

2018

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Recommended Citation

Sagara, J. et al. (2018) Some Design Proposals to Support Independent Life of the Elderlies with Mild Cognitive Impairments who Live Alone. Universal Design & Higher Education in Transformation Congress, 30th October - 2nd November 2018, Dublin Castle

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Some design proposals to support independent life of
the elderly with Mild Cognitive Impairments who live alone.

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This research was supported by grants-in-aid scientific research by Ministry of Education, Culture, Sports, Science and Technology, Japan as 25282008, 22615047 and 16H03024 awarded to Jiro Sagara.

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Abstract

In Japan, the elderly persons will exceed 30% of population and the dementia will be more than 7 million in 2025. This means the one of five elderly persons will be dementia. Most of them will live in own house with his/her suppose or aged children, or alone. The dementia is progressive disease, so patients lose their abilities gradually in approximately ten years.

Mostly there are two types of countermeasure action for the dementia; one is care and the other is prevention such as brain training or cognition plus exercise. Even though they will do many things by themselves independently in the early stage of dementia or in the state of Mild Cognitive Impairment (MCI), they forced to quit daily activities such as cooking or outing by his/her relatives for reason of safety. This inhibition affects as the disuse syndrome, then he/she will lose own abilities faster.

As the main symptoms of the dementia is memory loss, the authors focused on prompting behavior by using IoT technology. The sensors in the house are watching the environment and send data to control center in the house. The control center tells the situation by the synthesized voice such as “the stove still burning”, or “the door of freezing chamber is open”, then store the data with time stamp. The resident with memory loss may think about the meaning then make decision and finally do or not do something. The results are stored in the server, so the relatives can monitor the situation of the resident from anywhere.

Keywords. Dementia, MCI, Autocue, Independent life, IoT

Background and Aim

Japan is well-known as highest aged country in the world. The population ratio of 65+ is 28.1% in 2018, and expected that it will exceed 30% in 2025, in which the baby boomers will be 75+. The average life span of Japan is 80.75 years in male and 86.99 years in female in 2015, and expected 84.95 years in male and 91.35 in female in 2065 (Cabinet Office, Government of Japan, 2018). The late-stage elderly tends to risk of fractures, disease, depression, or dementia than the early-stage elderly. To be the dementia is one of the great fear in aging for large majority, not only for elderlies but also the family member of elderlies. The Ministry of Health, Labor and Welfare (MHLW) announced that there are 4.62 million dementias in 2012 and expected 7 million in 2025, in Japan (Toshiharu Ninomiya, 2015). This means around 20 % of elderlies will be dementia in 2025.

The dementia is progressive disease, start with memory loss, then confusion, dysfunctional behavior, loss of judgement or other core symptoms follows, consequently depression, wondering, insecure, dirty action, or sleep disorder called as Behavioral and Psychological Symptoms of Dementia (BPSD) may happen which trouble heavily his/her family or neighborhood. In the case of Alzheimer disease which is most popular type of dementia, brain nerve cells of the patient are destroyed by the amyloid beta, then the episode memory totally disappear in short term. This symptom pulls the trigger of mistake in daily life of the person with early stage of dementia or the MCI. For example, when cooking on the stove, some interrupt such as phone call or delivery occurred, his/her interest switched to the interrupt, consequently the pot on the stove burned out. After such mistake, his/her family inhibit cooking for reason of safety, however his/her abilities rapidly lost by disuse syndrome (Lena Rosenberg, 2009, Brian O'neill, 2015).

As the countermeasure against the dementia, most of them are for prevention and the others are how to take care of them (Toshiharu Ninomiya, 2015). Definitely some assistive devices or dementia friendly devices are already put in the market, such as the medication reminders and dispensers, the item locator, the large calendar clock, the time-timer, and so on, which are introduced at the web site of the Alzheimer's Society or web site of the "at dementia". However, these devices are not enough to support persons with early stage of dementia in their daily life. Some of them require some operation or support to use.

Persons with dementia want to do daily activities independently. They can do a lot of things

with prompt advice or guidance, so the authors started to develop assistive system which provide cue in daily life. When the sensors and calendar clock will detect necessity of some kind of behavior, the system tell him/her the situation of surroundings such as too cold or time to take medicine to recommend to do proper activity for the situation by the synthesized voice.

