A Study on the Feasibility of IoT and AI-based elderly care system application

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Abstract

This paper conducted a feasibility study by applying an Internet of Things and Artificial intelligence-based management system for the elderly living alone in an aging society. The number of single-person families over the age of 50 is expected to increase, and problems such as health, safety, and loneliness may occur due to aging. Therefore, by establishing an IoT-based care system for the elderly living alone, a stable service was developed through securing a rapid response system for the elderly living alone and automatically reporting 119. The participants of the demonstration test were subjects under the jurisdiction of the "Seongnam Senior Complex," and the data collection rate between the IoT sensor and the emergency safety gateway was high. During the demonstration period, as a result of evaluating the satisfaction of the IoT-based care system for the elderly living alone, 90 points were achieved. We are currently in the COVID-19 situation. Therefore, the number of elderly living alone is continuously increasing, and the number of people who cannot benefit from care services will continue to occur. Also, even if the COVID-19 situation is over, the epidemic will happen again. So the care system is essential. The elderly care system developed in this way will provide safety management services based on artificial intelligence-based activity pattern analysis, improving the quality of in-house safety services.

Keywords: Elder Person, IoT, AI, Senior Care, Alone Elderly Care

Major Classification Code: Internet of Things, Elderly care service,

1. Introduction

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Currently, Korea is entering an aging society, and as a result, the economic burden and social difficulties experienced by dependents are increasing. One out of four domestic households is a 'single-person household (26.5%)', and 50.1% of single-person households are aged 50 or older.

In addition, the number of single-person families over the age of 50 is expected to continue to increase, and problems such as health, safety, and loneliness may arise due to aging.

Currently, the elderly live alone away from their families, and they feel psychological loneliness due to disconnection from communication with family and society. It is also predicted that the elderly in need of nursing care will

increase in proportion to the aging population. As the elderly population increases, the functional decline and cognitive impairment of the elderly rise. With the advancement of medical science, the proportion of the disabled population living with disabilities is increasing due to the increase of life expectancy and the opportunity to save lives from trauma caused by diseases or accidents. As a result of the study of the difficulties in the elderly living alone, health-related nursing problems were counted the most at 37.2%, followed by psychological loneliness at 24.4%. The elderly living alone often feels a sense of alienation and helplessness due to physical and mental aging limitations, and they feel a sense of psychological atrophy due to the inability to properly accept external stimuli due to the aging of sensory stimuli. As the number of single-person family increases, the number of deaths from unrelated persons is increasing, and it was found that those in their 60s (22.7%) and 70s (21.4%) account for more than 44% of the total deaths. The elderly living alone facing the death of loneliness is becoming a social topic. The end of loneliness is increasing due to the disconnection of conversation partners and the worsening of diseases. In the future, as we enter a super-aging society, the cost of supporting the elderly and health insurance continues to rise, which spreads to the deterioration of the national health care and welfare finances, which is emerging as a social problem. According to a research report by the "National Health Insurance Service", the total medical expenses for the elderly over 65 years of age were about 22 trillion won in 2015 and is expected to exceed 91 trillion won by 2030.

According to the projections of the old-age support contribution of major OECD countries, in 2075, 1.25 working-age population will support one older person, which is expected to bear the highest support cost for the elderly among major OECD countries. The World Health Organization (WHO) confirmed that the burden of mental health disorders was the third largest among the burden of disease and disability that humans are most concerned about in life. They were expected to be the most burdensome. However, most people accept that they are healthy if they do not have any diseases, and they tend to focus only on their physical health and neglect their mental health. The WHO report (2003) states, 'Mental health has been hidden behind a curtain of stigma and discrimination for too long. Recently, the risk level of the elderly due to COVID-19 has been raised, and the lack of care for the elderly is a serious situation. For adults, the risk of severe illness from coronavirus increases with age, with older adults being the most at risk. There are many cases of older people having difficulty daily living alone and having difficulty in mobility being infected at nursing facilities or nursing hospitals, or those involved in facilities being

infected. Of the ten deaths caused by the domestic virus, nine were aged 60 or older, and those over 80 accounted for 48% of the total. Therefore, although various non-face-to-face care services are provided, it is insufficient to indicate care for the elderly. It is a time when we need a method that can provide regular health care and companionship in accordance with the untact era while thoroughly observing personal quarantine rules.

