International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

Creating Smart & Barrier Free Environment for Elederly or Physically Restrained People

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***Abstract*:- Smart technology and the Internet of Things (IoT) can play an important role in ensuring the aging of elderly people in society. Focus on telemedicine, while places involving nursing and general built environment have less role in IoT and aging. Prior to, developments in intelligent aging support technology required a user-centric approach and better integration with wider systems. The life of the elderly staying at home. The purpose of this article is to conceptualize smart technology as the smart technology in the partial aging model, which can identify the interaction of smart technology with the built environment and care, and provide a framework for visualizing the interactions that require space. It reviewed the development of the eco-gerontology model and introduced a new model that recognized the role of technology in in-situ aging. Three case studies based on this model, template and the experience of elderly people using smart home devices. , apartment renovation and maintenance reprinted. They are used to demonstrate the "proof of concept" relationship presented in the HAST model and the predecessor of pattern to help people understand smart technologies and their role in supporting care and aging. The position of this document is that technologies such as the Internet of Things will continue to support the role of built environment and care, and provide results that enable the elderly to maintain autonomy, independence, safety and good condition at home. However, through case studies, maintenance issues, cost, and ease of use, some risks have also been identified, and preparation for use is a potential obstacle to the usefulness of considerations and smart technologies.**

Keywords—Intenet of things; architecture; planning; eledrly care; physically challenged; challenges;solutions

1. INTRODUCTION

1.1 SYNOPIS

In research from Stefanov et al. (2004) [1] smart houses are considered a good alternative for the independent life of older persons and persons with disabilities. Many smart devices integrated into the home environment can provide residents with all-weather health monitoring and mobile support. It can work without disturbing the user or causing pain, discomfort or restricted movement, but it can provide comfort and pleasure. It is important to have detailed data on disability and its covariates, as the growth rate of the elderly population (60 years and over) in India is three times that of the general population. According to the 2015 Indian Human Development Survey (a nationally representative panel survey), this is the first time of its kind to analyse the disability and covariates of the elderly from 2005 to 2012. Our econometric analysis clearly shows why the longer life expectancy of the elderly does not lead to a healthier life. The reason is the high vulnerability of the elderly and elderly women (mainly rural population), low affluence, non-communicable diseases (NCDs), insufficient participation in social networks, and increased prevalence of unique disabilities. Although the evidence is not detailed or conclusive, the possibility of an increase in the incidence of elderly people cannot be ruled out. The intent and procedural details of the 2016 Disability Act are commendable, and these details largely fail to mention the disability of the elderly (Kulkarni, 2018) [2].

As design professionals, we must incorporate various barrier-free design principles into the design of traditional apartments to create a housing stock suitable for this generation of special customers stated as per the research by Lueck, 1992 [3]. "*By consistently constructing barrier free environments we will be able to make accessibility the rule, rather than the exception*" (Lueck, 1992) [3]. As part of the comprehensive overview, this document analyses the main components of the smart home, focusing on the health monitoring subsystem as an important component to meet the basic requirements of various sensors implemented from a clinical and scientific perspective. In the later part of the paper there are some important issues of the future development of an intelligent residential space with a human-friendly health monitoring functional system has been discussed

1.2 AIM

To create an independent living for elderly people and persons with disabilities using smart home technologies and barrier free design.

1.3 OBJECTIVES

1. Understanding the needs for maintaining an ease and unobstructed movement into the daily life of targeted people which should be present in the smart home.
2. Creating a smart home environment scenario that is able to deal with doors, windows, light, fire alarm and safety for elders and people with physical disability.

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ISSN: 2278-0181
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3. The development of the floor plan which must be capable of satisfying the housing needs of many of the elderly and disabled individuals who are currently inadequately housed in community settings.

1.4 RATIONALE FOR SELECTION

1. In research from Agrawal (2016) [4], the link between aging and disability is a biological fact, and disability in the elderly is an important health indicator pointing to jeopardized quality of life. Physical Disability is an important public health problem especially in developing countries like India.
2. The problem will increase in future because of increase in trendy lifestyle and change in age structure. The issues are different in developed and developing countries, and some suitable measures should be targeted according to the needs of the disabled with community participation.
3. In India, there is less awareness about the technology called as "Smart Homes". Majority of the India's population do not pay attention to this technology and spend their large life span on traditional technologies or to the one which are less updated.
4. This dissertation report is all about the smart home technologies and creating a barrier free design for elderly people and persons with disabilities as we have a moral duty to do so. But most important, addressing these barriers will unlock the potential of so many people with so much to contribute to the world.
5. In this paper the home automation systems and barrier free design to support elderly and physically challenged people in providing them secure, safe and controlled environment is reviewed. By integrating smart home technology and barrier free design, the life of such people becomes easier and comfortable.

1.5 METHODOLOGY

1. Research question and aim was stated as seeking for the sensitive installation" of mobility aids that don't strip the occupant of his/her sense of independence.
2. Online data will be collected through research papers, articles and journals of professionals.
3. Literature data will be collected for respective disability like dementia and paralysis. Online verified experiments will be considered for observations.
4. New upgraded Smart Home technologies will be studied in terms of assistance.
5. Relevant case studies will be studies to create the best design plan.

1.6 SCOPE

The report will present an approach for eliciting requirements of an SH for PWDs and Elderly People. It will also elicit the essential requirements of an architecture based on the outcomes of a scenario-based user-centred design approach. The smart home can be created by in cooperating home automation systems and barrier free design into our planning. The planning standards and technologies will be discussed throughout the paper to achieve the ultimate goal i.e. to make the elderly and physically challenged population more self-dependent. This integration reduces stress by ensuring safety & security to an individual's home and boosts interdependency.

1.7 LIMITATION

1. The scope of this dissertation is to study various building services automation. There will be no discussion regarding assistive devices.
2. The report will not discuss about any specific medical treatments.
3. This dissertation report will not briefly discuss the cost factor.

1.8 PUBLICATIONS

PAPER-I

Ageing in Place and the Internet of Things – How Smart Home Technologies, the Built Environment and Caregiving Intersect (Carnemolla, P. 2018). *[29]*

The purpose of this document is to ensure that technologies such as the Internet of Things further support the role of the built environment and its maintenance, so as to achieve the result of enabling the elderly to remain autonomous, independent, safe and at home. However, some risks have also been discovered. In the case study, maintenance costs and availability and use preparation issues are potential considerations and obstacles to the usefulness of smart technologies.

Here the major purpose which seems throughout the paper is to examine the nature of the Internet of Things (IoT) system as part of a larger system supporting aging and to examine the role of the built environment and community care. Aging the network in place and integrating it with technology into the new HAST in-place aging model. The HAST model is founded in established environmental gerontology models of ageing in place. Therefore, this article has contributed to the theoretical development of the Internet of Things and aging. Three case studies show each specific relationship proposed in the HAST model, namely the interaction of technology and care, the built environment, and human functions in the home. The relationship between these elements is the key to in-depth analysis of the introduction clever. Moreover, considerable amounts of data might be needed to setup the devices in the design case and the system.

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PAPER-II

Smart Homes for Older People: Positive Aging in a Digital World (Lê et al., 2012).[30]

This article explores the concept of smart home in a technological society and its multi-functional contribution to improving the lives of the elderly. Then, the discussion focused on the challenges of using smart homes for the elderly, such as affordability and ethical issues. In order to lay a solid foundation for further discussion, a conceptual framework of smart home is created. The proposed framework shows that smart homes can be characterized or identified by five main characteristics:

1. *Automation*: ability to host automated equipment or perform automated functions.
2. *Multi-functionality*: ability to perform different tasks or achieve different results.
3. *Adaptability*: ability to adapt the needs of users.
4. *Interactivity*: the ability to interact or interact between users.
5. *Efficiency*: the ability to perform functions conveniently, economically and in a time-saving manner.

This paper highlighted the vulnerable users may not understand whether the technology they use is possible or not. Most computer development ethical codes assume that users understand the technology, suggests that certain aspects of information discussion and learning are not only including users, but also their direct social networks, such as family, friends, and service providers. PAPER-II describes the best general and social factors.

PAPER-III

The Smart House for Older Persons and Persons With Physical Disabilities: Structure, Technology Arrangements, and Perspectives (Stefanov et al., 2004). [31]

Paper-III, showed that for the elderly and the disabled, smart homes are a good choice for independent living. Many smart devices integrated into the home environment can provide residents with all-weather health monitoring and mobile support. Modern home-installed systems tend to be not only physically versatile in functionality but also emotionally human-friendly which means that they can perform their functions without disturbing or harming the user. Pain, discomfort, or inconvenience that is most likely to bring you comfort and happiness. As part of the comprehensive overview, this article studies the main components of the smart home, focusing on the health monitoring subsystem, which is a key component that meets the basic requirements of various sensors implemented from a clinical and scientific perspective. This paper also discussed the modern innovations or we can say the devices like WHERE/RITY/MANUS (devices) which makes an integrated smart home environment. In this paper futuristic IRH models have been also discussed which can be embedded into the variety of scaled spaces. The content fetched from this paper helps in categorizing the various environments and creating a complex environment which is user centric which ultimately helps in creating a barrier free design.

PAPER-IV

Energy Efficient Smart Home Automation Adoption- A Research ("Energy Efficient Smart Home Automation Adoption- A Research," 2019) [32]

Through this paper we have captured a different side of the SHTs where it says that with the advent of technology, the use of household appliances and the use of infotainment, entertainment, and communication technologies have grown at an alarming rate, but the energy consumption of these devices has also increased, requiring slow learning and planning of energy management. Control and control household energy loss caused by poor management of household appliances and home automation equipment.

The Internet of Things technology brings "smart home automation system." Home Automation also referred to as "Domotics", the process in mechanizing homes using IoT that would allow owners to control lighting, temperature, music systems and other electrical appliances via use of computers or handheld devices such as smart phones or tablets. Apart from the obvious benefit of the ability to remotely control, a home automation system offers multiple benefits such as enhanced security, energy efficiency, monetary savings, comfort & convenience and peace mind to a household that would adopt it. This paper attempts to determine which of these factors are most relevant and important to consumers, which may lead to the introduction of home automation systems and what are the factors which are of paramount importance when it comes to energy efficient home automation.

PAPER-V

Energy saving in smart homes based on consumer behaviour data (Zehnder, 2015) [33]

This paper notifies that apart from making smart home we do not have any standardized or generally accepted method to measure the intelligence of the system. The recommendation system developed in this research project is such an independent operating system. However, its intelligence is evaluated based on energy saving without loss of comfort. This paper paves a way to save energy without causing serious inconvenience to consumers. Therefore, it uses data from key devices recorded by existing smart home automation to analyse the behaviour in the house. The recommendation system gives suggestions for energy saving in smart homes, which would be really useful in our dissertation to propose a system in such a way where the environment is being smart with energy saving. Recommendations are based only on available event data. In addition, users should not configure parameters manually, the system is completely self-sufficient, and there is no interaction between consumers and the system except for energy-saving recommendations. Hence this paper does not discuss the physical

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

disabilities or its assistive smart technologies. It has just determined the behavioural pattern, which is sufficient and going to useful to support us in the design implementation part.

PAPER-VI

Smart Home Design for Disabled People based on Neural Networks (Hussein et al., 2014) [34]

As per this article, in order to make the daily life of people with disabilities easier, researchers have combined technologies such as computers, networks, and telecommunications in an environment called a smart home. The interesting thing about this work is that it allows them to overcome their disabilities by providing a system to replace what they lack. It have been achieved by integrating two types of neural networks into our system. The author developed the first prototype covering part of the theoretical design then further transformed the prototype into a real home from which the disabled can benefit. This paper also has software prototyping and data recorded through software simulation with respect to the monitoring of smart home technologies. Although this simulation is way technical portion, but might be useful for the research paper and its findings. We may use this content as a base data for our design development.

2. LITERATURE REVIEW

This chapter of the dissertation report will review the various challenges and disabilities that are faced by the people and what through other research papers, have shortlisted the various categories in smart home technologies.

2.1 CHALLENGES WITH DISABILITIES

When we talk about ageing, disabilities comes with it automatically because it is a natural process. Here term “disability” is used to refer all problems which comes along with the age and cannot be ignored. With rapid urbanisation and industrialisation the young age group of the society gets busy with their work by leaving their parents alone at home. This could be different in some case where senior citizens of the society are abandoned by their families, which is really painful. Case with people with disabilities is slightly different; some of them have been unfortunate by birth and are taken care by their families (care taker) or some who got unfortunate due to some accident or shock. The percentage of these people is lesser as compared to that of abandoned old aged parents, through the research done by Veena S.et al.,2018 [5] A smart home environment brings us an opportunity to avail independency to such people in the society. Conventional method of taking care is just not sufficient for them. As per the research by Carnemolla, 2018 [6] various old aged cases have been taken and showed that smart environment can help these oldies emotionally, physically and mentally better and not just this it even helps the care taker to monitor them through a distance. SHTs help in monitoring and recording the useful data throughout.

