Future changes to smart home based on AAL healthcare service

Donghyeog Choi, Hyunchul Choi and Donghwa Shon

**ABSTRACT**
As South Korea is expected to become a super-aged society by 2025, diligent efforts have been made to reduce the social burden by promoting a productive and healthy elderly lifestyle. Individuals are encouraged to prepare throughout their early lives and construct a healthy residential environment. As one of several alternatives home healthcare is using the Internet of Things – referred as ambient assisted living (AAL) – is drawing much attention. Although the individual technologies of healthcare and smart home have undergone rapid development, there has been little integration between the two. Moreover, many technological developments do not consider the actual lives of the elderly. To effectively respond to the aging problem, the two technologies should be integrated and applied to residential environments based on daily routines of the elderly. The purpose of this study is to suggest the future direction for healthcare in smart homes in South Korea. To achieve this goal, we first examined the possibility of embedding healthcare services into smart homes in a non-invasive manner. Second, in-depth interviews were conducted with elderly citizens and silver tower operators to elucidate characteristics of the elderly, and a healthcare scenario was suggested that could be applied to each smart home room.

**Introduction**
As of 2018, Korea has become an aged society, and will become a super-aged society by 2025 (Korean statistical information service 2018). This not only applies to Korea, but all East Asian countries and will extend to the European Union within a few decades (Figure 1). Medical technological developments have increased the human lifespan, but also prolonged diminishing health conditions (Porter and Heppelmann 2014). Increased medical expenses caused by an aging society creates a great socio-economic burden (Van Hoof, Demiris, and Wouters 2017; Venkat 2015; Sixsmith and Gutman 2013). To address this, efforts to decrease disparities in life expectancy on a global scale as well as improve the well-being of seniors have been the focus of aged societies, and various related fields of study have been initiated (Sakamoto 2006).

Due both to the deterioration of the physical and mental abilities of seniors, and the great amount of time they spend at home, government and private home care services are made available in residential areas in South Korea. Home care provides the elderly with the advantages of being able to live in a familiar space and maintaining independence (Van Hoof, Demiris, and Wouters 2017). However, many difficulties arise, such as the time, effort, and cost for the overall healthcare of the elderly – since those services tend to be individualized.

Therefore, healthcare services need to provide ambient assistance through the IoT (Internet of Things) or ICT (Internet and Communications Technology) to enhance quality of life for the elderly (Choi and Choi 2017; AALJP 2018; Sumit et al. 2017; Turner and McGee-Lennon 2013; Sixsmith and Gutman 2013). Today, technology is incredibly prevalent in our lives – especially in residential space – due to rapid development and public demand. Smart devices with electronic displays, voice recognition, Home automation, usage monitoring, and environment control are changing our lives dramatically. Due to these technologies, elderly people can live independently in a familiar environment (Belbachir, Drobsics, and Marschitz 2010) while improving cost-effectiveness (Belbachir, Drobsics, and Marschitz 2010; Sumit et al. 2017; Van Hoof, Demiris, and Wouters 2017; Sixsmith and Gutman 2013) with high-density healthcare monitoring.

From this perspective, many research institutes have investigated ambient assisted living (AAL) and projects using ICT. AAL refers to a fusion of ambient intelligence and assisted living that contains characteristics of the living space and social service area (Choi and Choi 2017; AALJP 2018). This abstraction was formed in 2007 by the research of the AAL JP (Joint Programme) that involves 23 countries of the EU that are undergoing aged society. Many projects such as UniversALL, CARE, SmartSenior, and Diamond’s House are now in progress (Belbachir, Drobsics, and Marschitz 2010) and several healthcare items are being developed rapidly and quantitatively.
However, most of the ongoing projects are focused on elderly healthcare specifically, rather than residential environments or elderly behavior. It is known that biology (20%), environment (20%), lifestyle (50%) and healthcare organizations (20%) are factors affecting health (Lalonde 1974). As two factors, lifestyle (elderly behavior) and environment (residence), affect health by as much as 70%, elderly health must be considered from these perspectives.

