2019 GLOBAL HEALTH FORUM IN TAIWAN

Technology and care for older people with dementia

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3G’s for the aged society: Gerontology, Geriatrics, Gerontechnology

• It is only natural to consider applying technologies for the care of older adults…

• First International Congress on Gerontechnology, 1991
• International Society for Gerontechnology, 1997

“Design technology and environment for independent living and social participation of older persons in good health, comfort and safety”

• Scope of Gerontechnology: Health, Housing, Mobility, Communication, Leisure, Work
Gerontechnology is only valuable if we can bring research to daily applications

A design approach to gerontechnology:
Creativity ➞ Prototype ➞ Products ➞ Sales

Mission: To carry out a successful industrial and educational experiment
One day when Zeng was out cutting wood among the mountains, there came a visitor to his house. After awaiting her son’s return in vein, his mother bit her finger.

Zeng felt heartache all of a sudden and knew there was an emergency. He rushed back home with a burden of wood, and on arrival, knelt down to asked his mother what happened. His mother replied, “Here is a visitor who needs you urgently. So I bit my finger to awake you to come back…”

From the “24 stories of filial piety”
Zeng was a disciple of Confucius 2,500 years ago…
Are you using telehealth systems to care the older adults?

Why technological products are not used for caring the older adults?

Wearable devices or, Leap beads 智慧佛珠?

Smart home, smart wheelchair, smart anything?
Persuasive technology: How technology is designed to change behaviors of the users

- A new behavior was created in 2007
- User Centered Design: Need ≠ Motivation

More fun than functions…

![Fogg Behavior Model](image-url)
If telehealth systems connect older adults with family members

The son is the trigger... Care, interaction, connection, in addition to health monitoring.
Supporting the caregivers --
Use smart technologies to provide real-time status and long-term patterns of the older adults
WhizPad is an extremely comfortable mattress capable of motion sensing. Pressure-relieve material for prevention of pressure ulcer.

- In Taiwan 2017, 22.5% hospital falls occurred when patients leave the beds.
- Three-stage leave bed alert (sit-up, sitting at the side, leave bed) for fall prevention.
- Four sensing areas / rule based.
- Private cloud IoT.
2nd generation: Machine Learning to capture the intention of leaving bed

• 1000+ learning samples from 31 testers in 7 weight groups
• 30 sensing areas, classification of Lying/sitting/left edge/right edge

• **Edge AI:** NeuralNet model deployed on chip
  - Testing accuracy: 96.0% (360 test examples)
• Individual patient management
  - 3-stage leave bed alert
  - Long pressure area alert

• Using 2 AAA batteries

• Amazon Web Service (AWS) for data storage and **Cloud AI:** Daily living pattern, sleep quality…
Daily living pattern obtained from WhizPad

64.58%

55.55%

59.72%

42.36%

46.52%

47.22%

43.05%
Accumulating the norm for in-bed activities

- 1 week
  - In-bed 51.09%

- 2 weeks
  - In-bed 45.88%
Use 70% as threshold to define “normal activities”

Normally, the older adult

1. Gets up no earlier than 05:50
2. Gets up no later than 07:30
3. Not in bed during the day
4. Goes to bed no earlier than 19:00
5. Goes to bed no later than 20:40

1. In-bed longer (64.58%)
2. Got up later than normal at 07:50
3. Back to bed multiple times during the day
4. Went to bed earlier at 17:30
5. Left bed multiple times during the night
Motion sensing *WhizCarpet*: Fall detection and mobility monitoring

- Mobility and pattern analysis, abnormal pattern alert
- Real time position display, fall detection and alert
- Easy and flexible set up; soft surface reduces risk of fracture when falling
- Mobility and pattern analysis, abnormal pattern alert
- Wandering behavior, path, hot spot analysis of demented patients

![Image of WhizCarpet setup]

![Image of WhaleNet}

![Graph showing fall detection and mobility monitoring]
Wandering patterns of dementia patients