Conventional old age homes are just the shelter spaces; it does not have the ability to boost their inner will to live life again. Absence of active care takers, no proper areas for their refreshment limited people to interact with (they usually discuss the misfortune happened with them). *“Home automation creates an independent living environment for elderly and disabled persons that focuses on making it possible for these people with disabilities to remain at home, safe, lively and comfortable”*(Stefanov et al., 2004) [1] Keys to the housing satisfaction of the elderly and disabled are as follows:

1. Enabling them to live in familiar communities.
2. Sensitive installation of mobility aids that don't strip the occupant of his/her sense of independence
3. Removal of all barriers (both physical and psychological)

Different structures are designed to adapt the specific needs and physical limitations of the user. The concept of smart home is usually used for people with special needs (PSN). Smart homes vary according to the type and location of the installed equipment and can be divided into the following groups:

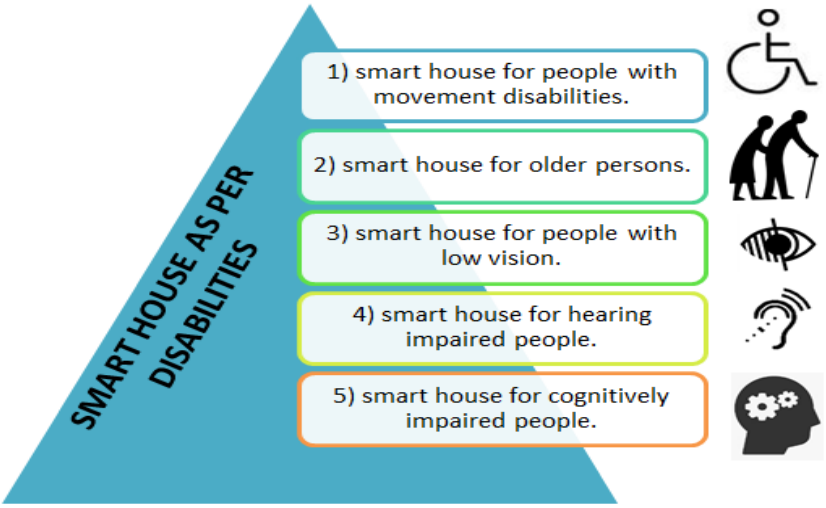

Fig.1 Smart House environments for various disabilities, Author, 2021

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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According to new research (Carnemolla, 2018) [6] Internet of Things (IoT) is a term that relates the connection of material devices to the internet as diverse as domestic appliances to health monitoring equipment to vehicles. Once connected, each thing is attributed a unique network address making it identifiable. Its sensor mean that it has the capacity to register changes to its environment and transmit that information over the internet, as well as the potential to store and process information, or independently initiate action (Yan et al., 2019) [28]. Applications of IoT have the potential to play a significant role in enabling older people to Age in Place. In this paper the IoT technology analysed is limited to smart home technologies – devices that relate specifically to managing tasks in the home environment – and health monitoring technology (Carnemolla, 2018) [6]

2.2 GENERAL STRUCTURE OF A SMART HOME

Several devices in the smart home installed in the home are connected to a common home network system. The home network is also connected to the health centre through a data link that transmits health data about residents and equipment installed in the house. The same channel is used for audio and video conferencing and remote control and configuration of equipment in the house from the care centre. Following figure explains the basic structure for any smart home which is needed to be installed. It also shows how internet of things helps connect a care taker sitting far from their people.

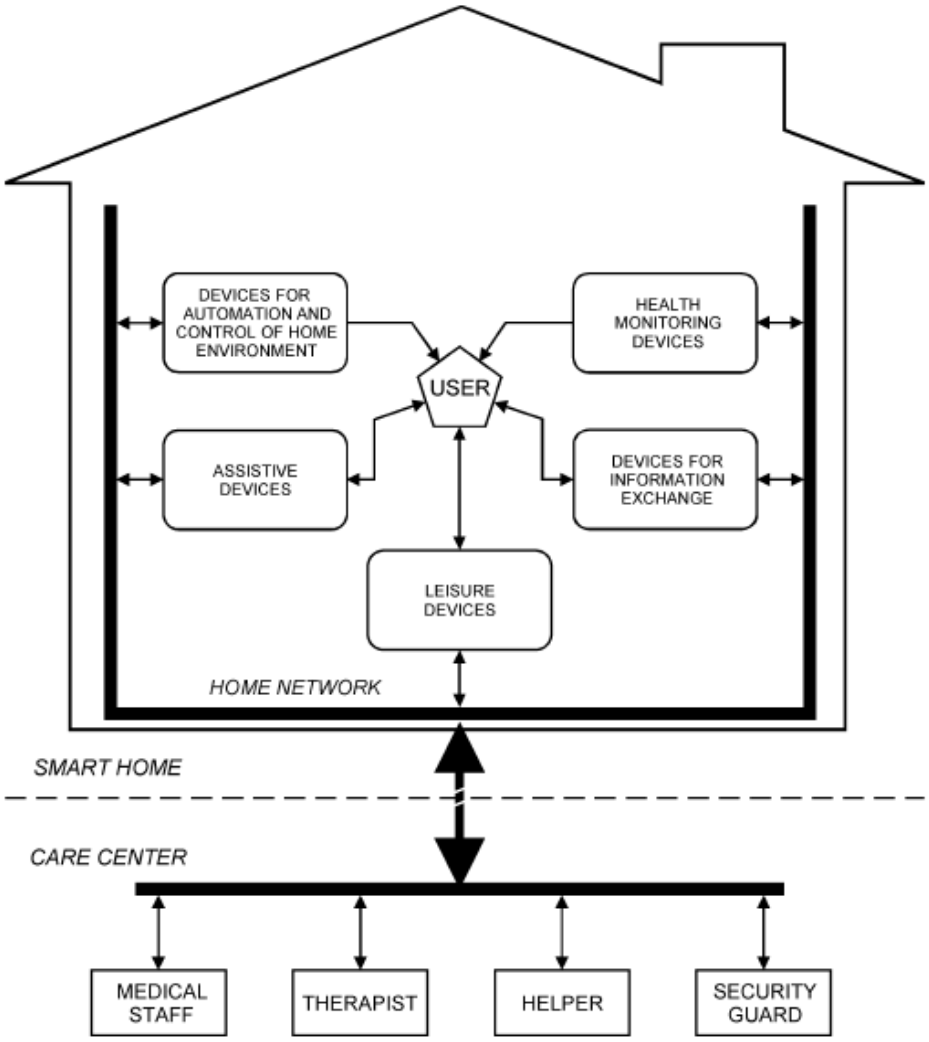

Fig.2 Smart house structure (Stefanov, 2004)

2.3 DEVICE CLASSIFICATION

Some people may need more than one kind of technology—for example, people with both movement and vision problems need technology for movement support as well as magnifiers and other vision interface. According to research (Stefanov et al., 2004) [1] regarding their functions, the installed devices can be classified into the following five groups:

1) Devices For Automation And Control Of The Home Environment
2) Assistive Devices
3) Devices For Health Monitoring Of Important Vital Parameters
4) Devices For Information Exchange
5) Leisure Devices

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The proper choice of the devices should give the user an integrated feeling of confidence for mobility, manipulation, communication, and environment control.

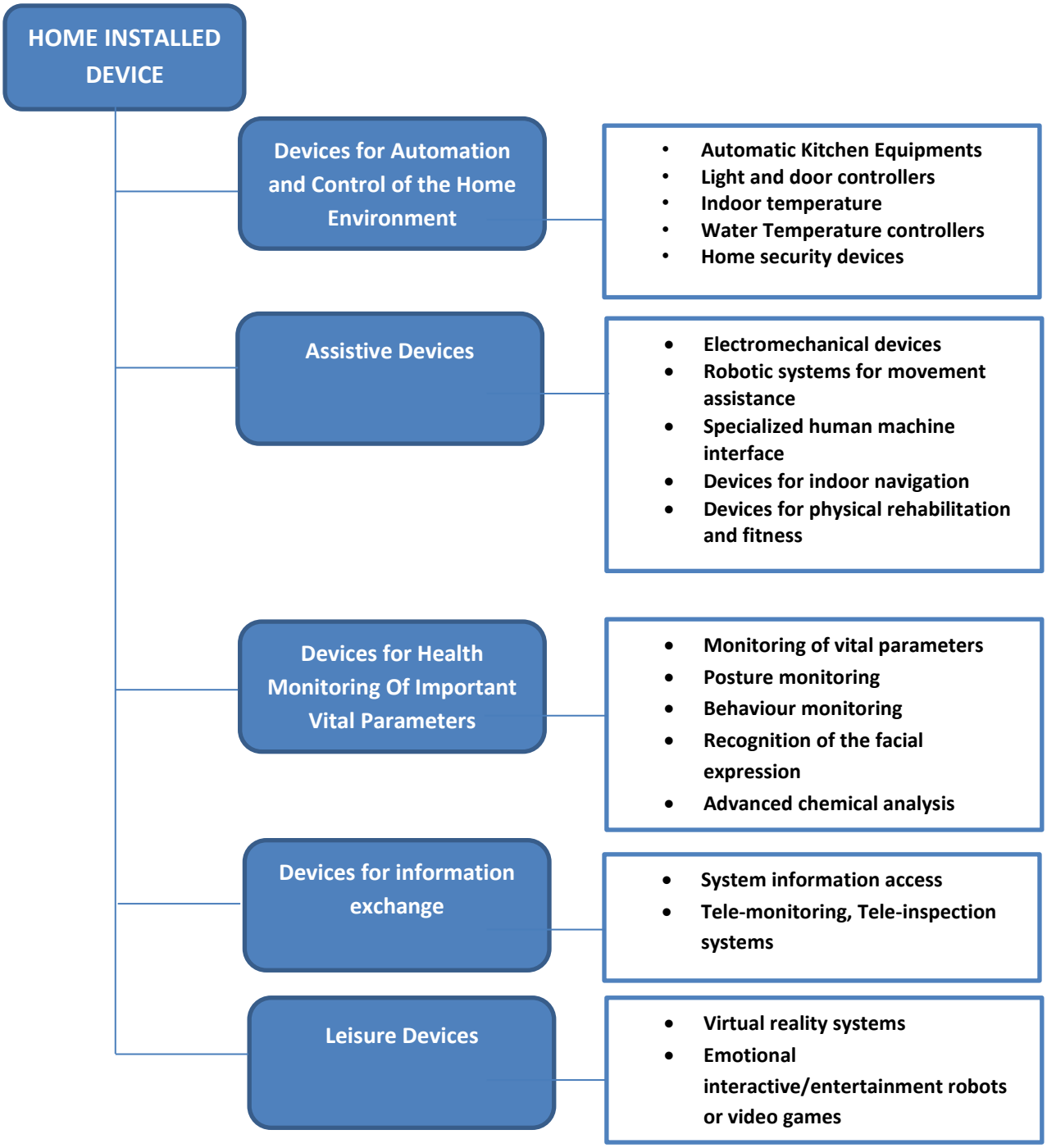

Table 1.(b) Analogies In Other Aspects Of The Human Skin And The Building Skin

3. TECHNOLOGICAL ASPECTS OF DEVICE CLASSIFICATION

3.1 DEVICES FOR AUTOMATION AND CONTROL OF THE HOME ENVIRONMENT

One can find that there are various kinds of devices for automation and control of the home environment, such as:

1. **Automatic Kitchen Equipment**- Includes washing machines, programmable electric ovens, dishwashers, etc., suitable interface should be provided in the form of a large size display, simple command setting, suitable hand gripping devices, and switches.
2. **Light And Door Controllers**-Automatic windows opening/closure, remote control of entrance doors, kitchen appliances, and lights.

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3. **Indoor Temperature Controllers**- Technically-advanced structures of the home environment often integrate subsystem for temperature and humidity control.
4. **Water Temperature Controllers**- Water inflow and overflow system
5. **Home Security Devices**-The measurement of the concentration of gas, carbon dioxide, chemicals, anti-theft alarm systems.

The **goal of *HOME-AOM*** (*Home applications Optimum Multimedia / multimodal system for Environment control*) was **to develop a multi-modal system**, **facilitating remote control of a variety of household appliances by speech, gestures, touch- sensitive displays (*touch screens*) and telephone.** (*DOMOLOGIC - HOME-AOM*, n.d.) [7]

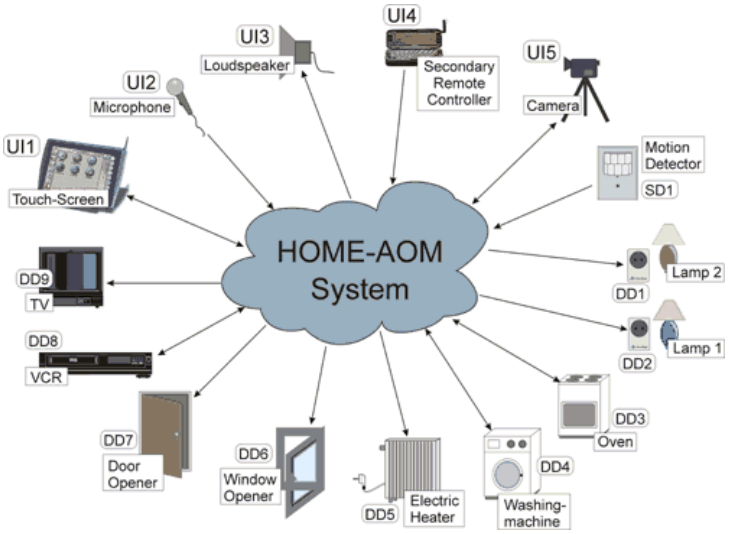


Fig.3 (*DOMOLOGIC - HOME-AOM*, n.d.)

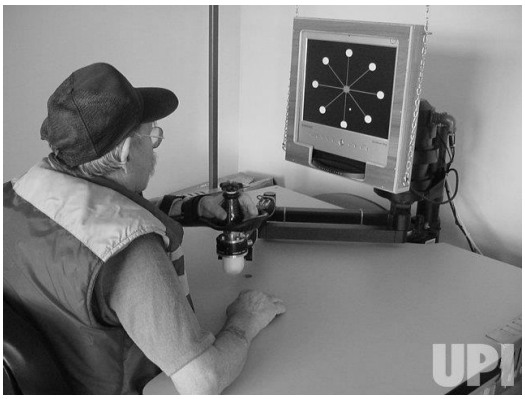
3.2 ASSISTIVE DEVICES CATEGORIES:

1) Electromechanical Devices For Movement Assistance-Typical EDMA include powered wheelchairs, specialized lifting devices for transfer of the user between the bed and the wheelchair, specialized standing-up devices for powered wheelchairs, bath lifts, walking and lifting aids. Some highly effective powered wheelchairs named the INDEPENDENCE IBOT Mobility System and developed by Dean Kamen**.**

2) Robotic Systems For Movement Assistance

a. Desktop mounted robots
b. Wheelchair-mounted robots

Mobile autonomous robots



MANUS

THE INDEPENDENCE IBOT

3) Specialized Human-machine Interface- HMI refers to the operational sub system to control a wheelchair, rehabilitation robots, and other home equipment such as telephones, lamps, doors, home security systems, TV sets, etc. Movement paralysis affected, able to make only a few preliminary motions as the commands, head-tracking devices, facial detection optoelectronic detection of light-reflective head-attached markers, eye-movement control, brain control, Voice control.