In South Korea, the IT industry is rapidly growing and attracting worldwide attention (World Economic Forum 2018). Naturally, healthcare and smart home technologies are quickly progressing. However, overlap between the two technologies has been limited. To effectively respond to the aging problem, the two technologies should be integrated and applied to residential environments based on the routines of the elderly.

**Research purpose**

The IoT – garnering recent publicity – can provide a solution for the complications inherent to an aged society. IoT provides control and management of all devices connected via smart home technology in a residential space. Moreover, it should enhance the user’s convenience, healthcare, and safety. In particular, specialization for daily healthcare and provision for super-aged society are the most significant directions for future development of smart homes (Sumit et al. 2017). Therefore, integration of healthcare and smart homes based on elderly behavior is needed.

In this research, we first examine the possibility of embedding healthcare services into smart homes in a non-invasive manner. Additionally, we scrutinize alterations in the smart home industry based on technological advancements and contemplate directions for smart home development involving healthcare. Second, in-depth interviews are conducted with elderly citizens and silver town operators to elucidate the characteristics of the elderly. The results are used to review possible healthcare service elements and present strategies for healthcare in residential space, room-by-room.

**Super-aged society**

**Status of aged society**

Based on WHO and UN standards, 7% of a total population over 65 years old is referred to as an aging society, 14% is aged society, and 21% is super-aged society. Modification of social structure to an aged society is a predicament that not only Korea is facing, but also the world (Figure 1). Aged society is an inevitable consequence of an elongated life expectancy resulting from augmented medical technology. Unfortunately, in addition to extended life, cases of suffering due to illness and poverty are lengthened (Sakamoto 2006). In 2015, the Korean life expectancy was 82.1 years (Korean statistical information service 2018) and average health span was 73.2 years (WHO 2018). The disparity of 8.9 years between life expectancy and health span needs to be decreased to ensure a longer, active senior life and reduce the social burden. Continuous low birth-rates and aged society will instigate a super-aged society that escalates the expenditure for senior healthcare. As a result, a socioeconomic crisis will be inexorable (Sumit et al. 2017; Gelineau 2018; Canadian Institute for Health Information 2018).

First, we need to identify the impediments that seniors currently face (Weiner 1980). Many conflicting disputes arose, but economic, social, physical, and psychological issues are the most typical. Elders become frail as they age – both physically and psychologically; they enter retirement, lose their stable income, and experience social and economic difficulties. In Korea, absence of work or activity and loneliness more significantly impact the quality of elderly life than illness and other economic difficulties (Kim 2008; Kim et al. 2008).
Elderly healthcare in residence

To both minimize the disparity between life expectancy and health span, as well as to enhance elders’ quality of life, the concept of active aging has been proposed (WHO 2018). The WHO prescribe that fulfillment of three categories – physical, social, and mental health – maximizes seniors’ well-being (Figure 2). Additionally, the WHO recommends the minimum social support for elders and highlights their independence and self-reliance as a principal value. Put differently, extravagant, lopsided support will infringe upon elders’ autonomy and be a detriment to their mental health. However, in grievous conditions, reliance on assisted living (AL) facilities may be the only option. Therefore, health management from adolescence is salient for active aging (Choi et al. 2016). It is more efficient to cope in a familiar, personal residential space in a consistent manner.

Various methods for senior healthcare services are set amid living spaces where much of their time is spent. Countries of an aged society often have housing for elders with liaisons from hospitals and care facilities. Alternatively, they may provide caretakers who periodically visit elders who live in their own housing. In Japan, through the elderly housing with supportive services system, easy-to-use housing is provided for the elderly and managed by experts. VivaceNisshinMachi is a case in which a house and hospital are linked in one building. YuimaruIgawadani is a case of linking elderly facilities with housing and 24-hour professional care. Harborside, in the Netherlands, combined residential and nursing facilities to implement assisted living.

