THE REPUBLIC OF TURKEY
BAHCESEHIR UNIVERSITY

SMART HOME STRATEGIES FOR AGING IN PLACE

Master's Thesis

ASIM MARAŞİ

ISTANBUL, 2018

THE REPUBLIC OF TURKEY
BAHCESEHIR UNIVERSITY

GRADUATE SCHOOL OF
NATURAL AND APPLIED SCIENCES
MASTER OF ARCHITECTURE

SMART HOME STRATEGIES FOR AGING IN PLACE

Master's Thesis

ASIM MARAŞİ

Supervisor: ASSIST. PROF. DR. DURNEV ATILGAN YAĞAN

İSTANBUL, 2018

THE REPUBLIC OF TURKEY

BAHCESEHIR UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCE
ARCHITECTURE

Name of the thesis: Smart Home Strategies For Aging In Place
Name/Last Name of the Student: Asım Maraşi
Date of the Defense of Thesis: September12th, 2018

The thesis has been approved by the Graduate School of Natural and Applied Sciences.

Signature
Assist. Prof. Dr. Yücel Batu SALMAN
Graduate School Director

I certify that this thesis meets all the requirements as a thesis for the degree of Master of Architecture.

Signature
Prof. Dr. Emine Özen EYÜCE
Program Coordinator

This is to certify that we have read this thesis and we find it fully adequate in scope, quality and content, as a thesis for the degree of Master of Architecture.

<u>Examining Comittee Members</u>	Signature
Thesis Supervisor Assist. Prof. Dr. Durnev ATILGAN YAĞAN	-----------------------------
Member Associate Prof. Dr. Ali Devrim IŞIKKAYA	-----------------------------
Member Associate Prof. Dr. Bülent Onur TURAN	-----------------------------

ACKNOLEDGEMENTS

I would like to use this opportunity to express my gratitude to every person who supported and encouraged me throughout my thesis journey. I would like to extend my gratitude to my supervisor Assist. Prof. Dr. Durnev Atilgan Yağan for her guidance, patience and contractive criticism which assisted me to set my thesis structure and reach my thesis target.

I would like to thank the examining committee members Associate Prof. Dr. Ali Devrim Işikkaya and Associate Prof. Dr. Bülent Onur Turan for their valuable comments and positive critique which directed me to complete this thesis.

Last but not the least, I would like to thank my parents. Thanks for your love, support, and encouragement. Thanks to my wife for being supportive and had a faith in me. Thanks to my brother for being with me in every step of this process.

Istanbul, 2018 Asım Maraşi

ABSTRACT

SMART HOME STRATEGIES FOR
AGING IN PLACE

Asım Maraşi

Master of Architecture

Thesis Supervisor: Assist. Prof. Dr. Durnev Atilgan Yağan

September 2018, 77 pages

Home is the place with emotional significance on its inhabitants, particularly for the elderlies. The inevitable outcomes of becoming older generally necessitate the elderly to make undesirable transitions in their living environments or become further reliant on family and friends. One of the reasons impacting the elderly capability to age in place is the house design which creates obstacles to autonomous life.
Architecture has the responsibility to observe the requirements of the people and be the reforming tool between them and their environment. The thesis main objective is to depict what smart technology concepts have to offer regarding the elderly' living condition, wellness, and autonomous life at home along with the undeniable requirements of universal design principles. The thesis using data and case studies obtained from three parts; old age phase, universal design home, and smart home technology to provide a theoretical, architectural and technological guideline to enable aging in place.

Keywords: Elderly living, Aging in Place, Universal Design, Smart Technology

ÖZET

YERİNDE YAŞLANMA İÇİN AKILLI EV STRATEJİLERİ

Asım Maraşi

Mimarlık Yüksek Lisans Programı

Tez Danışmanı: Dr. Öğr. Üyes, Durnev ATILGAN YAĞAN

Eylül 2018, 77 sayfa

Ev, ileri yaştakiler başta olmak üzere tüm sakinleri için duygusal öneme sahiptir. Yaşlanmanın kaçınılmaz neticeleri yaşlıları genellikle yaşam alanlarında istenmeyen değişiklikler yapmak veya aile ve arkadaşlarına daha da bağımlı olmak zorunda bırakır. Yaşlıların bulundukları yerde yaşamlarını sürdürme imkanlarını etkileyen sebeplerden bir tanesi, özerk bir yaşam sürdürülmesini engelleyen konut tasarımıdır.

Mimari, insanların gereksinimlerini gözlemleme ve onlarla çevreleri arasındaki iyileştirme aracı olma sorumluluğuna sahiptir. Tezin temel amacı akıllı teknoloji konseptlerinin yaşlıların yaşam koşullarına, refahına ve evdeki özerk yaşamlarına ilişkin neler sunabileceği yanı sıra, evrensel tasarım ilkelerinin yadsınamaz gerekliliklerini ortaya koymaktır. Tez, "bulduğun yerde yaşlanmayı" mümkün kılmak için teorik, mimari ve teknolojik bir kılavuz sağlamak amacıyla yaşlılık evresi, evrensel ev tasarımı ve akıllı ev teknolojileri olmak üzere üç bölümden elde edilen veri ve örneklerden yararlanır.

Anahtar Kelimeler: Yaşlı yaşayan, Yerinde Yaşlanma, Evrensel tasarım, Akıllı Teknoloji

CONTENTS

TABLES

FIGURES

ABBREVIATIONS

AARP	:	American Association of Retired Persons (www.aarp.org)
CDC	:	Centers for Disease Control and Prevention (www.cdc.gov)
RFID	:	Radio Frequency Identification

1. INTRODUCTION

1.1 PROBLEM DEFINITION

Beyond a physical house, a place for living or building, home is a place that has emotional and personal significance. People incorporate their identity and values, expressing their feelings, recollections, and backgrounds through their place of residence and over the years, a sense of belonging and identification emerges from that place, and turns the house into a home and surrounding space into a hometown. Giuliani (2003) regards the desire for home stability as a demand for safety and protection. This demand is utmost in our earliest and oldest years and it is not connected to the physical safety of home, but rather a sense of permanence. The importance of home comes from the experience with home history, whether it is protection, family love, or the disparity between home and non-home and being at home against the feeling of traveling.

During the last decade, the life expectancy has increased significantly and today, most people are expected to reach 60 years and over in incident takes a place for the first time in history. The Ageing and Health Report of 2015 has pointed out that, nowadays, a newborn is anticipated to live an additional 20 years longer than someone born 50 years earlier. The projected population of elderlies in 2050 is 21% of the world population with a life expectancy of 77 years old (see Table 1.1).

The inevitable outcomes of becoming older involve the elderly to encounter bodily failure and have difficulties in living at home independently. This necessitated the elderly to make transitions in their living environments or becoming further reliant on family and friends. Gilleard (2007) revealed that as the elderly lost their residential maneuverability, they grew more connected and had a deeper affinity with their home and community. An American Association of Retired Persons (AARP) survey on elderly reported that 9 out of 10 elderlies wanted to stay at their homes instead of moving to a health care center or retirement facilities.

One of the reasons that can impact elderly capability to age in place is the design of the home. The most common cause of elderly relocation is found to be the physical barriers at home according to research on elderly housing (Kemppainen 2006).

Reasons such as lack of elevator and ramps, narrow doorways, and inability to fully use the kitchen and bathroom fittings, were creating obstacles to autonomous life at home. Further, Center for Disease Control and Prevention (CDC) indicated that one out of three elderlies is susceptible to home-related injuries as a result of barriers at home which limit elderly ability to manage daily life endeavors. Notwithstanding the living place, whether it is urban metropolises or rural communities, livability at home is rarely discussed till it is clear to the elderly that society cannot accommodate their aging requirements. By then the adjustments may be difficult to achieve and require solutions such as home modifications or moving to another place (AARP 2005).

Consequences of population aging on the society and the individual's, require urgent and considerate actions in many aspects. So, what is the responsibility of architecture towards promoting the living condition of the elderly?

What are the potential strategies that can enable the elderly to age in place?

Table 1.1: Projected Aging Population & Life Expectancy 1990-2100

Year	Aging/World Population- Percentage	Life Expectancy-Years
1990	9 %	65
2017	13 %	71
2050	21 %	77
2100	28 %	83

Source: United Nations Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2017 Revision.

1.2 MOTIVATION AND AIM OF STUDY

Elderly can participate in everyday life in numerous ways, whether it be spending time with family, being an active member of the community or being an independent person with new significant goals, the most important of it all is to be healthy. Independence is the keynote factor which any elderly would value the most, due to the associated feelings of dignity and self-confidence. Notwithstanding the need for assistance in old age for mobility and healthcare, the majority of elderly have chosen not to leave for another environment. In addition, medical professionals have found that the living conditions of the elderly improve if the surroundings were homelike and not a hospital (Reed et al. 2005). The necessity to empower the elderly to reside at home autonomously requires additional measures to be taken.

Architecture has the responsibility to observe the requirements of the people and be the reforming tool between them and their environment. For a long time, most house layouts have remained unchanged, lacking safety and accessibility requirements and no longer fulfilling elderly needs. The appropriate house design is essential for accommodating visitors of varied capabilities and ages. The Global Health and Ageing report (2011) have pointed out the importance of cost-effective methods to maintain the wellbeing of the elderly and implement current knowledge to prevent aging-related risks with variable development stages. The concept of ‘Design for each one of us’ is a promising approach since its target is providing accommodations for people of multi-ages, needs, and abilities.

Apart from the architectural point of view, smart home technology has integrated into our cities, lives and has become a part and parcel of our world. The final outcome of Habitat III held by the United Nations was to promote tapping into technological innovations to make technologies accessible to the people, especially, for those with special needs and the elderly (2017). Driven by this necessity, a growing number of smart commercial products and experimental designs currently capable of remotely observing the wellness of elderly at home, provide autonomy and assist in the resident’s best interest. Implementation of the technology into the home environment should follow architectural design solutions regarding people’s needs.

Along with the motivations behind those aspects, this thesis's main objective is to depict what universal design and smart technology concepts have to offer regarding elderly wellness and autonomous life at home.

1.3 SCOPE OF THE STUDY

This thesis doesn't intend to design a home or develop a technology for the elderly but rather to revise existing home solutions and technological improvements to upgrade the living environment of the elderly from an architectural and technological point of view.

The study will conduct a framework research on old age stage to clarify the elderly requirements in this stage of life.

An overview of universal design home and smart home technology will be studied, and the influence on elderly home-independency and general wellness will be stated.

Accordingly, the research will investigate case studies from diverse fields and combine them under architecture umbrella to come up with a theoretical, architectural and technological approach to enable aging in place.

This study differentiates from another thesis concerning aging in place, such as *"The evaluation of aging in place phenomenon in terms of residential use"* by Ipek Ceren Çakmak, by linking design research and technological advance research with aging in place concept and propose a guideline based on these three aspects. Further, thesis such as "*Evaluation of retirement houses service model and social participation of elderly people*" by Sinem Gülenç and "*Elderly staying in the nursing home and their family's points of view about nursing homes*" by Hatice Selin Irmak, have researched providing the well-being to the elderly in different environments, while this thesis, researching providing the elderly the well-being at their homes.

1.4 METHODOLOGY

This thesis uses a literature review and design research and analyzes the existing projects to develop and propose a guideline for smart home strategies for aging in place. The research can be an essential basis for further studies and research in terms of smart home development for the elderly.

The first part of the thesis articulates the concept of old age, living theories, elderly wellness, and legal aspects, with a goal of forming a theoretical background of elderly life.

The second part of the thesis investigates universal design in both, general and in terms of the elderly' accommodation, elaborate its home principles, provides a checklist, and examines existing case studies in this field.

The third part of the thesis conducts a survey on smart home technology for elderly wellness in the view of studies, projects, and products.

Lastly, the study compiles a learned-list based on aging in place, universal design home, and smart home technology, respectively.

1.5 LIMITATION

The Literature regarding the elderly well-being at home was minimal and lacking design considerations since the elderly care at home is dominated primarily by a social service and public health point of view.

The study had challenges of determining a wide adopted universal home design for the elderly since the common trend was concerning building alternative environments for elderly living.

Additionally, the study is limited by the number of smart home technology case studies executed till the date of the study.

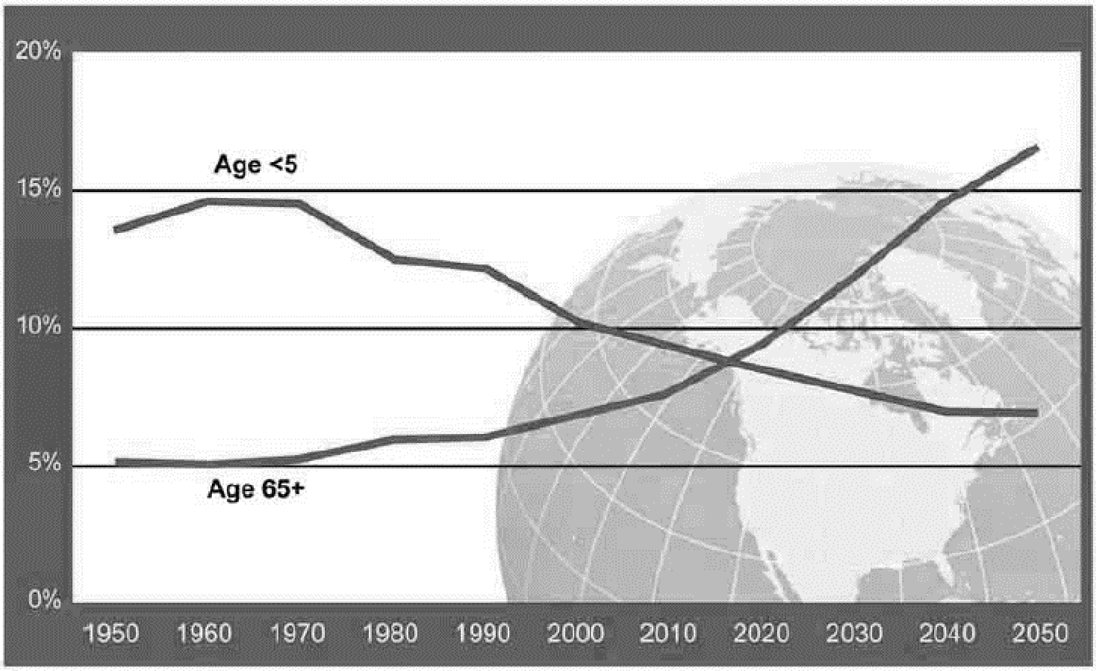
2. A FRAMEWORK FOR ELDERLY LIFE AND AGING IN PLACE

Since the beginning of time, the number of children was more than elderlies. In the year 1950, the elderlies' population were equaling 5 percent of the population and children population were 13 percent (figure 2.1). However, it is anticipated that in near future the equation will change, and the numbers will reverse as a result of decreasing in fertility rate beside technology advance and medical science which increase the longevity the life expectancy. World Health Organization (WHO) has pointed out in this case "we will shortly have elderlies' numbers more than children and the elderliness will be more than any time earlier". Elderly people are often susceptible to health issues, syndromes, and diseases due to their inadequate regenerative abilities. Other issues the elderly have to encounter with are the social ones such as loneliness and ageism. Adding years can cause many mental and physical diseases which can lead to a negative attitude toward the community (World Report on Ageing and Health 2015). Therefore, it is vital to understand whether our added years of life will be healthier and thus translate into personal and tangible gains for individuals and society. On the flip side, if the added years are accompanied by physical and mental health decline, then a greater burden is put on health and social care systems and the elderly will be constrained on what they can offer back to society. Predicting which case is happening is vital for developing an equitable and prioritized policy action.

The phrase of elderly (old age) use to classify the group of human being in their late stage of the life cycle; after youth and middle age period. Aging in the definition is a multi-faceted process, occurs from lifelong biological damage that continuously damages body functions and creates a greater risk of external factors that can cause a risk for disease, physical and mental deficiencies and finally, death. Aging though is not entirely predictable. Due to the randomness of aging, including behavioral and environmental factors, some elderly enjoy good general health while others show a marked decline and require extra support for fundamental needs (World Report on Ageing and Health 2015). Nearly all the developed countries recognize the age of 60 to 65 as eligible for retirement, and a person in this age is qualified to access senior social program. People in this age being referred to by names such as retired person and senior citizen.

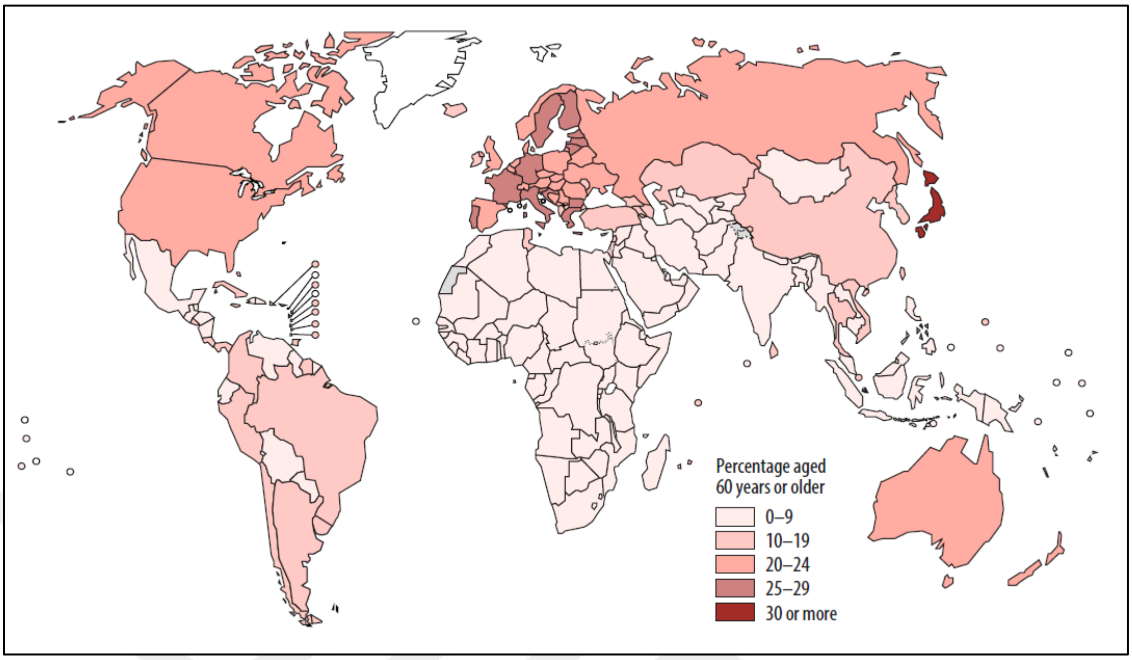
Notwithstanding, a study has shown that elderly people between the age range of 55 and 75 are capable to delay morbidity and postpone the elderliness by undertaking a healthy lifestyle. If the old age years are associated with a minimal probability of disability and illness, an adequate level of physical performance and productive participation in life, the elderly can accomplish what is termed “Successful Ageing”. People who had successes to meet these three components through their early stage of life are more likely to remain independent in the old age stage (Carr, Weir, Azar, R. Azar 2013).