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4) Gesture-based human–machine interface-

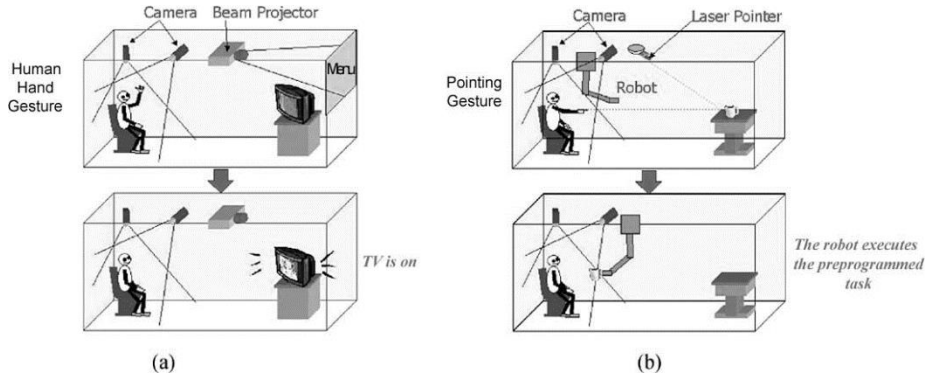

Fig.4. (a) Soft remocon and Pointing recognition system
(b) Pointing recognition system (Stefanov, 2004)

Fig.4 **(a) Soft remocon**—The user's hand gesture is automatically recognized by the TV-based image recognition system and the desired action ("Turn the TV on!") is executed, according to research done by Stefanov et al., 2004 [1] states.
(b) Pointing recognition system— The user displays the object to be replaced, and the robot performs a predetermined task by pointing to a specific object.
4) Devices for Indoor Navigation - According to the remote sensors installed in the house to determine the user's current location, they will issue synthetic voice commands to navigate and warn of possible obstacles along the suggested route. *Some wearable, hand-held, or cane-located personal sensor-based navigation devices for obstacle detection (such as an "artificial guide dog for blind people)* (Bhatlawande et al., 2014) [8].
5) Devices For Physical Rehabilitation - Used both by persons with physical disabilities and by older persons. **WHERE** developed at KAIST. The system is used for gait rehabilitation and assists users in walking by providing body weight support. The system will automatically detect the user's intention of walking speed and direction of travel (Stefanov et al., 2004) [1].

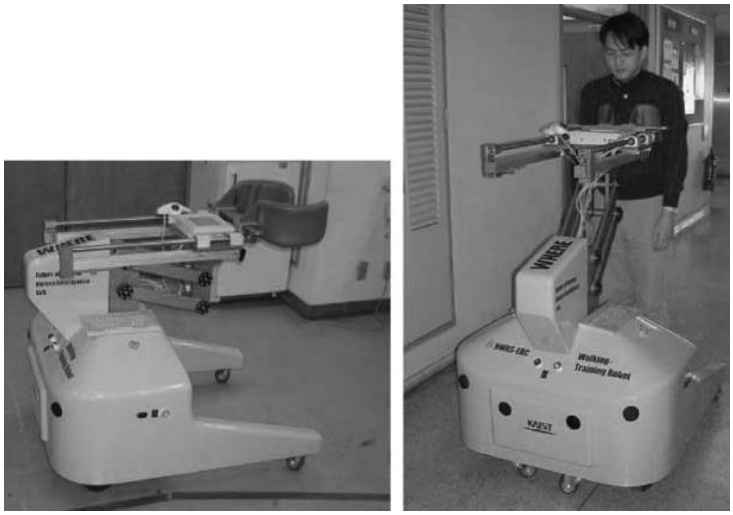

Fig.5 WHERE developed by KAIST to assist in navigating indoor spaces. (Bien & Stefanov, 2004)

3.3 DEVICES FOR HEALTH MONITORING OF IMPORTANT VITAL PARAMETERS

The structure of the personal health monitoring system is initially processed in the user's home, the health monitoring parameter data is transmitted to the medical centre, and the same data channel is used to remotely control the sensor equipment in the home and communicate with the residents.

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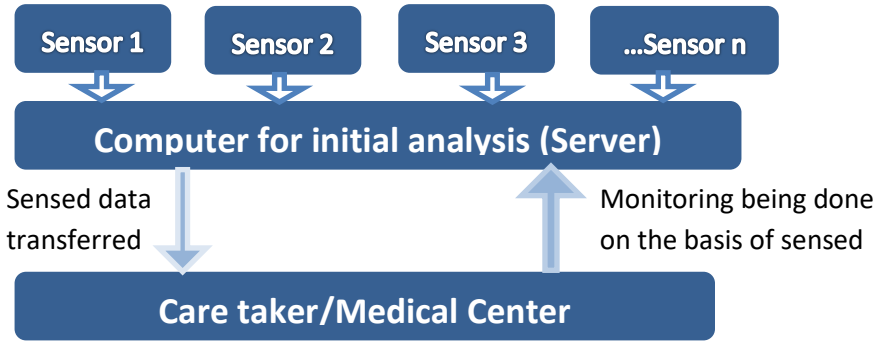

The following are frequently mentioned requirements of the sensors:
1) Non-invasive and Wearable
2) Convenient To Install, To Wear, And To Use
3) Minimal Restriction on the Normal User Movements
4) No Vibrations, No Noise, or No Light Signaling During Measurement
5) Minimal High-frequency And Light-energy Emission to the User
6) Insensitive to Motion Artifacts and Electromagnetic Interferences Caused by Other Sensors or home appliances
7) High Reliability and Long Life
8) Wireless Signal Transmission
9) Automatic Measurement
10) Waterproof And Easy For Sterilization
11) Low-power Consumption In The Case Of An Autonomous Energy Source.

3.4 DEVICES FOR INFORMATION EXCHANGE

The following systems and devices can be counted as items in this group for information exchange:
1) System for Information Access And Telecommunication;
2) System For Tele-monitoring, Tele-inspection, And Remote Control
3) Home Network.

3.5 LEISURE DEVICES

Virtual reality systems can entertain laymen through options such as interacting with virtual objects or playing games. Contact with virtual dialogue partners can increase the emotional comfort of elderly people living alone and ease their emotions. These computer programs can generate an image on the screen of a virtual interlocutor whose face, behaviour, and voice are similar to what the user likes, so it can simulate a natural conversation with the user.
Virtual creature “RITY” and his virtual world. The artificial creature can decide its behavior by itself based on its own motivation, homeostasis, emotion, and external sensor information. A user can teach the creature to do a desired behavior by an interactive training method. (Yong-Duk Kim et al., 2004) [9]

3.6 A FOUR LAYER ARCHITECTURE FOR SMART HOME

To create a smart home environment other than general structure, we need to have a four layered architecture based smart home system. These four layers will act as the base to setup and run the function of SHTs properly. In other words, these layers are the basic components of and smart supporting system. Smart homes can have a series of environmental, physiological and activity sensors, actuators connected through wireless environments, smaller and low-power systems of sensors, actuators and transceivers, as well as modern communication technologies and low-cost computer platforms, such as programmable Gate arrays, microcontrollers, and microprocessors paved the way for low-cost smart home systems.

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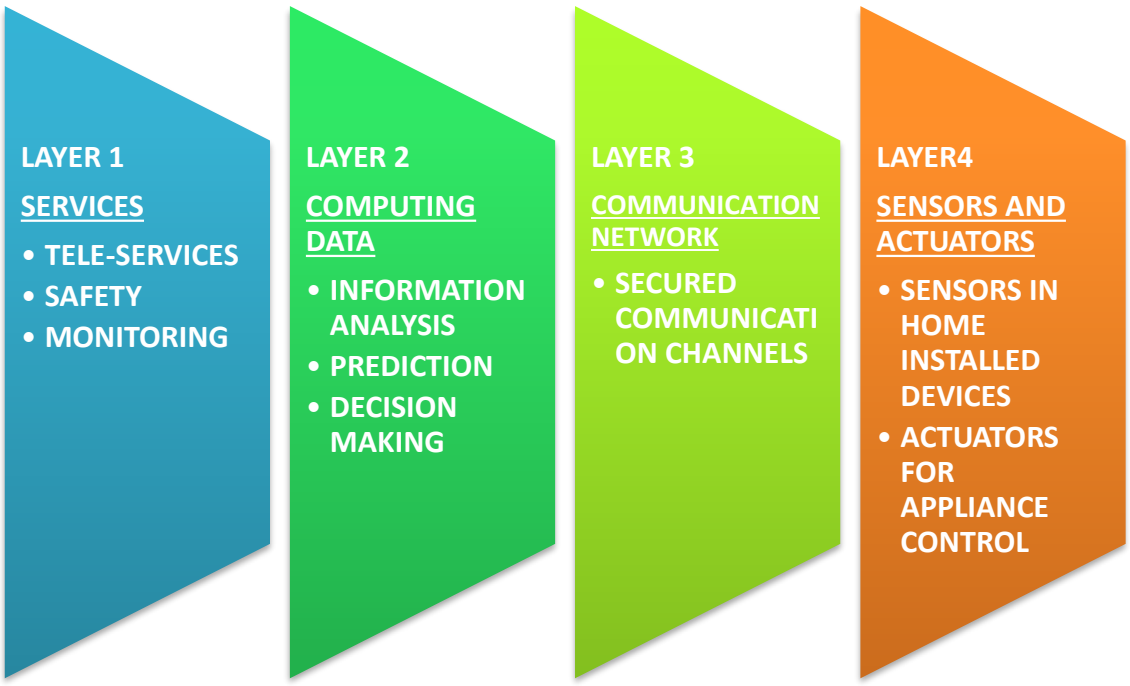

Fig.6 Four layers of smart home system. (Author, 2021)

Sensors and Actuators - Sensors and actuators play a key role in smart homes, bridging the gap between the physical world and the digital world (i-SCOOP, 2021) [10]. Smart homes use various sensors to collect data about the home environment, such as light intensity, temperature, and pressure. , Gas leak, oxygen level. And the movement or location of people using inertial units, RFID, or passive infrared (PIR) sensors. In research from Sagl et al. (2019) [11] portable devices can be used to measure physiological parameters such as blood pressure, heart rate, SpO, and galvanic skin response (GSR). Actuators can monitor or control the environment by performing small actions to respond to feedback from passengers or the central decision-making platform. Insulin and other drugs in passengers. These sensors and actuators can communicate with the central computer and make decisions. Sensors, especially wearable medical sensors, must be energy-efficient and cautious to achieve long-term monitoring. Sensors and actuators with integrated energy harvesting technology can effectively increase the running time of outpatient equipment.

Communication Network – All sensors and actuators in the smart home are connected to the central communication and decision-making platform through the communication network that forms the second layer of the smart home architecture. All physiological and environmental signals measured by the sensors are transmitted to the central data centre (Majumder et al. (2017) [12]. Nodes through wired and/or wireless communication media. Although wired connection is a possible solution for fixing environmental sensors, it is not suitable for portable monitoring systems. In the long run, the wired connection of a portable BSN will cause inconvenience to users, and restrictions may also lead to unexpected failures in the connection between body sensors. As an alternative to wired connections, conductive media based on textiles (such as conductive fabrics) can be used to communicate with body sensors. Conductive fabrics can be made using traditional textile techniques, such as weaving, sewing, embroidery, and screen printing. However, conductive fabrics have poor durability and limited washing ability, resulting in poor or insufficient adhesion after long-term use. Therefore, the current low-power wireless communication technology seems to be the most practical and reliable medium for short-range communication.

Computing and Decision Making Platform- The third layer of the smart home architecture is responsible for calculation and decision-making, thus acting as the brain of the system. This level is equipped with computer systems, such as smartphones, computers, or dedicated processing units based on programmable gate arrays (FPGA) or microprocessors. According to research (Krishnamurthi et al., 2020) [13], it collect data from sensors and actuators on WSN, process and analyse measurement data, and send feedback to users or actuators. It can also store measurement data, display the results to the user, and perform algorithmic prediction

Services- The upper layer of the smart home architecture consists of the services provided to users by service providers. These services may involve the health, environment, safety of the residents or the protection of the house and the residents. According to medical level or safety protection requirements, smart homes can adapt to the needs of residents. In smart homes, the gateway platform acts as a central service provider, such as the actuators required for control. Housing condition, door lock or delivery, automatic delivery (Majumder et al. (2017) [12]. The gateway system can use artificial intelligence technology to assess the safety and environment of the home, control smart devices, and better serve residents. The gateway can continuously check and monitor the physiological status of residents through wearable health sensors connected to the BSN. The artificial intelligence technology implemented in the gateway allows you to control the smart devices in the smart home. Customize your living

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environment you can also use environmental sensors installed in different locations of the house to monitor your living environment and detect dangerous situations, such as smoke or gas leaks. In the event of abnormal physiological or environmental conditions, the gateway will issue an alarm and send electronic notifications such as e-mails, text messages, and phone calls to auxiliary devices. Service providers. The secondary service provider is the backbone of all connected smart homes, responsible for the management, maintenance, connection and information security of the network and smart home systems. Continuously monitor alarms or emergencies, and immediately notify other third-party services, such as emergency services (EMS), caregivers, police stations, and fire stations when necessary (*MegAlign Pro Tutorials - User Guide to MegAlign Pro - 15.2*, n.d.) [14].