Healthcare based on living space provide services in Aging in Place have benefits: providing healthcare service by professional caretakers of psychologically stable status when elders are in physically weak and isolated from society.

Needs of healthcare in residence

Residential space is where people spend the majority of their time. Based on a report from the Korean National Statistical Office in 2014, the amount of time that a Korean spends daily in residential space is 14 hours and 59 minutes: more than half of the day. Elderly people, due to discontinuity of economic activities after retirement, spend an average of 20 hours a day in residential space – an increase of 5 hours. Because of retirement, reduced social network, declining health, and other factors, they spend only around 4 hours a day outside (Ministry of Construction and Transportation Korean Housing Association 2005).

Healthcare services with welfare facility liaisons and visiting experts employ constant monitoring of elderly people (Sumit et al. 2017). These services are strained by high costs and a limited workforce, and may violate elders’ independence and personal autonomy (Secker et al. 2003). To surmount these limitations and allow elders to achieve independent active aging, IoT technology is an important consideration (Choi et al. 2016; AALJP 2018; Sumit et al. 2017; Turner and McGee-Lennon 2013; Belbachir, Drobits, and Marschitz 2010; Van Hoof, Demiris, and Wouters 2017; Sixsmith and Gutman 2013).

Expansion of healthcare services that integrate with IoT technology will allow professionals to collect vital information outside of medical facilities with ease (Sumit et al. 2017). It particularly allows collecting bodily information from the comfort of the home. Additionally, it allows for consistent monitoring of oneself to adjust improper habits that may lead to disease.

Residential space provides the optimum environment for a resident to receive healthcare with great comfort. Healthcare in residential space should follow the three perspectives of the active aging principle: physical, mental, and social health. Moreover, this will provide a basic background for combining IoT healthcare with residential space.

AAL healthcare smart home

IoT in residence

The ICT field has come to a new inflection point due to tremendous progress in IoT technology – the vast network of devices that are embedded with sensors and communication functionality. Initial IoT technology connected a smartphone to a watch; now it can connects multitudinous home electronics using the refrigerator as a smart home platform (Samsung Eletronics 2018). Furthermore, it not only connects devices, but also collects, analyzes, and transports data from them (Figure 3) (Porter and Heppelmann 2014).

The IoT starts with a single appliance – such as a washing machine or refrigerator – that can be
controlled remotely. These appliances combine to form a home network that features console control of gas, security, and lighting systems. The smart home can be reached from outside by connecting each device wired/wirelessly and accumulate its daily information in the Cloud where data is stored and possibly shared over the Internet.

Recent residential spaces are already capable of monitoring electricity, gas, and water usage. Hence, the industry that provides those services has developed smart home consumption monitoring systems to not just inspect numbers, but also analyze usage patterns to customize services.

Home network companies are envisioning smart homes where lights, curtains, windows, security, and other sensors are controlled remotely and systematically. Home network technology developed by those companies is controlled via touch-screen wall pad with voice recognition. The system manages and analyzes usage patterns to provide users with comfort by unifying numerous interior elements.

Electronic companies that have relatively close interactions with customers are leading today’s Smart home trend. They consider a new residential lifestyle by interconnecting all possible home appliances and electronics: smartphone, TV, laptop, refrigerator, air conditioner, sleep-managing bed, and more.

Within those infrastructure, recent smart home trends apply IoT technology to architectural interiors, home appliances, and other residential spaces. Already, there are refrigerators on the market with voice recognition that function as a hub to control all home appliances, but many are not yet compatible between different manufacturers. However, diligent efforts for compatibility will soon allow interconnection and enhanced, intelligent, and automated performance (Porter and Heppelmann 2014). The arrival of smart homes that collect resident data, analyze user patterns, and automate residential conditions is certain.