Figure 2.1: Children and Elderly Percentage Between 1950-2050



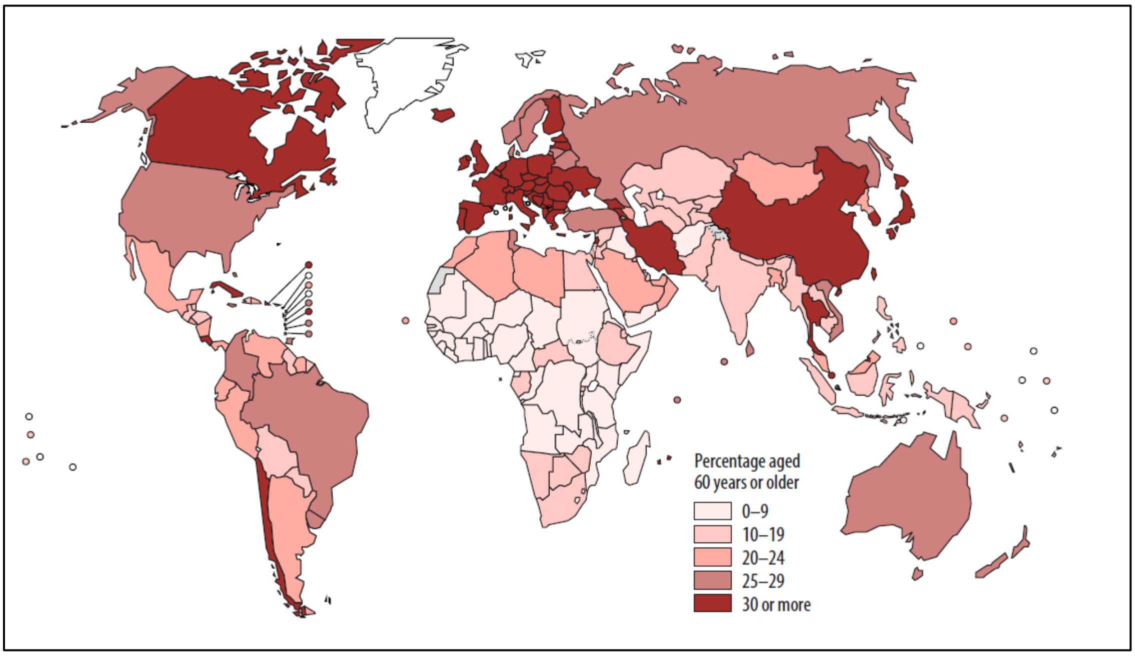
Source: United Nations. *World Population Prospects: The 2010 Revision.*
Available at: http://esa.un.org/unpd/wpp.

Figure 2.2: Age 60 Years or Older Population by Country, 2015 Projections



Source: World Health Organization, World Report on Ageing and Health 2015

Figure 2.3: Age 60 Years or Older Population by Country, 2050 Projections



Source: World Health Organization, World Report on Ageing and Health 2015

2.1 ELDERLY THEORIES OF LIVING

Apart from biological changes, old age stage is often associated with sociological and psychological changes. These changes emerge as a result of shifting in a social pyramid in job and family and relationships loss. In a survey regarding the elderly in Turkey, Cankurtaran and Eker (2007) referred that 49 percent of elderly considering old age is reliant on other, while, 76 percent consider it as a disease and 61 percent consider it the life termination. Gerontologists usually acknowledge that when individuals began their advanced years they will go through major role loss due to reasons such as exiting the workforce, children depart and begin their own lives and close people die. Further, responsibilities and tasks are not clear, thus, likely the elderly experience an absence of life goals and function. The way which old person discerns old age stage is considered a significant factor for defining the elderly mental health, too. Some theories and key concepts have tried to explain the life of elderly and the relationship between the elderly person and society to make a holistic theory of elderly living.

2.1.1 Disengagement Theory

Disengagement Theory is one of the theories which is explaining the social life of the elderly. The theory claimed that in the late age of human being, a mutual disengagement occurs between the elderly and the society. People in this period of life are able to delight in life as a result of releasing from work, family, and responsibilities. The theory has been criticized for pointing out that the detachment from social life is a choice and not inevitable. Further, society detachment is not the result of age, it is the outcome of unsatisfactory ties during the young age (Berk 2006).

2.1.2 Activity Theory

Activity Theory has appeared as a response to the Disengagement Theory. It is claimed that the detachment is taking a place due age consideration by society, which acts as a barrier to elderly engagement, although generally, productivity doesn’t seem to decrease with age. In fact, the researchers of one study concluded “older workers are especially able to grasp difficult situations and then concentrate on vital tasks. The theory has been reproached for not respecting the psychological aspect which happens in old age (Berk 2006).

2.1.3 Insideness Theory

Environmental gerontologists allege that individuals become more attached to their home but simultaneously become more conscious and exposed to their societal and physical settings (Lawton 1977, Lawton & Nahemow 1973). The theory of insideness advanced by Rowles (1978, 1983), attempts to mentally visualize connection to place, associated with three aspects: Physical Insideness, defined as residing for extended periods of time in one place and establishing a degree of control over a setting via a distinctive set of cadence and customs; Social Insideness, which associates the social connections that an individual creates with others; lastly, Autobiographical Insideness, the concept of the elderly's connection to a setting and the memories they possess that crafts their unique personality. Elderly with a durable connection to place further experience more ability, more protection and a confident sense of self. Further, researchers on the human environment indicated that the spaces where we live has a significant influence on our feeling and interacting in everyday life. Environmental changes in design can be a key to physical and psychological issues (Iecovich 2014).

2.1.4 Salutogenesis Concept

Worldwide, health care researchers are focusing on the causative reason for diseases and health issue in exchange to find the cure. Aaron Antonovsky proposed a different point of view in terms of the wellbeing of a human. Aaron indicated that the wrong questions about health sustainability are being asked. In 1970, Aaron had published his concept named "Salutogenesis" with the questions "what can sustain and move human in direction of good health?" and "why some people remain healthy and others don't despite undergone the same events in life?". Aaron had proposed to focus on the reasons which make human healthy Instead of focusing on the illness causes. He claimed that by avoiding unhealthy factors in human life, that would make humans healthier. These questions have created a new approach and framework towards health promotion. Further, Antonovsky has identified that poor health reason is not limited to disease, as well, good health factor is not only the absence of illness. The theory in core represents shifting people life orientation towards health factors and problem-solving. In light of the previous opinion, if architecture along with the technology provider has taken into the consideration this factor while designing homes, a positive influence on people health might occur (Lindström 2010). Further, a consequence of early health care has an effect on economic and society. As long as the elderlies can independent and sustain healthy and mobile, the resulted costs are lower to family and society in long term.

2.1.5 Active Ageing

In 2002, the WHO, via Active Ageing attempted to bring together different policies in a holistic way to define active aging as “the process of optimizing opportunities for health, participation, and security to enhance the quality of life as people age”, to be achieved with coordinated action across multiple sectors. The WHO identified 6 factors of active aging; economic, behavioral, personal, social, health and social services and the physical environment. 4 important factors of health policy were recommended; reducing the burden of chronic disease and disabilities, reducing the risk of major diseases and increasing protective health measures, developing appropriate health and social services for people as they age and providing education to caregivers.

2.2 ELDERLY WELLNESS

As individuals age, they have a higher vulnerability to illness and disease and the necessity of health care and support services grows as well. The high price of conventional medical services for older people brings financial burdens to their relatives and the government. These obstacles are fast approaching and must be handled in a way that ensures society is prepared for the coming aging generations. There is an imperative for the government to present other effective options in place of the conventional medical system and commence programs to overcome this obstacle (Alsinglawi et al. 2017). Medical professionals discovered that the living conditions of long-term care occupants were improved if their surroundings were such as homelike, with as few institutional characteristics as possible. Surroundings that resembled a home and not a hospital were discovered to improve eating encounters. Reed et al. (2005) inspected meal and liquid consumption of occupants in assisted living homes and found that eating in common spaces and home-like surroundings related to greater consumption.

The main cause of hospitalization among the elderly is found to be injuries. The outcome of becoming older allows the elderly to be exposed to specific home injuries such as falling. Failing is a dominant source of dying as a result of injury among the elderly, as noted by the CDC (Centre for Disease Control and Prevention). 33% of individuals over 65 years will generally collapse annually. For individuals above age 80, this generalized risk increases to 50%, with about 70% of collapses happening in the home are usually due to basic obstacles, like carpets, unguarded stairs, blocked passages and open environments with no supports. Due to this, a majority of the methods for creating more secure housing for older people concentrates on diminishing the fall hazards. Some adjustments must be incorporated into the whole home, whereas others will be limited to individual spaces (National Council for Aging Care 2017). This will allow the elderly to continue an autonomous life in their home and avoid unattractive options such as long-term care facilities. AARP (2005) indicate that when the independence is not achievable, the elderly common feeling would be associated with frustration, deficiency, and loss of efficiency, besides, social interaction with another people will decrease.

2.3 LEGAL FRAMES AND POLICIES

As a response to aging, policies should discuss methods that prevent the negative aspects of aging as well as methods that support recovery, adaptation, and psychosocial growth. These abilities are vital for understanding and receiving the assistance to handle their age-related health issues. Our strategies to improve aging should focus on the full spectrum of health and social classes of elderly people, especially the lower class, to account for scaling ability and functionality diversity and inequalities between elderly individuals.

This method touches on the principles of equality and non-discrimination as they obligate governments to reach populations that are vulnerable. Policy options should include steps to improve equity, including: guarantees that elderly citizens have equal access to enhancing their health; developing programs that account for inequality and the concepts of fairness so that the poorest populations are not prevented from obtaining services and in many environments a merging of approaches will be needed engaging elderly citizens and stakeholders to create solutions that can be applied locally and beyond. Policies that account for the social gradient spectrum are both equitable and can create important health benefits for the elderly (World Report on Ageing and Health 2015).

2.3.1 The Rights of Elderly Person

Many reasons are justifying the dedication of our resources to promote the health condition of elderly people. The first reason is the human right to health standards. The standard includes a wide range of policies, laws, and actions to ensure the appropriate health condition of the elderly person. The human rights have underlined the health determinants of elderly by nutrition, housing, and accessibility to a safe living and working environments. Furthermore, human right stated that the countries obligation is to provide sufficient health infrastructure, services, and programs to meet elderly needs. For the elderly, having the ability and right of choice is strongly connected to the idea of autonomy and have an important impact on an elderly's dignity, integrity, freedom, and independence regardless of their living circumstances Environmental and personal resources impact our autonomy in various phases of our lives (World Report on Ageing and Health 2015).

2.3.2 International Law of Human Rights

The rights of the elderly are protected under various international treaties and instruments, including Article 1 of the *International Covenant on Economic, Social and Cultural Rights*, which prohibits age-based discrimination. In the last 20 years, major advancements have been made regarding elder rights, particularly elderly women, migrants and the disabled and their right to secure health, security and living standards (World Report on Ageing and Health 2015).

Universal Declaration of Human Rights - Article 25: Each person has the right to a common level of lifestyle suitable for the comfort and good health of themselves and their family, included nourishment, shelter, clothes, health services and fundamental community services and the guarantee of protection in the circumstances such as losing one's job, illness, disability, advancing years or other deficits in the living standards outside of someone's management.

Madrid International Ageing Plan: In 2002, the UN General Assembly endorsed 3 priorities for action, namely the elderly and their development, improving health in old age, and ensuring the benefits from supportive environments. In 2015, many of these issues still remain relevant; promoting healthy living, access to health care services especially to the disabled elderly, training health care professionals, mental health services, support of caregivers, and preventing neglect and abuse of the elderly (World Report on Ageing and Health 2015).

2.4 CULTURAL FRAME FOR ELDERLY LIFE

"In different countries, the expectations and the realities of elderly life differ from one another. The integration of the elderly into social and communal life differs by country, as do the opportunities, degree of independence and the services available to them. In Turkey, elderly typically live at home with children or caretakers to assist them, while in Japan they may live in nursing facilities with other elderly in a more structured life. Slovenia may represent a middle ground between these two countries and encapsulates different approaches to housing and social integration of the elderly."

In Turkey, the responsibility for elderly care is mostly upon family members due to the custom and family loyalty followed in Turkey. Even though in the main cities, where family relations are likely to be weaker, offspring still anticipated to look after their parents in old age. However, adopting home care programs for elderly along with the followed home care can fall into the advantage of caregivers, in particular, if it is coordinated with both government and private health sectors. Cankurtaran and Eker (2007) pointed out that Turkey in a shortage of elderly care facilities such as social care, nursing home, day or night care, and geriatric hospitals. Elderly facilities in turkey are five located in the major cities with accommodation capacity of 1070 person. In the capital, there are elderly daycare facilities with equipped with the doctor, nurses, psychiatrists, physical therapist and geriatrician who are doing home-visits, yet, their number is still not sufficient to manage elderly people. The first elderly law was in 1930 and the last revision was made in 1997. Further, in the same year, the private sector had granted licenses to start operating services for elderly-care. The main elderly institutions in Turkey are the rehibition services, elderly homes, and elderly care. Nowadays, turkey has 64 elderly institutions with accommodation capacity of 6631 bed, 58 percent for the government sector and 42 percent of the private sector and nonprofit associations. The institutions include 18 rehabilitation centers and 20 and 26 of elderly homes and special needs respectively (Cankurtaran & Eker 2007).

In Japan, one of the earliest private care centers is called Toyama-style care, giving services to residents of all ages, in a home-like building. The facility provides care for the elderly and impaired residents as well as kids in the same setting. The idea of this initiative was to develop a single warm and friendly community for older people, the impaired and children. The results showed that a scaled-down facility was able to benefit the health and self-respect of the residents. In this atmosphere, usual routines and habits were prioritized, while guests and participants were invited to engage in beneficial and important activities arranged around domestic life. This environment differed from typical nursing facilities where life was centered on taking medicine, eating at a certain time and focused solely on the physical needs of residents. Further, some older people were even participating to take care of children. The elderly when grouped with kids they were able to supervise them properly and were able to better adapt to their personal situation. Generally, the elderlies were more joyful, felt productive and found a sense of self-realization gained through these duties. This programs also served to the advantage of the children, as they saw their elders as helpful and sympathetic teachers while also understanding their infirmity, delicateness and their mortality. Through these activities, older people learned they possessed important knowledge to pass to the youth. They were able to make kids cheerful, teach knowledge and culture, give them a feeling of self-restraint and provide them essential life lessons. The families of both generations also gained through this; parents were pleased and assured that their kids were under the direction of knowledgeable elderly and the elderly's families were happy with the care and interaction they experienced (Kurian & Uchiyama 2012).

In Slovenia, the elderly care based on various sorts of accommodations available to its older population; rental and sheltered homes and elder care facilities. Rental homes include non-profit homes and retirement homes, of which the share of the latter is 70% and 3%. Retirement homes are designed to accommodate the requirements of older citizens who want to stay autonomous and self-sufficient with only infrequent help. Sheltered housing is architecturally accommodated to the requirements of elderly at their home with simple connections to transportation system and a round-the-clock of medical support. This type is meant for older citizens who cannot completely support themselves but yet are able to reside comparatively autonomously. Elder care facilities provide a type of organized service for elderly that are unable to live unaccompanied because of health, personal or other concerns. The help provided in these homes substitute or accompany the capacity of a home or what a family could provide: housing, food, medical services and technical support. The life in this facility structured to give the maximum potential privacy and independence to residents, centered on their mental and bodily capacities (Kerbler 2014).

2.5 AGING IN PLACE

Every one of us has undergone a type of impactful relationship, positive or negative, enjoyable or not, with a place that is connected to our own present or previous history, or with a place that represents the future, such as our dream home. It may be a home we've resided in, a specific room in the home, the surrounding areas, the neighborhood, city or country. These places we bond with give substance to our reality and goes beyond simple recognition of the bond. The relationship we have with specific spaces sharply and constructively impacts our identity, and connections with home, workplace, neighborhood give our existence context and definition and a sense of beneficial identity.

2.5.1 Place Attachment

Giuliani (2003) resembled the connection with places like the connection between lovers. This connection is an emotional connection established on a long-lasting relationship where the one's lover is significant and irreplaceable with another, along with a tendency to preserve a continues connection to the lover, in the hopes of security, safety, and happiness. Such as when people may only recognize their attachment to their significant others when that relationship is endangered, a similar occurrence happens with their attachment to place. What's binds individuals to their home is the webs of personal and practical connections and consequently, this forms difficulty and stress when moving homes or changing cities or neighborhoods.

In the UK, a study was conducted to understand community attachment regarding the impact of sociological variables (Giuliani 2003). The outcomes were scored as such: the idea of belongingness to the living space, the concern of the neighborhood and the happiness or pain that moving would bring. Additionally, the time spent in that home were correlated with the sense of belongingness and to the pain of leaving that place. The desire for home stability is linked to person individual requirements, attributes, resources, along with happiness within the community.

2.5.2 Meaning of Home

“Home is where one starts from. That much is obvious” (Rykwert 1991). A home is not equivalent to a dwelling thus, we require diverse terminology for them. Home can be as simple as a fireplace. According to Rykwert (1991), a fireplace is the center point where our attention begins and without this attention, it does not constitute a home. Home doesn’t necessitate a physical structure, yet a dwelling is defined as such. A dwelling needs stone and wood, walls and floors, cement and plaster (Rykwert 1991). Home is superior to stone and wood, arranged areas and shaped structures, it is the convergence of the essential community ties binding its occupants together. What makes a dwelling a home involves intangible elements, such as one’s social and psychological involvement with the dwelling. Home is a sequential route, one that is understood after months or years and turn into an accustomed setting. Home can be the place where our kids grow up, where we socialize with others and where we return by the end of the days (Despres 1991). Home is a space that includes a feeling of belonging and identity. As individuals become elderly, the experienced time with their dwellings increase and the dwelling becomes a symbol of their tastes and interests. Representing them through furnishings, items, decoration, and symbol of their identity through their customs, shared unity and history. This will turn the dwelling into a place with a sense of direction, a place which touches on the idea of belonging, a place par excellence. This eventually will turn the dwelling into a home.

As such, attention needs to be applied when altering the home, as this feeling of identity is essential on the elderly, especially for those with mental or physical handicaps. The elderly might have challenges associated with the undertakings of their daily routine, which are diminished when done in places they know well. Familiarity with the surroundings and its elements allows the elderly to better navigate areas that may usually necessitate more effort (Guihen 2016).

This requires developing a personal area which is protected and safe to use by the elderly and enables the creation and maintenance of individual relationships and shared ties. Without the appropriate home-support, the elderly more likely to undergo psychological and physical declines which require movement to a nursing home facility, irrespective of their wish.