3.7 RESEARCH GAP

Through empirical evidences in this study, like literature study and virtual case studies, identification of the factors and levels that are relevant to solve the current subject problem is being done. Also, finding out the appropriate design approach through all the relevant collection of the data.

There are two major methodologies in Biomimetic design based on two major phases: **The Preliminary Design Phase and Superior Phase**. The Preliminary Design Phase involves elderly and physically disabled challenges investigation and the problem exploration which leads to the development of design concept. Here, we have considered the conceptual design/ prototyping the integration of the Barrier free standards and smart home technologies.

4. CASE STUDIES

4.1 CASE STUDY -A | Defining the problems/Testimony

Case 1 (Amrita 70 year old) (Stony Brook University, 2020)

Amrita is an increasingly frail 70-year-old with arthritis and gastro-oesophageal reflux disease (GORD). She is recently widowed and her family live interstate. Amrita lives alone and has following problems:

- Cognitive impairment (Loss of memory, depression, mental imbalance)
- Moderate/complete loss of sight
- Moderate loss of hearing
- Poor balance
- Poor body stamina
- Loss of upper extremity skills
- Difficulty in bending, kneeling
- Need walking aids

Case Highlights: Recently, Amrita had a fall in her bathroom tripping over a bath mat and broke her wrist. Her daughter came to visit while she was in hospital and set up smart home technologies to support Amrita to live more safely while remaining independent. Home modifications were also installed in the bathroom.

SHT installed:

- Automatic Light Sensors.
- PIR motion sensors
- Automatic door and window sensors.
- Smart reminders
- Water and temperature sensors.
- Automatic sprinkler system
- Video camera

Built environment

- Low height counters
- Grab rails at washroom
- Anti-skid flooring
- Minimum walls

Amrita's results are positive. The sensor light has improved Amrita’s confidence when moving from the bed to bathroom at night. Amrita's daughter is more comfortable and believes that changes in the environment, including light sensors, will make Amrita's home safer.

Case 2 (Mr.& Mrs. Nair 82 & 76 year old) (G. Singh, personal communication, July 04, 2021)

Mr. Nair is 82-year-old with arthritis and dementia. He is a retired railway officer and his son lives interstate due to his job and visits him occasionally. Mr. Nair lives with his wife who is 76 years old with few problems related to age only. They both live

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alone far from their live support. Mr.Nair has been suffering from dementia since 1.5 years and it has now become really worse. His wife also cannot perform all the activities spontaneously. And even sometimes when Mr. Nair receives panic attacks she gets panic and rush to neighbours for help. The case has following problems:

- Moderate loss of hearing
- Poor balance
- Poor body stamina
- Loss of upper extremity skills
- Difficulty in bending, kneeling
- Reliance on walking aids
- Dementia
- Anxiety
- Moderate loss of sight

Case Highlights: Mr. Nair uses a walking aid and has been feeling depressed since losing his memory and power of recognition of things around him and frustrated as he cannot do or help his wife in many of the household tasks he expects of himself. A recent panic attack at night due to lack of social interaction and unable to go outside and meet people created a major problem for him and his wife as well. After being medically treated his son arranged and setup a smart environment for his parents to make them feel better and live independent and to keep their 24x7 record.

SHT installed:

- Automatic Light Sensors.
- PIR motion sensors
- Automatic door and window sensors.
- Smart reminders
- Water and temperature sensors.
- Automatic sprinkler system
- Video camera
- Interactive devices with applications(playing music, interactive games, religious stories)
- Gesture recognizing T.V.
- Automatic Kitchen equipment
- Health monitoring through WSTs

Built environment:

- Low height counters
- Grab rails at washroom
- Anti-skid flooring
- Daylight exposure
- Green areas/ open sitting
- In built closets
- Minimum walls

Mr.&Mrs.Nair's results came better. The sensor based smart home helped his son to keep a check of their body temperatures and coordinate with the medical team easily .The interactive technology devices like Alexa, Google assistant reduced their anxiety and made him to chill and relax and do not let him to even give a thought about any ignorant topic. Now, with automatic kitchen equipments it has availed Mrs. Nair to cook quickly and healthy and spend some time with his husband which plays a major role in coping up with his anxiety.

4.2 BUILT ENVIRONMENT - CASE STUDY 1

MELIA FIRST CITIZEN

By Silver glades Sohna Road, Gurgaon

Smart and artificial intelligent homes powered by Amazon Alexa

Located in the foothills of Aravalis; First Citizen is part of The Melia's 17.5-acre parish and NCR's first high-level parish in Delhi. The concept behind this residential development is to combine first-class high-end residential areas with quality-conscious housing in modern communities to provide services for those seeking a beneficial lifestyle in a quiet and comfortable place near Gurgaon. First Citizen is strategically located in the Sohna, 35 area south of Gurgaon. It is quiet, safe and easily accessible from all corners of Gurgaon. There is nice connectivity with the city services. First Citizen enviably combines pure luxury and suburban living, heralding the next step for nursing homes by providing a series of comfortable one- and two-bedroom apartments. Silver glades is a partner of Age Ventures India (AVI), a non-profit organization. An organization that provides knowledge about how these families should make the elderly feel comfortable, what services and amenities they should elderly and elderly care in India Pacifica; the leading nursing home specialist in the United States. (*Silverglades*, 2019)

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[15] Meticulously designed by Arcop with profound understanding of ageing, First Citizen Homes incorporates special senior friendly features.

Fig.7 (*1BHK, Floor Plan 2019)*

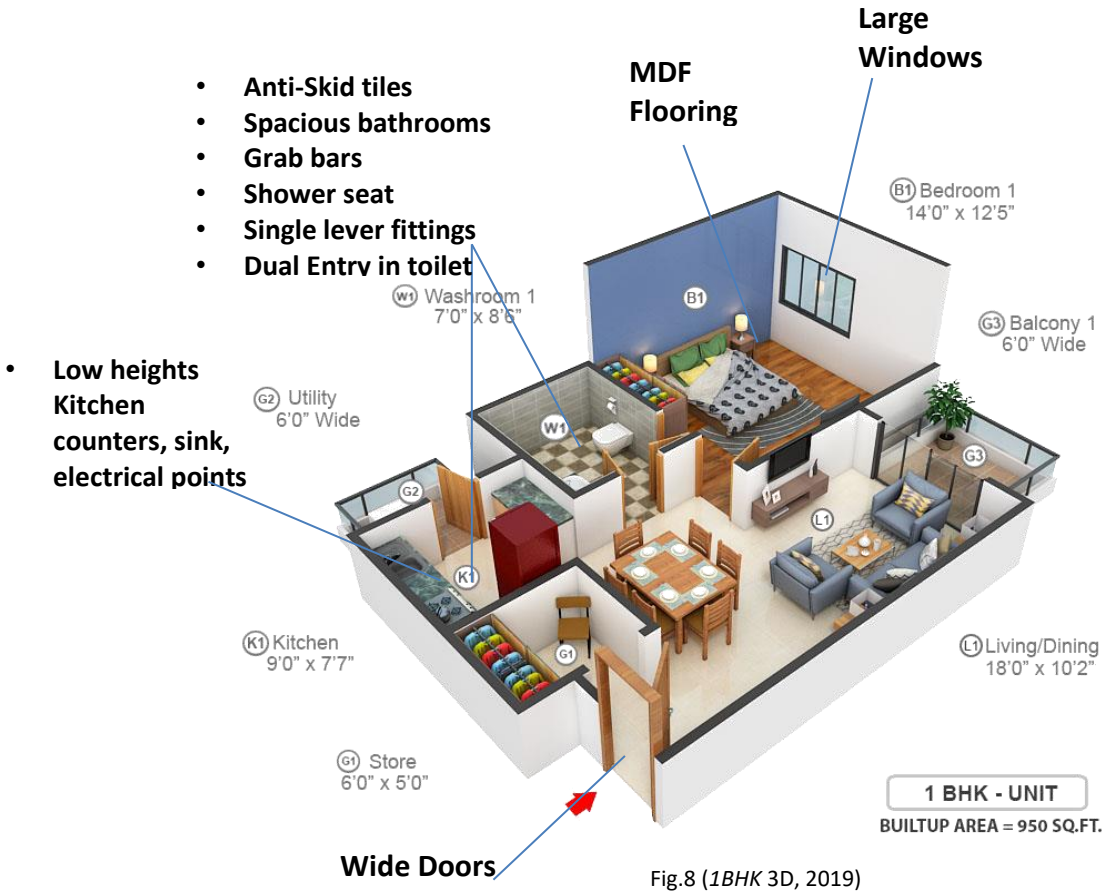

Fig.8 (*1BHK* 3D, 2019)

More features

- **Round corners**
- **Package shelves**
- **Double night peep holes**
- **No split levels**

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Apartment Features (2BHK)

Fig.9 (a) (*2BHK*, 3D, 2019)
Fig.9 (b) (*2BHK Floor plan*, 2019)

Apartment Features (2.5BHK)

Fig.10 (a) (*2.5 BHK*, 3D, 2019), (b) (*2.5 BHK*, floor plan, 2019)

- **Anti-Skid tiles**
- **Spacious bathrooms**
- **Grab bars**
- **Shower seat**
- **Single lever fittings**
- **MDF Flooring**
- **No split levels**

- **Large windows**
- **Low heights Kitchen counters, sink, electrical points**

More features

- **Round corners**
- **Package shelves**
- **Double night peep holes**
- **No step entries**

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Integrated Features of apartment into 3 categories and smart technologies embedded into it

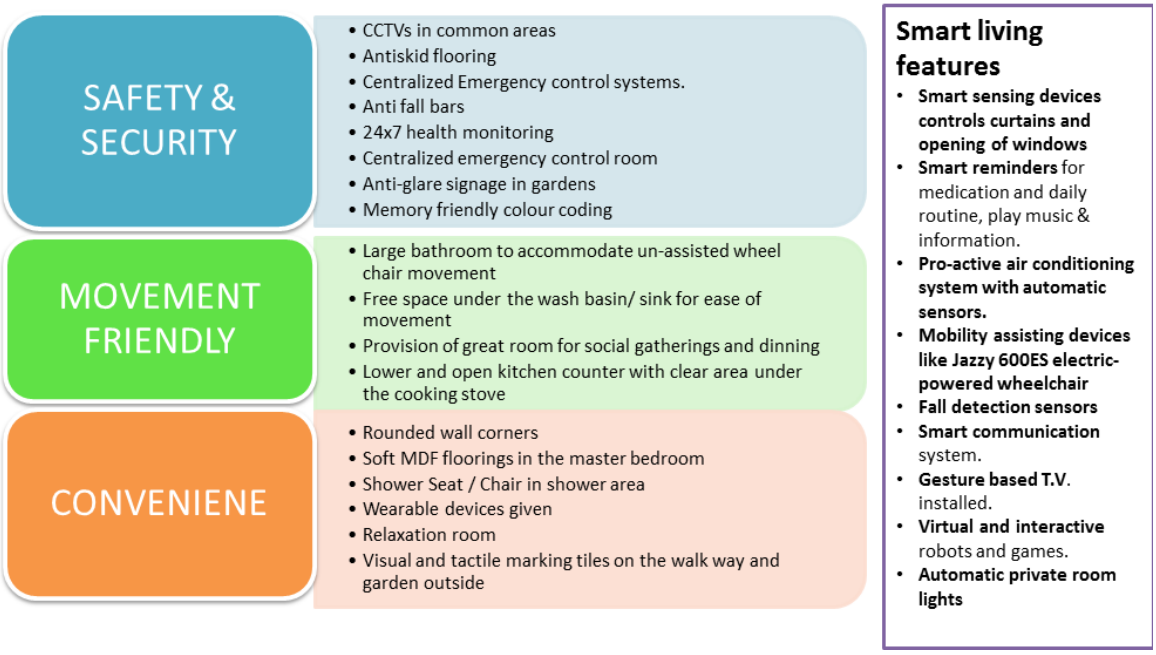

Fig.11 Integrated Features of apartment, Author,2021)

4.3 BUILT ENVIRONMENT - CASE STUDY 2

THE BURNHAM FAMILY MEMORY CARE RESIDENCE

Hartford, Connecticut

By Amenta Emma Architects

The Burnham Family Memorial Care Residence in Avery Heights transformed a 10,000-square-foot former independent apartment building into a safe 20-unit apartment building for seniors with dementia. 25% of the indoor space is dedicated to the living room/dining room/kitchen area, with plenty of natural light, leading to a large outdoor terrace and garden. The interior has a fireplace, a seating area, a rustic kitchen, two independent study rooms and a large public area. Dining table and other private dining tables for two and four people. The interior decoration and lighting are designed to add a warm atmosphere to the home, while at the same time make up for the impact of the elderly's vision loss due to the high light level and the sharp contrast between the floor and the wall surface. A large terrace for socializing, a winding sports path and a garden pavilion for reflection and relaxation. Plants are carefully selected mixtures of native species with various textures, colours and smells to stimulate the senses. (Amenta Emma Architects, 2020) [16].