**IoT in healthcare services**

There has been development of healthcare devices for distinctive purposes for a long time. However, those devices have a singular purpose and collect data for onetime use. Additionally, the method of use is inconvenient for the user (Sumit et al. 2017; Kekade et al. 2017). Now, the recent addition of internet upload compatibility in healthcare devices allows people to monitor health conditions for both medical treatment and healthcare purposes. An increasing number of new healthcare devices are manufactured with IoT technology and becoming more familiar to the public. With simple wearable devices, such as smart bands and watches to collect and check users’ physical information in real time, people can monitor and analyze their health condition. Besides information technology and electronics, manufacturers in sports and fashion are producing healthcare-related commodities (Figure 4). In recent years, smartphones have come with a manufacturer-installed healthcare apps. It is possible to collects information such as heart rate, walking distance, and body temperature through wearable devices. People can also monitor their number of steps and level of exercise through a sensor that attaches to the shoe. Furthermore, there are eyeglasses and bands that can analyze tears to measures blood pressure and sugar levels of diabetics.

Applying IoT technology in the healthcare industry will bring cost reduction, remedial options, prevention and control of disease, and convenience to daily life (Haghi et al. 2017). IoT technology can collect and
analyze information to provide accurate diagnosis so that people can manage their health and minimize medical facility visitation. In addition, this new direction of the health management system that is brought by healthcare devices will influence advanced possibilities for new telemedicine. In Korea, telemedicine is surrounded by several disputes concerning personal information and medical law. However, daily accumulation of data by these devices will increase diagnostic accuracy, produce innumerable quality data, and save time, as well as provide advantages to medical facilities and convenience to individuals (Saylor 2012).

**Future of AAL healthcare platform in residence**

In South Korea, development of smart home and healthcare devices is progressing. However, to cope with the aging problem, both technologies need to be integrated. Healthcare devices should be linked to smart home technology and embedded in residential space.

AAL in residential space aims to provide an unconscious healthcare service. AAL provides health management and pursues active aging by attributions of zero-constraints, zero-consciousness, and real-time monitoring on a bidirectional platform through ICT. Users can automatically receive health information, monitor health status, improve nutrition and exercise level, and learn healthy habits during their natural daily routine. It is a primary focus to retrieve health information from users without their conscious effort, and to adjust inadequate habits and posture frequently via monitoring (Sumit et al. 2017).

Until recently, access to electricity, water, telecommunication, fire service, heating, and air conditioning equipment was in the interior of the space. However, increasing user demand began in earnest when equipment embedded inside the framework became the norm of basic the architectural elements. Alike those, devices, sensors, and displays for AAL healthcare technology should be embedded inside of the ceilings, walls, and floors.

From the perspective of resident/device interaction and device lifespan, sensors, displays, and other electronic devices for AAL healthcare service are between regular electronic devices and architectural infrastructure. Therefore, it is important that device installation is regulated and installed on the architectural framework for ease of replacement. For this reason, research is in progress on an installment system for AAL healthcare service on the framework for ceiling and wall mounts (Choi and Choi 2017; Choi et al. 2018).

Based on the different healthcare service functionality and resident behavior in each room, methods of interacting with devices will influence mounting locations. The installation of each item will be based on characteristics of the product: items that require pressure and contact will be on the floor; those requiring speech interaction and touch will be on the wall; and light, sound, and movement detectors will be on the ceiling. Furthermore, information collected through the platform will be used as big data for healthcare service providers to have accurate information through an interconnected local society and professional medical institutions (Figure 5).