Problems found in interview

The authors interviewed 91 subjects who were solitary or solitary in day time (Kazue Noda, 2010), as mentioned in UD2014, Lund by Jiro Sagara (2014). Through this survey, the authors listed up problems responded by each subjects in four categories;

- a) problems which may be covered by autocue
- b) autocue may be effective but not so urgent
- c) important problems but not solved by autocue
- d) Unnecessary or unrelated

According to these results (Sagara, 2014, 2015) and other interviews to such as the dementias' family association in Osaka and the council of social welfare in Kobe, authors modeled up following auto cue scenes.

- 1) At the entrance, confirm appropriately dressed in outing
- 2) At the entrance, tell outdoor climate
- 3) At the entrance, detain according to time zone
- 4) In the kitchen, tell which door was opened, and forgot to close
- 5) In the kitchen, fire on the stove
- 6) In the living room, tell out of range of temperature and humid to evoke proper control of air-conditioner
- 7) In the living room, evoke tooth brushing after meals
- 8) In the toilet, tell forgot flushing.
- 9) In the bedroom, evoke toileting before sleep
- 10) In the bed, advice try to be asleep according to time

Adding these, the persons with dementia tend to lose important items such as wallet, bank book or keys as a result of memory loss. Sometimes he/she doubt relatives take away or hide them, then blames



Figure 1: A set of the MESH Tags

someone. This trouble is popular and serious problem for the family as closest person may be suspected. This is one of typical BPSD.

- 11) In the living room or in the hall, evoke to put wallet or porch in the definite area for example in the definite basket.

Design concept

The authors discussed what are required as the autocue system for the early stage of dementia or MCI. The aim of this system is to support decision making for the dementia by showing the situation of surroundings. Then, it prompt proper behavior which is forgotten by memory loss. So it should not urge or order target to do something, just tell the situation. Nobody prefer be ordered by someone especially by machine.

The system should not do anything instead of the target, so that the target does something by own decision and own way. The automation may take away the ability to do and to make decision. In case of secure, such as fire or accident, automated reaction should be taken, however the system must explain why and what has been taken instead of the target.

The system should run without any control by the target without any maintenance or supply.

Trial by using the MESH Tags

The authors adopted the MESH Tags by Sony Co. Ltd. to verify the operation of auto cue simply. This is consisted from four types of sensors, one LED light, one pushbutton switch and one General Purpose Input and Output (GPIO) devices connected by Bluetooth technology. The figure 1

shows 7 tags set of the MESH.

The free Web based Software Development Kit (SDK) is also provided by Sony, so the MESH Tags are simply combined as IoT devices with connecting each other. The voice output is available by recorded sound file via Bluetooth speaker, and the timestamp and calendar data are also available by iPad or iPhone.

The authors built up some autocue algorithm listed above, then confirmed the function of autocue. These autocue function were temporarily installed in the model house built at the Hyogo Rehabilitation Center, then the visitors who are concerned in care were explained and demonstrated the reactions of selected autocue function, which can be

demonstrated in short period that tells advice to proper dress according to time and schedule at the entrance. At the first, 3 axis accelerometer detect the opening of the door at living room, after that, infra-red motion sensor detects the approaching person, then some recorded message come out. After the