Various Areas of Site Plan

1. Great Room
2. Pantry
3. Entry Alcove
4. Snoezelen/Relaxation Room
5. Laundry/Electrical
6. Nurse Office/Family Meeting Room
7. Residents Room (Typ.)
8. Outdoor Living Area1
9. Garden Seating Area
10. Raised Activity Planter
11. Arbor/Gate
12. Garden Fountain/Perennials
13. 6 ‘Fence with Lattice Top
14. Garden Path
15. Birdbath/Butterfly Garden
16. Gazebo/Gathering Area

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Fig.12 (a & b) Explains the interiors of the care centre residence, Amenta Emma Architects 2020

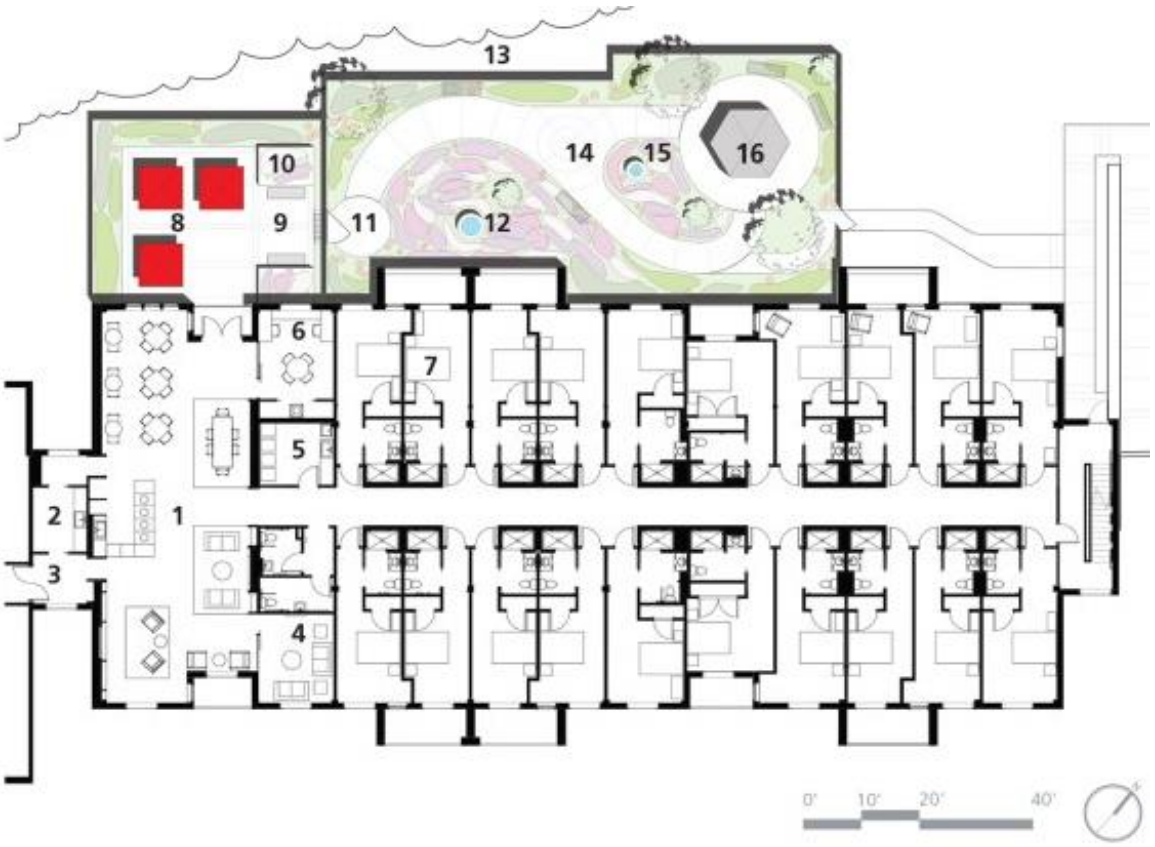

Fig. 13- Site plan, Avery Heights. (2020, September 18)

"25% of the interior space is a dedicated to a day light Interior features: A fireplace, sitting area, country kitchen, two private Activity Rooms, a large communal dining table and more private two and four person tables" (Amenta Emma Architects, 2020) [16]. The interior design and lighting are designed to bring a warm and familiar feeling to the home, while also compensating for the visual impairment of the elderly with high illuminance and sharp contrast between the floor and the wall surface. The outdoor area includes a large patio for socializing, a winding movement path, and a garden pavilion for reflection and relaxation. Plants are carefully selected mixtures of native species with various textures, colours and smells to stimulate the senses.

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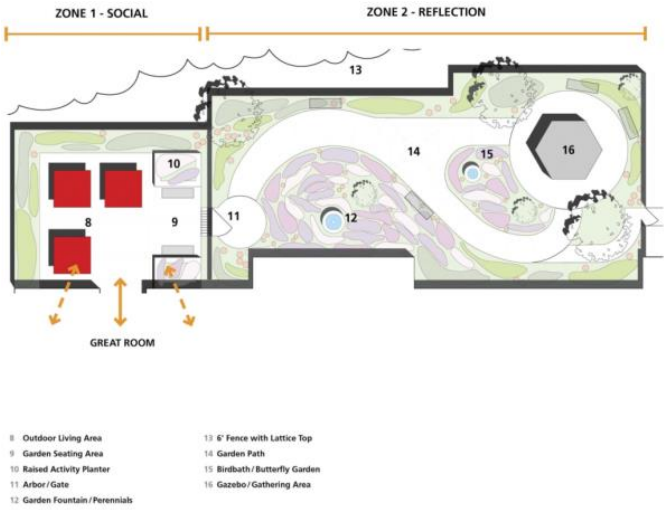

Fig.14 Garden plan Amenta Emma Architects, 2020

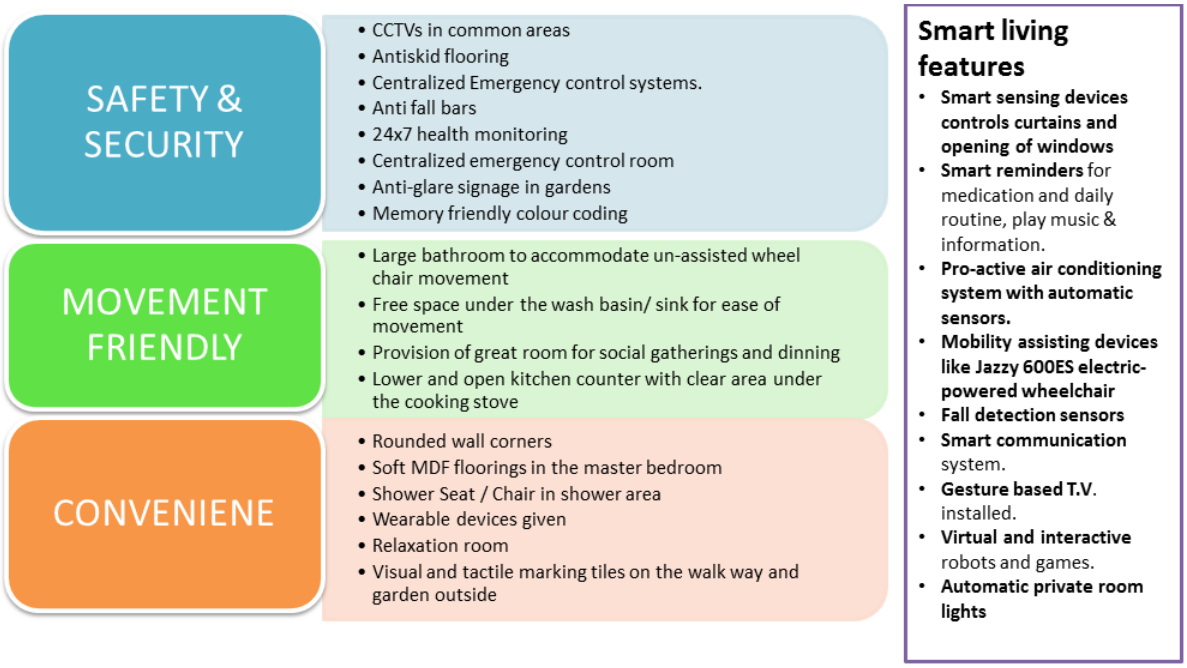

Fig.15 Integrated Features of care centres, 2020

Strategies found on the basis of case studies and literature studies need to be implemented into the floor plan options are as follows:

- General barrier free guidelines must be followed while planning the spaces.
- Planning must be done with respect to the levels of disabilities.
- Material selection plays a vital role.
- In order to make it more efficient proper installation and training must be done for all the installed technologies and systems to the primary and secondary user.
- Power backup is extremely important
- Technologies most required are:
  - Smart sensing and reminding, smooth movement across the space/PIR sensor.
  - Smart fire extinguisher system
  - Automatic sensing and on/off systems for toilets and kitchen and main doors

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- Adjustable kitchen and washroom counters
- Leisure or religious interaction games, programs must be present.
- Automatic Doors and windows
- Smart inbuilt closets
- Smart Water meters
- Health monitoring(B.P, Pulse rate, weight, BMI, Glycaemia, SpO2, ECG) (wearable / non wearable)
- Mood Recognizer and up lifter
- Automatic lighting
- Fall detection and vision providers(wearable / non wearable)

Intelligent robots for various activities like: garden trimming, house cleaning, to bring and take things

Compressed air is introduced to the bottom of BR. The gas emerges large air bubbles & generates an upstream water flow and turbulence to stimulate the algae to take in CO2 and light. Solar Leaf integrates all servicing pipes for the inflow and outflow of the culture medium and the air into the frames of its elements.

5. DESIGN AND ANALYSIS

Traveling across the country to rebuild houses to meet such high standards is economically impractical, but I believe that increasing the supply of new housing is very important for the future of our country. Ensure that the houses we design can accommodate certain responsibilities of the same diverse people as in government and commercial structures. Designers often associate the implementation of many standards with limited design freedom and institutional appearance, but this is not the case-design creativity should never be affected by designs with more suitable dimensions. Even if we follow the principles of barrier-free design, we can create spectacular spaces. We are accustomed to freely experimenting with ideas only in an institutional environment. By expanding our horizons and using barrier-free concepts and standards, we will better understand these design concepts even if they are not required by law, and you will no longer regard them as "special" that can be implemented. These ideas are proven in the model house that appears at the end of the text. (SPACE ALLOWANCE AND REACH RANGES, n.d.) [17].

- **Forward Reach** *Guide to the ADA Accessibility Standards*, 2021[18]: If the distance from the ground is only allowed to approach the object forward, the maximum advance range is 48 inches. The minimum reach is 15 inches.
- **Side Reach** *Guide to the ADA Accessibility Standards*, 2021[18]**:** If the clear floor space allows parallel approach by a person. In a wheelchair, the maximum high reach allowed shall be 54 in. and the low side reach shall be no lower than 9 in. above the floor.
- **Accessible Route** *Guide to the ADA Accessibility Standards*, 2021[18]: The minimum aisle width for a wheelchair is 36 inches, and the minimum aisle width for two wheelchairs is 60 inches.
- **Protruding Objects** *Guide to the ADA Accessibility Standards*, 2021[18]: Objects sticking from the walls with their forefronts between 27 Inches and 80 Inches. On top of the ground shall protrude no over 4 Inches into walks, halls, corridors, passageways, or aisles. Objects with their leading edge at or below 27 inches above the finished floor could protrude any quantity kind the wall.

- **Head Room** *Guide to the ADA Accessibility Standards*, 2021[18]**:** The minimum vertical spacing of the flow chamber should be 80 inches. If the vertical distance between adjacent areas is less than 80 inches, barriers must be installed to warn blind or visually impaired persons. One of these obstacles will be the railing.
- **Ground and Floor Surfaces** *Guide to the ADA Accessibility Standards*, 2021[18]**:** All floor surfaces must be stable, durable and non-slip. Vertical offset is up to 1/4 inch. You don't need edge. The height changes by 1/4 inch and 1/2 inch. Their bevel angle should not exceed 1:2. The height exceeds 1/2 inch. This is achieved through ramps. If a carpet is used, it must be firmly fixed, if any, with a strong backing.
- **Slope and Rise** *Guide to the ADA Accessibility Standards*, 2021[18]**:** Use the smallest possible slope for each ramp. The maximum slope of the ramps in the new building is 1:12. Any grade of less than 1:20 is not considered a ramp. The maximum slope of should be 30 for each run. The gap width of ramp should be 36 inches.

- **Landings** *Guide to the ADA Accessibility Standards*, 2021[18]: The deck is located at the top and bottom of each part of slope. The width of the deck must be at least the same as the width of the ramp leading there. The mat must be at least 60 inches long.
- **Handrails** *Guide to the ADA Accessibility Standards*, 2021[18] **:** If the slope of the ramp is greater than 6 inches or the span is greater than 72 inches, handrails must be provided on both sides. The inner track on a zigzag or curved ramp must always be continuous. The handrail must be at least 12 inches long for ramps the top and bottom of the segment. Handrail must be installed parallel to the ramp surface. The surface must be continuous and 34 inches to 38 inches above the ramp. 11/2 inches clearance is required. Between the handrail and, the end of the handrail should be rounded or smoothly returned to the floor, wall or column of. The armrest should not rotate in its mounting seat.

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- **Stairs** *Guide to the ADA Accessibility Standards*, 2021[18]: On each staircase, all steps must have the same step height and width. Jumper cannot be shorter than 11 inches. Article should not be harsh. The leading edge radius of step cannot exceed 1/2 inch.
- **Automatic Doors and Power Assisted Doors** *Guide to the ADA Accessibility Standards*, 2021[18] **:** The automatic door will not open for recheck within 3 seconds, nor does it require more than 15 pounds of force. Stop door movement
- **Lavatories and Mirrors** *Guide to the ADA Accessibility Standards*, 2021[18]: The height of the shelf or the edge of the sink should not exceed 34 inches above the ground. There should be a 29-inch gap at the bottom of the apron. As shown in Figure 11, the knee must be at least 30" from the foot and 19" wide from the knee. The floor in front of the sink should have a clearance of at least 30"x 48" to allow access from the front. Hot water and drain pipes under lavatories shall be insulated or configured to protect against contact. There must be no sharp or worn surfaces under the sink.
- **Mirrors** *Guide to the ADA Accessibility Standards*, 2021[18]: The bottom edge of the reflective surface of the mirror cannot be installed less than 40 inches above the finished floor.
- **Shower unit** *Guide to the ADA Accessibility Standards*, 2021[18]: The shower head must have a hose that is at least 60 inches long. The long model can be used as a fixed shower, and the can be used as a hand shower.
- **Grab bars** *Guide to the ADA Accessibility Standards*, 2021[18]: Grab bars in showers and baths will comply with Figures 12 and 13.