**Existing AAL-related case and platform**

Many countries facing aging population issues are researching various AAL-related platforms. One exemplary case, UniversAAL is developing a platform that provides a variety of devices and telecommunication product services through universal and standardized IoT technology (CORDIS 2018; UniversAAL 2018). It is utilizing the IoT’s unlimited potential in simplifying management and development, and elaborating on connectivity and extensibility between product and user (UniversAAL 2018). AAL JP is collaborating the EU’s multi-country research institutes and companies to use ICT for enhancing quality of life. It proposes a multitudinous solution via limitless, wide-range projects, such as home to workplace (AALJP 2018). AAL Products provides AAL-related ideas and technology from developers to market, and those ideas – ICT-related healthcare, smart home, and even regional service – are open to the public (AAL Products 2018). The West AAL project used fall sensors and different ICT devices with 70 elderly families to test and assess safety and comfort (West-AAL 2018). gAALaxy Programme stresses home automation and external communication function and uses motion, environmental, and other sensors to support elderly safety, independence, and communication (gAALaxy 2018).
The described cases are platforms utilizing AAL technology to solve the problems of an aged society. However, most cases are limited to resolving specific situations by ICT not whole residential living environment. In this research, we discuss AAL applications from a perspective of residential space through consideration of the current technological movement. Furthermore, we support general elderly behavior centered by spatial characteristics in a home.

Future AAL simulation based on elderly living characteristics

The nature of the elderly living environment

As a research method, we independently conducted in-depth interviews from April 2 to 5, 2017, with 16 elders who currently live in a silver town and 8 silver town operators. Each interviewee lives in a different facility and was selected randomly. The interview comprised a series of questions that allow us to deduce each interviewee’s environmental characteristics. We excluded contents that were unique to a specific facility and instead summarized elderly living characteristics from a universal perspective (Table 1).

As a result of the interview, we found elder’s characteristics to be relatively simple and their needs were clear. An aim of the interview was to gain an understanding of basic elderly tendencies through inquiries about preferred space, hobbies, social exchanges, and healthcare in the context of daily routines. Operators were asked for an objective view of elderly tendencies, activities, characteristics, mental or physical health, and social exchanges.

According to the interview results, entertainment and exercise primarily occur in living areas, while reading and sleeping take place in a bedroom. The daily routine of the elderly is faster than that of the general public, and most of the day is spent at home with TV or exercise. This implies that more activities can take place in residential space, and a plan should be established for healthcare in the life of the elderly.

The interviews described a common interest in exercise for health. However, due to the decline of both physical and mental health for many interviewees, a positive response toward dependence on the healthcare system was also observed. The interview results show that aggressive application of the healthcare smart home will help improve quality of life for the elderly.

Elderly people tend to avoid social activities despite feeling lonely. The reason for low participation in social activities is that the aged population – which has become physically and mentally weak – experiences fatigue from socializing. Therefore, there is a need for measures to enable social participation from the comfort of the home. There is a need to plan for social exchanges through hobby activities while appropriately protecting private spaces in the residence.

Plans for AAL in residential space

In this chapter, we explored determined exemplary cases for how an AAL platform could be applied to future living environments. Based on previously analyzed environmental characteristics of the elderly, the research categorized different functional spaces that can be measured and managed from a physical, psychological, and social perspective to promote active aging. The technology described in the following table is intended to be applied to the AAL healthcare smart home. It is within the scope of existing sensors and described based on previous research into elders’ residential living conditions (Table 2).

As shown in the interview, subjects expressed high contentment toward healthcare service in overall everyday life, however, conveyed fear of using high-tech electronics. In our research, the AAL healthcare smart home service employs an unconscious and subliminal concept that makes no difference to living. Therefore, it is of utmost importance that implementation and monitoring of healthcare devices becomes natural and easy for users or authorized people. In this case, there is personal information security, privacy, and ethical concerns regarding who and how personal health information will be gathered or used, and the possibility of technical failure (Turner and McGee-Lennon 2013). These concerns must be addressed by clarification of the relationship between users and those in charge of information.

In the interviews, subjects commonly expressed that they predominantly use the living room and bedroom for reading books, watching television, and exercising. People spend more time in a bedroom than living room due to sleep. As such, the bedroom requires a proper plan to support the user’s sleep by automatized light and posture adjustment through analysis of sleep patterns. The elderly often sleep and wake earlier than others and use the bathroom frequently. Therefore, it is of utmost importance to provide healthcare for sound sleep during the night, early morning bathroom use, easy access to light in the dark, and to prevent accidents caused by sudden light exposure. Moreover, a planned feature that received praise in the interview is an external emergency call service for seniors who live alone to avoid lone death. Additionally, it is important that the system allows for easy and frequent communication with family members to prevent sleep depression and other emergencies that could potentially arise from social solitude in a bedroom.

