

Rochester Institute of Technology

**RIT Digital Institutional Repository**

---

Theses

---

5-11-2021

## **Personal Cognitive Assistive Robot for Alzheimer's Disease Patients' Practicing of COVID-19 Hygiene Measures**

Jeehoon Yu  
jy8457@rit.edu

Follow this and additional works at: <https://repository.rit.edu/theses>

---

### **Recommended Citation**

Yu, Jeehoon, "Personal Cognitive Assistive Robot for Alzheimer's Disease Patients' Practicing of COVID-19 Hygiene Measures" (2021). Thesis. Rochester Institute of Technology. Accessed from

This Thesis is brought to you for free and open access by the RIT Libraries. For more information, please contact [repository@rit.edu](mailto:repository@rit.edu).

**Personal Cognitive Assistive Robot for Alzheimer's Disease  
Patients' Practicing of COVID-19 Hygiene Measures**

**by**

**Jeehoon Yu**

**Department of Industrial Design**

**College of Art and Design**

**Rochester Institute of Technology**

**Rochester, NY**

**May 11, 2021**

Thesis Documentation for Master of Fine Arts Degree in Industrial Design

College of Art and Design

Rochester Institute of Technology

Title: Personal Cognitive Assistive Robot for Alzheimer's Disease Patients'

Practicing of COVID-19 Hygiene Measures

Submitted by: Jeehoon Yu

Date: 11/5, 2021

Thesis-Committee-Approval

Alex Lobos

Professor

Signature:

Date:

Lorraine Justice

Professor

Signature:

Date:

## **Abstract**

During the COVID-19 pandemic, some home-based family caregivers of Alzheimer's disease (AD) patients became full-time caregivers with little or no help from medical facilities and services due to the risk of viral infection. The challenge that the new full-time family caregivers experience is not only caring for their loved one's daily routines, they also have to protect them from the infection since the weakened health condition and the dementia-related behaviors make AD patients vulnerable to the infection (Alzheimer's Association, n.d.).

To help the new full-time family caregivers to reduce their burden of preventing their loved ones from the infection, this thesis project focused on the design of a cognitive assistive device that integrates monitoring and reminding solutions for the AD patients' practicing of COVID-19 hygiene measures including hand washing, mask wearing, and social distancing. The final output is a personal cognitive robot functioning with a combination of computer vision and machine learning technology.

Firstly, this paper introduces a concept of a cognitive assistive robot that has been developed within the area of eldercare robots. Next, this paper explains the impact of COVID-19 on caregivers and the importance and challenging factors in managing AD patients' practicing of hygiene measures. Based on the verified user needs, there is a brief overview of existing solutions. After the research part, this paper illustrates three stages of the concept development from the initial to the final stage. As a conclusion, this paper suggests the potential impact of the design and next step of research based on the final concept and user scenario.

***Keywords: Cognitive assistive robot, Alzheimer's disease, COVID-19, hygiene measures***

## **1. Introduction**

This paper addresses the project which had developed a cognitive assistive robot design that helps the caregivers prevent their Alzheimer's disease(AD) patients' COVID-19 infection by monitoring and reminding three hygiene measures including hand washing, mask wearing, and social distancing as a supplementary caregiver.

Globally, the robots designed for caregiving have been developed to reduce the burden on human caregivers as the senior population grows rapidly. For example, Japan, the country which has the oldest population has made up most of the global market for nursing care and disabled aid robots in 2016. (Foster 2018). Japan has shown the development in the elderly care robot industry to deal with the aging population and shortage of professionals in the eldercare sector (Foster 2018).

Among the various types of caregiving robots, one type defined as a cognitive assistive robot has been developed to help the patients to perform their daily activities (Koutentakis, Pillozzi, and Huang 2020). Some are used in the similar concept of reminder devices that help the patients remember their daily routines based on programmed schedules. More advanced robots can detect certain operational conditions with advanced sensors and decide when and what they will prompt.

The project had focused on the future role of cognitive assistive robots as care units that can be used for managing patients' hygiene personal during pandemic. Throughout the research, various insights came from the area of cognitive assistive robots and related technologies. Based on the insights, design concepts were considered and combined into a form of a personal

cognitive assistive robot which can be a future solution for AD patients' COVID-19 hygiene measure issue.

## **2. Background**

### **2-1. Intensified Level of Caregiving during Pandemic**

COVID-19 has been taking a heavy toll on the Alzheimer's disease community. According to the Centers for Medicare & Medicaid Services(CMS), almost 32,000 patients have died from the virus in care facilities because of the infection (Centers for Medicare & Medicaid Services 2020). Currently, the disease is not considered as a direct risk factor of covid infection but the disease-related behaviors and the weakened physical health condition of patients are suggested as factors that increase the risk of infection (Alzheimer's Association, n.d.). For example, the impaired memory of patients makes it difficult to keep up with personal hygiene. Also, since the patients are mostly aged, some of them may have deteriorated immune strength or respiratory systems. Therefore, they could get easily infected and die from the rapid development of the virus.