Empowering the elderly who can stay autonomous in their own homes, to “age in place”, ought to be a primary component of any strategy dealing with elderly changing demographics, to the advantage of the elderly and the public as well (Guihen 2016).

2.5.3 Aging in Place Concept

University of Missouri scientists created a prudent program, named “Aging in place” to enable the elderly to live at home autonomously (Alsinglawi et al. 2017). The concept of Aging in Place refers to providing people with the possibility to stay in their own familiar home or neighborhood independently and improve their health care and quality of life (Tomita et al. 2010). Minor changes to the current environment can support people to remain in their place, preserve the social cohesion with family and initiatives the dignity and independence (Ball 2012). The concept has been proposed as an alternative to nursing at home (Tomita et al. 2010). The transition to senior housing and eventually to health-care facilities are typically the result of habitat failures to reconcile the various challenges of the elderly due to health, social alienation, impediments to accessibility in both home and the outside world and a lack of fundamental and beneficial care. Aging in place requires ideas to be developed for a home to be more useful and safer for the elderly by giving access to home support systems that can assist in daily life. The goal is that even sick elderly can remain protected in their homes if they have suitable systems and services. The basic definition is typically used to define a policy directive of being able to stay at home autonomously while aging and preserving a sense of agency, capacity, security, and confidentiality. The elderly discerned aging in place as being about possessing options to their housing, preserving a sense of community and connection with others, feeling protected within their households and neighborhood, and a sense of autonomy and sovereignty (Iecovich 2014). The concept should cover a wide variety of home independency solutions and programs that head towards solving many types of impediments such as, changes in the healthcare needs, decrease of the mobility, financial worries and house maintenance (Ball 2012).

2.5.4 Aging in Place Objectives:

Aging-in-place consists of two primary objectives; firstly, from the perspective of the elderly and their families, is that most elderly would choose to remain in their homes until it is no longer tenable as it offers them a sense of security, preservation of identity and allows the agency and choice regarding their lives. Moving often results in lost social connections, a change in their established everyday conventions and lives, abandoning items of sentimental value which will not fit in their new accommodations and losing their autonomy. A study has shown that 26% of individuals who were afraid of assisted living expressed that by and large, they were afraid of a loss of autonomy. The outcome of this can be anxiety, despondency, isolation, challenges in adapting, loss of capability and crippling their health and happiness. Additionally, it can be a financial stress for the elderly, especially if they're with low incomes (Iecovich 2014).
Secondly, institutional care is far costlier than receiving care in an elderly's own home or community from the view of policy designers. The immense expense to government coffers regarding assisted-living encouraged policymakers as well as industry insiders to offer more diverse solutions to care for the enfeebled elderly in their communities. In fact, large numbers of aging societies have backed policies that greatly emphasize aging-in-place, with home and community-oriented assistance have begun to spread. This has enabled new choices for elderly who require help in keeping a degree of autonomy in their lives as well as elderly who are averse to nursing homes. Both the general public as well as officials are accommodating the wants of the elderly to age-in-place (Iecovich 2014).

2.5.5 Aging in Place Programs and Key Components

Ball 2005 has pointed out to the key components of Aging in Place as Choice, Flexibility, Mixed Generations, and Smart Growth.

a. Choice

Choice requires providing the ability to fulfill the healthcare and housing needs. Choices for elderlies should be various and affordable to their retirement income such that all people or their care providers can select from a spectrum of options. One example in the USA, the Atlanta Commission financed household services to implement a program for caretaker vouchers. People are given a fixed number of vouchers, enabling them to select from private or municipal providers to support their main necessities. Participants have hired people to finish landscaping service, gotten medical supplies from their community pharmacist and used daily elder-care facilities. With an importance placed on choice, the voucher initiative shows the outcomes that can be attained by people identifying their own requirements and subsequently selecting the most appropriate supplier for their necessities.

b. Flexibility

Aging in Place Flexibility offers a variety of services to be utilized in a spectrum of contexts. Flexibility aims to provide an adjustable level of housing health in different environments such as private home, family home, or public elderly home. People have a diverse list of requirements and concerns in their home. For example, New York State launched program called "Nursing Home Without Walls" in 1978. Participants have the option to take an in-residence service program instead of going to an elder care facility. The program gives suitable medical and domestic services to an equal degree as those provided in live-in elder facility. The program gives the flexibility for the participant to select a mixture of services that is most appropriate for their requirements and demonstrated success be priced at 75% of the price of a traditional elder facility.

c. Mixed Generations

Living with a diverse age group of people has advantages being of together. The elderly can babysit, teach and provide a sense of constancy when they participate in the lives of youthful families. The youth help the elderly to stay involved and energetic as they age. This reciprocally advantageous connection requires planning to allow the generations to mix. Maximizing the capacity of elderly people for self-care, independence, and contribution to the community can be achieved by preserving mixed generation society. The relationship between the elderly people and younger age group can be described as mutual interest. Young parents are often seeking for childcare whilst elderly person might require an assistant to go to the store or perform a physical task. Youths need an extra job after the school whilst elderly person needs support in a small job in the house. Modern design, regulation and construction methods typically deter multi-generational housing. This planning leads to communities fully comprised of multi-bedroom large family homes that are not suitable for single people or elderly couples. Likewise, other communities my only be comprised of small apartments or town homes and are unwelcoming to families with children. Urban designers generally dislike "spot zoning" that enables these diverse mixes of housing. The Penn South Housing promotes and designs for constructive exchanges between generations. With purposefully designed surroundings, pedestrian and rest areas for the elderly are adjacent to playgrounds of children. One garden space has been planned as an "intergenerational garden" with a mark places for elderly and children side to side.

d. Smart Growth

For a generation nearing retirement, society may anticipate demographical changes and most elderly will move to places that are prepared for smart elder friendly growth. Smart Growth is creating surroundings with enhanced approachability and comfort in line with the of Smart principles to help every citizen. For many elderly citizens, the suitable home design is more than just an aesthetic, it is a basic essential. Aging in place enabling the elderly to sustain in their place and be active and participatory in their communities.

3. UNIVERSAL DESIGN FOR ELDERLY LIVING

The demands of housing accessibility-rights were raised in 1960 in the USA. Those with special needs and elderly people have initiated a protest to claim a solution for their daily barriers and difficulties facing them in life (Duncan 2014). As time changed, new challenges have emerged, and accessibility in housing design became an important aspect at the beginning of the 1980s. Ronald Mace termed the phrase ‘universal design’ in 1985 to explain the goal of creating environments that are more practical to all people, despite their maturity or bodily capabilities. Additionally, the progression of current healthcare and the increase in longevity has promoted utilizing universal design in housing construction and products, technologies, and utilities (National Council for Aging Care 2017).

Universal design is developing a setting that is accessible to all individuals despite their maturity, size, capacity, and handicaps. The aim is to advocate the idea and principles of universal design and inspire architects and developers to be inventive regarding resolutions that can satisfy the requirements of all types of building users (National Disability Authority 2014).

3.1 UNIVERSAL DESIGN PRINCIPLES

A group of engineers, product designers, environmental design researchers, and architects cooperated to list the Principles of Universal Design to be a guide on a broad set of design fields such as products, environments, and communications. Using principles, designers and customers can become more knowledgeable about assessing existent designs, advising the design development and creating a better understanding of the aspects of more convenient environments and products for all. (Connell et al. 1997).

The Universal Design Principles are divided into 7 Principles:

a. Equitable Use: The design should be convenient for all individuals with varied capabilities and allow a similar user experience. Additionally, it should not divide or diminish any user while providing safeguards for protection.

Figure 3.1: Universal Design Equitable Use

Source: Connell et al. 1997

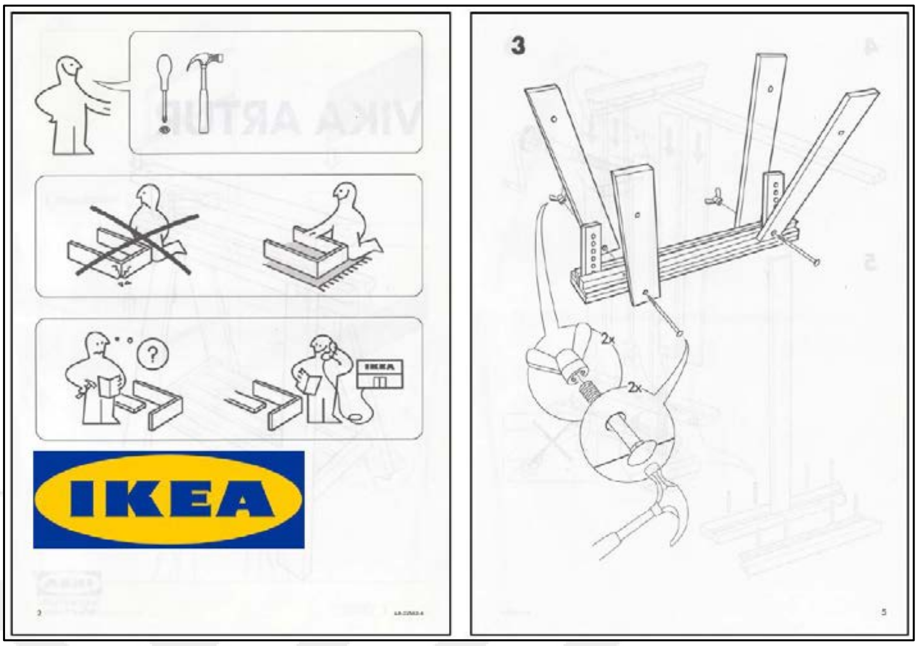
b. Flexibility in Use: The design should account for a broad spectrum of personal choices and capabilities, give options for operation, and be able to adjust to the user speed.

Figure 3.2: Universal Design Flexibility in Use

Source: Connell et al. 1997

c. Simple and Intuitive: The design should be simple to comprehend despite different levels of consumer ability and practical background. Ideally, it should avoid complications and be compatible with consumer assumptions.

Figure 3.3: Universal Design Simple and Intuitive



Source: Connell et al. 1997

d. Perceptible Information: The design should transmit vital data to the consumer despite the consumer's capability regarding the senses. Ideally, it should provide crucial feedback and discern components to be easily explained, such as directions or instructions. Lastly, it should accommodate harmony between various techniques or products utilized by individuals with sensory handicaps.

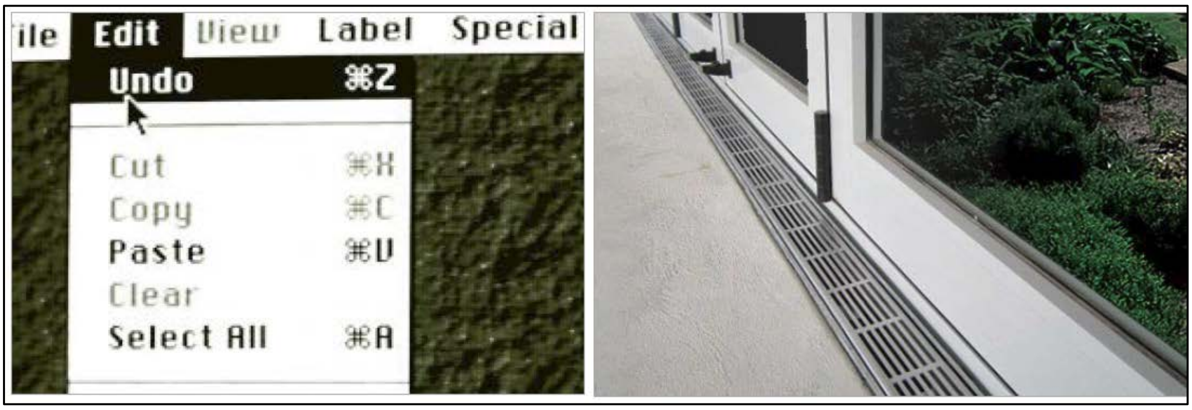
Figure 3.4: Universal Design Perceptible Information

Nanakuma Line, Japan
Each station is color coded and is identified in English, Japanese, and by its accompanying unique symbol. Symbols generally relate to the station's surroundings.

Source: Connell et al. 1997

e. Tolerance for Error: The design should decrease risks of unintended behavior. Ideally, it should organize components to diminish risks and failures of frequently used elements and give notifications regarding risks and mistakes.

Figure 3.5: Universal Design Tolerance for Error



Source: Connell et al. 1997

f. Low Physical Effort: The design has the ability to be utilized in a convenient and pleasant manner to lessen tiredness. It should grant the user to keep a relaxed posture and lessen continuous bodily exertion.

Figure 3.6: Universal Design Low Physical Effort

Source: Connell et al. 1997

g. Size and Space for Approach and Use: The design should be of a proper size and area is given for the access, distance, control, and utilization indifferent of the consumer's bodily shape.

Figure 3.7: Universal Design Size and Space for Approach and Use

Source: Connell et al. 1997

3.2 UNIVERSAL DESIGN HOME

Throughout life, our needs evolve, whether in lifestyle, family and finally regarding our condition of well-being. As it is mentioned in chapter 2.5, the idea of home is important for the sustainability of the elderly identity over time that has to do with place attachment and that aging in place is an important concept in that aspect. A universal design for the home is able to evolve alongside us by incorporating from the beginning some essential design aspects that can enhance the life quality of all residents of a home with multi-ages, needs, and abilities. Universal Design Home residency reduces the necessity for moving or expensive renovations as the person and family's demands evolve. In the case of re-fits to existing living environments, "The Global Health and Ageing report (2011) point out the importance to maintain the wellbeing of the elderly that is affordable. Besides, current knowledge should be implemented to prevent aging-related risks. The method of Universal Design erases or diminishes the requirement of costly retrofits or adjustments to satisfy the requirements of specific groups in a future time.

Baczynski (2012) emphasizes the subject of the universal design for homes as a solution to daily obstacles and difficulties facing the elderly. The demands of elderly people, or even our aging body, should be taken into consideration while laying out the home concept. The aim is to produce an easily accessible space for elderly living along with comfortableness and socializing. The design should cover a large segment of people with different needs without further adaptation.

Gerring & Wozniak (2016), presents a list of six universal design homes to support aging in place. Further, the national disability authority in Ireland has provided a guideline which is in line with these seven principles. These principles can be used for designing new homes to avoid future renovation or to update existing homes. The authors claim that implementing the principles into home layout will be the wiser use of spaces without necessitating any additional space. Figure 3.21 shows an example of a modified home plan according to universal design principles to allow the accessibility of a wheelchair user to the bathroom without requiring further space to the home.

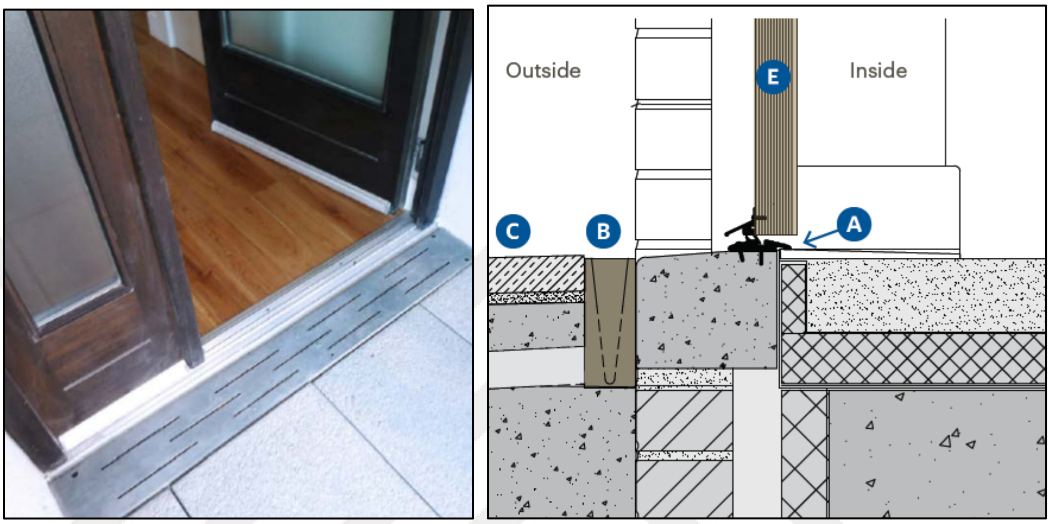
3.2.1 Accessible Entry

Supply at least one ramp from the street to the home entrance.

Provide the home with doors not less than 90cm in width.

Equip the external doors with a level threshold and internal doors with a level transition.

Figure 3.8: Accessible Entry Threshold with Level Drainage Strip



Source: National Disability Authority 2015

Figure 3.9: Accessible Doors

Source: National Disability Authority 2015

Figure 3.10: Accessible Ramp

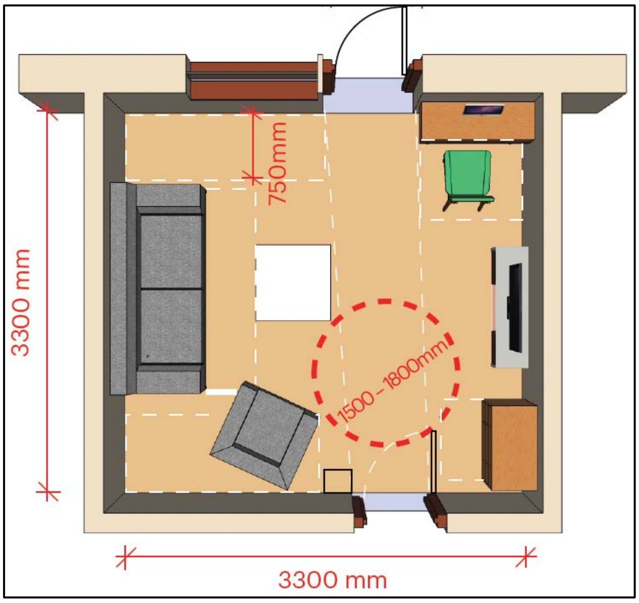
Source: Gerring & Wozniak (2016)

3.2.2 Accessible Horizontal Circulation

Provide the home with a 150cm of turning radius in rooms, kitchen, and bathroom to enable easy wheelchair maneuvering.

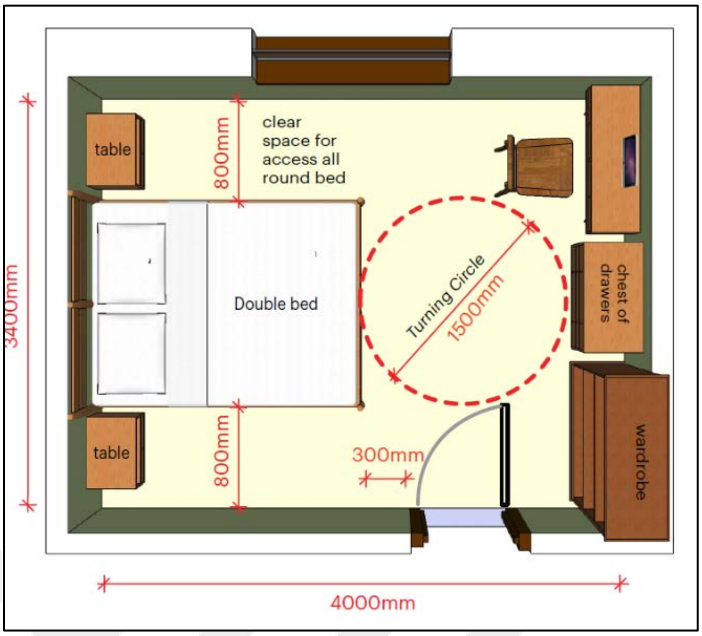
Ensure that home corridors have a clear width of 120cm to provide accessibility to walking aids or wheelchair users.