2. Related Research

According to a study in Silverlink: Smart Home Health Monitoring for Senior Care Joshua, Lubaina, Shuo, Zhu, Casper, Owen, Li, Lu, and Hsinchun senior care has become one of the pressing societal challenges that many developed and emerging countries face, including the US (the aging baby boomer) and China (the reverse 4-2-1 family pyramid due to the one-child policy). Despite failing health, most senior citizens prefer to live independently at home. Hence, the focus of current healthcare technologies has shifted from traditional clinical care to "at-home" care for senior citizens. (Joshua, Lubaina, Shuo, Zhu, Casper, Owen, Li, Lu, & Hsinchun, 2017). According to a study by Akiko Akiyamaa, Hiroo Hanabusab, and Hiroshi Mikamia, Characteristics of home care supporting clinics providing home care for frail elderly persons living alone in Japan, From July to August 2009, 998 home care support clinics in Tokyo, Japan, sent self-diagnosis questionnaires by mail to investigate the characteristics of home care support clinics (EPLA) targeting the elderly living alone. Home care provision worked significantly with four or more home-visiting nursing homes (42.5%), four or more nursing managers (58.7%), and had sufficient medical equipment such as ventilators, ventilators, and intravenous hyper nutrients. The findings suggest that the factors enabling home care for frail EPLA are the first collaboration with nursing managers, a second collaboration with home nursing stations, and finally, adequate medical equipment. (Akiko, Hiroo, & Hirishi, 2011). To study by Sung-Hoon Lee, June-Yeop Lee, and Jung-Sook Kim, a monitoring system for the elderly living alone was established using sensors such as temperature, humidity, motion detection, and gas leak detection. (Lee, Lee, & Kim, 2017). A sensor is a system that periodically collects various status data of the elderly and sends it to a server, creates a real-time graph based on this data, and monitors it through the web.

It was designed and implemented to support the safe life of the elderly living alone by adding a function to notify the sensor's status by sending a warning text message to the guardian when the sensor is out of the set value during the monitoring process. According to Han-Sol Jang, Soo-Jung

Kim, Young-Ho Park's SilverLinker: IoT Sensor-based Alone Elderly Care Platform study, it is possible to respond to risks by detecting motion and sound and transmitting images in real-time. Therefore, based on the detection of the IoT sensor and the classification of the situation through an algorithm, a system capable of monitoring the elderly living alone on mobile and responding in case of danger was implemented. It is expected that this system will provide psychological stability to the elderly living alone and prevent death by loneliness as it is possible to judge the situation and respond to risks remotely. (Jang, Kim, & Park, 2018). According to DebanjanBanerjee's Age and ageism in COVID-19': Elderly mental healthcare vulnerabilities and needs. It marked the emergence of a global health threat that has brought the world to its knees in the past year and a half. Coronavirus disease 2019 (COVID-19) caused by SARS-CoV-2 has damaged the public health, economy, and daily life of billions of people. Originating in Wuhan, China, it took about a month for it to be declared an 'international public health emergency, and less than two months after it emerged as a pandemic. (Debanjan, 2020).

As COVID-19 cases continue to rise worldwide, it is time to pay more attention to the mental health of older people in addition to their physical vulnerability to ongoing infections. They will need additional care and support to take care of their overall well-being. Md. According to Ambient Sensors for Elderly Care and Independent Living: A Survey by Zia Uddin, OrcID, Weria Khaksar, and Jim Torresen. Caring for the elderly at home is of great concern if the elderly live alone, as unforeseen circumstances may arise that affect their well-being. Publications were included in this investigation when they primarily reported ambient sensor-based monitoring technologies that detect geriatric events (e.g., activities of daily living and falls) to facilitate independent living. Various non-contact sensor technologies such as motion, pressure, image, object contact, and sound sensors were mainly identified. In addition, multi-component technologies (eg, a combination of ambient and wearable sensors) and smart technologies have been determined. In addition to room-mounted ambient sensors, sensors from robotics-based geriatric care operations are also reported. Research related to behavioral monitoring techniques in the elderly is widespread but still in its infancy and consists mainly of limited-scale studies. Elderly behavior monitoring technology is a promising field, especially in long-term care for the elderly. However, monitoring technologies need to be taken to the next level, with more detailed studies evaluating and demonstrating their potential to prolong independent living in older adults. (Md, Weria, Jim, & Park, 2018). According to Hur, Hwa-La, Park, Myeong-Chul Design of Monitoring System based on IoT sensor for Health Management of an Elderly

Alone. a health status monitoring system for socially marginalized elderly households living alone. This system is implemented by collecting various PHR biometric signals and residential environment information through IoT devices. In addition, the company aims to establish a basic infrastructure that can understand the situation of lonely deaths and implement prevention programs by strengthening the predictive ability through data analysis of the DB server based on PHR and information collected from IoT sensors (Hur & Park, 2020). The COVID-19 disease is that the elderly is by far the most vulnerable population group. Therefore, public authorities target older people in order to convince them to comply with preventive measures. However, we still know little about older people's attitudes and compliance toward these measures. J. -F. Daoust studied "Elderly people and responses to COVID-19 in 27 Countries" In this research, they aim to improve our understanding of elderly people's responses to the pandemic using data from 27 countries. Results are surprising and quite troubling. Elderly people's response is substantially similar to their fellow citizens in their 50's and 60's. Therefore, services for caring for the elderly living alone are more and more necessary (Daoust, 2020).