Due to the susceptibility to the virus, caregivers have faced changes. Nursing homes and hospitals restricted the visitations or re-established their core principles to prevent the spreading of the virus in their facilities. In the same context, daycare centers closed and the workers of visiting services were unemployed due to the risk of interpersonal infection. This situation defined as "isolation" or "lockdown" intensifies the level of caregiving. Caregivers in nursing homes and home-based family caregivers get exhausted both physically and emotionally due to

the extensive tasks they have to deal with within the limited workforce and isolated care environment. In the case of family caregivers who have their loved ones in the facility, they experience anxiety due to the problem in assessing the health status of their loved ones.

## **2-2. Alzheimer's Disease**

Alzheimer's disease (AD) is the most common type of dementia which accounts for up to 80% of dementia cases (Alzheimer's Association, n.d.). As a progressive brain disorder, AD entails memory loss, cognitive impairment, and negative emotional change (Alzheimer's Association, n.d.). The age-related changes in the brain have been considered as the most risk factor of AD (Alzheimer's Association, n.d.).

There are three stages to Alzheimer's: Mild, Moderate, and Severe. Along with the progression, the disease gradually exacerbates patients' brain and body functions. Therefore, patients in the later stage require extensive care in their routine (Alzheimer's Association, n.d.). Since global aging progresses rapidly, dementia including AD has become one of the major global health issues. The worldwide number of dementia patients in 2016 was about 44million (Lancet Neurol and GBD 2016 Dementia Collaborators, 2018). Moreover, the estimated number of global dementia patients in 2050 is over 135million (Ricci 2019, 1).

## **2-3. Family caregivers of Alzheimer's disease patients**

The term “family caregiver” indicates the person who gives care for a family member who has mental or physical disease (Lett 2021). Centers for Disease Control and Prevention(CDC) reported that eighty percent of patients receive home-based care and more than 16 million US citizens give more than seventeen billion hours of unpaid care for family members or friends who have Alzheimer's disease or related dementias (Centers for Disease Control and Prevention 2019). According to the CDC, caregivers of Alzheimer's disease and related dementias provide a longer duration of care than caregivers who provide care for other conditions of patients (Centers for Disease Control and Prevention 2019). Also, the report states that due to the demands of caregiving causing insufficient self-care, Alzheimer's disease patients and related dementia caregivers are exposed to poor quality of living (Centers for Disease Control and Prevention 2019).

## **3. Target User**

### **3-1. Alzheimer's patients in the Early to Moderate stage.**

In the cases of the mild to moderate stage patients who are not hospitalized yet are likely to stay at their home during the pandemic. The patients included in one of these cases may receive care from non-professional family caregivers in the relatively less controlled environment than nursing homes and hospitals. It means there might be a lack of professional support and strict rules for infection control. Therefore, the patients in the mild to moderate stages have been considered as the main target stage of disease for this project.



- 1) Patients who have been received care from the visiting caregivers and their family members in their home;
- 2) Patients who have been received care by professional caregivers and their family caregivers in the nursing home;
- 3) Patients who have been received care from the daytime nursing staff and their family members in the nursing home and their home.

### **3-2. Isolated Family Caregivers during Pandemic**

In this project, the design aims to cover the family caregivers who have to provide home-based full-time care with little or no support from professional care service. Within the isolated care environment, they have to not only give care but also prevent their loved one from infection. Furthermore, they need to manage their own health to sustain their home-based care environment. Therefore, the family caregivers isolated during a pandemic have been considered as the most urgent user group in this project.

### **3-3. User Need**

Among the tasks of the family caregivers during the time of pandemic, the most important task is to protect their loved ones from COVID-19 infection. This project focused on three hygiene measures including hand washing, mask wearing, and social distancing. These three measures have been recommended by international health agencies such as WHO and CDC.

### **3-4. Challenge (Frustrations)**

Managing Alzheimer's disease or related dementia patients' hygiene is known to be not easy.

There are two main obstacles related to the symptoms of the disease. Due to those obstacles, caregivers should monitor, remind, convince, and demonstrate hygiene measures. Furthermore, they even need to argue when their loved one's resist complying. This situation may get the family caregivers exhausted mentally and physically.

#### 1) Memory impairment:

Since Alzheimer's disease causes progressive memory impairment. The patients in the moderate-severe stage may not remember why they need to practice hygiene measures.

Moreover, even if they remember the concept of a certain hygiene measure, they may not complete practicing without the assistance of their caregivers.

