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A Study on the Development and Implementation of Smart Technologies in Care Centers

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Abstract: This study examines the challenges posed by Taiwan's rapidly aging society. As the post-war baby boomer generation enters their senior years, coupled with advanced medical technology extending life expectancy, Taiwan is facing a significant demographic transformation. By 2025, the population aged 65 and above is projected to exceed 20%, marking Taiwan's entry into a super-aged society; by 2039, this figure will surpass 30%, making Taiwan one of the fastest-aging nations globally. In response to this trend, this study focuses on investigating the physical and mental health needs, safety considerations, and living environments of the elderly, with particular emphasis on the application of smart technology in long-term care. Research objectives include: developing innovative care solutions, reducing care costs, integrating smart systems with architectural design to achieve energy sustainability, and establishing more efficient institutional operational models. Through these research aspects, we aim to construct a long-term care blueprint that meets the needs of Taiwan's super-aged society, promoting successful aging while mitigating the impact of population aging on social development.

Keywords: Aging Society, Long-term Care, Smart Technology

I. Introduction

The post-war baby boomer generation in Taiwan is progressively aging, and advancements in medical technology have significantly extended average life expectancy, resulting in a steadily rising proportion of elderly individuals. In recent years, shifts in family dynamics, driven by delayed marriages, declining birth rates, and the pursuit of higher living standards, have further influenced the nation's overall fertility rate. The continuous growth of the elderly population, coupled with a marked decline in birth rates, has created a dual challenge characterized by low birth rates and low mortality.

Statistics reveal that in 2018, individuals aged 65 and older accounted for 14% of the total population. By 2025, this figure is projected to surpass 20%, ushering Taiwan into the era of a "super-aged society." By 2039, this percentage is expected to exceed 30%, positioning Taiwan among the fastest-aging nations globally.

This rapid population aging poses substantial challenges to society, including a dramatic increase in the demand for medical and long-term care resources, leading to significant supply and demand imbalances. These pressures have strained the social welfare system and human resources, particularly due to shortages of caregivers and healthcare professionals. Moreover, the aging crisis has had far-reaching impacts on the development of socio-economic industries.

Addressing the challenges posed by an aging society while simultaneously improving the quality of life for the elderly has become a critical priority. Transforming the burdens of long-term care into a driving force for progress and turning the challenges of aging into opportunities within the "silver economy" are essential strategies for mitigating the impacts of demographic changes and fostering sustainable socio-economic development.

1.2 Research Objectives

This study seeks to address the challenges posed by Taiwan's rapidly aging society and propose effective solutions. As demographic shifts lead to an increasing burden of a super-aged population, the importance of care facilities and welfare policies becomes ever more critical. The research will begin by examining the physical and mental health needs, safety concerns, and living environments of the elderly to promote healthier aging, extend their active lifespan, and mitigate the societal impacts of aging, thereby achieving the goal of "successful aging."

In response to the growing demand for healthcare and long-term care resources, this study focuses on the application of smart technologies in elderly care. It aims to develop innovative solutions to enhance the quality of care while reducing associated costs. Furthermore, the research will explore how the integration of advanced

technological systems with architectural design can optimize energy efficiency and achieve low-carbon, sustainable care environments.

By leveraging smart technology, this study intends to revolutionize the operational models of elderly care centers, ensuring they are more efficient, effective, and capable of meeting the needs of a super-aged society. Through this approach, the research aspires to establish a blueprint for the future of elderly care that aligns with Taiwan's evolving demographic landscape

II. Literature Review

1. Care Service Units and Systems

As aging-related challenges intensify, the demand for elderly care services has grown significantly. The literature explores various types of care service units, including nursing homes, retirement communities, and long-term care facilities, analyzing their unique characteristics and functions. These units offer a range of services, from medical care and primary health insurance to recreational facilities and medical alert systems. Research emphasizes that care facilities must be planned and allocated based on the health conditions and needs of the elderly to ensure their safety and quality of life.

2. Social Welfare and Policy

The review examines Taiwan's long-term care policies, particularly the "Long-Term Care 2.0" program, designed to address the challenges of an aging society. This program highlights the role of community-integrated service centers and provides a variety of service models tailored to the needs of older adults. The literature underscores the critical role of government policies in providing adequate care and social support for the elderly while suggesting potential improvements for future policy development.