The purpose of study was, by using ICT (information and communication technology), to monitor the activities of the elderly living alone in real-time in the main living space and to design a service that enables emergency response in case of an emergency, for the 20 elderly living alone in an apartment building in Songpa-gu. The service was conducted for two months from August to October. In this study, before implementing the empirical model, the service model design was planned by deriving the health and safety needs through a user-centered face-to-face contextual interview. After implementing the practical model, the effectiveness of the service was confirmed based on the T-test on the Fall Efficacy Scale (FES) and the Hospital Anxiety and Depression Scale (HADS). Based on these assignments, living alone can be accompanied by several difficulties. Older people living alone are more likely to be poor, and the longer they live alone, the greater the likelihood of poverty. Many older people living alone complain of loneliness and isolation. Because eating is generally a social activity, some older people living alone may not eat a balanced diet. Therefore, there is a risk of nutritional deficiency. For patients with health problems or vision or hearing problems, it is too easy to go unnoticed by worsening disease symptoms. Many older people living alone have difficulty following the directions of prescribed treatment. Therefore, stable and sustainable care services based on ICT are needed for the elderly living alone.

3. Empirical examination

This study is a single elderly care system composed of an 8-inch monitor-based gateway and IoT sensor devices and provides customized emergency and living management services for the vulnerable. In an emergency such as a fire or a fall in the house, various sensors can provide real-time data transmission to take 119 relief measures promptly. An alarm is delivered to the life manager and guardian simultaneously. In a situation where the coronavirus spreads through the gateway's service, the chat service, and the video call function, life managers and guardians can provide non-face-to-face care through ICT technology. In addition, as additional services, dementia prevention exercise program, weather information, and voice recognition function are equipped to support the daily care service care program for the elderly. Integrated management such as emergency status management, service target management, and statistical service analysis by the situation is possible through the IoT-based single elderly care operation system. When detected, an automatic 911 report and emergency call service are provided immediately. The gateway transmits the IoT sensing device status check and collection data to the service platform. This automated checks whether in-house status information is stable and updates the history management DB in the service platform.

3.1 Application of AI-based technology

To apply AI-based technology is service platform technology is needed to preoccupy the 4th industrial market. Currently, the welfare industry using IoT technology in Korea has global competitiveness in terminals and networks. It is judged that each connected technology possesses. However, since the number of connected sensors is large to apply IoT technology 1:1, it is required to process it at once. Several technologies can be processed at once, but a configuration that connects to the platform is necessary for this study. However, it isn't easy to solve with the current platform technology. According to Kwak and Kang (2020), a study on methods to prevent the spread of COVID-19 based on machine learning, a study was conducted to find a self-diagnosis method to prevent the spread of COVID-19 based on machine learning. COVID-19 is an infectious disease caused by a newly discovered coronavirus. Studies like this show that the elderly will be even more complicated when the general public is struggling. Therefore, an AI-based service platform and personalized service are needed as a starting point for preoccupying new markets in the era of the 4th industrial revolution and nurturing it as a new future growth engine industry. In addition, if welfare services are

implemented through an AI-based service platform, active, interactive services will be possible. However, in this study, we intend to prepare the feasibility of commercialization by applying the IoT-based platform's technology. The research process is as follows;

1. Collect data from scattered sensors based on IoT.
2. Pre-process the collected data according to the field of application.
3. At the same time as data collection, an alarm sounds in case of an emergency.
4. When an alarm sounds, an SOS notification is called to the emergency center, and the control is set in real-time when an emergency occurs.

Therefore, if an IoT-based care service is provided, it is possible to monitor the elderly living alone 24 hours a day. It is expected that AI-based big data analysis will be possible by using the collected data.

