Services

HDB completes trial of smart elderly monitoring and alert system

Smart Activity Monitoring Service (SAMS)

SINGAPORE - When an elderly living alone deviates from his typical behaviour, such as spending too long in the toilet, an alert system will send an SMS to his or her caregiver.

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**Technology-enabled community care**

**Key Takeaways**

- **Supportive Ecosystem Beyond Technology**
- **Accessibility & Unobtrusiveness for Sustained Use**
- **Data-Driven Care Can Improve Wellness**

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"Can non-intrusive technologies be used to better enable community care for me to age-in-place?"

- Mr Tan, 78yo, living alone

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**Source:** The Straits Times, 12 April 2012

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**SMU-TCS iCity Lab**

*SHINESeniors (Nov 14 – Oct 17) is an SMU-led research project supported by the Ministry of National Development and National Research Foundation under the Land and Liveability National Innovation Challenge (L2NIC) Award No. L2NICCFP1-2013-5.*
IoT-Enabled Community Care Ecosystem

Assessment of community care needs of elderly living alone

Multi-modal data collection
- In-home unobtrusive monitoring
- Survey & ad-hoc observations

Multi-modal analytics
- Wellbeing assessment
- Activity/wellbeing-based care alert

Personalized, As-Needed Community Care

User-feedback & Refinements

ADL-based Care models

Aging-related Policy Enablers

Requirements

Regional Community Care Enablers

Technology Enablers
Understanding elderlies’ needs & wellbeing

Psychosocial Surveys & Regular Ground Observations

- Social-demographic profile, family support, financial status
- Physical health, mental health, medication, sleep patterns and quality, activities of daily living
- Social function, overall happiness and wellbeing, liveability, technology
- Routines and unusual events (hospitalization, faint spells, family visits etc)
Physical health profile

Top 10 physical health conditions (n = 105)

- Cataract: 70.48%
- High blood pressure: 64.76%
- Hyperlipidemia: 60.95%
- Joint pain, arthritis, rheumatism or nerve pain: 46.67%
- Diabetes: 29.52%
- Heart attack, angina, chest pain: 19.05%
- Parkinsons: 13.33%
- Chronic back pain: 13.33%
- Other fractures: 12.38%
- Digestive illnesses: 12.38%
Mental health profile

- A score of 6 or less suggests cognitive impairment at the time of testing:
  - 0-3 Severe impairment
  - 4-6 Moderate impairment
  - 6 Normal

- A score greater than 5 suggests depression
In-home unobtrusive monitoring

Legend:
- Gateway
- Motion Sensor
- Door Contact
- Sensorized medication box
- Help button
Activity-based alert and care

- Help request
- Data analysis & anomaly detection
  - Going out
  - Zonal activity level @ home
- Inferred medication
- Overall activity level @ home

Community Care Model
- Activity-based Personalized Care Execution
  - Care evaluation
  - Refinements
  - Anomaly-triggered alert
  - Help button alert

Care evaluation

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Example: Prolonged Inactivity @ home

A period of prolonged inactivity at home can indicate trouble for the elderly resident.

When inactivity exceeds a threshold, trigger an alert to caregivers.

Challenge: How to set the right alert threshold for different elderly with different daily routines.
Example: Prolonged Inactivity @ home

Early 80s

High blood pressure, diabetes and high cholesterol

Aunty Tan
- Stays home mostly
- Frail, pain in legs, fall history
- Socializes infrequently, with few visitors

Aunty Chan
- Goes out frequently, daily exercise routine
- Generally fit with no fall history
- Socializes frequently with family and neighbours, with regular visitors
Survey on inferred medication

~50% of elderly do not pack their medication

~60% of elderly store medication in plastic bags or containers
IoT solution to detect medication non-adherence

Sensorized medication box
To fit existing habits

Detection of medication non-adherence

Caregiver group alert & intervention
Intervention improves adherence

Improved medication adherence after intervention in Sep 2016
(medication reconciliation)
Wellness-based notification and care

Activity level @ bedroom

Multi-modal Data analysis

Activity level @ kitchen

Going out

Activity level @ bathroom

Overall activity level @ home

Wellbeing indices
- Loneliness/Social Isolation
- Frailty
- Depression
- ...

Community Care Model

Wellness-based Personalized Care Execution

Care evaluation

Poor / worsening wellness level?

Refinements
Detecting loneliness in elderly living alone

**Loneliness**

**Social loneliness**
- E.g. There is always someone I can talk to about my day-to-day problems

**Emotional loneliness**
- E.g. I experience a sense of emptiness

Prevalence among the Marine Parade elderly sample

- Social loneliness: 11%
- Emotional loneliness:
  - 5 to 10: 6 to 10 (13%)
  - 11 to 15: 11 to 15 (13%)
  - 16 to 20: 16 to 20 (27%)
  - 21 to 25: 21 to 25 (40%)
  - 26 to 30: 26 to 30 (13%)

Correlated with:
- Depression (Geriatric depression scale)
- Sleep (Pittsburgh sleep quality index)
- Cognition (Abbreviated mental test)
- IADLs (Instrumental activities of daily living)
Detecting social isolation of elderly

<table>
<thead>
<tr>
<th>Sensor-derived feature</th>
<th>Emotional loneliness</th>
<th>Social loneliness</th>
<th>Social network</th>
<th>Social Isolation Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average daily away duration</td>
<td>-0.22 (0.144)</td>
<td>-0.38* (0.011)</td>
<td>0.31* (0.037)</td>
<td>-0.42* (0.005*)</td>
</tr>
<tr>
<td>Away count</td>
<td>0.13 (0.392)</td>
<td>-0.10 (0.503)</td>
<td>-0.07 (0.656)</td>
<td>0.08 (0.606)</td>
</tr>
<tr>
<td>Napping duration</td>
<td>-0.08 (0.597)</td>
<td>0.32* (0.038)</td>
<td>-0.26 (0.101)</td>
<td>-0.05 (0.777)</td>
</tr>
<tr>
<td>Night time sleep duration</td>
<td>-0.12 (0.448)</td>
<td>0.24 (0.133)</td>
<td>-0.14 (0.373)</td>
<td>-0.16 (0.297)</td>
</tr>
<tr>
<td>Average time spent in the living room</td>
<td>0.31* (0.049)</td>
<td>-0.01 (0.973)</td>
<td>-0.23 (0.149)</td>
<td>0.17 (0.292)</td>
</tr>
<tr>
<td>Kitchen activity</td>
<td>-0.11 (0.48)</td>
<td>0.03 (0.854)</td>
<td>0.03 (0.852)</td>
<td>0.10 (0.508)</td>
</tr>
</tbody>
</table>

P values are in parenthesis

*** p < 0.001, ** p < 0.01, * p < 0.05

AWAY DURATION, NAPPING DURATION and TIME SPENT IN THE LIVING ROOM are correlated with social isolation dimensions
Impact of SHINESeniors on Ageing-in-Place

**2015**
- 80 Elderly Beneficiaries
- 3 Care Partners, 2 Estates, 3 Govt Partners

**2016**
- 52 Help Requests
  - Timely Assistance to 8 Elderly in 13 Cases
- 14 Elderly at Risk of Social Isolation
  - Personalized Intervention Achieved
  - Reduced Isolation
  - Medication Adherence for 24 Elderly
  - Personalized Intervention Improved Adherence in 2 Elderly

**2017**
- Prolonged Inactivity Detected in 17 Elderly
- 1 Elderly Found Unwell and Warded in Time!
Thank you for your attention

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