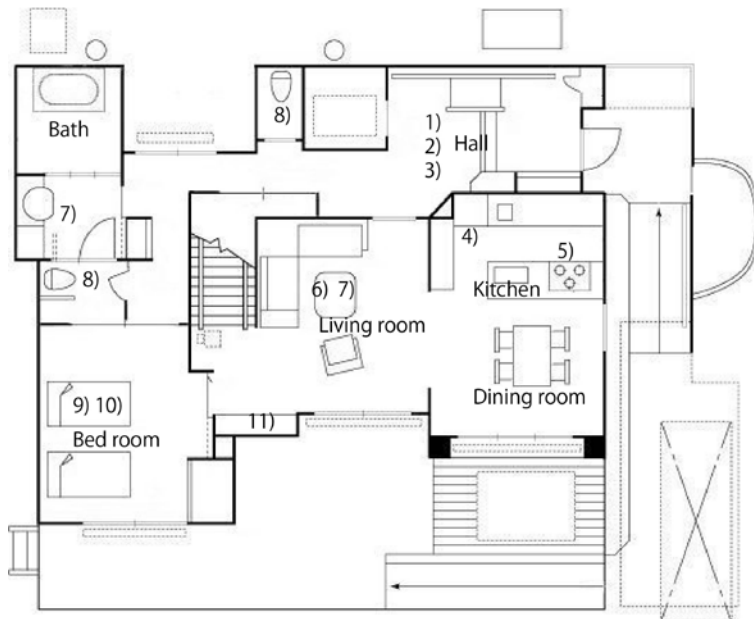


Figure 2: The layout of each autocue



Figure 3: Temporary settled the MESH Tag in the circle

explanation and some experience, the visitors answered questionnaire sheet. The figure 2 shows floor

plan of the model house and settled places of each autocue. The figure 3 shows temporally settled autocue

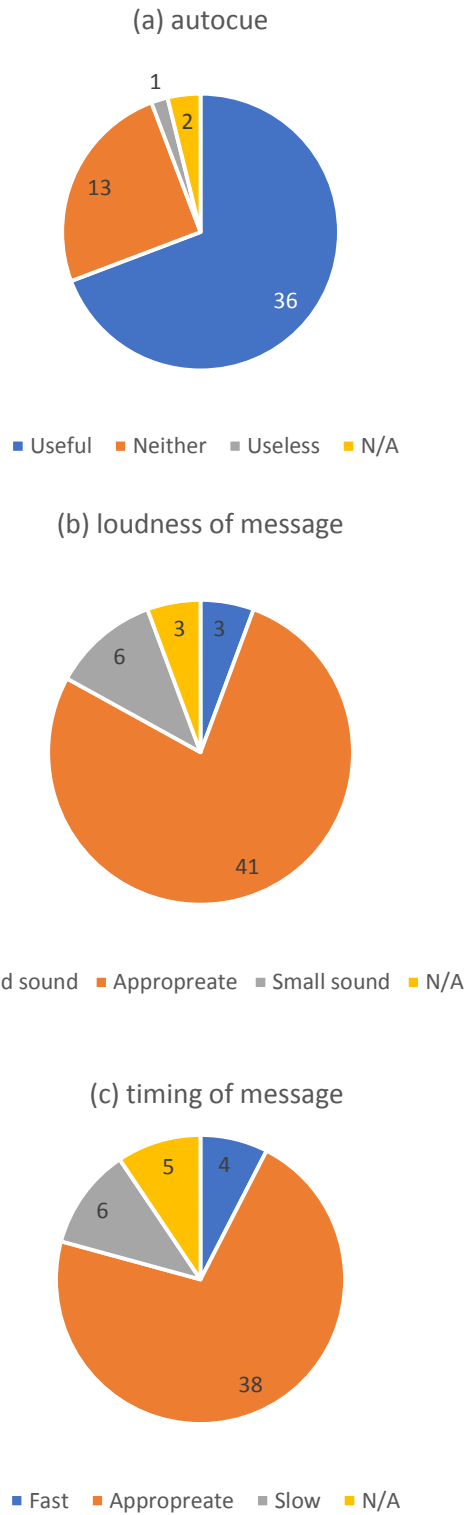


Figure 4. Evaluation for the demonstration of autocue

at the entrance.

Results

The 10 types of autocue are verified operation by the MESH Tags, however the fire of the stove and still human sitting on the sofa or laying in the bed also cannot be detected by the MESH Tag. Fifty-three answers are gathered after the explanation and demonstration at the entrance. The details of the responders showed in table 1 and 2.