During daytime, the living room is where elders spend time watching television, reading books,
Average 6 hours of sleep from around 11 pm. Mealtime is faster than other age groups. Heavy lifting or physically challenging house chores are done by housekeeping service or family members. Desire for social interaction to palliate sense of loneliness, but simultaneous desire to avoid communal activities. Exercising, reading, watching TV is usual. All responded around 1 to 3 hours per day of exercise. Health management is vital. Outdoor activities (such as hiking and traveling) and indoor activities (such as watching TV and reading) are frequent for health management.

**Summary of elderly characteristics.**

**Table 1. Summary of elderly’s characteristics.**

| Classification | Summary |
|----------------|---------|
| Operators       | Fitness: Skeletal muscle, memory, weakened eyesight (blurry, less peripheral vision), difficult distinction of color and chroma, auditory sense, tactile sense, weak skin (abrasion, laceration, contusion). Psychology: Anger, loss, less patience, psychological atrophy due to desensitization, tendency of dependence due to weakness, tendency to resolve immediate desire. Activity: Early morning activities such as sauna, (institution) food, medical, and exercise service in the communal area are preferred. Communication: Desire for social interaction to palliate sense of loneliness, but simultaneous desire to avoid communal activities. Residents: Rising/Bedtime: Average 6 hours of sleep from around 11 pm. Mealtime is faster than other age groups. Housekeeping: Heavy lifting or physically challenging house chores are done by housekeeping service or family members. Leisure: Exercising, reading, watching TV is usual. All responded around 1 to 3 hours per day of exercise. Health management is vital. Outdoor activities (such as hiking and traveling) and indoor activities (such as watching TV and reading) are frequent for health management. TV Program: Living room and bedroom are predominant. They watch 1 to 3 hours of TV daily for news, religious, sports, or other programs. Especially interested in healthcare programs. Hour/Location: Predominant Activity/Space: Mostly spend time in the home for avocation or physical training. Based on their health condition, those activities can be mainly for treatment. Exercise and watch TV in living room. Reading books in either reading room or bedroom. High dependency in bathroom due to physical impediment. IT System Requirement: Currently, silver towns provide emergency call, movement detection sensor, and other services with great satisfaction. However, subjects have a hard time using the wall pad. Silver Town Pros and Cons: Many responded that services, food, amenities, and natural environment are advantages. However, they expressed difficulty socializing, lack of transportation system, and limited choice of food. The Necessity of Healthcare Service: Except few who have a hard time with high-tech devices, many show interest in buying healthcare devices. Primarily food and health management and overall daily life support of healthcare services are wanted. |
| Room      | Physical | Function       | AAL planning cases                                                                 |
|-----------|----------|----------------|-----------------------------------------------------------------------------------|
| Bedroom   |          | Deep sleep     | Motion bed control with recognition of posture and pattern for deep sleep           |
|           |          | Environment    | Embedded sleep checker device for healthcare monitoring                            |
|           |          | Accident       | Control devices such as window, air purifier, air conditioner, lights and curtain  |
|           |          | prevention     | Foot-level, indirect guiding lights to prevent glare at dawn or night               |
|           | Mental   | Social activity| System for interactive conversation at detection of long, silent activity          |
|           |          | Deep sleep     | Assisting deep sleep with comfortable lighting and music in case of insomnia        |
|           |          | Correct posture| A sensor embedded in the chair is calibrated to unhealthful position while reading and detects when to move |
|           | Social   | Accident       | Rescue call in detection of unusual physical information eg, make an emergency call if a physical anomaly appears, and contact family if psychological anxiety is detected |
| Living Room| Physical | Indoor activity | Promote activity with alarm and video in response to insufficient movement          |
|           |          | Medication     | Notification of important medication type and time with voice and lighting          |
|           |          | notification   | Automatic curtain adjustment for sufficient solar radiation during daylight        |
|           |          | Daylight       | Open curtains and alarms for periodical observation of outside scenes for eye health |
|           |          | control        | Intersactive communication support system for regular brain activity               |
|           | Mental   | Comfortability | Adjustment of lighting, music, and display for relaxed emotions                    |
|           |          | Dementia       | Interactive communication support system for regular brain activity               |
|           |          | prevention     | Autoadjust of washbasin height according to stature to relieve back pain           |
|           | Social   | Social activity| Exchange of memories, information, and knowledge with family members who are allowed private exposure |
|           |          | Accident       | Rescue call by emergency detection through signals from floor, voice, and camera   |
| Bathroom  | Physical | Body management| Measure of daily health status with fees examination and body composition analysis  |
|           |          | Correct posture| Adjustment of washbasin height according to stature to relieve back pain           |
|           | Mental   | Health         | Smart bathtub for underwater exercise and water massage                            |
|           |          | therapy        | Check water temperature by color without touching (prevention of secondary accident) |
|           | Social   | Accident       | Remote monitoring for slip and fall accident                                      |
| Kitchen   | Physical | Ventilation    | Rescue call for a slip accident in the bathroom                                    |
|           |          | Nutrition      | Ventilation with automatic window opening and fan operation in case of air contamination while cooking and cooling |
|           |          | management     | Display suggests proper diet and recipes according to nutritional status           |
|           | Social   | Social activity| Communication system for cooking methods and expertise through social media        |
| Entrance  | Physical | Accident       | Check necessary items such as a hearing aid, mobile phone, or car key              |
|           |          | prevention     | Shutoff for gas, water, electric heater, and security system at the entrance door  |
|           | Mental   | Necessary item | Check necessary items such as a hearing aid, mobile phone, or car key              |
|           |          | check          | Shutoff for gas, water, electric heater, and security system at the entrance door  |
| Corridor  | Physical | Correct posture| Share information of outdoor activities for the elderly                            |
|           | Mental   | Relaxation     | Relaxation with lighting and sound during movement                                  |
|           | Social   | Social activity| Reduced need for privacy allowing for social activities: games, conversation, etc.  |
Conclusion