- **Medicine Cabinets** *Guide to the ADA Accessibility Standards*, 2021[18]: The location of the medicine cabinet should be such that at least one shelf is no more than 44 inches from the floor.
- **Controls and Operating Mechanisms** *Guide to the ADA Accessibility Standards*, 2021[18] **:** There must be free space on the floor so that the person using the wheelchair can move forward or parallel to the controller, fuel pump, socket and other operating equipment above the floor. The highest operating part of the component must be within the maximum forward range of at and on the indication side of the disabled passenger as shown in section above.
- **Audible Alarms** *Guide to the ADA Accessibility Standards*, 2021[18] **:** The tone of the audible alarm must be at least 15 dBA higher than the equivalent sound level in the room or room or higher than any maximum sound level for 60 seconds at 5 dBA, , whichever is higher. The alarm should not exceed 120 dBA.
- **Hearing Aid Compatible and Volume Control Telephones** *Guide to the ADA Accessibility Standards*, 2021[18]: The mobile phone must be compatible with hearing aids. The volume control can be between a minimum of 12 dBA and a maximum of 18 dBA above the normal value. A large percentage of elderly individuals in a population should also result in a larger percentage of dwellings capable of accommodating these individuals. We should implement standards that will increase the production of the type of structures that can be easily modified to meet the needs of an aging or disabled individual.

Now, based on the data collected in literature review and analysed in chapter 4, following is the matrix developed which helps in setting up the appropriate smart environment for needy people.

Matrix to create smart environment

	Installed Devices			Users					
Categories	**Types of installed devices**			**Normal Users**	**Disabled Users**	**Aged people**	**Low Vision**	**Hearing Impaired**	**Cognitively Impaired**
Devices for Automation and Control of the Home Environment	Automatic Kitchen Equipments			✓	✓	✓	✓	✓	✓
	Light and door controllers			✓	✓	✓	✓	✓	✓
	Indoor temperature			✓	✓	✓	✓	✓	✓
	Water Temperature controllers			✓	✓	✓	✓	✓	✓
	Home security devices			✓	✓	✓	✓	✓	✓
Assistive Devices	Electromechanical devices				✓	✓			
	Robotic systems for movement assistance				✓	✓			
	Specialized human machine interface				✓	✓	✓	✓	
	Devices for indoor navigation					✓	✓		✓
	Devices for physical rehabilitation and fitness			✓	✓	✓	✓	✓	✓
Devices for Health Monitoring Of Important Vital Parameters	Monitoring of vital parameters			✓	✓	✓	✓	✓	✓
	Posture monitoring				✓	✓			✓
	Behavior monitoring				✓	✓			✓
	Recognition of the facial expression				✓	✓			
	Advanced chemical analysis			✓	✓	✓			✓
Devices for information exchange	System information access				✓	✓	✓	✓	✓
	Tele-monitoring, Tele-inspection systems				✓	✓	✓	✓	
Leisure Devices	Virtual reality systems			✓	✓	✓	✓	✓	✓
	Emotional interactive/entertainment robots or video games			✓	✓	✓	✓		

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6. DESIGN IMPLEMENTATION

To make a smart home, technologies won't serve the purpose alone; to make it more sensible, proper/appropriate architectural design considerations must also be kept in mind. Therefore, few options have been developed which shows the integration of barrier free space with smart home technologies.

6.1 OPTION 1 (SYSTEMS INSTALLED IN AN EXISTING HOME ENVIRONMENT)

There are currently many researches on non-intrusive wireless sensors that will be used in existing home environments to transform them into smart homes. This type of monitoring system is the main requirement to turn it into a smart home at home. This sensing system has a variety of important applications, including energy monitoring, home automation, and health care. (Gaddam, 2021) [19]. In the system determines the activity level of the elderly with the help of home automation sensors. The system is equipped with sensors to monitor and detect abnormal conditions of the elderly, household items such as bed and chair sensors, mini computers connected to TVs, and medical sensors. This system is specially developed for elderly patients who wish to spend time in their own four walls. The system can improve the independence and quality of life of the elderly who choose to own a house. "*The system analyses the activity patterns of the elderly, and the central computer uses intelligent methods such as fuzzy logic to detect abnormal behaviours. Applications stored on the Web server use smart methods to analyse data and medical history from home automation sensors and medical devices. "Like fuzzy logic or other more complex cognitive systems to discover potential health problems. The system can trigger an alert when it detects a possible problem. This is the automatic transmission of data to the doctor* (Gaddam, 2021) [19].

The whole system is connected to a care centre via cloud based wireless network like ZIGBEE/FOG which helps in monitoring the activities and take rapid actions in case of emergency.

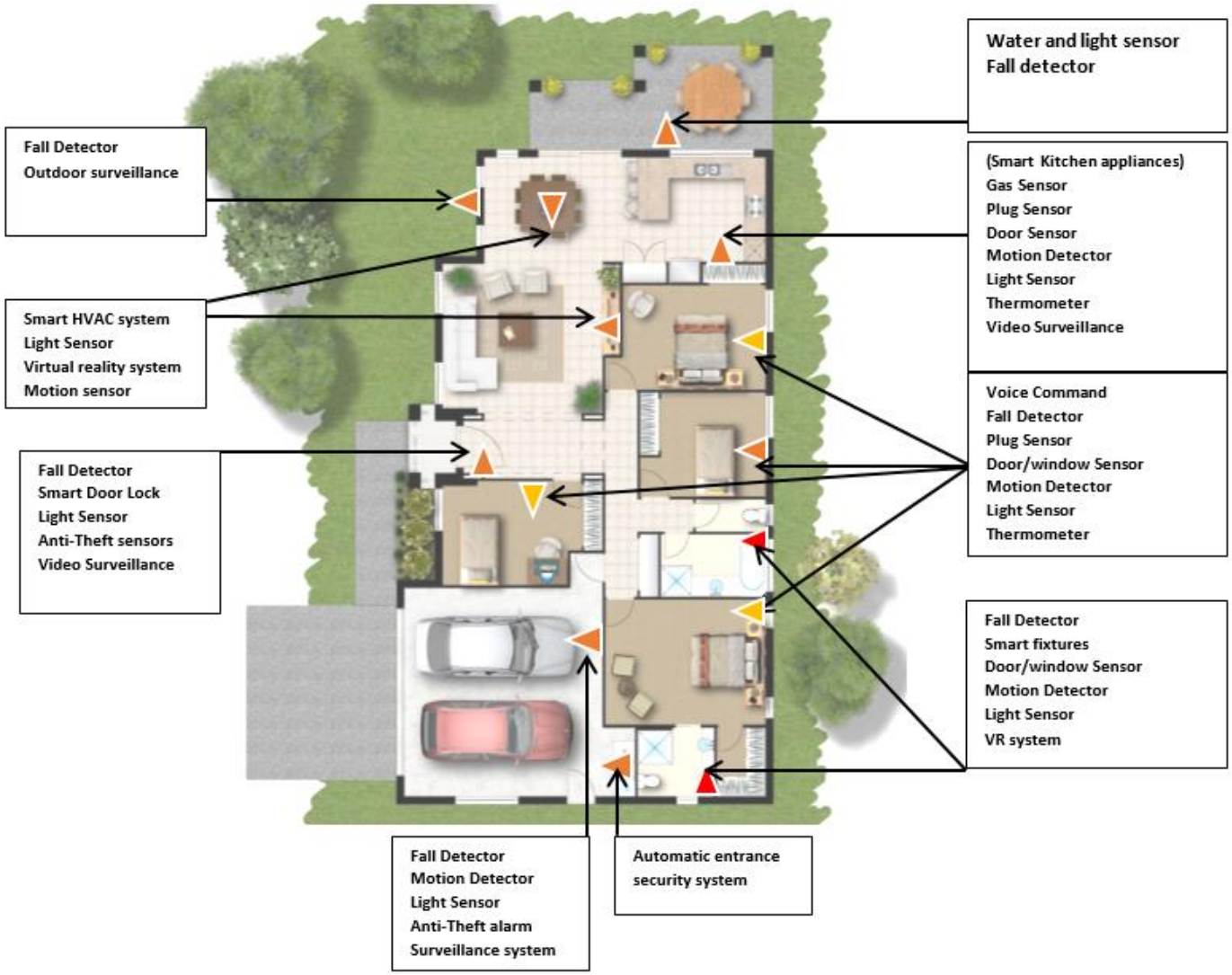

Fig.16 Smart Home Technologies installed in an existing home (Author, 2021)

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6.2 Option 2 (Systems installed in new home environment)

The initial work of the smart environment focuses on the new living environment that can improve the residents' experience, applications such as positioning, personnel tracking, and activity detection are one of the first methods to lay the foundation for the smart environment. These formed the foundations of the intelligent environment. In research from Tyrer et al. (2006)[20] have used ultrasonic location tracking sensors to build smart floor for accurate location calculation of the resident in a smart home According to the research Abowd et al., 2000[21] used ultrasonic sensors along with RF technology, floor sensors to identify Patterns of the resident in a smart home. Tracking people in a scientific environment has been done using various sensors, including RFID badges and infrared or ultrasonic sensors.

The researchers used a series of motion detectors and touch switches from the Medical Automation Research Centre (MARC) of the University of Virginia to detect residents' daily activities.

The research centre uses an expert system based on fuzzy According to new research (Nourizadeh et al., 2009) [22] called "iDorm" to track the interaction between households and equipment in the house. Forecast the needs of residents and monitor energy consumption. The MavHome (Adaptive Multifunctional Home Management) project at the University of Arlington in Texas (Zhongna Zhou et al., 2009) [23] uses sensors and device controls to monitor and provide comfort for the elderly. The system uses tools such as artificial intelligence, data mining, and prediction to make automated decisions. They are identified and stored in the system every day. This data is used to predict the next move of residents to automate selected repetitive tasks.

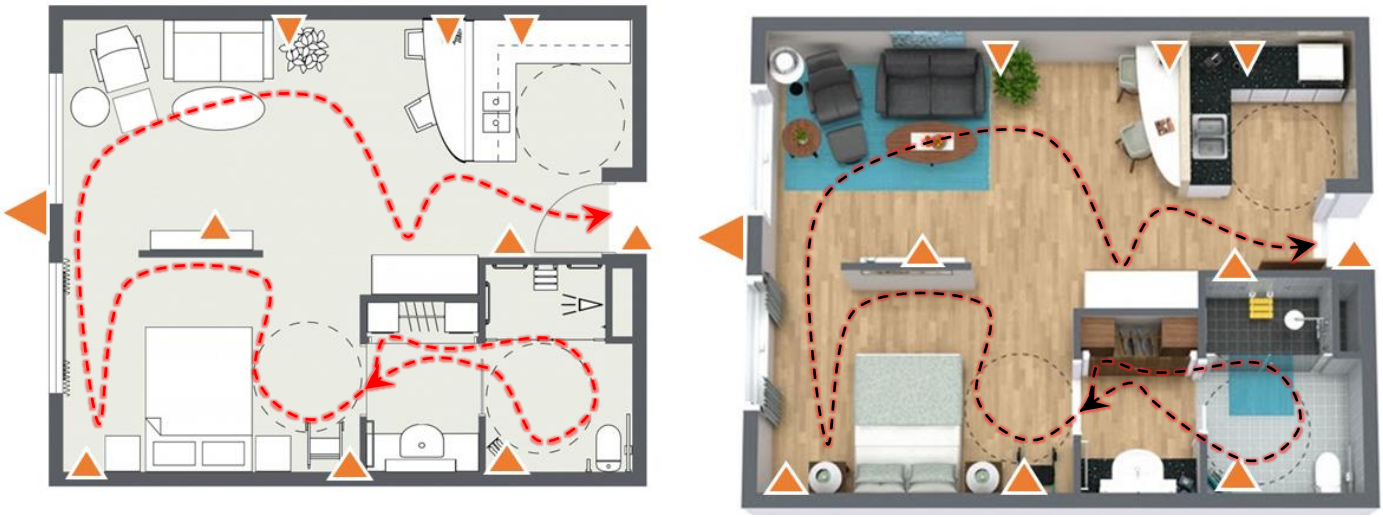

Fig. 17 New Home floor plan depicting the integration of architectural considerations and SHTs,Author 2021

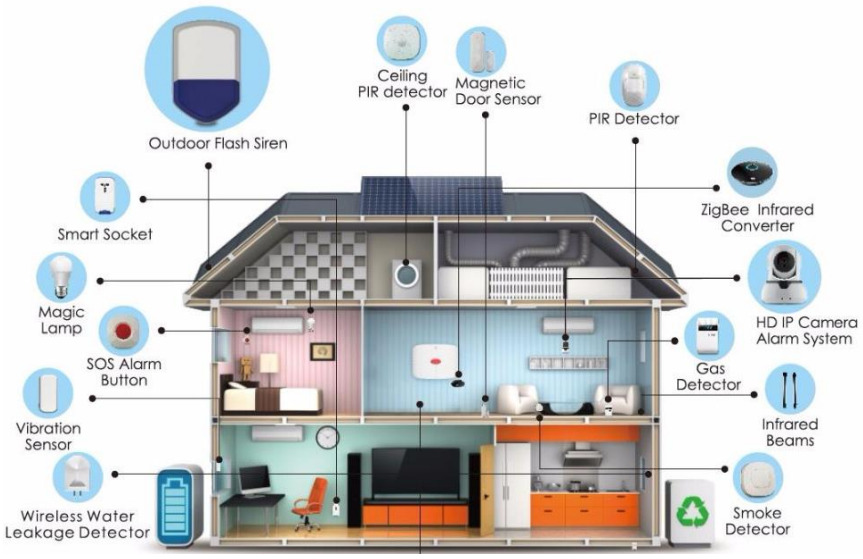

Fig. 18 Minimum SHTs must be embedded into smart care home.