3. Successful Aging

The concept of "successful aging" is widely discussed in the literature, focusing on three core aspects: physical health, psychological well-being, and social engagement. Successful aging involves not only maintaining physical health but also achieving emotional satisfaction and fostering social connections. Studies reference Rowe and Kahn's three-component model of successful aging and incorporate additional perspectives, exploring how cultural, spiritual, and cognitive strategies influence the quality of life for older adults.

4. Care Units and Smart Technology

The rapid advancement of smart technology has led to its increasing application in elderly care services. The literature investigates the use of health monitoring systems, safety surveillance, and assistive devices in care facilities. These technologies improve care quality, reduce labor costs, and address workforce shortages in the elderly care sector. Additionally, smart technology's ability to leverage data analytics for personalized health management plans highlights its transformative potential for the future of elderly care.

5. Application of Indoor Positioning Systems (IPS)

The use of Indoor Positioning Systems (IPS), particularly Ultra-Wideband (UWB) technology, is crucial in enhancing safety and health management in elderly care facilities. UWB technology provides highly accurate indoor positioning, enabling effective monitoring of daily activities and health conditions. This supports the smart management of care centers and serves as a reliable tool for professionals.

Research indicates that UWB-based IPS systems significantly improve fall detection and emergency response times in elderly care environments. By accurately tracking residents' movements and locations, these systems enable immediate alerts during falls or abnormal activity patterns, reducing response times and improving safety outcomes. The integration of UWB technology with wearable sensors further demonstrates its potential to combine precise positioning with real-time health monitoring, allowing care providers to track both the location and vital signs (e.g., heart rate and body temperature) of elderly residents. This integration facilitates proactive health interventions, minimizes hospital visits, and supports independent living.

Moreover, the application of UWB technology in smart homes has garnered attention. Accurate positioning data can be utilized to automate household systems based on residents' movements, such as adjusting lighting or activating assistive devices. This creates a safer and more comfortable living environment for the elderly, enhancing their overall quality of life.

UWB technology in elderly care facilities not only enhances safety and monitoring but also provides robust support for advanced health management and smart living solutions. These innovations highlight UWB's potential to shape the future of elderly care and its vital role in addressing the challenges of an aging society.

III. Research Methods

3.1 Literature Analysis

This method involves reviewing a broad range of resources, including government reports, academic papers, and journal articles, to gain a comprehensive understanding of issues related to aging societies and the current applications of smart technologies in care centers.

Case Study Method

Representative case studies were selected for in-depth analysis, including the Shuanglian Care Center in New Taipei City, Taiwan, FremtidensPlejehjem in Denmark, and Kampung Admiralty in Singapore. These cases provide insights into design concepts and the integration of smart technologies, offering valuable inspiration and practical knowledge.

Case Selection

1. Taiwan – Shuanglian Care Center in New Taipei City

This case highlights the application of ICT technologies in smart long-term care, serving as a model for the interdisciplinary integration of Taiwan's long-term care system with smart technology.

2. Denmark – Fremtidens Plejehjem

Fremtidens Plejehjem was selected as a case study due to its innovative combination of smart technology and modern design. This nursing home focuses on enhancing elderly residents' autonomy and comfort while fostering interaction with the local community.

Research Methods Include:

a. Case Study Analysis

A detailed examination of Fremtidens Plejehjem's design philosophy, facility layout, and operational model is conducted to explore its innovative practices in elderly care. Special attention is given to the use of smart technologies (e.g., pressure-sensitive floors, movable washbasins, and iPad communication systems) and modern facilities (e.g., communal balconies, fitness centers, and cybercafés) to promote independent living among elderly residents.

b. Qualitative Interviews

Interviews with designers, managers, and residents of the nursing home are conducted to understand the design considerations for elderly needs and their practical experiences. The interviews investigate how needs analyses were performed during the planning phase and how the design philosophy was aligned to enhance the autonomy of elderly residents.

c. Participant Observation

By participating in the nursing home's daily activities, this method observes how elderly residents interact with smart technology facilities and how these facilities impact their daily lives and social interactions. Additionally, interactions within and beyond the nursing home community are documented to assess the effectiveness of the design in integrating the elderly into the broader community.

d. Data Analysis

Data on the use of smart technologies in the nursing home, such as alarm records from pressure-sensitive floors, facility usage frequency, and resident satisfaction surveys, are collected and analyzed quantitatively. This approach evaluates the effectiveness of smart technologies in improving the quality of life for elderly residents.