#### 2) Personality changes:

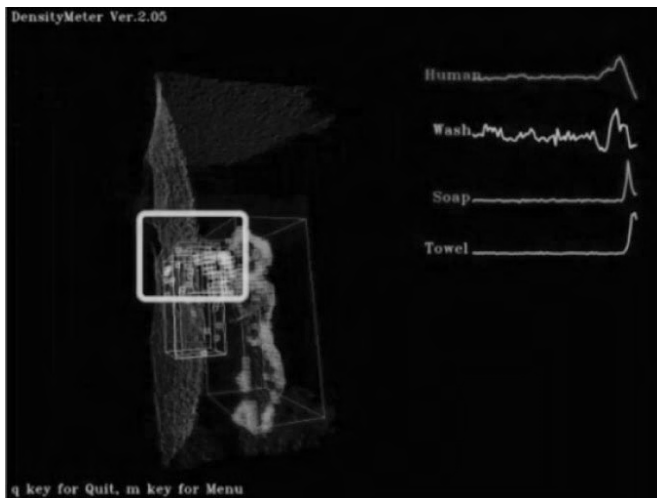
Alzheimer's disease not only causes memory loss but also changes in their personality.

Therefore, they may refuse to bathe, changing a cloth, or brushing teeth. According to a journal published by AgingCare, some emotional factors such as depression, boredom, a sense of being controlled over their own life can cause the patients' refusal (Bursack 2020). It means even if the patients remember the reasons and steps of certain hygiene measures, there might be a challenge in practicing.

## 4. Existing Solutions

### 4-1. Computer Vision with Machine Learning

Recently, a combination of computer vision(CV) and machine learning(ML) has been considered as a trending solution for the COVID-19 hygiene issue. Also, the combination of two technologies have been applied to some advanced cognitive assistive robots before the outbreak. Following cases are showing how the CV and ML are used for managing three different types of COVID-19 hygiene measures.



**Fig 4.1:** Hand Wash Monitoring for Kids developed by Hitachi-LG Data Storage



**Fig 4.2:** Actlyzer developed by Fujitsu Laboratories Ltd.

During the outbreak, Hitachi-LG introduced a handwashing monitoring solution based on 3D lidar sensing as a response on COVID-19 (Hitachi-LG Data Storage LiDAR, TOF May 22, 2020) (Figure 4.1). Fujitsu launched a new business with their single lens AI camera hand washing monitoring system that was originally developed as a surveillance system before pandemic (FujitsuJpPR 2020) (Figure 4.2).



**Fig 4.3:** Face-mask detection developed by Tryolabs



**Fig 4.4:** Robot Pepper developed by SoftBank

When it comes to wearing a face mask, CV using ML has demonstrated its capability based on face detection and recognition technologies. Recently, SoftBank updated a face mask monitoring feature of a cognitive assistive robot Pepper (SoftBank Robotics Europe 2020) (Figure 4.3). The company developed an AI algorithm for the new feature based on CV development platform and the robot's depth camera module. Tyrolabs applied ML to traditional CCTV based face recognition models for analyzing the public's compliance of mask wearing (Tryolabs 2020) (Figure 4.4).



**Fig 4.5:** Robot Spot developed by Boston Dynamics



**Fig.4.6:** Social Distancing solution developed by Aura Vision

Tracking social distancing in workplaces and public spaces also has been dealt with the application of CV and ML. Robot spot has performed as a social distancing monitor by analyzing the number of people in a place with its camera module and machine learning system. Singapore introduced it for monitoring and reminding social distancing between park visitors (Tay and The Straits Times 2020) (*Figure 4.5*). London based company Aura vision developed a public space human traffic solution for the COVID-19 safety in public spaces such as airports and stations (Aura Vision, n.d.) (*Figure 4.6*). The system that detects crowded spots in certain places can be operated with existing security cameras.

## **5. Research Summary**

Throughout the research, helping Alzheimer's disease patients practice hygiene measures for COVID-19 prevention was verified as a newly added but the most important task in caregiving during the pandemic. Also, it became apparent that the symptoms of AD and the isolated care environment caused by the outbreak make the caregivers difficult to manage the task.