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With the extension of people's life expectancy, the proportion of elderly people (65 years and above) in the total population in many countries has been increasing, which has had a positive impact on the home design and decoration trends of the elderly. Provide a more elegant life for the elderly. According to new research *Design Ideas for a One Bedroom Assisted Living Apartment*, 2021, [24] .Many seniors choose to stay at home and add available features as they age. Another popular option is to provide serviced housing for those who need or want help with some daily household chores. And laundry, gardening and contacting someone 24 hours a day. Assisted living spaces can be converted into multi-family houses, apartments or purpose-built living spaces. Some important considerations in senior and assisted living spaces are:

Extra navigation space – Whether or not a walker or wheelchair is needed at move-in time, having the space available to use one in the future is a good idea. Many elderly care facilities are designed to be "barrier-free." This means that the design includes features that make it suitable for people with disabilities, whether they are people with limited mobility, sight or hearing. Many facilities are designed to be "barrier-free." This means that the design includes features that make it suitable for people with disabilities, be they people with limited mobility, eyesight or hearing impairment. This floor plan also shows wide hallways, as well as wide pocket doors instead of normal swing doors. According to the research (*Davincitheverbalarteest*, 2020) [25], standard wheelchair is 24-27" (approx. 600- 690 mm) wide. In order to accommodate a wheelchair, doors should be at least 32" (815 mm) wide but ideally 36" (915 mm) wide. The extra space allows for easy access for a wheelchair, especially if the door is accessed from a hallway, and you'll have to turn the wheelchair to enter. Tip: If you are interested in more detailed accessibility specifications, see the Americans with Disabilities Act (ADA). The plan also shows wide corridors and wide sliding doors.

Fig.19 Extra space serving an ease in barrier free movement throughout the house, Author 2021

Kitchen

How many and which appliances to provide, given that most assisted living facilities provide some meals. The kitchen area of a serviced apartment is usually small because most serviced apartments provide some or all meals. This kitchen features quartz countertops and walls and large stone tiles on the back. The lockers are in the popular shaker style and are provided below, so items are readily available. The built-in mini refrigerator blends harmoniously with the decoration through the use of a special agitator-style front panel. A microwave and coffee machine are also provided. There Neither an oven nor a stove, because most of the entire meal is served in the shared dining area of the supervised house.

Design and style elements –With the products available today, assisted living units can be stylish and design-oriented .It is not necessary that an assisted living apartment have to look like a hospital room.

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Fig.20 Extra space serving an ease in barrier free movement throughout the house,Author 2021

Bathroom

If necessary, there is a place to roll the wheelchair underneath. The large sleek mirror is suitable for sitting or standing users. In addition, the room should have bright lighting, which is also very important for the elderly. Their eyesight may not be as good as before.

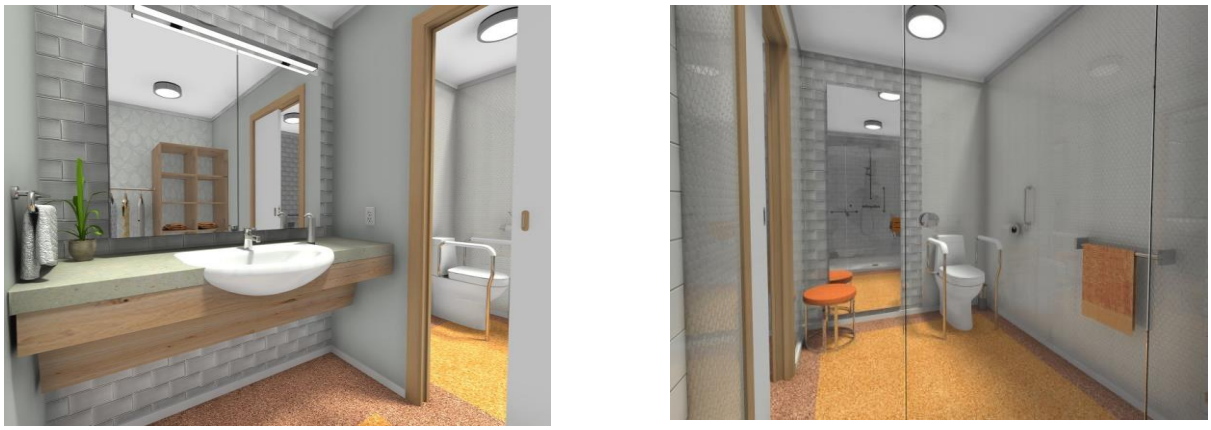

Fig.21 Grab bars, anti-skid flooring and soothing interior finish, Author 2021

In research from bathrooms use medium-sized tiles, and smaller tiles and more grout are less slippery than large tiles. The bathroom has a higher toilet and folding grab bars, which can be used if necessary. The toilet will remain open in case the pick-up needs an escort. The shower area has a roll-in shower with wide doors for easy entry and exit. It also includes a folding bench and hand shower, allowing users to take a shower while sitting. The shower is big enough and there is a helper in it. In the shower. Shower if necessary. Note the few handrails that provide more stability and prevent slipping. It is also a good idea to choose non-slip tiles or add a non-slip surface to improve safety.

Living Area

The living room is a large open space for hikers or wheelchair users. In research from BigRentz, Inc. [26], most storage space is also limited, so items are always on hand. This apartment has large windows with plenty of natural light. Look around the comfortable lounge area by the floor lamp window to get a better view when reading at night.

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Fig.22 Living Room with extra spaces and natural lighting being the prime focus, Author 2021

Bedroom and Storage

The important thing for any bedroom is clothing storage. The housing of the device has a built-in lighting function, which makes it easier to find objects. There are many shelves for storing foldable items, most of which are knee-high; older people will find it difficult to be attracted. The clothes are too high or too low. The suspension rod is suspended at a medium height for easy access to clothing. According to a research the bedroom floor plan also provides ample space for easy navigation and sliding doors leading to the dressing area that can be kept open for easy access.

Fig.23 Smart In-Built Sclosets, Smart Wardrobe 2021

Fig.24 Free movement space and smart lighting is the key for bedrooms, Author 2021.

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6.3 DESIGN BASE CASE

Now that we have studied technologies, investigated challenges through interviews and with the relevant literature review about all the technologies and smart networks and planning strategies a base case has been selected on that basis and all the gained knowledge has been implemented into it. According to various research when designing a complex we need to keep few things in mind targeting our ultimate goal. It states that we should not have permanent partition walls. Planning should be made very simple and open. The base case considered is a proposed project and located in Greater Noida, Uttar Pradesh, India. In research from Place Design Partnership (2019) [27] the land area is 48,020 square meters (57,372 square yards) or 4.8 hectares (11.9 acres). The floor area is 61,665 square meters (663,061 square feet). There are 315 apartments, starting from 56 square meters. 599 square feet (599 square feet) to 1,003 square feet (93 square meters) and 600 parking spaces. Very bright and funky interiors are even the exteriors spoils the soul of the design. We need to keep the fact in mind that more the complex design is tougher it will be for the end user (elderly and physically disabled). For our base case here DS Charitable old age home (proposed) is taken.

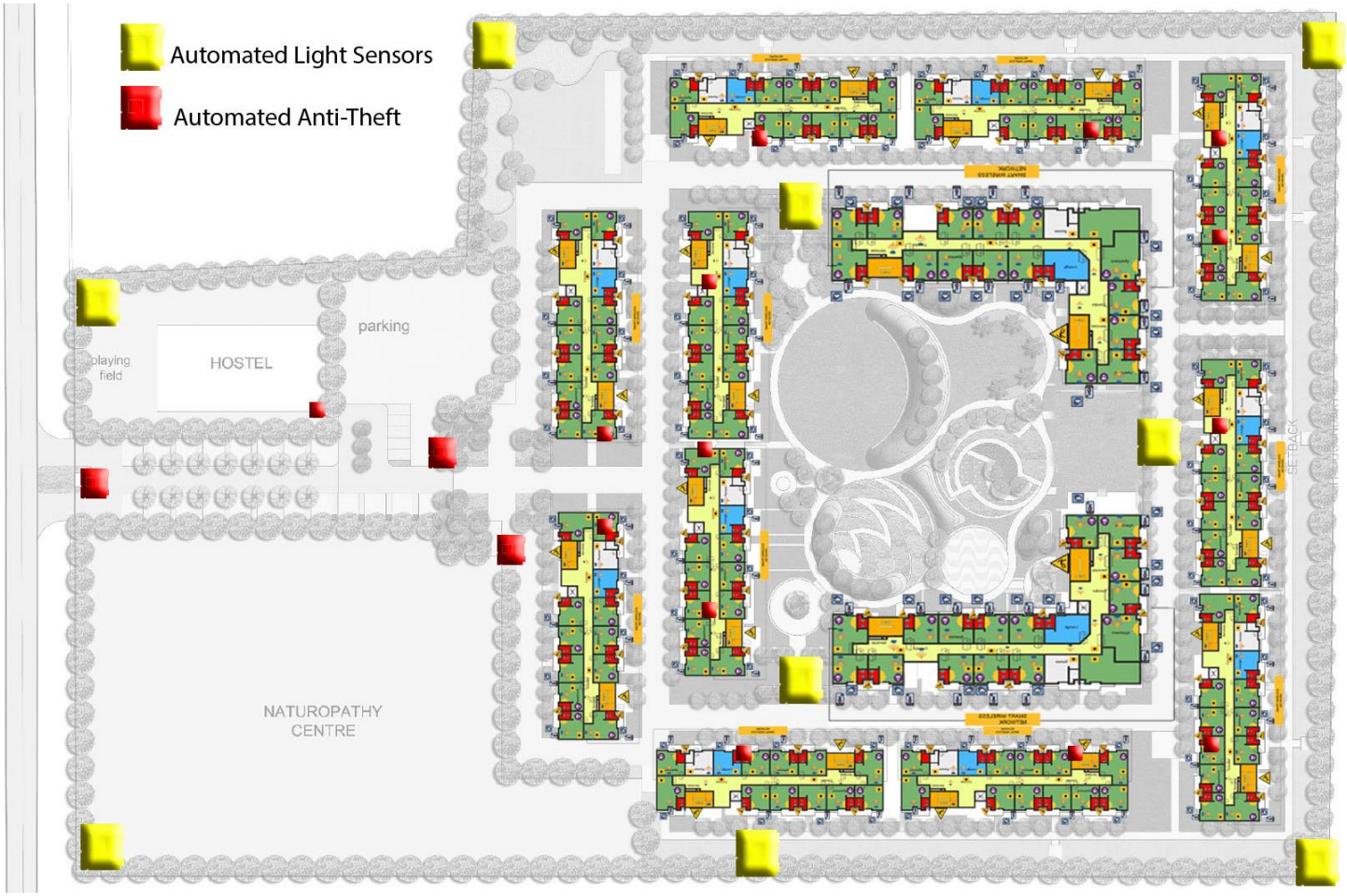

Fig. 25 Site Plan D.S. Charitable old age care centre, Author, 2021

The site of the old age home contains residential apartment, specially planned to take of the old aged people with central landscaping zone to provide a refreshment and keep the aged people close to nature. Placement and orientation of the cluster has been done in such a way that it has no inside vehicular movement a parking is located right at the entrance of the site.
Also a naturopathy centre is place at the entrance to provide quick treatment and evacuation to the patience residing outside the complex.
To make it a smart site we have installed Anti-theft sensors at the entrance of each block and automatic light sensors on to cover the complete site. Two types of clusters has been placed on the total site, where type –A has 11 blocks and Type-B has 2 blocks.