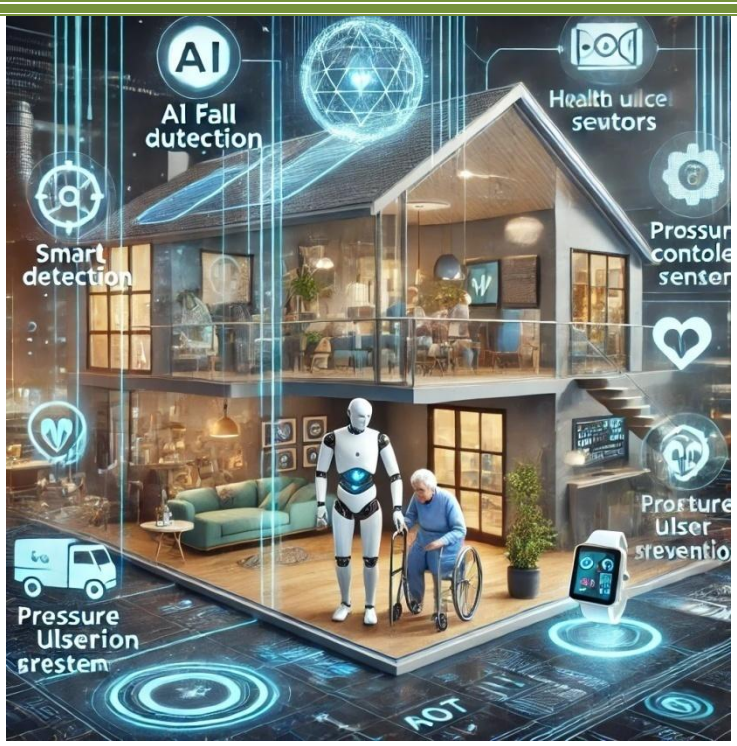

Figure 1. Pressure-sensitive flooring, source: Future Care Home official website

Singapore Case Study

Singapore – Kampung Admiralty

This study selects Kampung Admiralty in Singapore as a case study, focusing on sustainable development and community integration while providing a comprehensive solution for elderly care centers. The research employs the following methods:

a. Case Study Analysis

An in-depth analysis of Kampung Admiralty's design philosophy and spatial planning is conducted, examining how the "sandwich layer" concept was applied to create a "Vertical Kampung" within the constraints of a 0.9-hectare site and a 45-meter height limit. The analysis highlights how the design effectively integrates the Community Plaza, Medical Centre, and Community Park, fostering interdisciplinary collaboration and promoting active aging.

b. Qualitative Interviews

Interviews are conducted with the planners, architects, and managers of Kampung Admiralty to gain insights into the considerations for sustainable development and community integration during the design and planning process. The interviews explore how the design addresses the needs of elderly residents, focusing on facility utilization, community acceptance, and resident satisfaction with the provided facilities and services.

c. Participant Observation

By engaging in daily activities at Kampung Admiralty, the study observes interactions between residents and the public within the Community Plaza, Medical Centre, and Community Park. It documents elderly residents' use of these spaces for socializing, exercising, and participating in wellness activities, as well as interactions across generations. This analysis evaluates the effectiveness of the facilities in fostering community integration and intergenerational connections.

d. Data Analysis

Operational data from Kampung Admiralty is collected, including usage frequencies of the Medical Centre, participation rates in Community Plaza activities, utilization of the Community Park, and satisfaction surveys from elderly residents regarding housing facilities. Quantitative analysis is conducted to assess the project's impact on enhancing the quality of life for the elderly, supporting community integration, and

achieving sustainable development goals. Additionally, the financial feasibility of the design is evaluated through an analysis of the planning process and economic benefits associated with the facilities.

A. Application of Smart Technology:

Health Monitoring Technology: The emergence of wearable devices and smart health monitoring systems has revolutionized elderly care by enabling the real-time tracking of health data. These advancements pave the way for personalized health plans and represent a promising future for healthcare in elderly care facilities.

(a) Safety Monitoring Technology: Incorporating smart sensing devices and home safety monitoring systems, these technologies are designed to ensure the safety and well-being of elderly residents.

(b) Assistive Monitoring Technology: Leveraging artificial intelligence and voice recognition technologies, these systems empower elderly individuals with self-management tools and support for their daily activities.

B. Indoor Positioning System (IPS):

This study focuses on the application of Ultra-Wideband (UWB) indoor positioning systems to enhance the safety and health monitoring of elderly individuals in care facilities. Simultaneously, it seeks to optimize energy management and achieve a smart and sustainable developmental framework.

C. Research Methodology:

Our comprehensive research methodology is aimed at demonstrating the potential of smart technology in the design of elderly care facilities.