Figure 3.11: Accessible Horizontal Circulation (Living Room)



Source: National Disability Authority 2015

Figure 3.12: Accessible Horizontal Circulation (Bed Room)

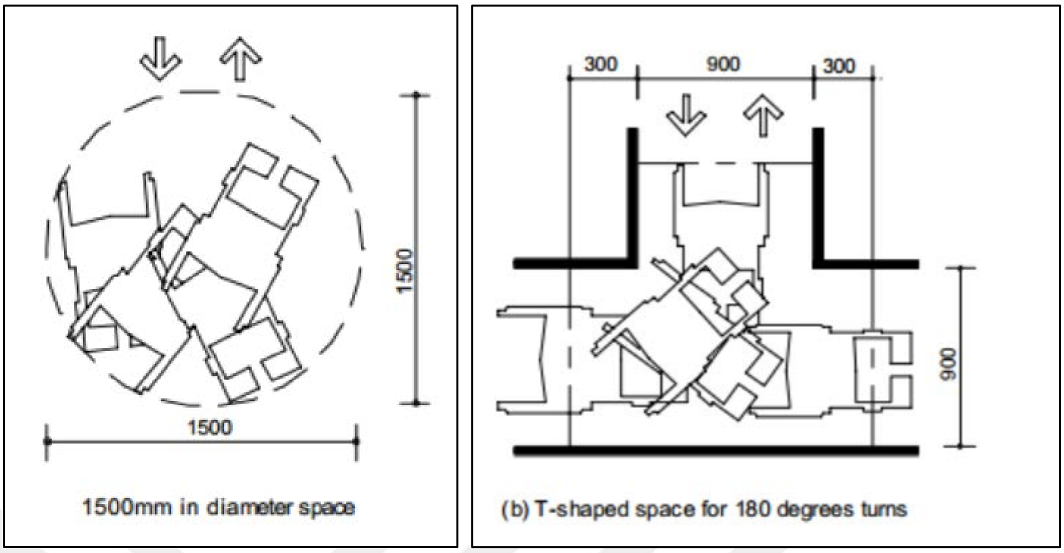


Source: National Disability Authority 2015

Figure 3.13: Accessible Horizontal Circulation (Corridor)

Source: National Disability Authority 2015

Figure 3.14: Accessible Horizontal Circulation (Wheelchair Turning Circle)



Source: National Disability Authority 2015

3.2.3 Accessible Vertical Circulation

Avoid designing stairs with single steps as it engenders a risk of falling.
Provide a width of 90cm to the stairs to permit installation of stair-lift if it is required.
Equip the surface of the stairs with non-slip materials or non-slip bands.
Provide extended handrails of 30 cm after the stairs end.

Figure 3.15: Accessible Vertical Circulation (Stairs and Handrails)

Source: National Disability Authority 2015

Figure 3.16: Accessible Vertical Circulation (Stair Lift)

Source: Gerring & Wozniak (2016)

3.2.4 Accessible Kitchen

Ensure that kitchen worktop is without cupboards underneath to permit use by a seated person.

Provide 120cm of distance between facing kitchen units.

Equip the kitchen with handles and not knobs for easier grip by weak hands.

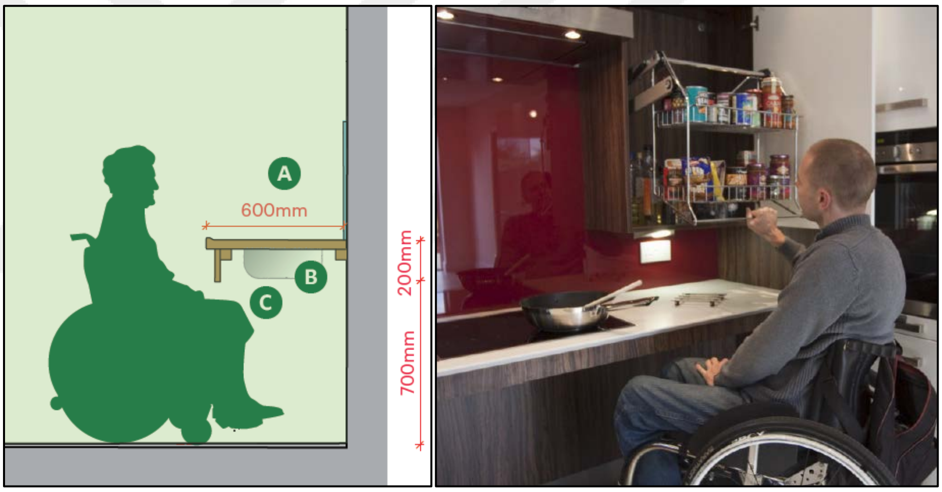
Use tiles for the kitchen with non-slip and non-reflective surfaces as it can cause disorientation for elderly with sight difficulties.

Figure 3.17: Accessible Kitchen

Source: National Disability Authority 2015

Source: National Disability Authority 2015

Figure 3.18: Accessible Kitchen (Height Adjustable Kitchen Worktops)



Source: National Disability Authority 2015

3.2.5 Accessible Bathroom

Equip the shower with a level transition to provide autonomous use by an old person.

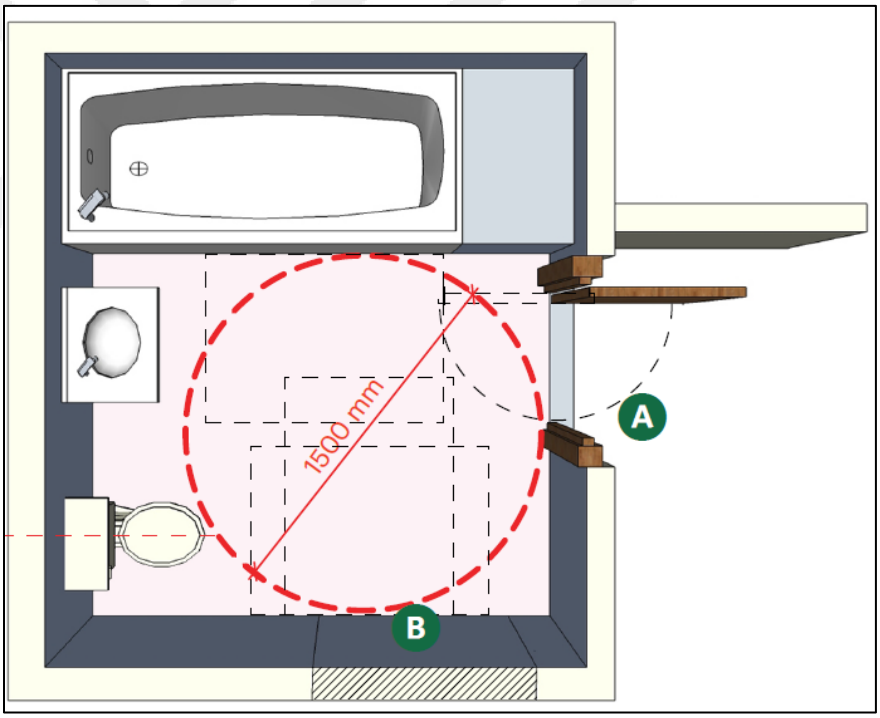
Equip the bathroom walls with reinforced spots near to the toilet and shower to enable installation of handrails as required.

Provide 40cm of space from the wall prior to toilet installation to grant sufficient space for grab bars and from the opposite side provide appropriate distance for the person moving from a wheelchair.

Adjust the height of the basin to 80cm with clear space underneath to allow access of a seated user.

Use tiles for the bathroom with non-slip and non-reflective surfaces.

Figure 3.19: Accessible Bathroom



Source: National Disability Authority 2015

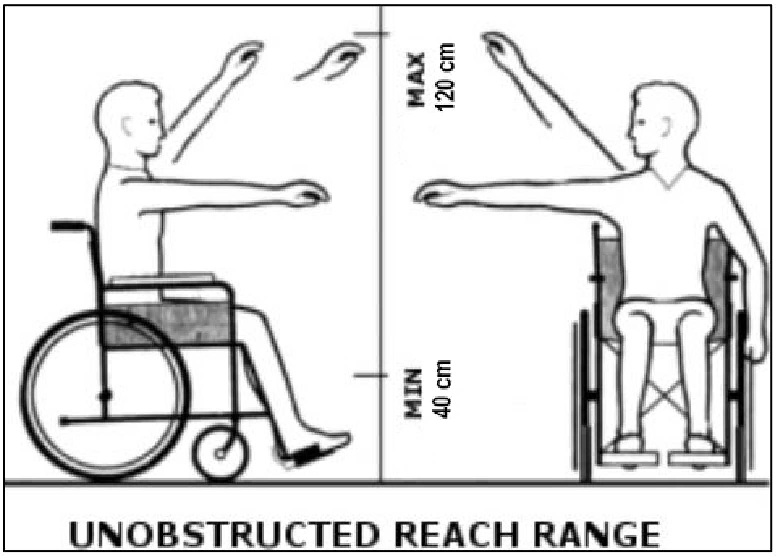
Source: National Disability Authority 2015

3.2.6 Accessible Fixtures

Provide the doorbell at 120 cm from the floor and avoid using knob handles and use lever ones.

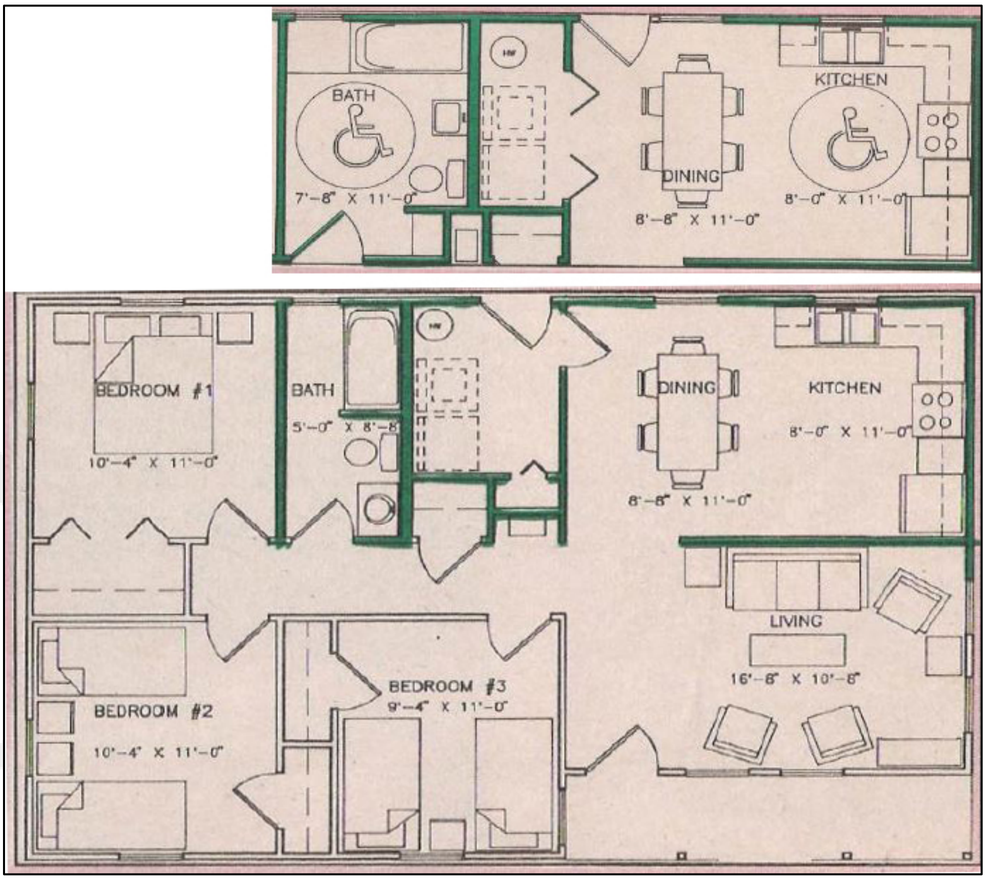
Supply the home with electrical sockets and switches besides HVAC controls at a height of 120cm.

Figure 3.20: Accessible Fixtures (Switches Hight for Wheelchair User)



Source: http://www.carolinahomeplans.net/age-in-place-plan-details-article.html

Figure 3.21: Adjusted Home Plan According to Universal Design Home



Source: Gerring & Wozniak 2016

3.3 UNIVERSAL DESIGN HOME CASE STUDIES

The following section demonstrates three house models which have adopted universal design home principles. This case studies highlight key design features for elderly' houses in a practical and effective approach. According to principles and aspects developed above, “A Checklist of Universal Design Home-Requirements for Elderly” is listed in Table 3.1. Following notes will be used for assessment: Not applicable: (-), Weak: (-+), Mediocre: (+), Strong: (++). Additional concepts observed by the study of cases can be added as an extended checklist for universal design home principals.

Table 3.1: A Checklist of Universal Design Home-Requirements for Elderly

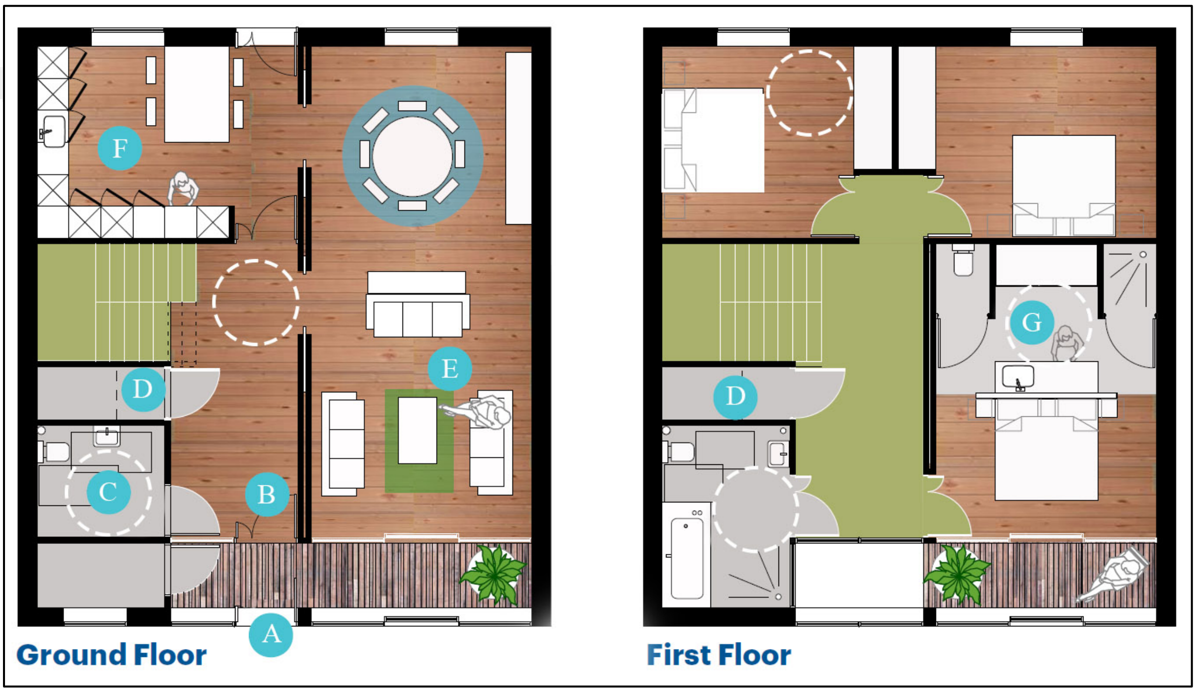
Accessible Entry	Supply one ramp from the street to the home entrance.
	Provide the home with doors not less than 90cm.
	Equip the external doors with a level threshold and internal doors with a level transition.
Accessible Horizontal Circulation	Provide the home with a 150cm of turning radius in rooms, kitchen, and bathroom.
	Ensure that home corridors have a clear width of 120cm.
Accessible Vertical Circulation	Avoid designing stairs with single steps.
	Provide a width of 90cm to the stairs.
	Equip the surface of the stairs with non-slip materials or non-slip bands.
	Provide extended handrails of 30 cm after the stairs end.
Accessible Kitchen	Ensure that kitchen worktop is without cupboards underneath.
	Provide 120cm of distance between facing kitchen units.
	Equip the kitchen with handles and not knobs.
	Use tiles for the kitchen with non-slip and non-reflective surfaces.
Accessible Bathroom	Equip the shower with a level transition.
	Equip the bathroom walls with reinforced spots near to the toilet and shower.
	Provide 40cm of space from the wall prior to toilet installation.
	Adjust the height of the basin to 80cm with clear space underneath.
	Use tiles for the bathroom with non-slip and non-reflective surfaces.
Accessible Fixtures	Provide the doorbell at 120 cm from the floor and avoid using knob handles and use lever ones.
	Supply the home with electrical sockets and switches besides HVAC controls at a height of 120cm.
	Use tiles for the home with non-slip and non-reflective surfaces, practically, for kitchen and bathroom.

Source: National Disability Authority 2015

3.3.1 Dublin House

The national disability authority in Ireland has Illustrated an example of an existing house in Dublin city which is in line with the universal design approach. The aim of this house is to raise awareness among architect, engineers, and planners and provide a practical guideline to assist the delivery of the universal design home for all ages (National Disability Authority 2015).

Figure 3.22: Dublin House



Source: National Disability Authority 2015

The home entry has a level street access and a level threshold (A), the entrance hall has wide of 150cm of an unobstructed corridor (B), the bathroom in the ground floor with 150cm of turning radios and adequate space allowing shower installation if it is needed (C). Near the stairs, a storage room of 100×150cm, suitable to allow floor-lift installation in the later stage if it is required (D). The living room has sufficient space adequate for movement of everyone including seated person (E). Accessible L shape kitchen with worktop and fixture to be used by old or seated person (F). Accessible bathroom with the level transition to shower and reinforced walls next to the toilet to allow handrail installation (G).

Universal Design Home Checklist: *Not applicable: (-), Weak: (-+), Mediocre: (+), Strong: (++)*
Accessible/Entry: (++), Horizontal Circulation: (++), Vertical Circulation: (++), Kitchen: (+), Bathroom: (+), Fixtures: (+).

Learned aspects:

Accessible Vertical Circulation: a two-story storage room can be used to install floor-lift if it is required.