- **Wandering pattern: the “Martino-Saltzman (MS) model”**

- **Fractal dimension is often used as an index for the complexity of a path.**

- **“Fractal dimension was significantly and negatively correlated with cognitive status as measured by the MMSE”**

<table>
<thead>
<tr>
<th></th>
<th>Dementia</th>
<th>No dementia</th>
<th>Stat. significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractal D</td>
<td>1.37 (.06)</td>
<td>1.25 (.07)</td>
<td>t=4.56, p&lt;.001</td>
</tr>
<tr>
<td>MMSE</td>
<td>13.8 (7.9)</td>
<td>23.2 (4.7)</td>
<td>t=3.64, p&lt;.001</td>
</tr>
<tr>
<td>Rate of travel</td>
<td>.33 m/s</td>
<td>.50 m/s</td>
<td>t=3.15, p&lt;.01</td>
</tr>
</tbody>
</table>
Walking paths and fractal dimensions obtained from WhizCarpet

- Fractal dimensions ranges from 1~2;
- Accumulate walking paths and corresponding fractal dimensions;

- Use fractal dimensions, path lengths, walking speed as features for machine learning to identify wandering behaviors.
Bluetooth IoT gateway WhizConnect: AIoT bedroom integrating Bluetooth products

- Environmental data
- Vital signs
- WhizSeries
- Real time status and event alerts
- Long term health and living pattern
**WhizTouch: IoT call button for bedridden older adults**

- Big button; mobile phone as receiver; green light to confirm the call
- But…

**IoT care products at home?**

- Internet usage is low for older adults (31.1% /8.6%@2018). High monthly fee for Internet service is not acceptable.
- Connecting the IoT product to home Wi-Fi AP has been a major usability issue; Wi-Fi coverage is often poor in bedroom
- LPWAN: Sigfox, LoRa?

**Narrow Band IoT: the last mile**

- Sim card connects directly to NB-IoT base station; used anywhere without setup
- NB-IoT based WhizConnect
IT structure for AIoT bedroom for elder care

**Cloud AI:**
- pattern recognition

**Edge AI:**
- event identification

3rd Party service cloud

Cloud

- AWS IoT
- AWS ML
- AWS DB
- AWS Lambda

**Vital signs**
- Blood oxygen
- BP/BG

Wearable

Body Temp.

Commercial Bluetooth healthcare products

Temperature/humidity

Environment

WhizConnect

- WhizPad
- WhizTouch
- WhizCarpet

Activities

Far Eastone

Restful API

MQTT API

MQTT

FCM (Android)

APNS (iOS)

NBLoT
Serious games for non-pharmacological intervention for preventing cognitive decline in older adults
Non-pharmacological intervention appears to be effective...

• … in reducing behavioral and psychological symptoms of dementia (BPSD).

• Physical activity (PA) programs for older adults could integrate challenging cognitive exercises to improve cognitive health.

• In an meta analysis of 41 studies, combined PA + CA (cognitive activity) intervention showed significantly larger gains in cognition relative to the control group. (Gheysen et. al, 2018)

<table>
<thead>
<tr>
<th></th>
<th>Cognitive</th>
<th>ADL</th>
<th>BPSD</th>
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<tbody>
<tr>
<td>Cognitive training</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cognitive rehabilitation</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cognitive stimulation therapy</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Snoezelen/multisensory</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Reality orientation</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Reminiscence therapy</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>Validation therapy</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>Physical activity</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Light therapy</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>Music therapy</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>Aromatherapy</td>
<td>−</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>Animal-assisted therapy</td>
<td>−</td>
<td>−</td>
<td>+</td>
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Takeda et al. (2012)
Designing serious games for people with dementia

• Serious games use technology to combine multimedia, entertainment, and experience (Laamarti et al., 2014), to design “games that do not have entertainment, enjoyment, or fun as their primary purpose” (Michael et al., 2006)

• Recommendations for serious games for people with dementia [Dietlein et al, 2018]:
  - Interventions should be supervised to support people with dementia to help them understand the instructions and the technology of the games
  - Serious games should be well adapted to the target population and their individual impairments, capacities, and interests
  - Interventions should be played in groups in order to guarantee enjoyment and commitment to the games and to foster social behavior and interaction
What are the values brought by technologies?