- Defining the Research Scope: Establishing the research focus on the application of smart technology in care facility design, guided by expert insights and industry expertise.
- Conducting Case Studies: Investigating real-world applications of smart technologies and energy management strategies. Additionally, the study evaluates the feasibility and effectiveness of implementing UWB indoor positioning technology in elderly care centers.

3.2 Case Studies

1. Taiwan – Shuanglian Care Center in New Taipei City:

The Shuanglian Care Center is a multifunctional and multi-tiered facility that highlights the integration of smart long-term care technologies. By leveraging Information and Communication Technology (ICT), the center addresses workforce shortages while improving the quality of care. Recognized as a successful example of smart long-term care in Taiwan, it serves as a model for transitioning from Long-Term Care 1.0 to 2.0 policies. The center provides comprehensive services and diverse care options while fostering collaboration among government, industry, and academia, establishing itself as a demonstration site for smart technology in long-term care.

2. Denmark – Fremtidens Plejehjem (Future Nursing Home):

Fremtidens Plejehjem is an innovative long-term care facility in Denmark that seamlessly combines architectural design with welfare technology. It embodies the "aging in place" philosophy, strategically located in urban areas to encourage elderly participation in community activities and reduce social isolation. The facility offers smart assistive technologies, including customized living spaces and shared public areas, to enhance autonomy and social engagement among the elderly. Its design prioritizes interaction between the community and older adults, fostering improved quality of life through inclusive architecture and a supportive environment.

3. Singapore – Kampung Admiralty:

Kampung Admiralty is a mixed-use development in Singapore that integrates elderly care facilities, kindergartens, medical services, as well as retail and dining spaces. The project adopts the concept of a "vertical village," creating a space that encourages intergenerational living and interaction. Featuring extensive greenery and eco-friendly design elements, it emphasizes environmental sustainability and eco-protection, aiming for net-zero carbon emissions. The development offers a variety of community services and public amenities, highlighting intergenerational connections and social integration, while promoting interaction and mutual support within the community.

3.3 Differences and Integration of Design Strategies

1. These three case studies reflect distinct approaches to elderly care, each shaped by its unique social and cultural context.
2. The Shuanglian Care Center in New Taipei City prioritizes the integration of technology and policy transformation; Denmark's Fremtidens Plejehjem (Future Nursing Home) emphasizes community-oriented design; and Singapore's Kampung Admiralty showcases sustainability and the concept of intergenerational living.
3. From an integrated strategy perspective, these designs address the needs of older adults while responding to the challenges of modern society, offering innovative and diverse solutions.

3.4 Care Center Design Planning

1. Site Context and Existing Conditions:

Design planning must account for the geographic location and surrounding environment of the site, including transportation accessibility, nearby facilities, and the characteristics of the local community. Emphasizing the "aging in place" concept, facilities should be located in urban centers or areas with convenient transportation links to enable elderly residents to participate in community activities and mitigate feelings of isolation effectively.

2. Site Analysis:

An in-depth analysis of the site's natural conditions, such as sunlight exposure, wind direction, and topography, is crucial as these factors influence the layout and structure of the building design. The internal spatial requirements and functional divisions of the site are also assessed, with specific zones allocated to accommodate various activities and services.

3. Design Strategy:

The design strategy serves as a fundamental component of the planning process, shaping the overall vision and approach for the project. The strategy prioritizes flexibility and adaptability, ensuring spaces can evolve to meet changing demands. It also emphasizes the integration of green spaces to provide comfortable recreational areas for the elderly and reduce the urban heat island effect caused by buildings. Furthermore, the strategy advocates the adoption of smart technologies, such as advanced health monitoring systems and Ultra-Wideband (UWB) indoor positioning systems, to enhance the safety and health monitoring of elderly residents while optimizing energy efficiency.

4. Smart Devices:

Integrating smart devices such as health monitoring systems, safety surveillance technologies, and assistive monitoring systems is a strategic initiative. This approach fosters a more efficient and safer care environment while enhancing confidence in safety measures. A smart cloud system is employed for data collection and analysis, enabling the delivery of personalized care services and improving management efficiency.

5. Design Drawings:

Comprehensive design drawings are provided, including floor plans, elevations, cross-sections, and functional zoning plans. Each floor is meticulously planned and divided into functional zones, such as well-lit areas, recreational spaces, educational zones, and living quarters. The adaptable design ensures flexibility to accommodate diverse activity requirements confidently.