3.3.2 Keith Collins Universal Design Home

As the elderly are living longer than ever, several homebuilding companies in the USA have tried to address the obstacles facing the autonomous living at home and providing custom-made and universal design homes for them. In her article "Building Homes to Age In", Ludden (2010) examined the life of one elderly after his move from nursing home to universal design home built by Keith Collins. The older man was using a wheelchair and had lived for 13 years in a nursing home prior to leaving to the universal design home designed to suit his needs. The home was built from the beginning to be convenient for the requirements of a wheelchair user. The homebuilding company claimed that the construction cost is no more than a traditional home if it was built from the beginning as a universal design home for the elderly. In comparison to a nursing home, the older man describes the home, as the place of greater freedom, dignity and independent activity. The home plan designed without steps to allow easy maneuvering, doors with lever handles (A), and kitchen with large space for movements and grab bars (B, C). the bathroom provides level access shower (D) and shower valves have a lever handles (E) and the sink with free space underneath to allow the use by a seated person (F).

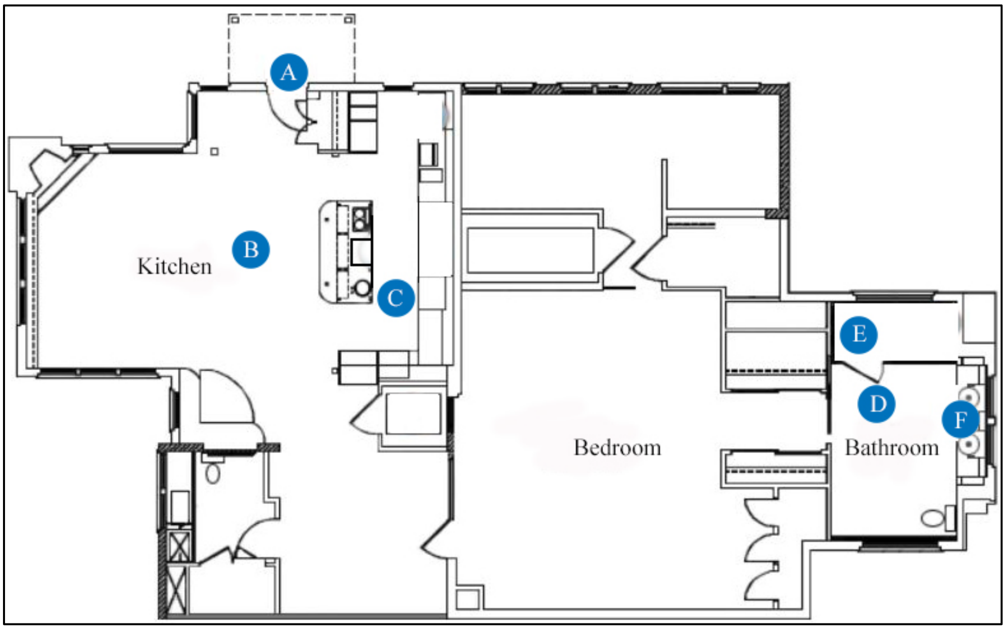
Universal Design Home Checklist: *Not applicable: (-), Weak: (-+), Mediocre: (+), Strong: (++)*
Accessible/Entry: (++), Horizontal Circulation: (++), Vertical Circulation: (-), Kitchen: (-+), Bathroom: (++), Fixtures: (++).

Learned aspects: The cost of the universal design home is not more than a traditional one if it was built from the beginning as a universal design home for the elderly.

Figure 3.23: Keith Collins Universal Design Home

Source: Ludden (2010)

Figure 3.24: Keith Collins Universal Design Home Plan



Source: https://www.npr.org/templates/story/story.php?storyId=129320864

Figure 3.25: Keith Collins Universal Design Home Interior

Source: https://www.npr.org/templates/story/story.php?storyId=129320864

3.3.3 FabCab Home

As a response to resident wellness living at home, architect Emory Baldwin designed FabCab in 2010 in the USA. The FabCab home is based on universal design features with high-quality materials and with using solar panels for energy efficiency. The company constructs universal design homes, besides custom-made homes, as per user requirements such as the following home which is designed for two-wheelchair users. FabCab designed their home to allow easy maneuvering, have a home-like appearance and not seem like a care facility and lastly, grant them the ability to age in place (Budds 2016). The architect has designed the home plan in two sizes, one-bedroom (60m2), (see figure 3.27) and two bedrooms (90m2), (see figure 3.28). The doors are 90cm in width along with equipping sliding interior doors. The kitchen has low-level cupboards and knee clearness space under the sink for easy use by the users (figure 3.29). The bathroom has level access to the shower with seat and grab bars for both the shower and the toilet and to decrease the falling risk (figure 3.30), the ground covered with large format tile. Further, for declining vision in old age, the architect implements extra lights in the ceiling and above the kitchen countertops besides providing the home with large windows to give adequate daylight (Fabcab 2018).

Universal Design Home Checklist: *Not applicable: (-), Weak: (-+), Mediocre: (+), Strong: (++)*
Accessible/Entry: (++), Horizontal Circulation: (++), Vertical Circulation: (-), Kitchen: (++), Bathroom: (++), Fixtures: (++).

Learned aspects:

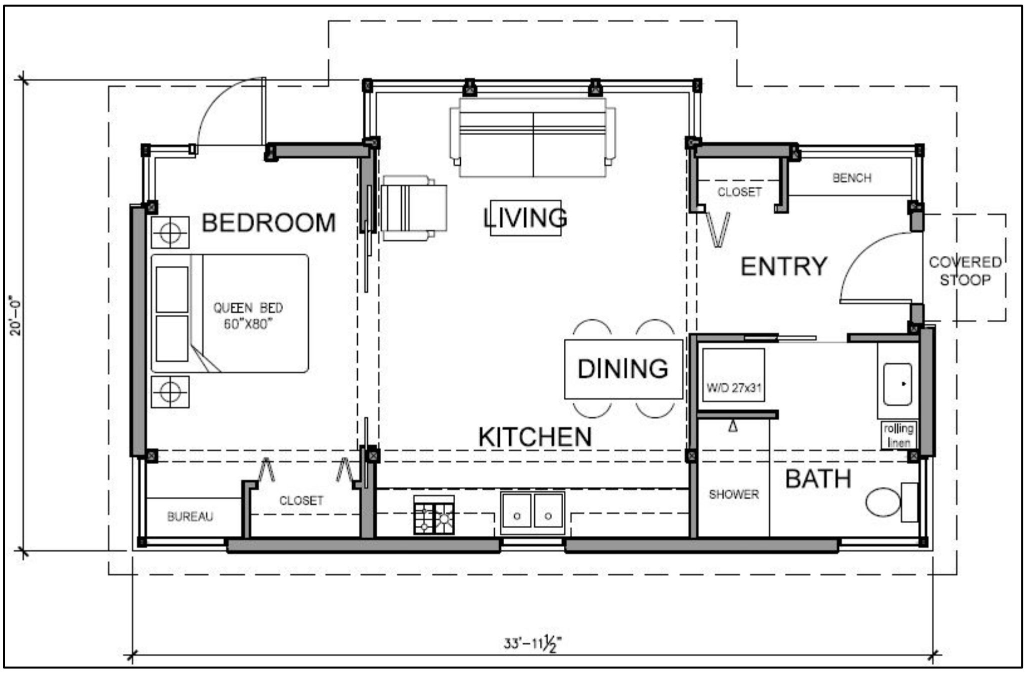
Accessible Entry: equip the internal doors with sliding door type.

Accessible Bathroom: use large format tiles to decrease the falling risk.

Figure 3.26: FabCab Home

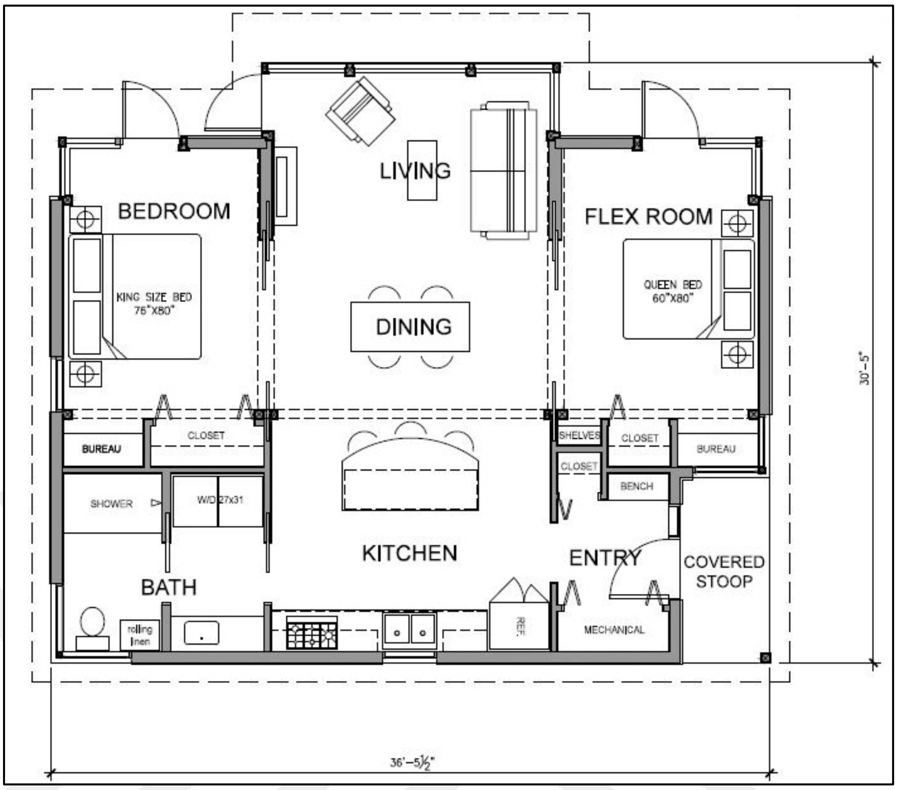
Source: Budds 2016

Figure 3.27: FabCab Home Plan (1 Bedroom- 60 m2)



Source: Fabcab 2018

Figure 3.28: FabCab Home Plan (2 Bedroom- 90 m2)

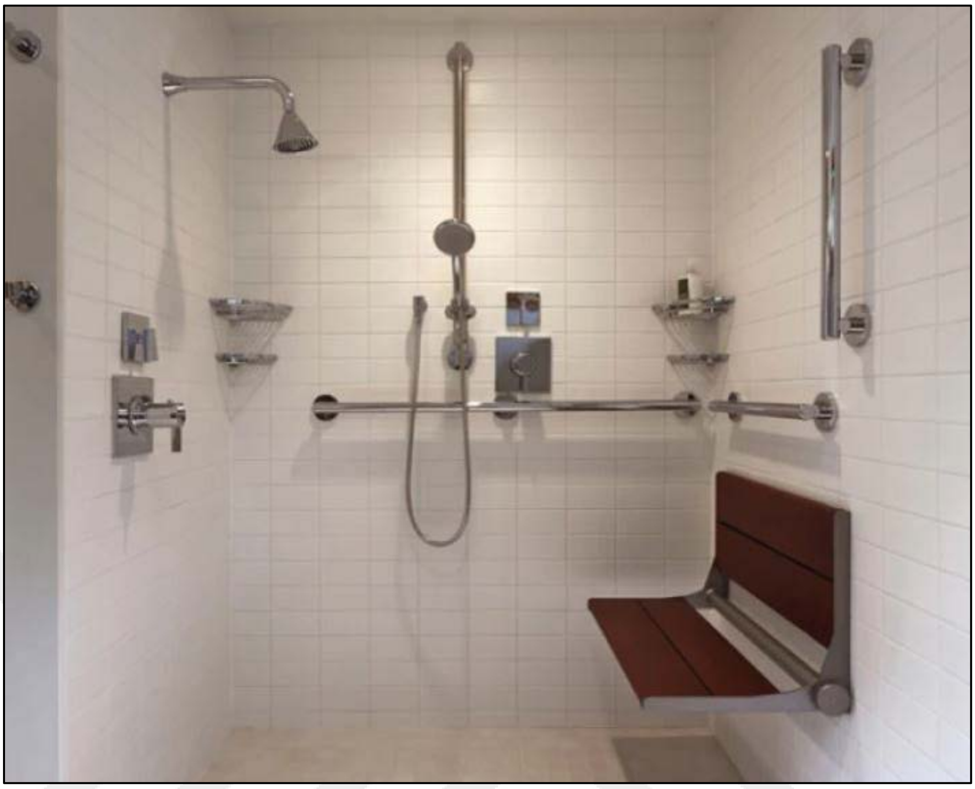


Source: Fabcab 2018

Figure 3.29: FabCab Home Kitchen

Source: Fabcab 2018

Figure 3.30: FabCab Home Bathroom



Source: Fabcab 2018

3.4 EVALUATION OF CASE STUDIES AND FINDINGS

The following section evaluates the previous house models which have adopted universal design home principles and highlights the differences between them in terms of the key design features. Accordingly, “Evaluation of Case Studies and Findings” is listed in Table 3.2. Following notes will be used for assessment: Not applicable: (-), Weak: (-+), Mediocre: (+), Strong: (++). Following the evaluation table, a learned aspect from case studies can be added as an extended checklist.

Table 3.2: Evaluation of Case Studies and Findings

Universal Design Home Principles	Dublin House	Keith Collins	FabCab
Accessible Entry	++	++	++
*Sliding internal doors	-	-	++
Accessible Horizontal Circulation	++	++	++
Accessible Vertical Circulation	++	-	-
*Storage room to be used as floor-lift	++	-	-
Accessible Kitchen	+	-+	++
Accessible Bathroom	+	++	++
*Large format tiles in bathroom	-	-	++
Accessible Fixtures	+	++	++

* Learned aspects

As shown in table 3.2, Fabcab has gained a strong assessment in all principles, while Keith Collins assessed as weak in kitchen accessibility due to the absence of worktop with clear space underneath (check figure 3.25-C).

3.5 UNIVERSAL DESIGN LIMITATIONS

Although Universal design concept promises a better quality of life for all and especially for elderly, accessibility to this perspective is not without problems and limitations. According to the AARP survey, the cost was the main factor which barred home modifications that were necessary to age in place. Additional causes were the difficulty in achieving the modifications personally and uncertainty about the nature of the required adjustments. The survey results pointed out to the necessity of social services to provide people with information, funding solutions, and architectural options (AARP 2005).

4. SMART HOME CONCEPT FOR ELDERLY LIVING

The phrases “smartness” typically symbolizes a person’s mental capability. Human intelligence includes various essential stipulations, such as awareness, communication, recollection, ability to learn, and preparing. Artificial intelligence is the analysis of intelligent parts that recognize its surroundings and decide the correct choices. Alternatively, collective intelligence is the cooperative ability of society to develop, share information, learn and discover. A merger of artificial, human and collective intelligence makes smart environments (Mitchell 2008). Colldahl, Frey & Kelemen (2013) claimed that the smartness in our cities is a result of the integration between three city types which consequence a new planning approach. These three cities are knowledge city; which promote personal development; eco-city which aims to use renewable resources for environmental sustainability; and the digital city which targets investing in technological infrastructure. The smartness in cities can be visualized as being in a place where there is forward thinking in governance, environment, economy, mobility, people, and living. The concept basically grounding in combining urban planning methods with information and communication technologies to deliver technological solutions and strategies to enhance the life quality of its citizens.

The concept of the smart home is a part of the smart living characteristic of the smart city (see figure 4.1).

Figure 4.1: Smart City Characteristics

Smart Economy Innovative Spirit Productivity Flexibility of labor market	**Smart Environment** Attractiveness of natural conditions Environmental protection Sustainable resource	**Smart Governance** Participation in Decision-making Transparent Governance
Smart Mobility Local Accessibility ICT infrastructure Sustainable, innovative and safe transport systems	**Smart Living** Cultural Facilities Health Conditions Housing Quality Social Cohesion	**Smart People** Affinity for life-long learning Participation in public life Creativity and flexibility

Source: Colldahl, Frey & Kelemen (2013)

The phrase smart home was first used in the 1980's by the American Association of House Builders. While the architecture and the construction are smart, as well as environmentally suitable components, a smart home is smart due to its composition of interactive technologies that allow command and administration of the home in acknowledgment of user's requirements. This progress started in the 1950's and smart homes proceeded to develop with technology. In the 21st century, smart homes are being constructed globally, especially in high-income nations, such as USA, Denmark, and the UK have already designed and commenced such initiatives. A wide range of technological amenities, once equipped, can enable a home to be "smart". (Faanes 2014). Smart Home based on a combination between sensors and actors with a varying range of abilities, starting from, basic responsive performances built on predefined standards, to self-learning devices that adapt and changes to a resident demand. The imperative notion of smart homes revolves around their ability to enhance the quality of life of its inhabitants and providing independence, in addition, it can provide regulation of lighting, climate, multi-media, and health connected solutions.

Le, Nguyen, and Barnett (2012) proposed a theoretical structure using various types of components and capabilities that smart homes possess. The theoretical structure is composed of 5 items:

a. Automation: the capability to incorporate automated equipment to accomplish automated duties
b. Multifunctionality: the capability to accomplish different tasks or produce different results
c. Adaptability: the capability to conform to fit the requirements of users
d. Interactivity: the capability to communicate with or grant for communication between users
e. Efficiency: the capability to carry out duties in an efficient, affordable and useful fashion

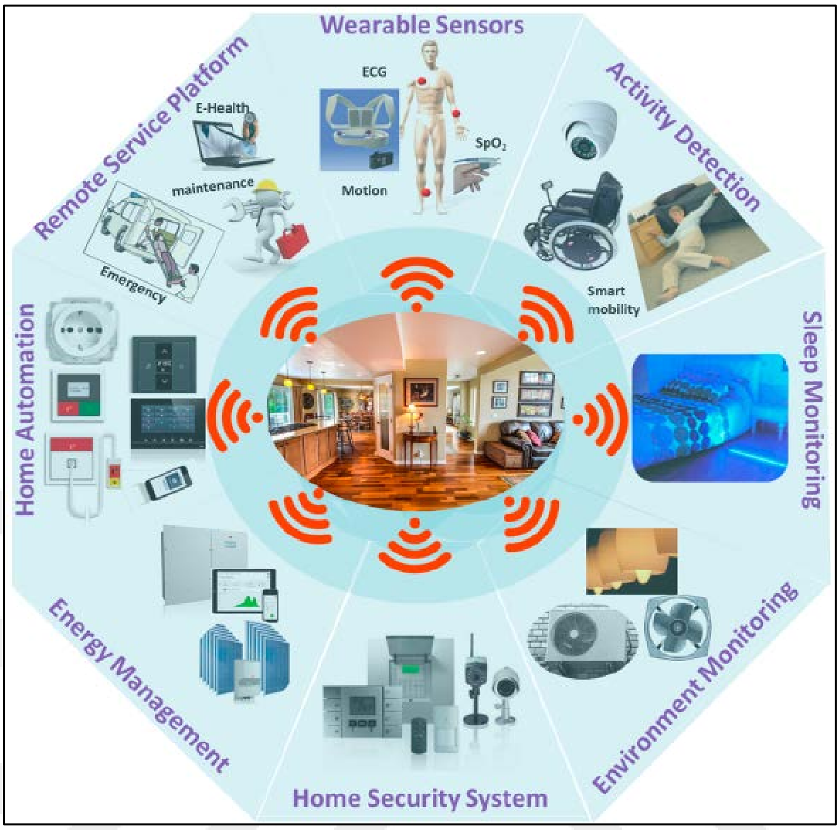
We need to study aspects of elderly living under the concept of smartness, to build a well-rounded structure for smart strategies for aging in place. Elderly wellness, comfort levels, and emergency predications will be studied separately under this chapter.