3.2 IoT-based Single Elderly Care System Configuration and Operation Scenario

This study is a single elderly care system composed of an 8-inch monitor-based gateway and IoT sensor devices and provides customized emergency and life management services for the vulnerable. In an emergency such as a fire or a fall in the house, various sensors can provide real-time data transmission to take 119 relief measures promptly. An alarm is delivered to the life manager and guardian simultaneously. Can do. In a situation where the coronavirus spreads through the gateway's service, the chat service, and the video call function, life managers and guardians can provide non-face-to-face care through ICT technology. In addition, as additional services, there is a dementia prevention exercise program, weather information, and voice recognition function so that the daily life of the elderly is not dull, and it serves as a companion. Integrated management such as emergency status management, service target management, and statistical service analysis by the situation is possible through the IoT-based care for the elderly alone. According to the set period of the IoT sensor installed in the house, the collected data is transmitted to the gateway. When an emergency is detected, an automatic 119 report and emergency call service are provided. The gateway sends IoT sensing device status check and collection data to the service platform. This automatic checks whether in-house status information is stable and updates the history management DB in the service platform. Figure 1 Shows the operating scenario of an IoT-based care system for the elderly who live alone.
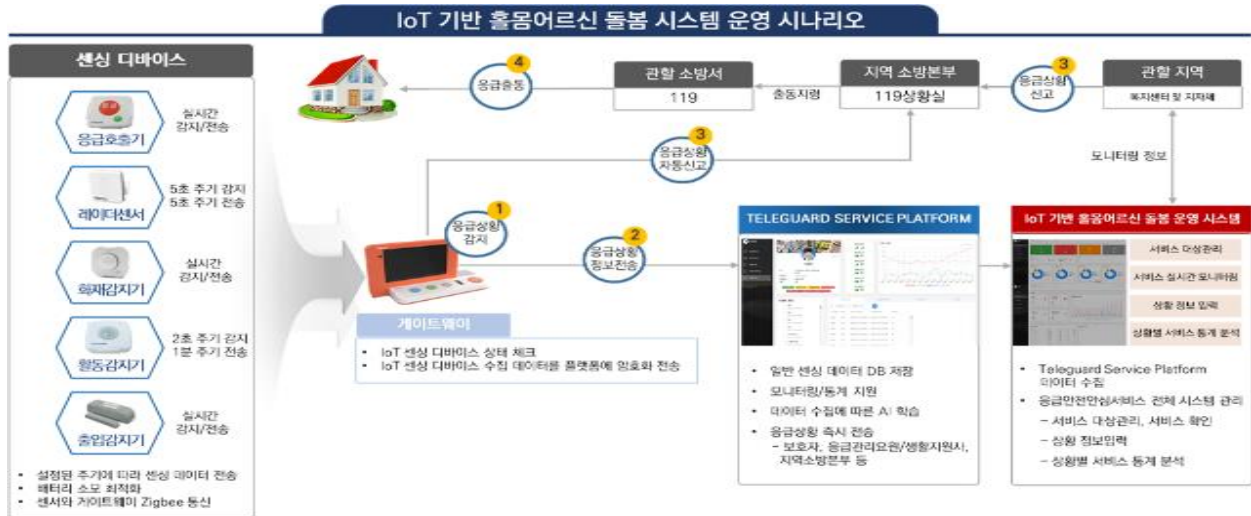
Figure 1: Operating Scenario of an IoT-based Care System

3.3 System Function and Interface Implementation Plan

It monitors real-time home emergencies and calls SOS notifications to emergency centers and control sets in real-time when an emergency occurs.

LTE CAT.4 based data communication and Zigbee-based sensor device communication are possible, and voice/video call connection and SMS/MMS are provided.

Emergency call 119, life manager call, call, and cancel buttons are provided, and operation data is periodically transmitted to the integrated control server.

(1) Definition of the system interface section

The IoT-based sensor communicates with gateway and Zigbee and communicates with AES-based 128-bit encryption. It operates not only with the sensor but also with the platform and operating system.

Table 1: Main system interface contents

Interface	Main system interface contents
sensor ↕ gateway	- Zigbee-style data connection interface configuration between IoT sensors and gateways installed for each purpose - According to each IoT sensor, the data collected in the house is transmitted according to the period set by the gateway.
gateway ↕ Platform	- Perform emergency recognition and reporting (119, living support staff, etc.) functions according to the type of data collected - Transmitting data collected from the gateway to the platform through the LTE network
Platform ↕ Operating System	- Data statistics on sensing and gateway status information collected from the platform

(2) Emergency safety gateway standard

The following standards were tested for home installation of a care system for the elderly alone. Table 2 showed the specifications of the gateway.

Table 2: Specifications of the gateway

Type	Spec
OS	Android 10 GO
CPU	Cortex-A53, 1.5GHz Quadcore
Display	8inch 1280X800 IPS Touch LCD
Memory	RAM 2GB, Storage 32GB
Network	LTE Cat.4, Wi-Fi, Bluetooth, ZigbeePro2.4GHz
Dimensions	320 x 132 x 170 mm
Weight	1,078g
Power	12VDC/1A

It is easy to install and upgrade contents using the USB port, and it can operate for more than 48 hours even in case of a power failure by adopting a large-capacity battery.

