
Intelligent Design Optimization for Residential Buildings Designed for Smart Elderly Care — Analysis of the Functional Requirements of the “Mind Cultivation” Platform

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Abstract: Based on “Mingzhi Yang” platform’s function requirements, aiming at improving intelligent planning and design for residential buildings under background of smart eldercare system, it analyzes main functions requirement of “Mingzhi Yang” platform from eldercare service etc. health monitoring and scenario adaption, evaluates the suitability of current smart design methodologies to such needs in retirement homes, proposes specific optimization measures from an architectural design perspective, and discusses ways to combine functional needs with intelligent building design; this research can provide some reference guidance in optimizing the intelligent aging of elderly housing buildings as well as improve the system of architectural design for the smart elderly care industry.

Keywords: Smart elderly care; Residential buildings; Intelligent design optimization; Mental well-being platform

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1. Introduction

In the context of population aging, intelligent elder care is one of the important directions to upgrade elder care model. Elderly apartment building is the main carrier of elderly housing and the scientificity and flexibility of intelligent design for building residents will have a direct impact on the level of care services, “Mingzhi Yang” platform realizes the matching between care resources and the needs of the old people by using intelligence, providing accurate functional guidance to guide intelligent design of elderly building. Currently some such buildings have issues such as inconsistent with actual nursing needs in function layout etc., as well as lack of proper interplay between technologies and architecture. Design optimization studies for the given platform functionality are required immediately. The present work attempts to fill that gap, by exploring co-relationships among the platform functionality and the architecture, thus promoting a better application practice for smart design of aging building.

2. Analysis of the core functional requirements of smart elderly care and the “mental health care” platform

2.1. Functional requirements characteristics of residential buildings under the smart elderly care model

With the popularization and application of intelligent elderly care mode, the function demand for the old-age building is changing, moving from the conventional age-friendly design toward a holistic system with intelligence and scenario-based solution, and personalization. Senior citizens today require built environments not only physically accessible, highlighting the need for incorporating digital features including healthcare, safety alerting, and intelligent interaction – requirements which change continuously in accordance to one’s physical state and lifestyles. The buildings should be able to achieve a combination between pragmatic spatial planning and interoperability among smart technologies, smoothly combining smart functions in life scenes according to the different requirements of senior citizens with various ages and physical conditions, and based on the behavior pattern and application habit of elderly people. The design of smart senior building should be based on user-friendliness as a top priority; and Smart design needs to fit for senior’s operation ability without complicated technology interface.

At the same time, the intelligent features in houses should also have flexible adaptability and provide personalized intelligent service under different situations like daily life, leisure activities, and health care, such as smart lighting at home, environment control of leisure places, and medical health monitoring through physiological measurements.

2.2. Core service modules and functional architecture of the “mind nurturing” platform

The “Mental Health” website is a virtual hub of smart elder care services integrated with the main elements in health management, service integration, and intelligent communication are integrated together to form a complete elder care system. The health management unit, as the brain of the system to realize online collecting, analyzing and early-warning for elders’ physiological information, while linking medical resources to provide remote consultation and health checkup. The service coordination module integrates the offline care resources, rapidly matching domestic support, nursing care, and delivery service according to the needs of the elders. The smart interaction module realizes the information exchange among the elders, their family members and caregivers via voice and touchscreens^[1]. Motivated by practicality requirements, the system is designed with a multi-tier architecture: data collection layer collects older adult’s life activity and healthcare data from smart objects; the data analytics layer uses big data and AI techniques to analyze, transform and synthesize those factors into personalized treatment plans; and the service delivery layer transforms processed information into tangible services offered through the platform interface and intelligent buildings.

2.3. Key requirements for intelligent design of senior living buildings from a platform perspective

Based on the realization of “mental health” platform functions, the key to smart building planning in old-age houses is the smooth integration between hardware and software integration into the platform, which guarantees the intelligent facility in the building can integrate with the data collection layer of the platform and service application layer of the platform; guaranteeing timely information collection, rapid response of services provided. The system should be built with appropriate interface at the hardware level and software level for upgrading technologies in the future and able expansions, avoiding incompatibility problems which may make the smart system unusable and guaranteeing the platform’s complete functioning in the home environment. In terms of the platform perspective. In addition to supporting young users, intelligent design must also consider senior citizens’ requirements including context-aware layout and elegant design in smart functions. In the health monitoring module.

The next must also be placed on priority spots like the bedroom, bathroom for vital sign monitoring, emergency calling capability. A dedicated smart service for the service dispatch module is required, interfaces for on-site help from staffs. For the interactive module, friendly terminals should be located in common places as well as living rooms so that

users can easily operate for elders. Moreover, its design needs a trade-off between energy consumption and reliability of systems for reducing operation cost and outage rate.