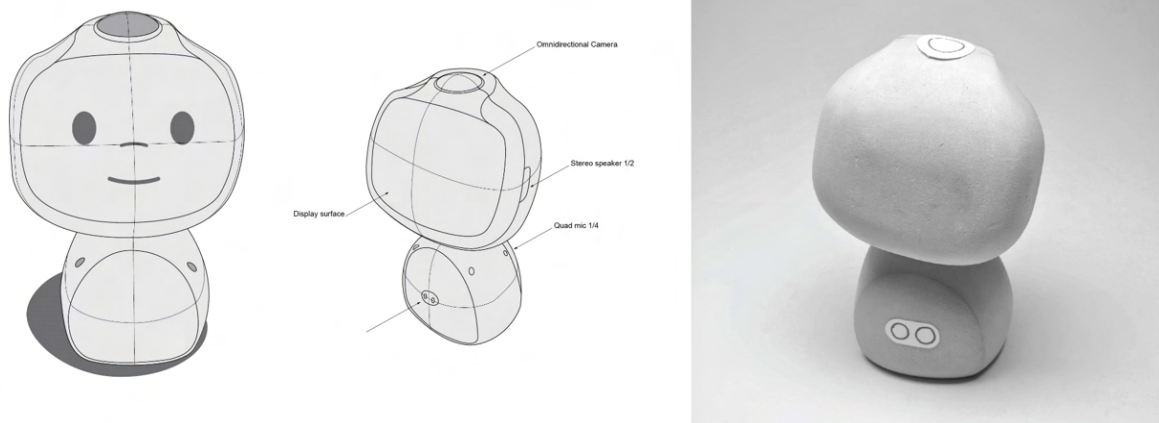
There were insightful existing solutions that could be benchmarked for a cognitive assistive design to deal with the patients' practicing of hygiene measures. However, since the set of COVID-19 hygiene measures includes three different hygiene activities, it was difficult to find a design case that integrates a set of solutions into one product or system. Also, since the solutions are mostly developed for the public use, there was a need for a personal use solution that can be utilized through the daily lives of the isolated caregivers and patients.

## 5. Design Statement

“Design a personal cognitive assistive device for Alzheimer’ patients that can reduce caregivers’ burden with the integrated monitoring and reminding systems for COVID-19 hygiene measures”.

## 6. Concept Development

### 6-1. Initial Concept

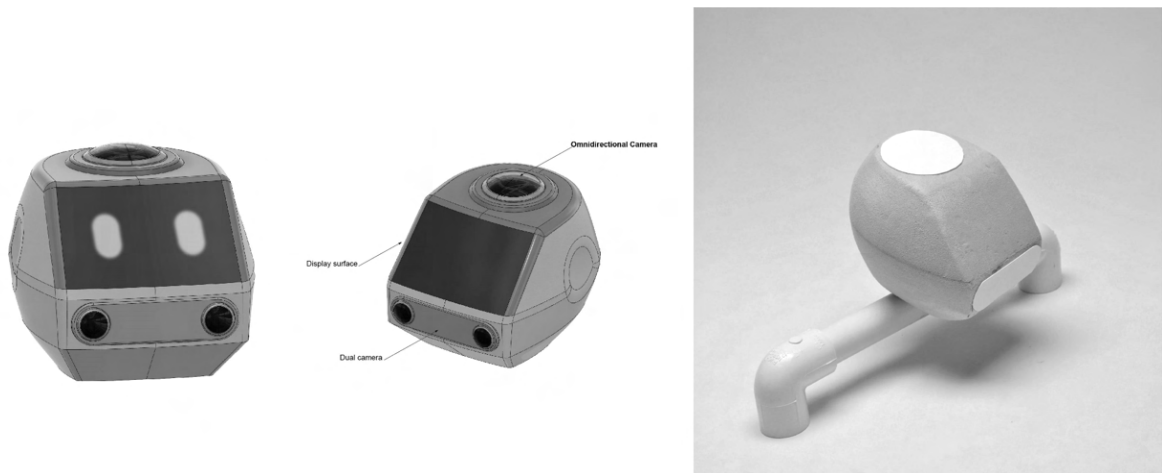


**Fig 6.1:** Initial concept

Initial concept is a portable & table top companion robot type (*Figure 6.1*). This portable design suggested both indoor and outdoor uses with a portable cradle. The form and size that remind of abstracted and animated humanoid robots were designed based on typical appearances of companion robots. it monitors the user’s compliance of social distancing and mask wearing with its omnidirectional camera based on 2D face detection. For handwashing it monitors critical handwashing procedures with its depth camera based on 3D object and motion detection. When

the user forgets practicing hygiene measures, it reminds the user with its visual and audio prompts. One of major concerns was the portability of the robot. Since, the design of robot was plush doll size, advisors and some peers in the program said that the robot doesn't seem to be carried even by the caregivers.