6. Sustainable Development and Low-Carbon Design:

The design incorporates the principles of sustainable development, employing low-carbon building techniques and utilizing renewable energy sources such as solar power and rainwater harvesting systems. By optimizing building energy efficiency and resource utilization, the design reduces carbon emissions and promotes sustainable community development.

7. Community Interaction and Intergenerational Living:

The design integrates the concept of intergenerational living, creating diverse spaces for community interaction that strengthen connections between elderly residents and other generations. Shared facilities, such as restaurants, fitness centers, and gardens, encourage elderly participation in community activities, fostering social engagement and enhancing social connections.

IV. Design Focus and Key Performance Indicators

1. Architectural Design:

The design of the care center is fundamentally centered on the needs of older adults, emphasizing a "de-institutionalized" approach to align their living conditions and lifestyles with those of mainstream society. The design must achieve a balance between autonomy and safety for residents, offering diverse public spaces to promote community integration and social interaction while mitigating isolation. Attention is given to lighting, ventilation, and greenery to create a comfortable living environment that enhances the quality of life for older individuals.

2. Smart Technology:

The integration of smart technologies, such as Ultra-Wideband (UWB) indoor positioning systems and health monitoring devices, enhances the efficiency and effectiveness of smart management in the care center. Internet of Things (IoT) technologies are employed to collect and analyze daily health data, enabling personalized health management plans. Smart sensing systems, including intelligent lighting and temperature control, are implemented to optimize energy management and reduce carbon emissions.

3. Project Indicators:

The success of the design plan is measured against several key indicators, including architectural functionality, safety, environmental comfort, and the effectiveness of technology integration. Sustainability metrics focus on low carbon emissions in building design, energy efficiency, and the use of environmentally friendly building materials.

V. Conclusions

5.1 Conclusion

1. This study highlights the critical role of integrating smart technologies into the design of care centers to enhance the quality of life and ensure the safety of older adults.
2. The findings reveal that smart technologies, such as Ultra-Wideband (UWB) indoor positioning systems and health monitoring devices, significantly improve management efficiency and reduce energy consumption, driving the development of intelligent and sustainable care centers.
3. Case studies demonstrate that the design of care centers varies across countries and regions, reflecting local cultures, policies, and technological advancements to create living environments better suited to the needs of older adults.
4. This research proposes an innovative design model that combines architectural design with smart technologies, placing the needs of older adults at the core and facilitating the realization of successful aging.

5.2 Recommendations

(1) Policy Support and Promotion:

To enhance the technological capabilities of care facilities, it is recommended that the government strengthen policy support for the integration of smart technologies in care centers and fully implement the Long-Term Care 3.0 policy.

(2) Technology Upgrades and Maintenance:

Regular upgrades and maintenance of smart devices in care centers should be encouraged to ensure the reliability and efficiency of technological systems while preventing safety risks caused by equipment malfunctions.

(3) Community and Family Integration:

More public spaces should be designed to facilitate better integration of the elderly with their communities and families. This approach fosters intergenerational interaction and enhances the elderly's sense of social participation and well-being.

(4) Environmental Sustainability:

Care center designs should incorporate environmentally friendly principles, utilizing renewable energy sources and energy-efficient devices to reduce carbon emissions and promote sustainable development.

(5) Personalized Services:

Providing tailored care services is essential. Individualized health management plans should be developed to meet the specific needs of older adults, thereby improving service satisfaction and quality of life.

Multi-Criteria Decision-Making Recommendations

(1) Develop Comprehensive Evaluation Criteria:

Establish diverse evaluation standards for comparing different design proposals or technology applications. These criteria should consider user needs, technological feasibility, economic cost, and environmental sustainability.

(2) Conduct Case Studies:

In-depth case analyses of various design proposals can help identify their strengths and weaknesses, offering valuable insights for problem-solving and future decision-making.

(3) Implement Smart Decision Support Systems:

Leverage smart technologies, such as the Internet of Things (IoT) and Artificial Intelligence (AI), to automate data analysis and provide decision support, assisting managers in making optimal choices.

(4) Foster Collaborative and Interdisciplinary Input:

Encourage collaboration and cross-disciplinary efforts to integrate the perspectives of various experts into the decision-making process, ensuring comprehensive consideration of all factors.

(5) Combine Quantitative and Qualitative Analysis:

Adopt a holistic approach to decision-making by combining quantitative metrics (e.g., energy consumption and cost-effectiveness) with qualitative user experiences (e.g., elderly needs and social impacts) for a well-rounded evaluation.

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