3. Existing issues and adaptability analysis of intelligent design for senior living buildings

3.1. Insufficient integration between intelligent building functions and platform services

Current smart design approaches in elderly care residential buildings suffer from an imbalance between technological sophistication and system integration. The functional design of smart facilities lacks effective alignment with the service modules of the “Mental Well-being” platform, creating data silos. Although some buildings are equipped with smart monitoring and emergency call systems, the collected data cannot be transmitted in real-time to the platform, and the platform’s service dispatch functions fail to interface with the building’s smart infrastructure. This prevents the platform’s digital services from being effectively implemented in residential settings, limiting smart facilities to isolated local functions and undermining the synergistic benefits of intelligent elderly care. The poor integration between building smart systems and platform services is further exacerbated by inadequate standardization of hardware/software interfaces—interfaces from different brands and types lack uniformity and are incompatible with the “Mental Well-being” platform’s technical architecture, increasing technical complexity and costs for system integration. Additionally, some buildings failed to adequately address the platform’s functional requirements and technical standards during the smart design phase. Subsequent interface modifications, constrained by spatial and structural limitations, often yield suboptimal results and may even compromise the building’s original age-friendly design.

3.2. Spatial adaptability of intelligent design and its compatibility with elderly care scenarios

The lack of spatial flexibility for smart design in elderly housing is still a significant problem, some buildings are simply stacking smart functions while ignoring the living context and lifestyle of elders, leading to poor usability: e.g., sensors for health parameters (e.g., heartbeat) may be installed out of reach from elderly users; while the emergency call button is installed in a position where it cannot be easily accessed by people with limited physical ability. This situation does not make service convenient, and moreover causes inconvenience from inappropriate design of space layout, contradict with the basic ideas of smart elderly design, there is a gap between the intelligent design and the actual care situation. With intelligent features that do not match specific requirements for various scenarios like caregiving at home or recreation or recovery facilities. Most facilities are generic in nature where the same set of intelligent appliances are installed for all situations without considering their usability and users’ needs; for instance, rehabilitation facilities are not equipped with dedicated smart healthcare monitoring functions and recreation rooms do not have sufficient smart environment regulation capabilities.

3.3. The imbalance between the practicality of intelligent technology applications and age-friendly design

The current intelligent design of the elderly housing building pays too much attention to “high-end fashion” in terms of application of smart technologies, while ignoring practicability, aging friendliness. Even if there are many high-end smart devices and functions in a building, their complicated operating procedures are beyond the understanding and capability of elderly people, so that such facilities remain unused and do not achieve their goals. For example, some buildings have sophisticated control systems that require complex operations on a smartphone; older persons who do not know how to operate such systems, are not able to use smart service, and finally stay away from using smart services with their habitual lifestyle. The imbalance between smart usage preference and aging friendly design also appears in the lack of human centered designing of smart facilities, which does not take into consideration the physical and mental features that characterize elderly people ^[2].

4. Intelligent design optimization principles for residential buildings based on the “mind-nurturing” platform

4.1. Principle of functional synergy: Deep integration of platform requirements with architectural design

Principle three: Functional Synergy Principle, the design of the elderly residence house should take into account the functional needs of the “Mental Care” platform as the primary basis for smart elderly housing design to ensure the close coordination between the platform services and the functions of the elderly houses. breaking through the boundaries of hardware and software, establishing a comprehensive intelligent elderly care life system. In the early stage of research, the building plan should be completely consistent with the system framework of each module in the platform and the technology used and functions required; integrating with its health management, service coordination, intelligent interaction functions in each element of space design and smart facilities planning so as to achieve organic combination. In accordance with such a rule, it needs to build up the cooperative design model between platform and architectural designers, ensuring constant interaction and collaboration of the platform development team and architectural design team during the process for quick resolution of any integration problems. The intelligent building design should take into consideration the platform’s current functionality as well as future upgrades, leaving some degrees of freedom for architectural decisions regarding the space organization, as well as software/hardware interfaces so that after an update on a platform level it is possible to quickly adapt smart buildings (without large-scale reconstructions).

4.2. Age-friendly priority principle: Intelligent technology services addressing actual elderly care needs

Elderly-first is the main guidance line for intelligent design of elder-care building, which requires that all intelligent technology or facility should be designed to meet the real need of elderly people; aligns them with their physiological and psychological traits, along with use habits in order for these technologies to truly serve their daily life; intelligent design must discard “technology first”, not adopting the latest technology at the expense of more proven, reliable, intuitive tools to facilitate use and lower entry costs for operations, enabling elders to easily learn the usage of the smart facilities ^[3]. Following this guideline, differentiating intelligent designs for diverse ages and health condition is required to meet their personalized nursing demands. For young, healthy elders, increased interactive/recreational facilities would be advised; elderly people with decreased functional capacity/disability, priority of the development on health monitoring, emergency response system and day-to-day care function such as one touch calling button or intelligent nursing home.

At the same time, the design of smart buildings must pay attention to user friendly details with age-friendly features like big fonts, simple icons, verbal instructions, and eye-catching signs at important locations so that seniors could easily and safely use them.