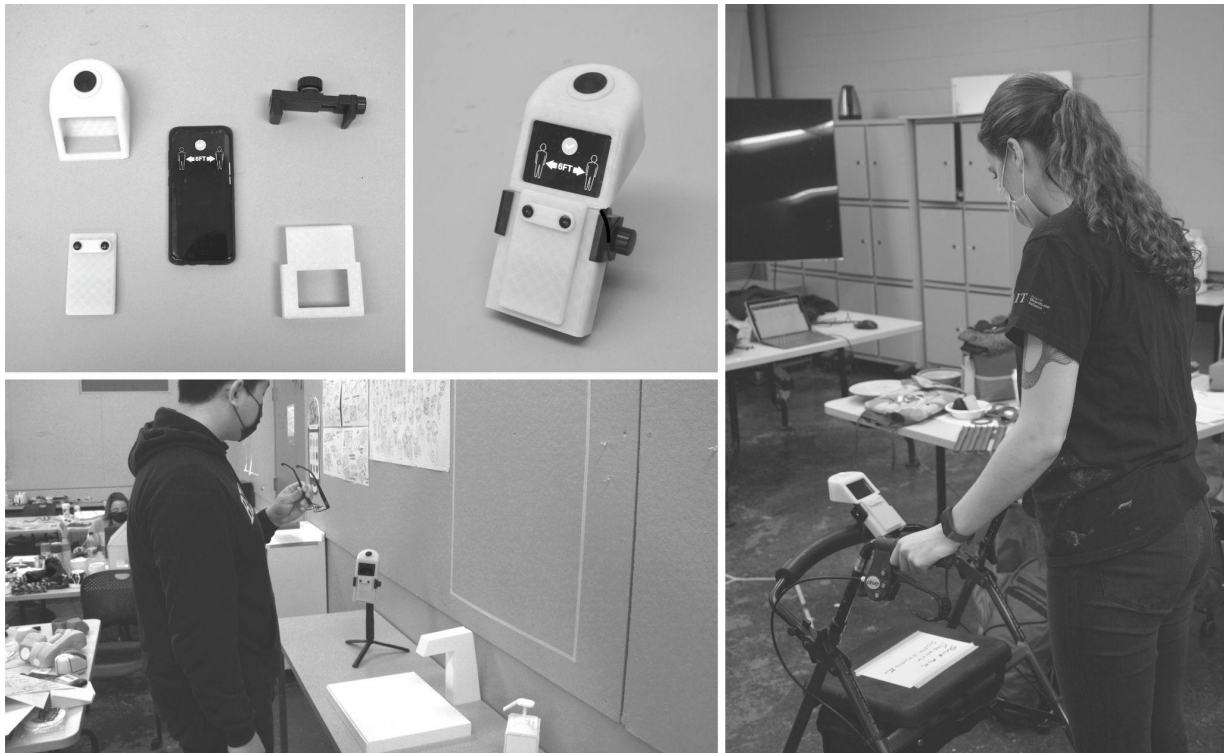
## 6-2. Mid-level Concept



**Fig 6.2:** Mid-level concept

Mid-level concept is a portable rail bar-mounted robot type (*Figure 6.2*). This portable robot suggested both indoor and outdoor uses with its action-camera size of body and rail- bar mounting system. Based on the monitoring and reminding system and hardware of the initial concept (*Figure 6.1*), the scale of the product was significantly reduced for the portability.

## 7. Concept Evaluation



**Fig 7.1:** Concept evaluation

Mid-level concept was evaluated by nine adults around age twenty to thirty who are expected to give care for the aged in future (*Figure 7.1*). They were selected as a respondent group to evaluate the concept from the perspective of caregivers. Among them, three people have experience in giving care for their grandparents with dementia. To simulate the visual and audio prompts a smartphone housed with 3d printed exterior was used. By using the mockup, the respondents could test the visual and audio prompts and examine user scenarios.

Mostly, respondents expected that managing patients' hygiene measures will be less exhausting with the robot. Some respondents commented that the robot will be helpful especially in certain situations when caregivers cannot keep their eyes on their loved ones in public spaces.



However, most of the respondents were not sure about the efficacy of the visual prompt because of the small size screen. Also, some respondents commented that the robot could annoy users if they can not control the operational condition of the reminder in public spaces.

When it comes to discussion about the ethical issue, none of the respondents worried about the matter of patients' dignity. Rather, one respondent who has been caring for an AD patient replied that the use of robots rather could be the way of empowering the patients' dignity. The respondent commented that being reminded by the robot can be less frustrating for patients than by their caregiver. However one respondent replied that in public spaces, the reaction from encounters on the use of the robot can be varied depending on the regional severity of COVID-19.

## **8. Final Concept**

### **8-1. Refined Concept Description**



***Fig 8.1:*** Final concept



**Fig 8.2:** Omnidirectional camera



**Fig 8.3:** lidar sensor and RGB camera

Final concept is a portable cognitive assistive robot (*Figure 8.1*). As an action-camera scale, users can mount the robot to the rail-bar of mobility assistive products such as a bariatric walker and rollator walker for outdoor use. With the omnidirectional camera on its top, the robot will monitor the patient's social distancing and wearing of a face mask. For indoor use, the users mount it to the charging module in the bathroom. It will monitor their handwashing with a lidar sensor and perspective RGB camera. Once the robot detects the condition that requires reminding, it reminds the patients with its visual and audio prompts to help the user remember to practice with Covid-19 hygiene measures.