Table 1: Responders age groups

| Ages | 25 – 44 | 45 – 64 | 65 - 84 |
|---------|---------|---------|---------|
| Numbers | 20 | 20 | 13 |

Table 2: Responders' relationship to dementia

| Relationship | In the job | As a family | Job or Family |
|--------------|------------|-------------|---------------|
| Yes | 42 | 22 | 48(90.6%) |
| No | 10 | 29 | 5(9.4%) |
| N/A | 1 | 1 | 0(0.0%) |

Table 3. Scenarios described in free answer

| Scenario | Numbers |
|-------------------------------------|---------|
| Take medicine | 7 |
| Take water | 5 |
| Locking front door | 5 |
| Air conditioning / room temperature | 5 |
| Take meals | 2 |
| Counterplan for suspicious person | 2 |
| Others | 6 |

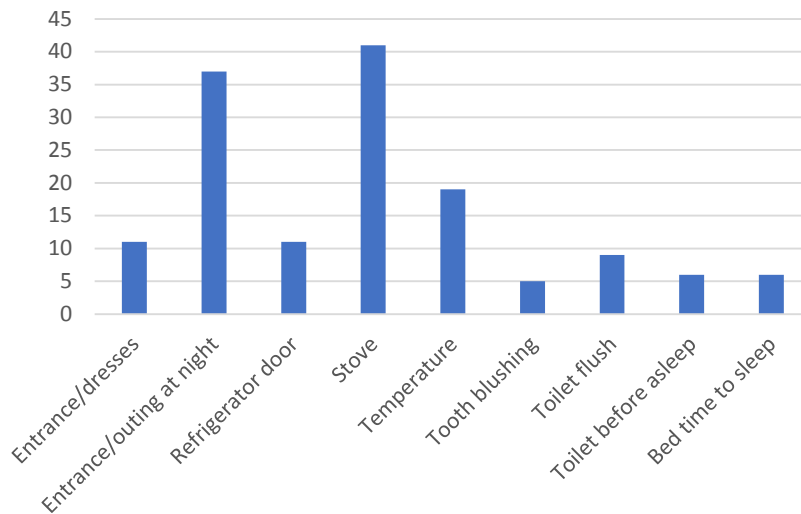


Figure 5. Useful autocue scenarios. In Entrance/dresses include outside temperature

Around 70% of responders answered this autocue as useful, but one answered useless because the severe dementia feels uncomfortable in sound. The volume and the timing of the message were answered as proper. These results are shown in Figure 4.

The responders choose best three scenarios from 9, and freely answered as shown in Table 3 and Figure 5.

Discussion and Proposals

The responders most of them have relationship to the dementia considered this kind of autocue as useful for secure or safety in daily life. The authors aim to apply autocue for MCI or early stage of dementia, so the negative answer of one responder is excludable. As taking medicine, there are several reminding devices already on the market, so the linkage to total autocue system has to be considered.

In case of number 11th autocue function, we adopt other devices instead of the MESH Tags, as the required function beyond the MESH Tags. In this function, the distance between porch and the basket should be recognized. So, we adopt the TWE-Lite 2525A wireless device produced by the MONOWIRELESS Co. Ltd. In Japan, that one pair of the devices communicate each other and can calculate the rough distance between each by the radio power. One 2525A tag transmit signal every 3 second, the other caught the signal then transferred to the ESP-8266 micro control unit with Wi-Fi function which can programmed on the Arduino SDK which is most popular environment to develop

these kinds of devices. The ESP-8266 checks the distance between two 2525A, then according to the distance, it announces the designated messages through the ATP3012 micro synthesized voice processor produced by the Aques Talk Co. Ltd. In Japan. The distance calculated by the radio power depends on the direction of two antennas, so additional sensor is equipped to detect correct position of the porch in the basket. Besides the 2525A runs with a CR2032 lithium battery for more than one year when it transmits signal 3 seconds interval, it tells the voltage of the battery also, so the ESP-8266 can make announce the low battery to the user. If it placed in Wi-Fi environment, the ESP-8266 put the data of behavior with timestamp to some kind of the cloud data storage server service web site, such as the Google cloud or the WASABI, IFTTT, and so on. The figure 6 shows the diagram of this device, and figure 7 shows prototype.