4.1 SMART HOME FOR ELDERLY WELLNESS

Demiris and Hensel define smart home health care as home installed with technological components which observe the health and life of its users to enhance their general quality of life, expand autonomy and avoid crises (2008). It is intended to assist older and handicapped, people who reside alone and need continuous medical support, also, individuals with persistent health problems that necessitate being confined to a hospital or to the nursing house. As a supplement of conventional healthcare, smart home enhances medical care and averting crises. Evaluating information from smart homes enables fast identification of possible issues and provide assistance when needed. Smart homes depend upon information collected through connected sensors and systems that add, automation, intelligence and environmental awareness in the residence. Sensors placed in floors, ceilings and walls, entrances and furnishings provide environmental data through wireless or wired systems, such as motion sensing, movement explanation, pressure sensors, and visual capture (see figure 4.2).

This obtained information realize the life habits of a resident, such as walking, resting or eating. Typically, various sensors in tandem are necessary for accurate recognition of different actions. These activities form a pattern which recognizes irregularities in resident behavior. Reviewed with a health professional can be utilized in deciding choices in the interest of the resident or provide a fully interactive system (Bennett, Rokas & Chen 2017), (Ni, Hernando & la Cruz 2015).

Figure 4.2: Smart Home for Elderly Health Care



Source: Majumder et al. 2017

Laberg (2005) proves examples of user's experience with a smart home, a handicapped man who experienced the smart home as modern, slept easier and reduced upper body suffering due to the technology's functioning. Laberg's questioning of a smart home complex's faculty reveals growth in the quality of services offered, reducing manpower needs and mental stress. In addition, the technology can identify when help is required from medical professionals and engage them promptly. Chan (2009) studied related factors of smart home technology, such as identifying people's movement and the adeptness of sensor technology and concluded that smart homes are a convenient and economical option for older and handicapped individuals at home. The technology in these programs is comprehensive and offers a diverse set of answers to varied groups of users, such as old people, the feeble and infirm, and handicapped individuals.

4.2 SMART HOME TECHNOLOGY OVERVIEW

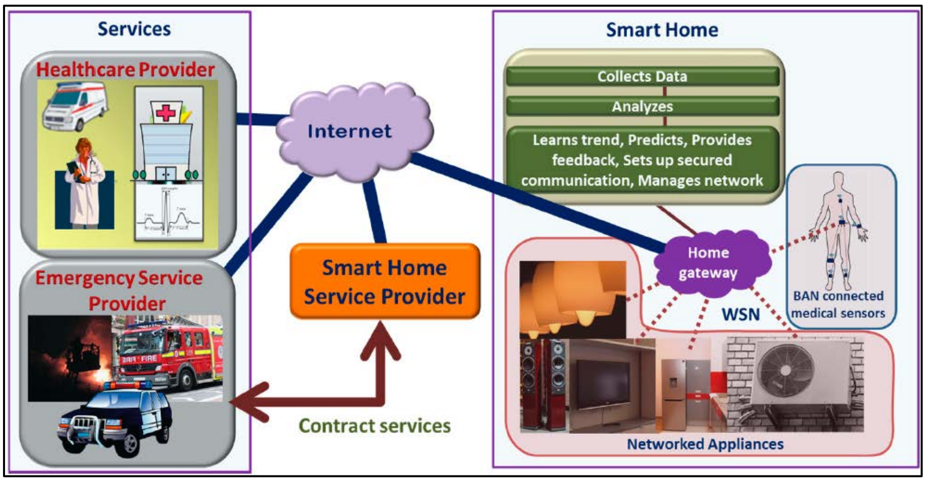
Smart home utilizing various components organized in four layers (see figures 4.3). In each of which, the system is able to use individual actions to deliver health services to the home resident. Information is gathered via the physical layer with sensing technology and passed to the communication layer and then to the processing layer, where it is evaluated for action identification and patterns finding. The result turns into a sort of information via the interface layer to occupants and care provider. In case of abnormal behavior occurs, the system sends an emergency alert to the required authority (see figure 4.4), (Amiribesheli, Benmansour & Bouchachia 2015).

Figure 4.3: Smart Home Technology Layers Structure

Interface Layer	**- Caregivers and residents interfaces**
Data Processing Layer	**- Machine Learning ontology** **- Data storage and presentation**
Communication Layer	**- Wireless/Wired sensor networks.**
Physical Layer	**- Residents, environment and physiological sensors**

Source: Amiribesheli, Benmansour & Bouchachia 2015

Figure 4.4: Smart Home Technology Network



Source: Majumder et al. 2017

4.2.1 Physical Layer

The physical layer consists of sensors and supplemental technology such as command modules and Gateway. Sensors embedded and joined into the home infrastructure and connected to the network, wirelessly or wired, to collect circumstantial data regarding people's behavior and the environment (Amiribesheli, Benmansour & Bouchachia 2015). Generally, the activity observation methods are in two types: a sensor-based method; which identify peoples' actions in certain spaces of home using simple/non-visual sensors integrated into home infrastructure, and the second type is an Audio/Visual-based method; which watches for residents' activity and changes in their surroundings using visual sensors such as cameras. Table 4.1 outlines the four typical sensors in the smart home for the elderly (Ni, Hernando & la Cruz 2015).

Table 4.1: Sensors in Smart Home

Sensor	Measurments	Data Form	Advantages	Disadvantages
Video Camera	Human Actions - Environmental State	Image, Video	Precise information	Privacy issues
Simple Sensors	User object interaction detection, movements and location identification	Categorical	Low cost and low privacy sensitivity	Provide limited information for multi-user monitoring
RFID	Object and user identification	Categorical	Low cost and small size	Range limited, reader and tag collision
Temperature	Environmental parameters	Time series	Intuitive monitoring of environment and objects	

Source: (Ni, Hernando & la Cruz 2015)

a. Video Camera Sensors

Video camera sensors are economically effective and accurate which gather broad background data regarding peoples' activities and surrounding circumstances. By watching and identifying movement in the surveilled space, video surveillance collects precise information in the home such as occupant's quantity at home. While there are certainly benefits for using video cameras, such as watching many occupants' actions at once, there are concerns such as data processing costs and privacy concerns (Ni, Hernando & la Cruz 2015).

b. Simple Sensors

Simple sensors, including sensors such as motion, pressure and contact switches sensors, are integrated into home infrastructure and utilized on various items in the home. Motion sensors, using Infrared presence technology, can identify a resident and their place of existence in the home. Pressure sensors can be integrated into furniture and home surfaces to detect usage by the occupant. Contact switches can be set up on the kitchen doors of cabinets, rooms, and refrigerator, and identify activity occurring between the occupant and these items. The reality is that using one sensor type is insufficient to give an understanding of occupants' actions, thus, utilizing many sensors is necessary to effectively gather activity data. The simple sensors are economical and simple to set up while also respecting privacy concerns (Ni, Hernando & la Cruz 2015).

c. Radio-Frequency Identification (RFID)

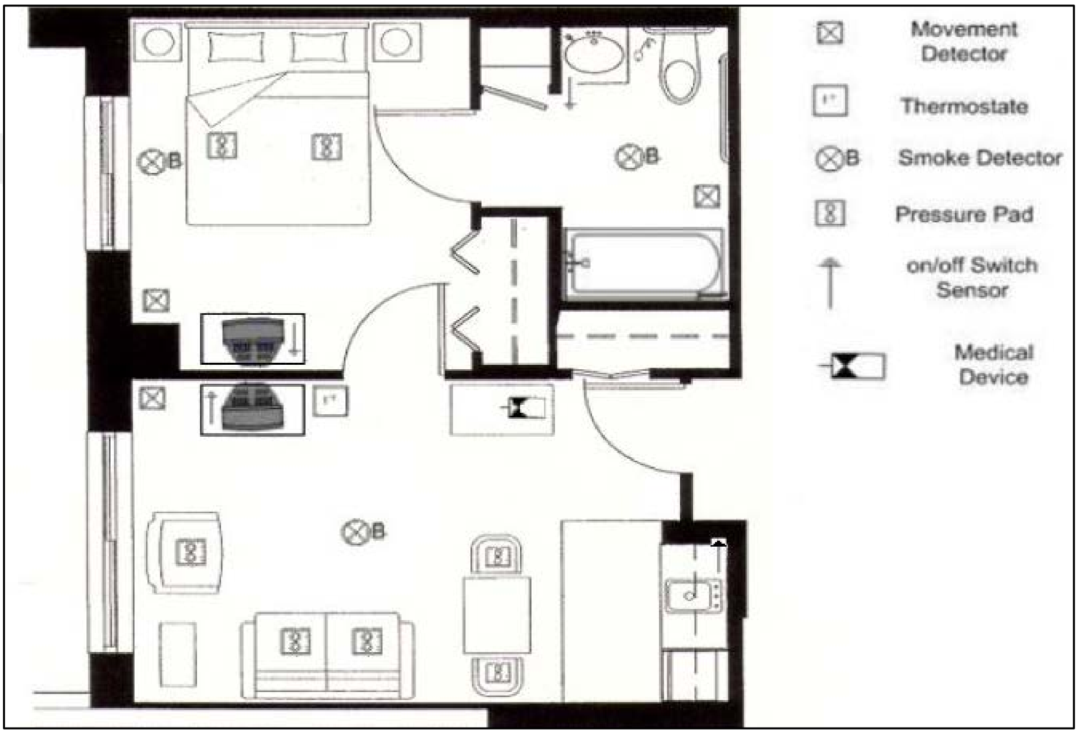
The RFID functions as a mix of wearable and environmental sensor by utilizing a "reader" on the participant and an item affixed with an electronic chip. Fujinami et al. (2011) was able to identify motion patterns and habitual activities in a group of dementia patients using RFID trackers in footwear, providing data about the patient's location and measurements of physical activity to understand their health situation. Due to its inexpensive and compact nature, RFID is useful for monitoring many occupants' positions and behaviors (Ni, Hernando & la Cruz 2015).

d. Temperature, Humidity and Light Sensors

Climate sensors, such as humidity, temperature and light sensors, can indicate the temperature of an item, the amount of moisture in the air or the concentration of light within a particular space (Ni, Hernando & la Cruz 2015).

Kazmierzak (2012) presented an example of implementing sensors in the home layout. The sensors which used in the example were movement detector, a pressure detector, temperature detector, pressure pad, switch sensor and for safety smoke sensor. The layout of sensors was distributed as followed: movement and smoke detector in each room, pressure pad under the furniture, temperature sensor and medical device in the living room and switch sensor in the kitchen (see figure 4.5).

Figure 4.5: Physical Sensors Layout

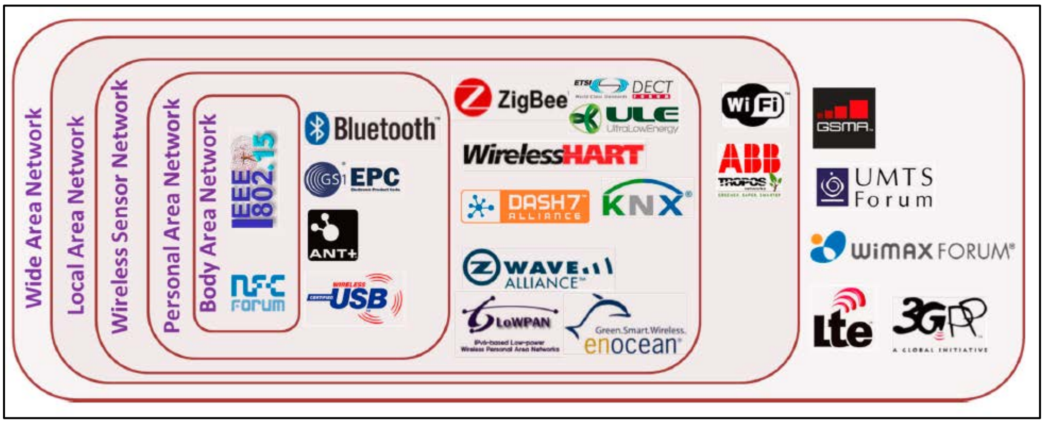


Source: Kazmierzak (2012)

4.2.2 Communication Layer

The communication layer is the essential component for networking the various actuators, sensors, storage devices, and gateway. The communication layer includes technologies such as power line, mobile telecommunication, WIFI, ZigBee, and Bluetooth, besides having the operating system and drivers (see figure 4.6), (Amiribesheli, Benmansour & Bouchachia 2015).

Figure 4.6: Smart Home Wireless Communication Platforms



Source: Majumder et al. 2017

4.2.3 Data Processing Layer

The data processing layer is the intelligent component of the operation, discovering both usual and unusual behavior and identifying action with a healthcare objective to produce information that health professionals can use to understand developments in an occupant's well-being, detect issues with long-term illnesses and prompting occupants about upcoming actions, like using medication, and sound alarms in emergencies such as a collapse (Amiribesheli, Benmansour & Bouchachia 2015).

4.2.4 Interface Layer

The Interface layer is modeled to be convenient for three main users: occupants such as an elderly or disabled person, family members or others unofficial caregivers, and professional caregivers such as hospital staff or medical experts. As an example, a medical professional may be sent the status of an occupant's issues, sugar levels or blood pressure. Yet this data may not be relevant to a family member (Amiribesheli, Benmansour & Bouchachia 2015).

4.3 SMART HOME CASE STUDIES

For completeness, an overview of important prototypes and products have been presented to provide an understanding regarding smart home and to learn how the technologies are implemented into houses. The projects demonstrate varied methods of data collection by utilizing different sensors and providing automated crisis awareness (Bennett, Rokas & Chen 2017). The cases will be checked through a "Smart Home Technology Checklist" acquired from the physical layer of smart home (check 4.2.1), that includes sensors: video camera, simple sensors, RFID and temperature, in addition, a checklist for emergency predication, information provided, cost and life quality. Following notes will be used for assessment: Not applicable: (-), Weak: (-+), Mediocre: (+), Strong: (++). Additional concepts observed by the study of cases can be added as an extended learned list for smart home technology.

Table 4.2: Smart Home Technology Checklist

Type	Prototype
	Product
Sensors	Video Cameras
	Simple
	RFID
	Temperature
Emergency predication	Yes
	No
Information provided	Image, Video
	Categorical
	Time series
Cost	
Life quality	

4.3.1 Microsoft EasyLiving

A pioneering attempt to develop “context-aware” via video cameras in place of physical sensors. The system is able to detect movement, residents, and the surrounding atmosphere such as furniture and surfaces. A singular feature of this system is the recognition of interactions between residents, items and locations in the house. This data allows behavioral predication mappings by understanding the common use of an item and its relationship to residents (Bennett, Rokas & Chen 2017).

Smart Home Technology Checklist: Type: (Prototype), Sensors/Video:(+), Simple:(-), RFID:(-), Temperature:(-), Emergency predication:(Yes), Information provided:(Image, Video), Cost (-).

Life quality: -

Learned aspects: -

4.3.2 MavHome

Created by the University of Texas as a home which can perform as an intelligent healthcare agent. The home uses simple sensors including motion, pressure and temperature sensors (see figure 4.7). Further, the home equipped with electric sensors which can automate light and blinds. These sensors are integrated into surrounding to collect and identify the daily event. MavHome can predict a realistic prediction of the occupant’s future behavior by sampling and examine behavior as it is learned in a known chain. If something abnormal occurs, the applicable corrections are undertaken. The MavHome architecture as shown in figure 4.8 consists of four cooperating layers starting from the physical layer with sensors, the communication, then Information layer and ending by the decision layer (Youngblood, Cook & Holder 2004).

Smart Home Technology Checklist: Type:(Prototype), Sensors/Video:(-), Simple:(+), RFID:(-), Temperature:(+), Emergency predication:(Yes), Information provided: (Categorical, Time series), Cost:(-).

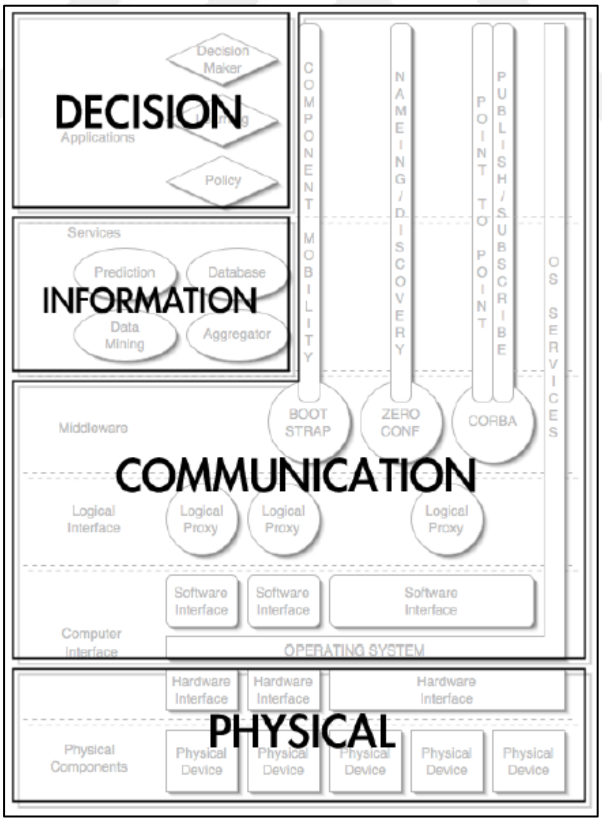
Life quality: Automation of light & blinds.

Learned aspects: -

Figure 4.7: Mav Home Lab

Source: Youngblood, Cook & Holder 2004

Figure 4.8: Mav Home Abstract Architecture



Source: Youngblood, Cook & Holder 2004

4.3.3 The Smart Condo

The University of Alberta has researched the utilization of technology in order to empower medical experts and workers to provide superior services to their subjects. By composing a group of academics from industrial design, occupational therapy and computer science backgrounds, the Smart Condo program aimed to merge universal-design approach with sensor technology to solve the requirements of residents living in their homes. The Smart Condo is a singular big room (80m2) situated on the campus of the University of Alberta. Taking inspiration from the Edmonton Glenrose Rehabilitation Hospital's independent-living rooms, the program wished to model a similar experience as the patients who underwent substantial operations and would rest for a few days prior to being discharged. While in the facility, they should exist autonomously and supply their own needs similar to if they were in their own house. Medical professionals should remotely observe and only intervene if necessary. The main study goal in the creation of the Smart Condo was clarified that using sensors only, an exact image of the Condo's resident which can be inconspicuous and uniformly beneficial similar to if medical personnel were, in reality, observing the resident through video equipment (see figure 4.9). Smart condo space divided into a six-suite condominium. In every suite, models have been built for various household equipment (see figure 4.10). Within this area, wireless sensors were utilized for the motion sensor, pressure sensor, and contact switches. The movement detectors encompass the suite appropriately to successfully find the condo's resident. Seats and beds with pressure sensors were used to identify residency, contact switches to detect user interference with the home appliance (Nikolaidis, Sadowski and Stroulia 2011).