## **8-2. Monitoring System**

The robot has three different types of sensors. The omnidirectional camera is for monitoring mask wearing and social distancing (*Fig 8.2*). The lidar sensor and RGB camera are for monitoring hand washing (*Figure 8.3*). The omnidirectional camera can detect unregistered human faces and the human face without a mask based on 2D face detection and face recognition. The set of a lidar sensor and a RGB camera can detect hand washing motion and objects such as a faucet, soap dispenser, and running water based on motion detection and object

recognition. Once these sensors capture an image, the programmed algorithm on the GPU will analyze the images in real time and send the result to the CPU that operates the reminder system.

### 8-3. User Scenario

There are three different user scenarios. First scenario is monitoring and reminding hand washing (Figure 8.4). Second scenario is monitoring and reminding mask wearing (Figure 8.5). Third scenario is monitoring and reminding social distancing (Figure 8.6).

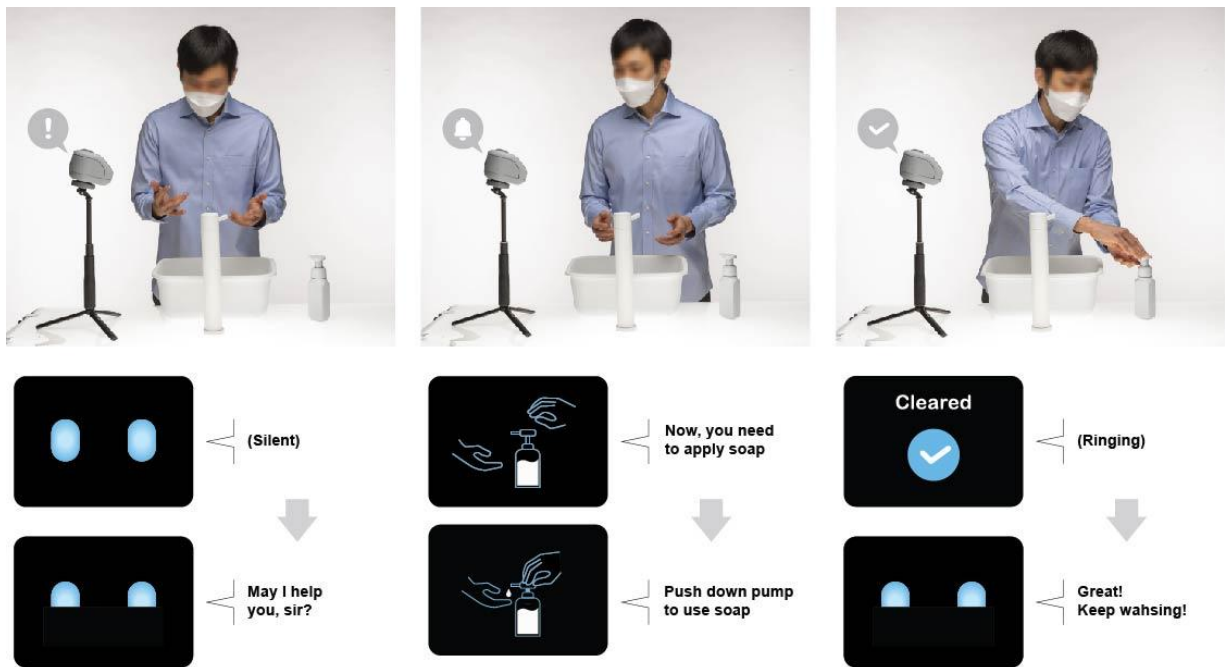
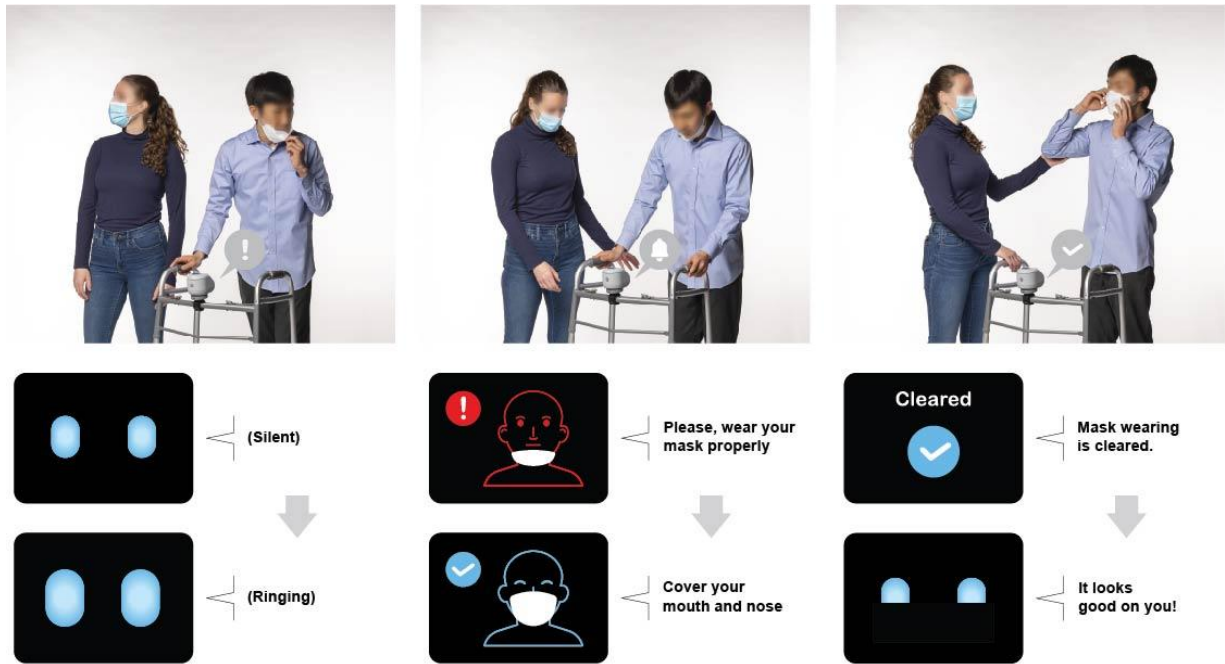
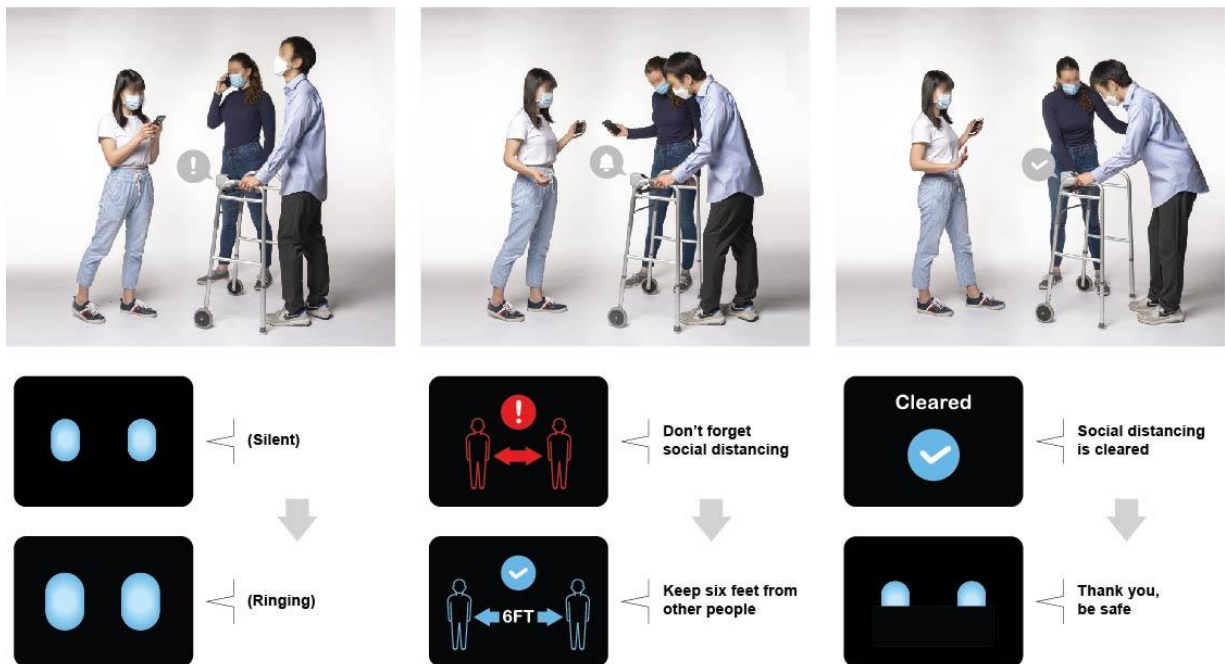


Fig 8.4: Monitoring and reminding hand washing



**Fig 8.5:** Monitoring and reminding mask wearing



**Fig 8.6:** Monitoring and reminding social distancing

## **9. Conclusion**

In public spaces, the robot can be an arbitrator role that eases the tension between people caused by the virus since the robot will remind not only the owners but also people near them with its audio prompt. During concept evaluation, some respondents commented that being reminded by the robot's audio prompt would be more acceptable than being asked by strangers to wear a mask or keep six feet distance. In that context, the patients are expected to be the owners of a device that encourages the public to comply COVID-19 hygiene measures.