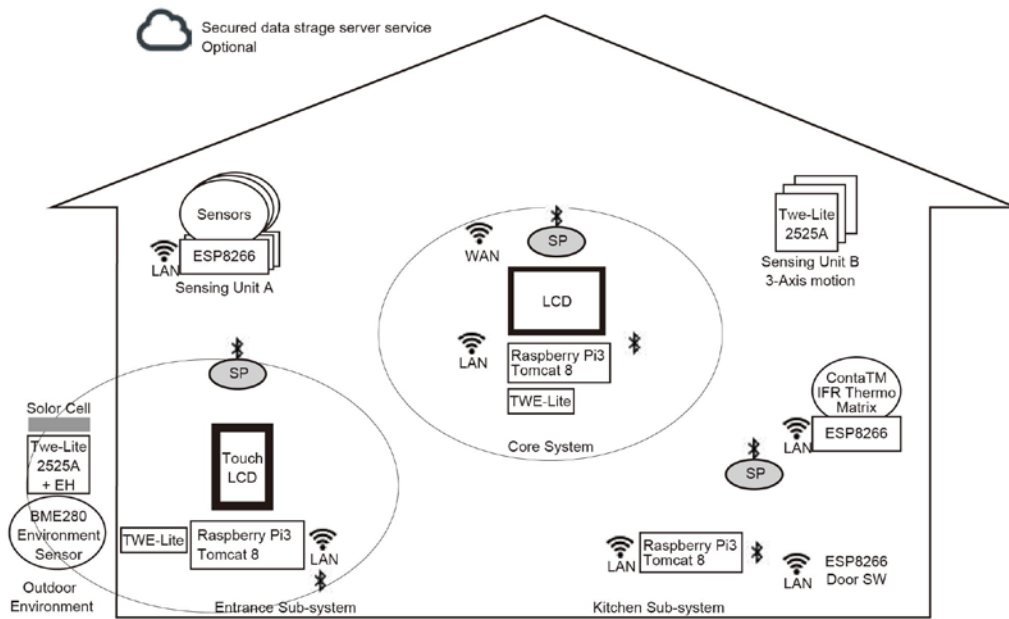


Figure 8. Total system of whole house autocues
Basket



Figure 7. The prototype of the Porch and the Basket

The MESH Tags work short term by reason of the included battery and the tablet also not suit for continuous and specified purpose. Additionally, the fire on the stove cannot be detected by the MESH Tags as mentioned before. The authors designed special purpose machines for autocue system. The system consists with core system and some sub system. The core system gather data from sub system and integrate all. The kitchen sub system detect fire on the stove and some doors of appliances such as refrigerator or microwave oven and human body. When someone in the kitchen, it talks locally but no one there, it sends data to core. We adopted the Raspberry Pi 3 as core control unit and the ESP-8266, the 2525A and the TWE-Lite depend on phenomena to detect. In the kitchen sub system, the Conta™ thermos graph with the infra-red array sensor AMG8833 by the Panasonic Co. Ltd. It detects thermos

range of 0 to 80 degrees Celsius in 60 degrees' cone as 8 x 8 matrix, so this can detect both the human body and the fire on the stove.

The TWE-Lite can run by very low energy such as solar cell and capacitor, so the indoor and outdoor climate can be gathered without batteries. Although the ESP-8266 requires more power to run, two AA or AAA batteries are enough to run more than year.

The figure 8 shows total system of autocue.

Conclusions

Through the trial and demonstration of autocue subsystem, the authors found usability in automated prompt message for the elderly in early stage of dementia or woh is MCI to support independent behavior or reduce failure in daily life. The authors have plan to setup in the real residence which lived by elderly dementia husband and his spouse as verification test.

When connecting to the internet via Wi-Fi, the secure connection, such as anti-hacker should be taken. We adopt API-key and API-encrypt-key to Java Servlet Program.

Acknowledgement

This research is supported by grants-in-aid scientific research by Ministry of Education, Culture, Sports, Science and Technology, Japan as 25282008, 22615047 and 16H03024.

Professor Louise Nygård in Karolinska Institute, and their post-Doctoral students exchange useful information in discussing cross-cultural survey.

Kobe Design University, Kobe University and the Hyogo Institute of Assistive Technology Research Institute gave us research resources and time for execution of this research.

All subjects of our interview gave us a lot of valuable information or suggestions.

The authors would also express gratitude to all of them.

Annotation

The series of our research have been passed the ethical examination by Kobe University and the latest one by the Hyogo Assistive Technology Research Institute.

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