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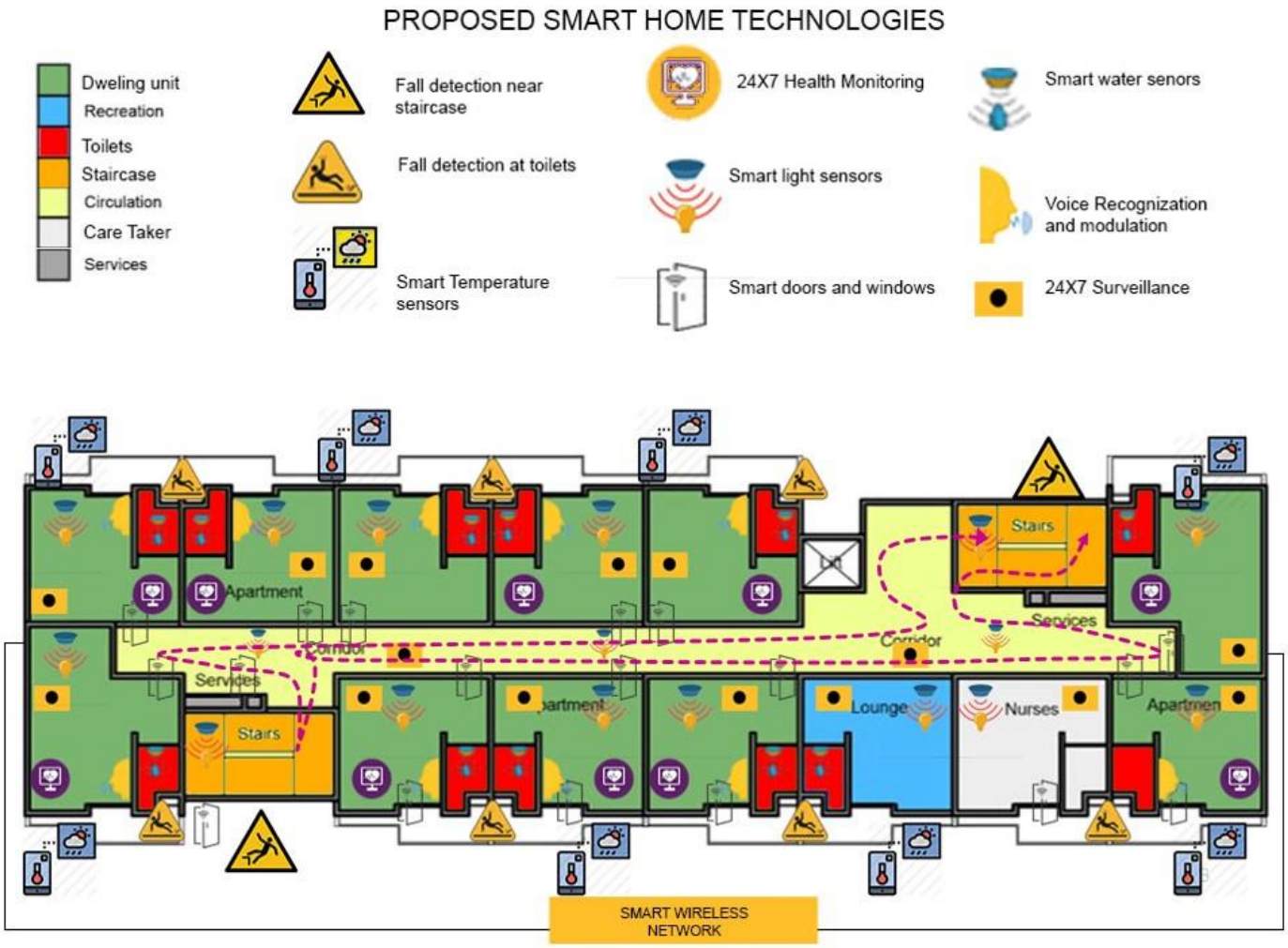

Fig.26 Type-A Building, Author, 2021

Type-A Building which contains private apartment units with a lounge and a nurse/ care taker room. Here planning of cluster has a provision of lift as well. To turn the floor into a smart home or smart care centre we have proposed several required technologies. Such as:

1. Fall detector / sensor near staircase
2. Fall detection in all the bathrooms
3. Smart temperature sensors are installed din al the residential units
4. 24x7 health monitoring via wearable devices and sensors installed
5. Smart light sensors
6. Automatic / Smart doors and windows.
7. Intelligent water sensors in bathroom and Pantry
8. Voice recognition/modulation devices for interactive and pro-active routine.
9. 24x7 surveillance to monitor the continuous activities by care centre.

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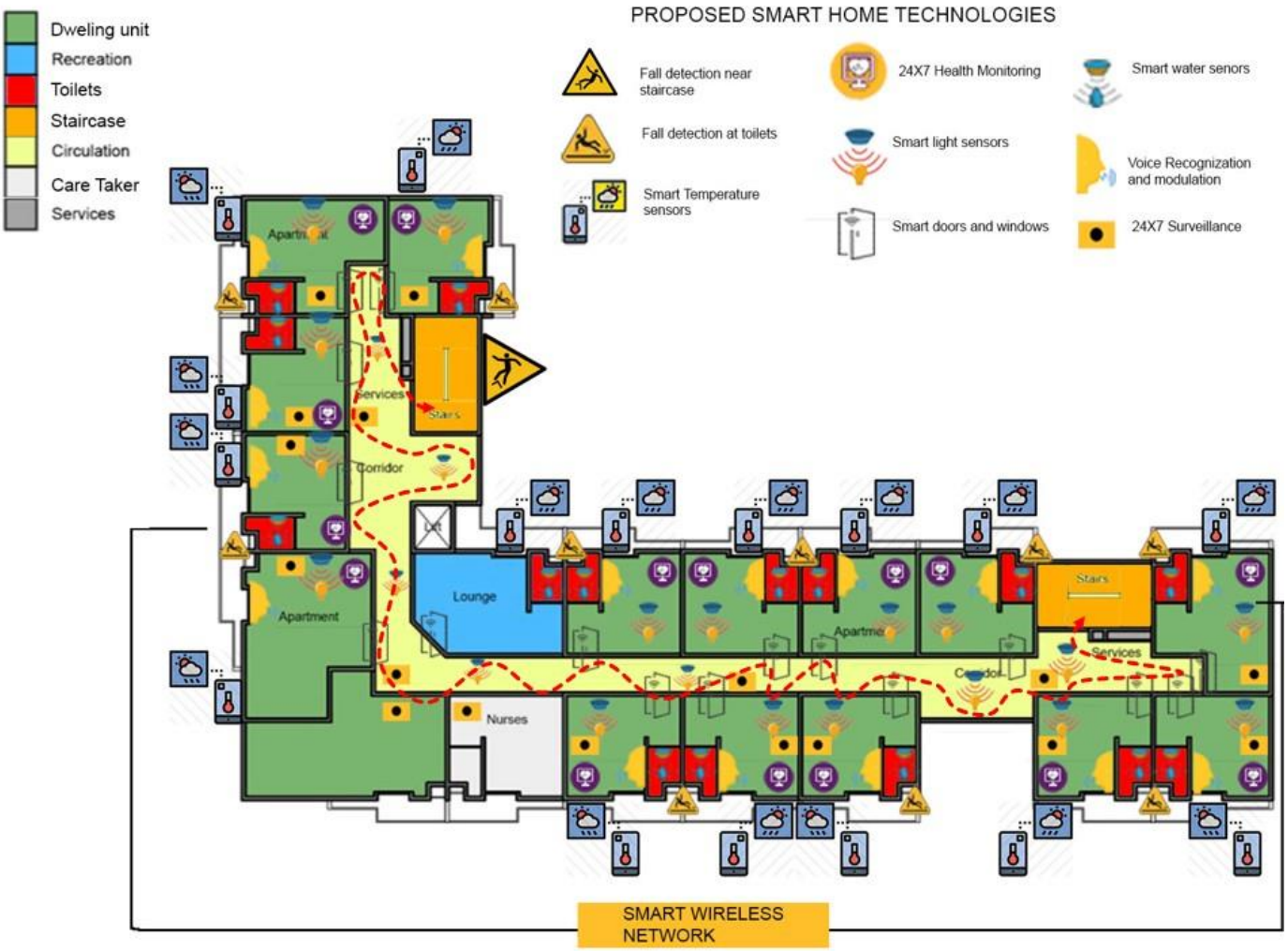

Fig.27 Type B Building, Author, 2021.

Type-B Building, it has same requirements as Type-A building. There is a difference of areas. Also it contains semi private apartments, with a common lounge and a nurse/ care taker room with attached toilet. Here planning of cluster has a provision of lift as well. To turn the floor into a smart home or smart care centre we have proposed several required technologies. Such as:

1. Fall detector / sensor near staircase
2. Fall detection in all the bathrooms
3. Smart temperature sensors are installed din al the residential units
4. 24x7 health monitoring via wearable devices and sensors installed
5. Smart light sensors
6. Automatic / Smart doors and windows.
7. Intelligent water sensors in bathroom and Pantry
8. Voice recognition/modulation devices for interactive and pro-active routine.
9. 24x7 surveillance to monitor the continuous activities by care centre.

Whole design has been designed by considering barrier free standards and thoroughly studying the most appropriate smart technologies.

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6.4 IMPLICATIONS

Implications which can be stated through all the available data collection, its analysis and discussion with field experts are now an important step to be taken as this dissertation report will serve as:

Strategic suggestions to create an integrated floor plans or to perform the planning of space which includes barrier free design and smart home technology.

The prototypes developed in the report can be referred as for basic planning of a space and then stepping forward to design a large space or area. It has elaborated the challenges and how these challenges can be encountered by variety of smart technologies available in the present market.

The Prototype and research foundation can be used as stepping stone that tread for similar line of enquiry. Obviously, the proposed work will be a great treasure for the planning of care centres, individual units, and other public/commercial/residential spaces, technology, cities and interior aesthetics.

The report has thoroughly discussed about various smart home technologies divided into five different categories and a matrix has been developed which will act as defining the basic environment for a home to be smart for physically disabled and even for normal occupants.

7. OUTCOMES

7.1 RECOMMENDATIONS

1. In the unit design, although the dining, living, and kitchen areas are part of one large space. Each space is distinguished from the others by the manipulation of ceiling
2. There is a double door from the dining room to the garage which makes moving furniture in and out of this unit particularly easy. Levers are used as opening devices on all doors. This way each space can have its own identity without using walls to make the divisions. It is important to eliminate unnecessary walls which tend to minimize the amount of perceived space within the dwelling.
3. There is a keypad located outside the front and back door. Elderly persons who have accidently locked themselves out of their apartment can gain entrance by inputting a four digit code on the keyboard.
4. The kitchen in the house has been designed to accommodate a multitude of users.
5. The refrigerator, sink, and range are all located within close vicinity of one another. The food preparation cycle starts with the refrigerator and works counter clockwise around the plan of the kitchen in the house.
6. Along the east side of the kitchen in the house design is a refrigerator, a dishwasher, a sink, and a portable storage trolley.
7. The drains for the sink are placed towards the out sides and back of the bowls so that they don't interfere with the knee space necessary for wheel chair use.
8. Flexible piping allows the counter to be adjusted to any desirable height. The garbage disposal unit is located in the back corner of one of the sinks so that it too is out of the way of the user.
9. An 18 inch dish washer is located conveniently to the right of the sink.
10. A storage trolley is kept on the other side of the sink under the counter. This trolley can be utilized by a wheel chair user to transport meals to the dining area or return cleaned dishes to their respective storage areas.
11. The electric range consists of three burners placed in a row and set back ten inches from the edge of the counter, so that the user will never have to reach over one burner to get to another.
12. Electric burners are used opposed to natural gas to prevent lose clothing from catching on fire in an open flame. The controls to the range are located to the right of the burners so that they don't have to be reached over to operate, and so they aren't easily accessible to small children.
13. Flush mounting decreases the likely hood of spilling when lifting from one surface to another. The burners are mounted in a ceramic material allowing the user to simply slide a pot off the burner to cool.
14. A mirror is mounted over the range so that a wheel chair user can easily see the food cooking in deep pans.
15. Along the work space is a pullout board that can be used as an additional working surface.
16. The bottom of the cabinets above the counter tops are mounted 4'-4" above the floor surface so that they can be accessible to wheel chair users. They are counter balanced to make them easily adjustable
17. The underside of these cabinets are mounted various appliances such as a microwave in the corner, a coffee maker, and a can opener next to the stove. A spice rack is mounted underneath the cabinets for easy use.
18. The counters in this kitchen are all adjustable depending on the needs of the users. The counter tops are mounted on brackets. If there is one occupant that happen to be a wheel chair user, these counter tops can all be lowered to a height that is comfortable for him\her.
19. Bathroom that is accessible from both the master bedroom and the living room. This shortens the distance one has to travel should one have to go to the bathroom during the night. The shower is designed so that a wheel chair can be rolled directly into it.
20. There are no curbs around the shower, rather a folding door with a track that is recessed flush with the floor.
21. Flexible piping and a counter top that is mounted on brackets allow the occupant to adjust the lavatory to any height desirable

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22. Natural wood grab bars have been installed around the water closet according to the standard while modern grab bars with a textured plastic coating have been installed in the shower.
23. The direct access to the bathroom is beneficial to the elderly occupant Individuals with reduced maneuverability are provided with a short route to the outside in case of a fire.
24. One of the truly barrier free ideas within the bedroom that is made possible through the implementation of the Smart House system is located within the closet.
25. The clothes hanger allows an individual to use ones closet storage more efficiently. This system allows a wheel chair user, or an elderly occupant, to easily access their clothes on hangers with a touch of a button, these clothes can then be stored by smart house system high up 'in the closet where they're out of the way.

7.2 CONCLUSION

Currently the companies from different corners of the world has developed alternative ways of housing for elderly and physically disabled population. There are many researches still going on. People in nursing homes and even in care centres today don't really deserves to be there. Development of smart nursing homes or care centres/old age homes/rehabilitation centres took place because there is simply no other housing available that can adequately meet their needs. If such smart planning types made available, we could greatly reduce the number of individuals that are currently flooding nursing facilities. *The majority of dwellings that exist have to undergo major renovation in order to be converted into a dwellings that is usable to a persons with disabilities.* The two prototypes presented here can help solve the in general, the diversity of the population requires different solutions to comprehensively solve all existing problems. You can live an independent life in the community. Live such an independent life, but few houses can do it. The prototype developed for this paper does not solve all housing problems for the elderly and the disabled, but it will be a welcome solution for many people who want to live independently.

"It is also very important that building professionals are made aware of some of the new technology that is soon to be made available to consumers in the housing industry. By understanding how the Smart House system works, and all the ways that it can better the lives of both the elderly and the disabled occupant, we can begin to incorporate this system into a variety of elderly and disabled housing forms. This technology can be used for all types of elderly, from single-family homes to intensive care of patients. This new technology allows residents to better control the energy consumption of their homes. Our society pays more and more attention to the consumption of energy such as non-renewable energy. Energy sources such as oil, coal, and natural gas are declining. As we move to cleaner renewable energy, we must first protect the non-renewable energy that still exists on the planet. By using renewable energy in our homes, we invest in our future.

LIST OF FIGURES

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LIST OF ABBREVIATIONS

1. SH-Smart Home
2. SHT-Smart Home technology
3. PWD-People with disability/disabilities
4. PSN-People with special needs
5. GSR-Galvanic skin response
6. EMS-Emergency Services
7. FGPA-Field Programmable Gate Arrays
8. MARC- Medical Automation Research Centre (MARC)

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