There was a limitation to collect enough feedback from the family caregivers even though all respondents were the people who have a certain degree of knowledge about the memory problem of older adults. Therefore, the next step of research requires a secondary concept evaluation with the actual family caregivers of Alzheimer's disease and other related dementia patients based on the final design concept and user scenario suggested in this paper.

## Bibliography

Alzheimer's Association. n.d. "Coronavirus (COVID-19): Tips for Dementia Caregivers in Long-Term or Community-Based Settings." Alzheimer's association.

<https://www.alz.org/professionals/professional-providers/coronavirus-covid-19-tips-for-dementia-caregivers>.

Alzheimer's Association. n.d. "Stages of Alzheimer's." Alzheimer's

Association.<https://www.alz.org/alzheimers-dementia/stages#:~:text=Alzheimer's%20disease%20typically%20progresses%20slowly,progress%20through%20the%20stages%20%E2%80%94%20differently>.

Alzheimer's Association. n.d. "What is Alzheimer's Disease?" Alzheimer's

Association. <https://www.alz.org/alzheimers-dementia/what-is-alzheimers>.

Aura Vision, dir. n.d. *COVID-19 Solutions Suite: Aura Vision*.

<https://auravision.ai/covid-solutions/>.

Bursack, Carol B. (2020). "What to Do When a Senior Refuses to Bathe and Change Their Clothes." AgingCare.

<https://www.agingcare.com/articles/elderly-parents-who-wont-shower-or-change-clothes-133877.htm>.

Centers for Disease Control and Prevention (2019). "Caregiving for a Person with Alzheimer's Disease or a Related Dementia." Centers for Disease Control and Prevention.

<https://www.cdc.gov/aging/caregiving/alzheimer.htm#:~:text=Caregivers%20of%20people%20with%20Alzheimer's,for%20four%20years%20or%20more>.

Centers for Medicare & Medicaid Services. (2020). "Nursing Home COVID-19 Data and Inspections Results Available on Nursing Home Compare." CMS.gov Centers for Medicare & Medicaid Services.

<https://www.cms.gov/newsroom/press-releases/nursing-home-covid-19-data-and-inspections-results-available-nursing-home-compare>.

Foster, Malcolm. (2018). "Aging Japan: Robots may have role in future of elder care." *Reuters*, March 27, 2018.

<https://www.reuters.com/article/us-japan-ageing-robots-widerimage/aging-japan-robots-may-have-e-role-in-future-of-elder-care-idUSKBN1H33AB>.

FujitsuJpPR, dir. 2020. *Fujitsu Develops AI-Video Recognition Technology to Promote Hand Washing Etiquette in the Workplace*. [https://www.youtube.com/watch?v=P1BQWOza\\_jc](https://www.youtube.com/watch?v=P1BQWOza_jc).

Hitachi-LG Data Storage LiDAR, TOF, dir. May 22, 2020. *Hand Wash Monitoring for Kids*. <https://www.youtube.com/watch?v=2acEEx6PsW8>.

Koutentakis, Dimitrios, Alexander Pilozzi, and Xudong Huang. (2020). "Designing Socially Assistive Robots for Alzheimer's Disease and Related Dementia Patients and Their Caregivers: Where We Are and Where We Are Headed." *Designing Socially Assistive Robots for Alzheimer's Disease and Related Dementia Patients and Their Caregivers: Where We Are and Where We Are Headed* 8(2), no. 73 (March): 3. <https://doi.org/10.3390/healthcare8020073>.

Lancet Neurol and GBD 2016 Dementia Collaborators. (2018). "Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016." *Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study*, 18, no. 1 (November): 88.

[https://doi.org/10.1016/S1474-4422\(18\)30403-4](https://doi.org/10.1016/S1474-4422(18)30403-4).

Lett, Ashley H. (2021). "Caregiver Statistics: Facts about Family Caregivers." *AgingCare*.

<https://www.agingcare.com/articles/who-are-family-caregivers-459287.htm>.

Ricci, Giovanna. (2019). "Social Aspects of Dementia Prevention from a Worldwide to National Perspective: A Review on the International Situation and the Example of Italy." Edited by Aiko Osawa. *Social Aspects of Dementia Prevention from a Worldwide to National Perspective: A Review on the International Situation and the Example of Italy*, no. 8720904 (September), 1.

<https://doi.org/10.1155/2019/8720904>.

SoftBank Robotics Europe, dir. 2020. Covid-19: Mask wearing detection with Pepper the robot.

<https://www.youtube.com/watch?v=4Ll40uxssBs>.

Tay, Gin, and The Straits Times, dirs. 2020. *Spot robot patrolling Bishan-Ang Mo Kio Park*.  
<https://www.youtube.com/watch?v=viuR7N6E2LA>.

Tryolabs, dir. 2020. *Face mask detection | Crowd*.  
<https://www.youtube.com/watch?v=viuR7N6E2LA>.