Smart Home Technology Checklist: Type:(Prototype), Sensors/Video:(-), Simple:(+), RFID:(-), Temperature:(+), Emergency predication:(Yes), Information provided: (Categorical), Cost:(-).

Life quality: -

Learned aspects: merge smart technology with universal design.

Figure 4.9: The Smart Condo Home 3D Virtual World

Source: https://www.youtube.com/watch?v=MWWDAZmO6Hg

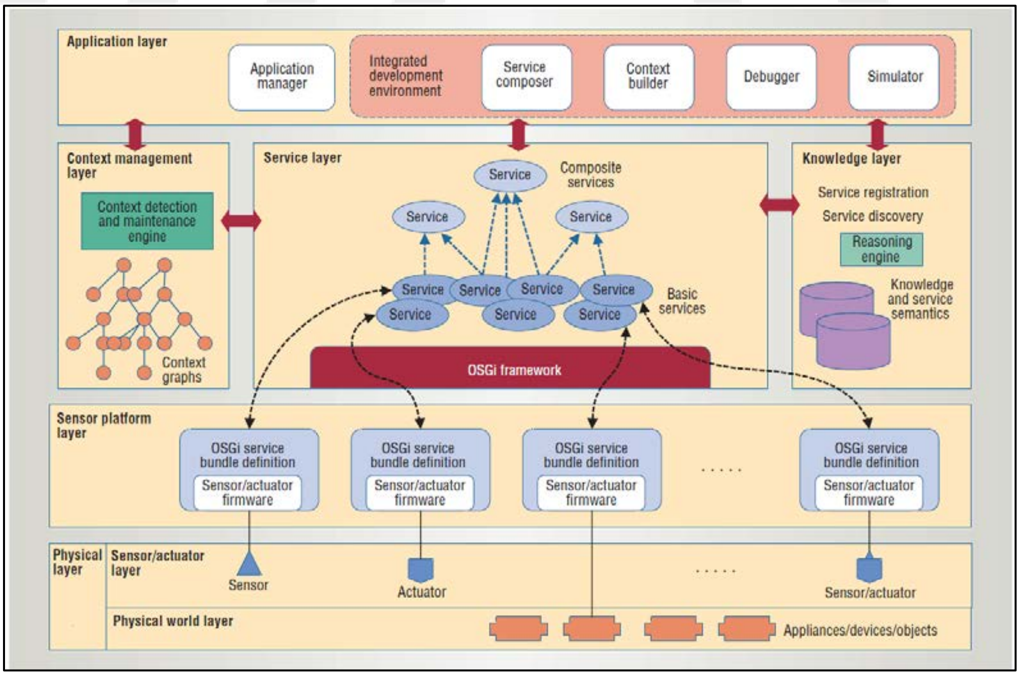
Figure 4.10: The Smart Condo

Source: http://www.360cities.net/image/smartcondo#183.10,6.70,66.3

4.3.4 The Gator Tech Smart House

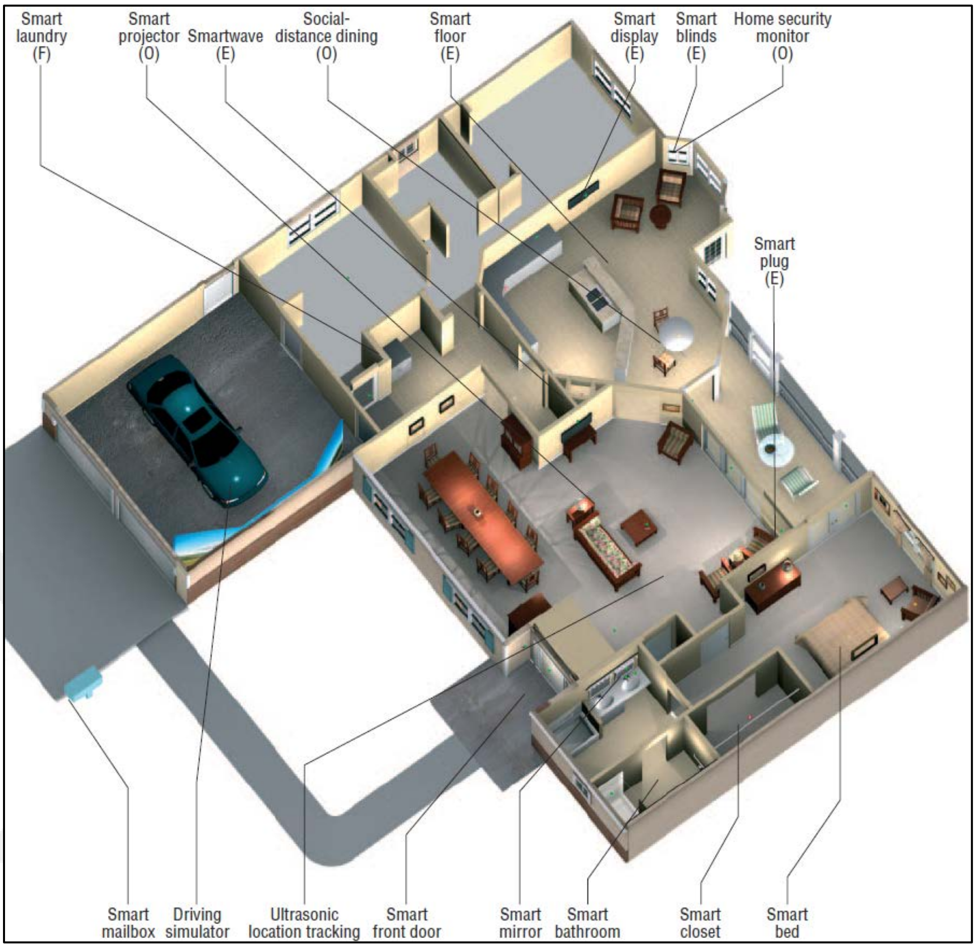
Created by the University of Florida as a house to promote wellness and independence living for the elderly. The house combining two forms of monitoring, the first are video sensors in non-private spaces and the second are simple sensors representing by motion, location and pressure sensors in private areas. As shown in figure 4.11, Gator Tech middleware architecture encompasses layers such as the physical layer, service and knowledge layer, ending with the user application layer. Gator Tech reports elderly movement along with sending an emergency alert to the authorized family members or care worker (Tomita el al. 2010). In addition to serving as healthcare functionality, the home offers technological supplements such as smart mirrors for medication reminders and smart door recognizing the guests with keyless entry allowable through using RFID sensors, bed analyze the sleeping patterns, smart bathroom with adjusted water temperature and flush detector and for safety, smart leak and smoke detectors (see figure 4.12), (Helal et al. 2005).

Figure 4.11: Gator Tech Smart Middleware Architecture



Source: Helal et al. 2005

Figure 4.12: Gator Tech Existing and Future Project Features



Source: Helal et al. 2005

Smart Home Technology Checklist: Type:(Product), Sensors/Video:(+), Simple:(+), RFID:(+), Temperature:(+), Emergency predication:(Yes), Information provided: (Image, Video, Categorical, Time series), Cost:(-).

Life quality:

Smart bed & bathroom.

Learned aspects:

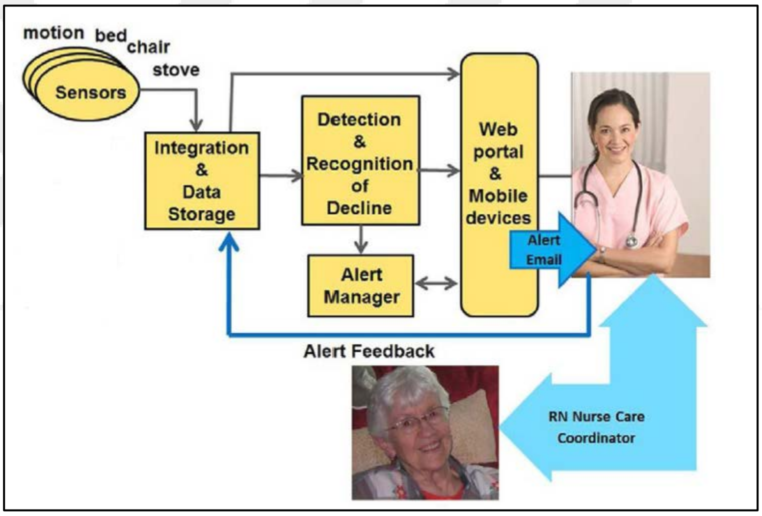
Simple sensors: Leak and smoke sensors.

Video camera: only used in non-private rooms.

4.3.5 Tiger Place

Tiger Place is a retirement facility designed for maximum occupant autonomy in their homes and served to design and assess the idea of Aging in Place along with combining both professional medical and home care assistance. Sensor systems were introduced to flats in Tiger Place starting in 2005, after which the Tiger Place team interviewed the elderly routinely to understand their feelings and interactions with this sensor technology. Accordingly, occupants were at ease with the sensor networks and would fail to remember its presence due to its non-interference nature in their lives. Figure 4.13 is a diagram of a sensors placed in Tiger Place occupants' flats (Rantz et al. 2013).

Figure 4.13: Tiger Place Sensors Networks



Source: Rantz et al. 2013

Tiger Place uses simple sensors including motion, pressure, and contacts switch distributed over the rooms, hallways, doors, toilet and under the chairs and mattress to detects the inhabitant's activity during the day. The technology monitoring without compromising the resident privacy and send an alert in case potential problem. The researchers at the university have found that the early intervention based on obtained data from home have reduced the severity of heart failure.

Through interface charts provided by Tiger Place, the elderly movement during the day can be tracked by medical professionals to distinguish irregular activates (see figure 4.14).

Tiger Place currently the system is in use and operated by 17 apartments (Boers et al. 2011).

Smart Home Technology Checklist: Type:(Product), Sensors/Video:(-), Simple:(+), RFID:(-), Temperature:(-), Emergency predication:(Yes), Information provided:(Categorical), Cost:(-).

Life quality: -

Learned aspects: -

Figure 4.14: Tiger Place User Interface

Source: Rantz et al. 2013

4.3.6 HoneyCo Smart Technology

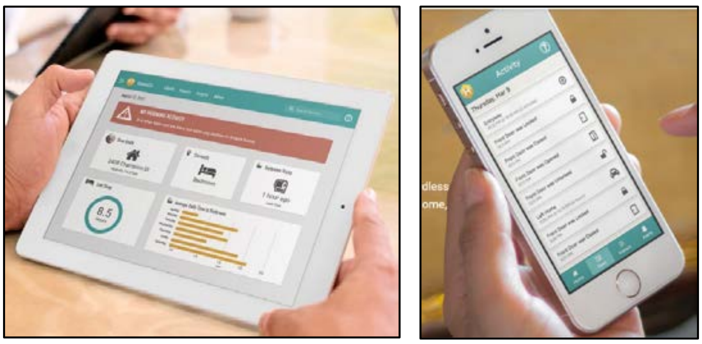
HoneyCo is a company which is producing smart technology products for elderly care in the USA. The product is complementary to autonomous living, allowing the care provider to check on independent elderly from afar and giving warning to occupants if a crisis or unusual incidence occurs. The working principle of technology monitors and provides feedback to the user besides security services in day-to-day life. The company uses simple sensors throughout the house to identify the normal habits of the occupants, such as waking up, sleep, eat, etc. Additionally, these sensors can identify abnormal motion or behavior, such as if an occupant uses the restroom but doesn’t exit after some time. The device will promptly alert the caregiver in the event that something abnormal or worrying as occurred, such as a user not waking up at their routine rising time. Further to wellness, the product provides safety sensors including gas and smoke sensors, and light automation. The customer will be able to control the entire system by mobile phone or tablet (see figure 4.15). The product system can be personalized to the requirements of the customer, with the simplest set costing $150 monthly and higher-end sets $350.

Smart Home Technology Checklist: Type:(Product), Sensors/Video:(-), Simple:(+), RFID:(-), Temperature:(+), Emergency predication:(+), Information provided: (Categorical, Time series), Cost:(150-350$/M).

Life quality: Home security.

Learned aspects: Simple sensors: Gas sensors.

Figure 4.15: HoneyCo User Interface for Mobile and Tablet



4.4 EVALUATION OF CASE STUDIES AND FINDINGS

The following section evaluates the previous prototypes and products of smart home technology and highlights the differences between them in terms of the diverse methods of data collection using sensors. Accordingly, “Evaluation of Case Studies and Findings” is listed in Table 4.3. Following notes will be used for assessment: Not applicable: (-), Weak: (-+), Mediocre: (+), Strong: (++). Following the evaluation table, a learned aspect from case studies can be added as an extended checklist.

Table 4.3: Evaluation of Case Studies and Findings

		Easy Living	**Mav Home**	**Smart Condo**	**Gator Tech**	**Tiger Place**	**Honey Co**
Type		Prototype	Prototype	Prototype	Product	Product	Product
Sensors	Video	++	-	-	+	-	-
	*Non-private	-	-	-	++	-	-
	Simple	-	++	++	++	++	++
	* Leak	-	-	-	++	-	-
	*Smoke	-	-	-	++	-	++
	*Gas	-	-	-	-	-	++
	RFID	-	-	-	++	-	-
	Temperature	-	++	-	++	-	++
Emergency		Yes	Yes	Yes	Yes	Yes	Yes
Information Provided		Image, Video	Categorical Time series	Categorical	Image, Video, Categorical Time series	Categorical	Categorical Time series
Cost							150-350$
Life Quality			Lights & blinds Automation		Smart bed & bathroom		Home Security

*Learned aspects

As observable in table 4.3, Gator Tech gained a strong assessment besides offering a video surveillance in non-private rooms and life quality features, while easy living, smart condo and tiger place earned the minimal.

4.5 CRITICISMS OF SMART CONCEPT

The success of the smart concept is fully related to the integration level of concepts to culture of the life and city. Clancy (2013) points out that several smart pilot programs didn’t succeed and end up by failure due to overlooking the engagement of the public in planning and designing of various smart projects. Le (2012) indicated that the usability issue is critical for the elderly with low-understanding of the smart home technology. Many current older people were not raised with technology and they feel awkward with smart home technology. A study centered on 45 older people looks at their considerations and willingness to use smart home technology. The elderlies were reported to have apprehensions about the usability of this technology while there is an absence of a human touch and required customization user education course (Demiris et al 2004). Further, audio-visual observation and automated functionality in smart homes present ethical issues that must be answered prior to their application. Additional questions regarding which entities possess the authority to examine these audio-visual records and how to safeguard personal data must also be answered (Faanes 2014). Another concern was that the smart components are closely knit, automated and requiring providing security to the system, therefore, failure in the system or even cyber-attacks can cause the whole system to break down or collapse in the worst scenario. Additionally, the cost of smart home technology is still way off from mass accessibility, due to the continuous evolution of technology, maintenance, and programming. The lack of funding for the smart home project along with the government’ policies toward their projects has created a huge obstacle standing in front of their development.

However, one of the EU programs called “The Smart Home for All”, performed trials using 31 older subjects, ages 47-91, to examine the eligibility and convenience of the technology. The reactions were that the technology is beneficial and older people were willing to trading some confidentiality for enhanced home services (Faanes 2014). The convenience and dependability of smart home technology should be convenient to elderly use and this requires providing education and training to enable smooth technology operation by them (Alsinglawi et al. 2017). In addition, the cost of smart technology can be reduced through public policy, loans and grants. Norway’s Housing Bank is a positive case of how the government can assist low-income individuals to attain smart home technology (Faanes 2014).

5. A GUIDELINE PROPOSAL FOR SMART HOME STRATEGIES FOR AGING IN PLACE

Based on the researches and case studies, a larger and more comprehensive table is developed to make a guideline for "smart home strategies for aging in place".
The learned aspects from the case studies of respective chapters are added to the checklist in table 5.1 "Evaluation of Case Studies and Findings" to make the extended checklist.
The learned aspects are then included in the main parts of the guide which are "aging in place", "universal design home" and "smart home technology".

5.1 EVALUATION OF CASE STUDIES AND FINDINGS

The following section evaluates the previous case studies and findings in terms of aging in place, universal design home and smart home technology. Following notes will be used for assessment: Not applicable: (-), Weak: (-+), Mediocre: (+), Strong: (++). Following the evaluation table, a learned aspect from case studies can be added as an extended checklist.

Table 5.1: Evaluation of Case Studies and Findings

	Dublin Home	Keith Collins	FabCab	Easy Living	Mav Home	Smart Condo	Gator Tech	Tiger Place	HoneyCo
Aging in Place									
Choice	+	+	+	-+	-+	-+	-+	-+	-+
Flexibility	+	+	+	-	-	-	++	++	++
Mixed Generations	++	++	++	-	-	-	-	-	-
Smart Growth	++	++	++	-	-	++	++	++	-
Universal Design Home									
Accessible Entry	++	++	++	-	-	++	++	-	-
*Sliding internal doors	-	-	++	-	-	-	-	-	-
Accessible Horizontal Circulation	++	++	++	-	-	++	++	-	-

Accessible Vertical Circulation		++	-	-	-	-	-	-	-	-
*Two story room to install a floor-lift		++	-	-	-	-	-	-	-	-
Accessible Kitchen		+	-+	++	-	-	++	++	-	-
Accessible Bathroom		+	++	++	-	-	++	++	-	-
*Large format tiles in bathroom		-	-	++	-	-	-	-	-	-
Accessible Fixtures		+	++	++	-	-	++	++	-	-
Smart Home Technology										
Sensors	Video cameras	-	-	-	++	-	-	+	-	-
	*only in non-private rooms	-	-	-	-	-	-	++	-	-
	Simple	-	-	-	-	++	++	++	++	++
	*Leak	-	-	-	-	-	-	++	-	-
	*Smoke	-	-	-	-	-	-	++	-	++
	*Gas	-	-	-	-	-	-	-	-	++
	RFID	-	-	-	-	-	-	++	-	-
	Temperature	-	-	-	-	++	-	++	-	++
Emergency Predication		++	++	++	++	++	++	++	++	++
Life Quality										
Automation of lights, blinds		-	-	-	-	++	-	-	-	-
Smart bed & bathroom		-	-	-	-	-	-	++	-	-
Home security		-	-	-	-	-	-		-	++

* Learned aspects added to the table

5.2 A GUIDELINE FOR "SMART HOME STRATEGIES FOR AGING IN PLACE"

As for the study findings, a guideline is listed below, founded on the aspects of aging in place, universal design home, and smart home technologies. This guideline is designed to be used as a checklist for "smart home strategies for aging in place". Further information regarding these three aspects can be located in chapters (2.5, 3.2, 4.2) respectively.