4. Experimental Results

An IoT care system for the elderly living alone was installed at home. Implementing organization (cooperation) Support was received from the Seongnam-si Senior Citizens Living Alone Support Center. As for the equipment, emergency safety gateway (1EA), radar sensor (1EA), activity sensor (2EA), access sensor (1EA), emergency pager (1EA), and fire sensor (1EA) were installed in Hadaewon-dong, Seongnam-si. The installation

period was established and tested from 2021.04 to 2021.05. A dashboard was constructed for the operation of the care system for the elderly alone.

(1) Target values according to the definition of significant performance indicators (Evaluation item 1) The data reception rate defined the performance index. Data reception rate (%) between IoT sensor and emergency safety gateway The reception rate of transmitted and received data was analyzed every 4 hours. As a result of the BMT method self-test, the reception rate was 100%. In the figure 2 The program is defined from the reception number to the reception rate, and the data received are shown.
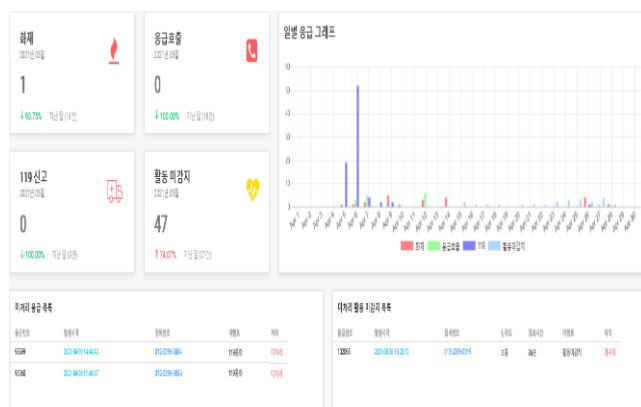

Figure 2: Dashboard of elderly living alone

(2) Accuracy of collected data

The definition of the performance indicator is IoT sensor data collection for the advancement of care services and data reliability, and the target is set at 99%. Data consistency was checked by comparing log data and server DB data. As a result, the accuracy was 100% as a result of the self-test using the BMT method. Figure 3 shows the log data of the BMT test in the laboratory.
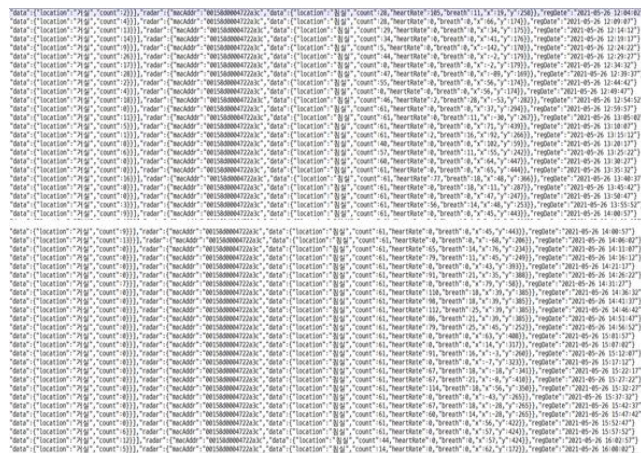

Figure 3: The log data of the BMT test

5. Conclusion

In Korea, the elderly aged 65 and over account for about 14.8% of the population entering an aging society. The number of single-person families over the age of 50 is expected to increase, and problems such as health, safety, and loneliness may occur due to aging. According to a research report by the "National Health Insurance Service", the total medical expenses for the elderly over 65 years of age were about 22 trillion won in 2015 and is expected to exceed 91 trillion won by 2030. Vulnerable people are relatively alienated from information and service benefits compared to the general public, and they have psychological alienation/loneliness/depression. Currently, institutions are guiding daily care and administrative welfare using AI robots. Still, the vulnerable are challenging to find and difficult to sign up for, so they cannot enjoy the service benefits. By adding AI devices such as AI robots, it is necessary to expand to advanced daily care services and integrate control and management through an open platform linked with the government/local government. In this study, it is possible to analyze the empirical data of the vulnerable class through an open platform and predict anomalies based on big data. Through future projects, it will be possible to eliminate blind spots in welfare services for the vulnerable and provide proactive health care and active welfare services for the helpless by linking with the government welfare system through preemptive care of daily care services tailored to the elderly living alone. In addition, IoT-based care services are expected to become more and more necessary skills in the Covid-19 situation.

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