(1) Combining physical exercise, cognitive training, and multi-sensory stimulation
(2) Caregivers can choose and design games suitable for older adults

Chasing game

Mahjong matching
(3) Generate and record data that are helpful to elderly care

- Timed up and go (TUG)
  3 meters

- Time (sec), step length (cm), cadence (steps/min), difference in left and right steps (%)

### Age vs. Seconds

<table>
<thead>
<tr>
<th>Age</th>
<th>Seconds</th>
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<tbody>
<tr>
<td>60-69</td>
<td>7.9 +/- 0.9</td>
</tr>
<tr>
<td>70-79</td>
<td>7.7 +/- 2.3</td>
</tr>
<tr>
<td>80-89</td>
<td>No accessories: 11.0 +/- 2.2</td>
</tr>
<tr>
<td></td>
<td>With accessories: 19.9 +/- 6.4</td>
</tr>
<tr>
<td>90-101</td>
<td>No accessories: 14.7 +/- 7.9</td>
</tr>
<tr>
<td></td>
<td>With accessories: 19.9 +/- 2.5</td>
</tr>
</tbody>
</table>

(Lusardi et. al, 2003)
Validation of TUG data from WhizToys

- WhizToys resolution in length is 12.5cm
- 15 participants, 3 tests/person

<table>
<thead>
<tr>
<th>Analysis items (Units)</th>
<th>WhizToys average</th>
<th>Video average</th>
<th>Max. difference</th>
<th>Avg. diff. (SD)</th>
<th>percentage error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average time (sec)</td>
<td>10.3</td>
<td>10.1</td>
<td>0.5</td>
<td>0.29 (0.14)</td>
<td>2.82%</td>
</tr>
<tr>
<td>Average step length (cm)</td>
<td>52.8</td>
<td>50.5</td>
<td>8.9</td>
<td>2.66 (1.70)</td>
<td>5.04%</td>
</tr>
<tr>
<td>Left Step length (%)</td>
<td>49.0</td>
<td>49.2</td>
<td>8.0</td>
<td>2.22 (1.98)</td>
<td>4.53%</td>
</tr>
<tr>
<td>Right Step length (%)</td>
<td>51.0</td>
<td>50.8</td>
<td>8.0</td>
<td>2.22 (1.98)</td>
<td>4.35%</td>
</tr>
<tr>
<td>Spm (step/min)</td>
<td>111.8</td>
<td>111.5</td>
<td>13.6</td>
<td>3.30 (3.16)</td>
<td>2.95%</td>
</tr>
<tr>
<td>Steps</td>
<td>11.1</td>
<td>11.4</td>
<td>1.0</td>
<td>0.40 (0.50)</td>
<td>3.60%</td>
</tr>
</tbody>
</table>
Finding the normal distribution to compare performance of the game

- 30-second chasing game (Whack-a-Roach)
- Collect scores from 73 participants
  - 54-69 years old: N=39
  - 70~92 years old: N=34
- Normal distribution for 70-92 years old
- For whacking 11 roaches: 65%
Similar technological products: MOTO Tiles, Stampede, TREAX pads…

What is the trigger for older adults?
“Pillow Fight”, 3rd Place in Stanford Center on Longevity Design Challenge

- Intergeneration game: Changed video game controllers to familiar household items - pillows, enabling older adults and children to play together by punching the pillow.

GRC Deputy Director Prof. CK Lim and students presenting “Pillow Fight” at Stanford, April 2019
We are designers!
UX: User Experience Design

The future world needs transdisciplinary talent

Find that Trigger — Caregivers are the best designers!

Thank you
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