4.3. Principle of spatial adaptation: Intelligent design aligned with the characteristics of elderly living spaces

The adaptability principle requires that the spatial aspect of architecture in old-age care facilities be considered by smart design, layout structure and the characteristics of the residence environment to realize the organic combination of smart facilities and space, so that the intelligent design can better meet the function of the space itself without destroying its own spatiality and practicability; the architectural intelligent design needs to be consistent with the elderly’s behavior mode and use habit, while causing minimal disturbance in the lives of residents. To accomplish that goal, it is necessary to integrate smart technologies and retrofitting techniques into already existing built environment and facilities for older adults, integrating the intelligent facility construction, barrier-free design, and safety protection design into one systematic elder care space pattern. Such as installing smart sensor activated lighting near accessible routes, and emergency call buttons next to slippery bathroom floors so that smart design and age friendly features can reinforce one another.

At the same time, the appearance of intelligent equipment needs not only beautiful but also reasonable selection, it is better that small size, simple style, so as not to make the whole room messy in order to affect the decoration effect of the whole house, which makes people feel very uncomfortable for the senior citizens.

5. Intelligent design optimization strategies for residential buildings oriented towards the “mind-nurturing” platform

5.1. Intelligent building perception design based on platform health monitoring functions

In response to the health management module requirements of the “Mental Nurturing” platform, elderly care residential buildings must enhance intelligent perception design to establish a comprehensive, seamless health data collection system that ensures real-time and accurate transmission of elderly residents’ physiological data to the platform. Non-contact physiological monitoring points should be integrated into bedroom designs, equipped with smart mattresses and wearable devices such as fitness trackers to collect heart rate, respiratory rate, and sleep data. Smart scales and blood pressure monitors should be installed in bathrooms to gather physical metrics, while intelligent sensing devices in common areas monitor residents’ movement patterns and behavioral states, enabling holistic health data collection across all scenarios. The intelligent perception design must prioritize real-time and accurate data acquisition by employing high-precision, high-stability sensing devices, optimizing installation positions and collection angles to minimize environmental interference with data collection.

At the same time, dedicated data transmission lines should also be designed in the building for convenient access of intelligent sensing equipment with “Mental Wellbeing”, ensuring collected data are transferred in real time to the platform’s data processing layer; installing data display terminals throughout the building, supporting the elderly person’s children or service workers in viewing health information anytime. According to the change of health information, our system can give prompt warning for the user’s health condition, providing accurate and quality of life care to senior citizens.

5.2. Intelligent building space design integrating platform service scheduling functions

To meet the service dispatching requirements of the “Mental Well-being” platform, elderly care residential buildings must adopt intelligent spatial design, incorporating dedicated smart service interface zones and optimized service pathways to enhance the efficiency and convenience of offline elderly care services. Intelligent access control systems and service reception areas with facial recognition devices should be installed at building entrances for rapid staff authorization and identity verification. A centralized smart service dispatch center in public spaces should integrate with the platform’s dispatching functions to enable swift allocation and coordination of on-site services. Service operation areas should be designated within living spaces to facilitate home visits by caregivers and domestic workers, minimizing disruption to seniors’ daily routines. The intelligent spatial design must prioritize functionality and flexibility, with service pathways strategically planned to ensure swift and efficient staff access to designated areas^[4]. Additionally, smart interactive terminals and service logging devices in service interface zones enable real-time service requests, comprehensive process documentation, and immediate feedback evaluations, establishing a closed-loop system of “demand–dispatch–service–evaluation”. Furthermore, barrier-free service spaces and pathways should be designed to meet the needs of specific elderly populations, equipped with intelligent assistive facilities to ensure that senior citizens and those with disabilities can conveniently access in-person elderly care services.

5.3. Design of intelligent building facility systems adapting to platform interaction requirements

To satisfy the demand from the intelligent interactive unit in the “mental health” system, old-age residence needs to improve the design of its intelligent service facilities and set up multiple channels, multi-mode intelligent interaction mechanism so that elders can interact with our system and their kids easily, and service providers. Smart interactive

terminals must be set up in the home environment as well as in public space, supporting different ways of interacting with the system (e.g., using speech, touch screen or a OneTouch call) so that elders can easily request services, make video calls to family members, and receive service notification. One touch button for operation needs to be embedded in the intelligent facilities, enabling elders to quickly realize some basic functions such as power on/off, parameters setting, call, etc., so that the operation is easier to use. When building the intelligent facilities system of the building, emphasize the system's interconnection and stability, select smart facilities consistent with the "mental health" platform's technical architecture, and establish a unified smart control system to centrally monitor and remotely control each type of smart facility in the entire building. Elderly people and their children can remote control this facility through the app on the platform or smart terminal machines, enabling smart home environments adaptation, telecare monitoring etc.

6. Epilogue

This research is based on the functional requirement analysis of "Mingzhi Yang" platform to systematically explore the intelligent design optimization for smart elderly housing building. It finds out where are the connections between the basic requirements of this platform and building design, discusses the major issues of existing smart design approaches such as information integration, reusability and age-optimized stability—and suggests three optimization criteria: function integration, age-optimized focus, and spatial adaptability, coupled to appropriate approaches for supporting the development of intelligent sensing, smart spatial design, and smart building services. This study provides a close match of the service functions and the intelligent features of the building structure, providing an explicit practical pathway to smart design of elderly care residential building.

Disclosure statement

The authors declare no conflict of interest.

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