In this study, we first evaluated overall possibilities of AAL healthcare technology within residential space as a potential direction for future smart home development. Second, based on behavioral patterns of the elderly in the home, a scenario for applying AAL was derived.

Today, IoT technology is rapidly and inexorably being incorporated into homes and giving rise to the smart home. A new medical paradigm is being made through the integration of the IoT and healthcare devices that accumulate daily health records into big data. In the future, the fusion of healthcare and IoT technology in residential space will form an AAL healthcare platform.

- IoT + Architecture = Smarthome
- IoT + Healthcare = Daily Healthcare Devices
- IoT + Healthcare + Architecture = AAL Healthcare Platform

An AAL healthcare platform that incorporates IoT technology should become an essential component to combat accelerating super-aged society. As such, this research examined problems inherent to an aged society and indicated complications of fusing smart home and IoT healthcare devices’ with architecture. Furthermore, we introduced a rudimentary direction for an AAL system in future residential space.

IoT technology in the home is expeditiously growing. However, a lack of unified administration – due to current healthcare services and IoT technologies being developed independently – is one of the setbacks. Therefore, construction of AAL housing that allows noninvasive bidirectional healthcare support in real-time is essential. As such, research into standardization of multidutinous technologies in residential space should come first.

Secondly, current research into appropriate in-home health management for the elderly is limited. In particular, research based on elderly behavior should be actively pursued from an architectural perspective. More effective health management will be possible if AAL platforms are based on the behaviors and desires of the elderly in residential space.

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ORCID

Donghyeog Choi http://orcid.org/0000-0002-6171-8257
Hyunchul Choi http://orcid.org/0000-0003-2681-7732
Donghwa Shon http://orcid.org/0000-0002-6737-3894

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