The first table provides a checklist for aging in place principles. The table can be checked by government officials and policymakers to enable the suitable city infrastructure for aging in place.

The second table provides a checklist for universal design home principles. The table comprises home-design considerations to be used by architects and designers to allow home accessibility and sustainability for the elderly.

The third table provides a checklist for smart home technology. The table can be used by caregivers or medical professionals for elderly wellness, safety and life quality at home.

Table 5.2: A Guideline for "Aging in Place"

	✓	**Aging in Place Checklist**
Choice	❒	Providing the ability to fulfill the healthcare and housing needs in affordable to elderly' retirement income.
Flexibility	❒	Give elderlies the services to suit their requirements in different environments such as their private home or family home.
Mixed Generations	❒	Maximizing the capacity of elderly for self-care and independence can be achieved by preserving mixed generation society.
Smart Growth	❒	Creating surroundings with enhanced approachability and comfort in line with the of Smart principles.

Table 5.3: A Guideline for "Universal Design Home"

	✓	**Universal Design Home Checklist**
Entry	❒	Supply one ramp from the street to the home entrance.
	❒	Provide the home with doors not less than 90cm.
	❒	Equip the external doors with level threshold and internals with a level transition.
	❒	Equip the internal doors with sliding type.
Horizontal Circulation	❒	Provide 150cm of turning radius in rooms, kitchen, and bathroom.
	❒	Ensure that home corridors have a clear width of 120cm.
Vertical Circulation	❒	Avoid designing stairs with single steps.
	❒	Provide a width of 90cm to the stairs.
	❒	Equip the surface of the stairs with non-slip materials or non-slip bands.
	❒	Provide extended handrails of 30 cm after the stairs end.
	❒	A two-story room can be used to install a floor-lift.
Kitchen	❒	Ensure that kitchen worktop is without cupboards underneath.
	❒	Provide 120cm of distance between facing kitchen units.
	❒	Equip the kitchen with lever handles.
	❒	Use tiles for the kitchen with non-slip and non-reflective surfaces
Bathroom	❒	Equip the shower with a level transition to the shower.
	❒	Equip the bathroom walls with reinforced spots near to the toilet and shower.
	❒	Provide 40cm of space from the wall prior to toilet installation.
	❒	Adjust the height of the basin to 80cm with clear space underneath.
	❒	Use tiles for the bathroom with non-slip and non-reflective surfaces.
	❒	Use large format tile in the bathroom to decrease the falling risk.
Fixtures	❒	Provide doorbell at 120 cm from the floor and use handles.
	❒	Supply the home with electrical sockets and switches besides HVAC controls at a height of 120cm.

Table 5.4: A Guideline for “Smart Home Technologies”

Smart Home Technologies Checklist			
Sensor	✓	**Type**	**Purpose**
a. Wellness Sensors	❒	Video cameras	Analyzing user actions
	❒	Motion sensors	Analyzing user movements & location
	❒	Pressure sensors	Detecting usage by user
	❒	Contact switches	Detecting user interaction with objects
	❒	RFID sensors	Detecting user interaction with objects
	❒	Temperature sensors	Temperature & humidity adjustment
Emergency Alert	❒		
b. Safety Sensors	❒	Smoke sensors	Detecting smoke existence
	❒	Gas sensors	Detecting gas existence
	❒	Leak sensors	Detecting leak existence
c. Life Quality	❒	Home security	Detecting security alert
	❒	Lights automation	Automate light level
	❒	Blinds automation	Automate blinds level

General Use Instructions:

a. Wellness Sensors

Video Camera: provide a video camera in non-private rooms such as hallway.

Motion sensors: provide motion sensors on the corner of each room.

Pressure sensors: provide pressure sensors under the furniture surface.

Contact switches: provide contact switches on doors, windows and kitchen appliances.

RFID sensors: provide RFID sensors on user' wrist and in footwear.

Temperature sensors: provide a temperature sensor in each room.

b. Safety Sensors

Smoke sensors: provide smoke sensors on each room roof.

Gas sensors: provide gas sensors in the kitchen.

Leak sensors: provide leak sensors in the kitchen and bathroom.

c. Life Quality

Home security:

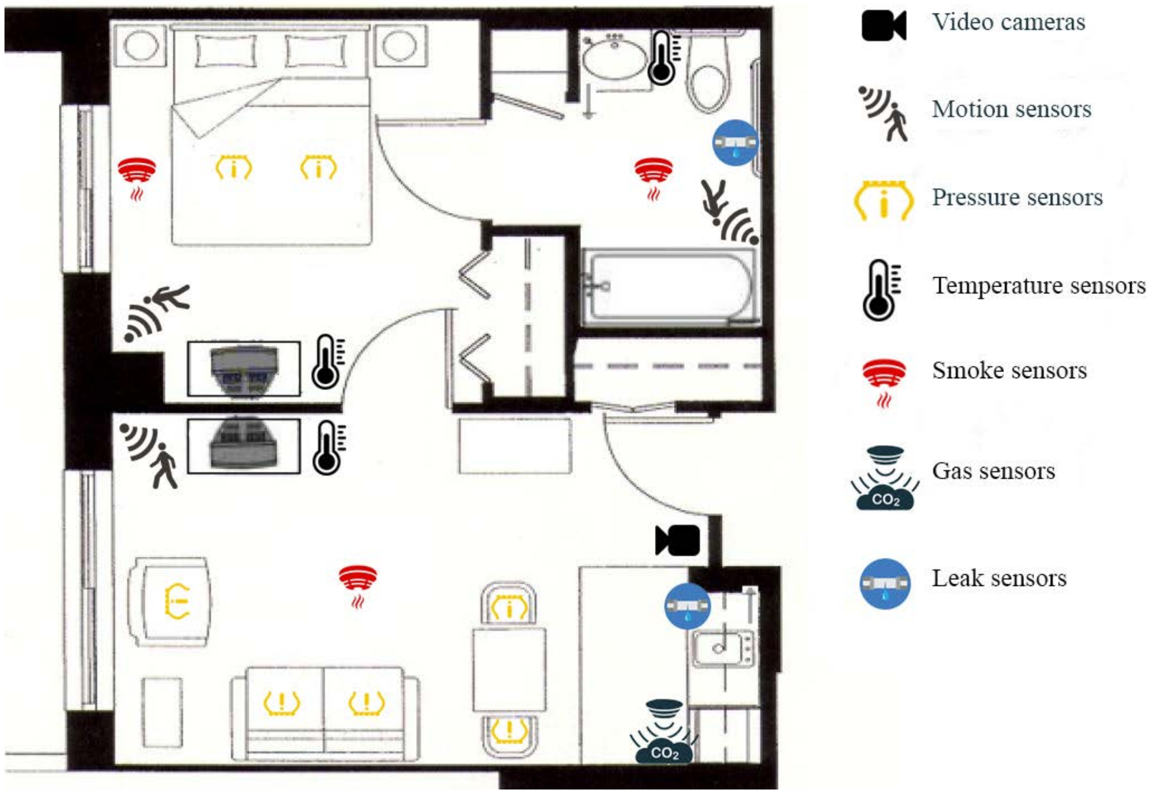
Lights automation: provide light automation sensors in room.

Blinds automation: provide blinds automation sensors for windows.

Smart Sensors Implementation

The following plan present an example of implementing smart sensors in home layout. The sensors which used in the example are video cameras, motion sensors, pressure sensors, temperature sensors, smoke sensors, gas sensors and leak sensors.

Figure 5.1: A Guideline for Smart Sensors Implementation



6. CONCLUSION

Declines in capacity have necessitated the elderly to make changes in their lifestyle and compelled them to leave their home for another environment. As home represents the symbol of elderly identity, with a sense of belonging and memories, maintaining this long-lasting reciprocal relationship requires providing the elderly the ability to age in place. Taking into consideration aging in place should allow the people to remain in their home and neighborhood in their late stages of age until it is no longer tenable. Aging in place strategies such as universal design home can reduce the accessibility obstacles facing the elderly in autonomous life at home and sidestep the need for unattractive alternatives such as care facilities. Similar to the case in Ludden's (2010) study, the result of providing an accessible environment resulted in elderly tenants leaving the care facilities after living there for 13 years. In addition, the construction cost equals the cost of a typical home, if it was built as a home to age in.

Further, smart home technologies have proven a high potential for observing elderly wellness at home and to make decisions in their best interest. This will not only assist the elderly but care providers as well. Smart technology is obtainable today within reasonable costs, such as Honeyco, the next step is the acceptance of this technology by the public. Adoption of this technology should generate a further widespread acceptance of this approach, particularly if the government initiates the process. Similar to the case in UK, where the government has initiated a mandate to install a smart meter in each home by 2020. Such an attempt should pave the road for smart technology to be widely accepted in every home.

As Tuan (1976) said: "Return is the resolution of the tension between home and journey, return completes the circle". Enabling the elderly to never leave their home demands officials' attention to supply and promote such home strategies. The vision towards the home of tomorrow should consider the user's upcoming requirements and provide a suitable home. However, it should be pointed out that the philosophy of universal design home and smart technology may not fulfill the needs of each person, since people have diverse requirements, but it should suit the needs of the vast majority. Therefore, attention to people's needs and cultural differences are required from policymakers, architect and designers etc., to get the ball rolling and create an aging-friendly environment.

REFERENCES

Periodicals

Alsinglawi, B., Nguyen, Q.V., Gunawardana, U., Maeder, A. and Simoff, S. 2017. *RFID systems in healthcare settings and activity of daily living in smart homes: A review*. http://dx.doi.org/10.4236/etsn.2017.61001.

Amiribesheli, M., Benmansour A. & Bouchachia A., 2015. A review of smart homes in healthcare. *Journal of Ambient Intelligence and Humanized Computing.* https://www.researchgate.net/publication/273636551_A_review_of_smart_homes_in_healthcare.

Baczynski, B., 2012. *Nextavenue.* https://www.nextavenue.org/why-universal-design-makes-beautiful-sense-when-renovating/

Ball, MS., *Aging in place a toolkit for local government*. 2012. https://www.aarp.org/content/dam/aarp/livable-communities/plan/planning/aging-in-place-a-toolkit-for-local-governments-aarp.pdf

Bengtson, VL., Coleman, PG. & Kirkwood, TBL. 2005. The cambridge handbook of age and ageing. http://assets.cambridge.org/97805218/26327/frontmatter/9780521826327_frontmatter.pdf

Berk, LE., 2006. *Development through the lifespan.* Issue no: 4. Allyn & Bacon

Biocca L. & Morini A., 2008. *Intelligent or smart houses: policies and state of the art in Italy.* United States: Int. Journal for Housing Science

Bitterman, N. & Shach-Pinsly, D. 2015. Smart home – a challenge for architects and designers. *http://dx.doi.org/10.1080/00038628.2015.1034649*

Boers, N., Chodos, D., Gburzynski, P., Guirguis L., Huang, J., Lederer, R., Liu, L., Nikolaidis, I., Sadowski, C. & Stroulia, E. 2011. The smart condo project: services for independent living.

Budds, D., 2016. *A house built for aging in place*. https://www.fastcompany.com/3062207/a-house-built-for-aging-in-place

Carr, K., Weir, PL., Azar, D. & Azar NR. 2013. *Universal design: a step toward successful aging*. https://www.hindawi.com/journals/jar/2013/324624/

Chan, M., Campo, E., Esteve, D., & Fourniols, H, Y. 2009. *Smart homes - current Features and future perspectives.*

Colldahl, C., Frey, S., Kelemen, J., 2013. *Smart Cities: Strategic Sustainable Development for an Urban World.* https://www.diva-portal.org/smash/get/diva2:832150/FULLTEXT01.pdf

Connell, B., Jones, M., Mace, R., Mueller, J., Mullick, A., Ostroff, E., Sanford, J., Steinfeld, E., Story, M., & Vanderheiden, G., 1997. The Center for Universal Design. NC State University. https://projects.ncsu.edu/ncsu/design/cud/about_ud/udprinciplestext.htm

Demiris, G. & Hensel, BK. 2008. Technologies for an aging society: a systematic review of “smart home” applications.

Demiris, G., Rantz, M., Marek, K., Tyrer, H. Skubic, M. & Hussam, A. 2004. *Older adults' attitudes towards and perceptions of "smart home" technologies: a pilot study*.

Despres, C., 1991. The meaning of home: literature review and directions for future researchand theoretical development. https://www.jstor.org/stable/43029026

Ding, D., Cooper, RA., Pasquina, PF. & Fici-Pasquina, L. 2011. *Sensor Technology for Smart Homes*. pp.131-136.

Duncan, R., 2014. National Disability Authority. *Universal Design.* http://universaldesign.ie/What-is-Universal-Design/Conference-Proceedings/Universal-Design-for-the-21st-Century-Irish-International-Perspectives/

Faanes, EK., 2014. *Smart homes and smart home technology*., http://biblioteket.husbanken.no/arkiv/dok/Komp/Smart%20homes%20and%20smart%20home%20technology.pdf

Fabcab., 2018. *Smart living begins here.* http://fabcab.com/wp-content/uploads/2018/04/TimberCab-information-packet-APRIL-2018.pdf

Gerring, D. & Wozniak, R., 2016. *Universal Design / Aging-In-Place.* Pennsylvania Housing Research Center., http://www.phrc.psu.edu/assets/docs/Publications/2016RBDCCPresentations/Gerring2-2016-RBDCC-Presentation.pdf

Gilleard, C., Hyde, M. & Higgs, P. 2007. The impact of age, place, aging in place and attachment to place on the well-being of the over 50s in England. Research on Aging. http://journals.sagepub.com/doi/pdf/10.1177/0164027507305730

Giuliani, M., 2003. *Theory of attachment and place attachment. https://www.researchgate.net/publication/228091197_Theory_of_Attachment_and_Place_Attachment*

Guihen, B., 2016. *Making space for ageing: embedding social and psychological needs of older people into smart home technology*. https://www.jstor.org/stable/j.ctv1xxrwd.9

Harper, R., 2003. Inside the smart home: Ideas, possibilities and methods. London: Springer – Verla

Helal, S., Mann, W., El-Zabadani, H., King, J., Kaddoura, Y. and Jansen, E., 2005. The Gator Tech Smart House: A Programmable Pervasive Space. https://www.semanticscholar.org/paper/The-Gator-Tech-Smart-House%3A-a-programmable-space-Helal-Mann/0c0cb5e78d14f168ec2e208185b0a41931359aeb https://pdfs.semanticscholar.org/41eb/94526ce0be1992783f1b49d9069e74569f75.pdf?_ga=2.147718263.1946515818.1532682155-1326346598.1532682155

Iecovich, E., 2014. *Aging in place: From theory to practice.,* https://pdfs.semanticscholar.org/f9fc/8e6e859408543cb512a499d37a4267edb348.pdf

Kazmierzak, F., 2012. *Smart home environment - concepts and solutions.* https://www.snet.tu-berlin.de/fileadmin/fg220/courses/WS1112/snet-project/smart-home-environments-kazmierzak.pdf

Kemppainen, Ö., 2006. *Alternative Housing Environments for the Elderly in The Information Society*. http://jultika.oulu.fi/files/isbn9514280822.pdf

Kerbler, B., 2014. Housing for the elderly in Slovenia: analysis of the most common forms. https://www.jstor.org/stable/24873497

Kurian, R. & Uchiyama, C., 2012. Models of elderly care in japan and the Netherlands: social quality perspectives.

https://www.jstor.org/stable/23972432?seq=1&cid=pdf-reference#page_scan_tab_contents

Laberg, T., 2005. Smart home technology: technology supporting independent living – does it have an impact on health?

Lindström, B., 2010. *Salutogenesis an introduction.* http://www.centrelearoback.org/assets/PDF/04_activites/clr-GCPB121122-Lindstom_pub_introsalutogenesis.pdf

Ludden, J., 2010. *Building Homes to Age In.* https://www.npr.org/templates/story/story.php?storyId=129260583

Mitchell, W. J. 2008. Intelligent cities. Knowledge Society. http://www.uoc.edu/uocpapers/5/dt/eng/mitchell.pdf

National Council for Aging Care., 2017. http://www.aginginplace.org/5-ways-to-make-your-entryway-safer/

National Disability Authority., 2014. *What is Universal Design*. http://universaldesign.ie/What-is-Universal-Design/

National Disability Authority., 2015. *Universal design guidelines for homes in Ireland.* http://universaldesign.ie/Web-Content-/Introduction.pdf

National Disability Authority., 2015. *Universal design guidelines section 2- entering and moving around. http://universaldesign.ie/Web-Content-/Section-2-Entering-and-Moving-Around.pdf*

Ni, Q., Hernando, A. & la Cruz I., 2015. *The Elderly's Independent Living in Smart Homes: A Characterization of Activities and Sensing Infrastructure Survey to Facilitate Services Development. http://www.mdpi.com/1424-8220/15/5/11312/pdf*

Quynh, L., Nguyen, HB. & Barnett, T., 2012. *Smart homes for older people: positive aging in a digital world.* http://www.mdpi.com/1999-5903/4/2/607/pdf

Rantz, M., Skubic, M., Miller, S., Alexander, G., Keller, J. & Popescu, M., 2013. *Sensor Technology to Support Aging in place. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3683379/*

Reeder, B., Meyer, E., Lazar, A. Chaudhuri, S. Thompson, HJ. & Demiris, G. 2013. *Framing the evidence for health smart homes and home-based consumer health* *technologies as a public health intervention for independent aging: a systematic review*.

Romoren, TI., 2003, *Last years of long lives.* Issue no 1.UK: Routledge

Rykwert, J., 1991. *House and home*. https://www.jstor.org/stable/40970630

Schulz, C., 1985. *The Concept of Dwelling, on the way to figurative architecture.*

Tamura, T., 2012. *Home Geriatric Physiological Measurements*.

Tomita M., Russ L., Sridhar R. & Naughton B., 2010. *Smart Home with Healthcare Technologies for Community-Dwelling Older Adults*. https://www.intechopen.com/books/smart-home-systems/smart-home-with-healthcare-technologies-for-community-dwelling-older-adults

United Nations, Habitat III, 2017, http://habitat3.org/wp-content/uploads/NUA-English.pdf, p.39

World Health Organization, *Global Health and Aging*, 2011, http://www.who.int/ageing/publications/global_health.pdf

World Health Organization, *World report on Ageing and Health*, 2015, http://www.who.int/ageing/events/world-report-2015-launch/en/

Youngblood, M., Cook, D. & Holder, L., 2004. *The MavHome Architecture.* *https://cse.uta.edu/research/Publications/CSE-2004-18.pdf*