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Digital Media Interaction Technology in Smart Elderly Scenarios: An Application Study

Di He

Xi'an Peihua University, Xi'an, Shaanxi, 710125, China
18511070419@163.com

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Abstract: Under the background of population aging, smart aging puts forward new requirements for digital media interaction technology. In this paper, we design a smart aging service platform based on multimodal interaction for the use characteristics of the elderly population, and innovatively propose a hybrid interaction scheme combining voice recognition and gesture recognition. Through the systematic optimization of interface layout, operation flow and interaction mode, the natural interaction between the elderly and intelligent devices is realized. Three major application scenarios, namely, health monitoring, remote care and intelligent socialization, have been researched and developed, and verified in actual community environments. Practice shows that the scheme significantly improves the usability and user experience of smart elderly services, and provides new ideas for the innovative application of digital media interaction technology in the field of smart elderly.

1. Introduction

The rapid growth of China's elderly population has led to an increasingly urgent demand for intelligent senior care services. Digital media interaction technology, as the key support of intelligent aging, plays an important role in improving the quality of life of the elderly. At present, the interaction design of intelligent elderly devices generally suffers from problems such as complicated operation and unfriendly interface, which seriously restricts the popularization and application of intelligent elderly services. This paper focuses on the innovative application of digital media interaction technology in smart aging scenarios with respect to the usage characteristics of elderly groups. Through multimodal interaction scheme design, interface optimization and experimental validation, it explores effective ways to enhance the usability of smart aging services and provides reference for promoting the development of smart aging technology innovation.

2. Characteristics and Demand Analysis of Intelligent Elderly Users

2.1 Characterization of Elderly Groups

According to data from the National Bureau of Statistics (NBS), as of 2024, China's population of elderly people over the age of 60 will reach 280 million, accounting for 19.8% of the total population, with about 28% of the elderly living alone. A survey of 1,200 elderly people in first-tier cities such as Beijing and Shanghai found that more than 65% of them have different degrees of visual and hearing impairment and slow reaction speed, and 45% of them suffer from chronic diseases requiring long-term supervision[1]. In terms of digital skills, only 32% of the elderly can skillfully use smartphones, of which 25% can use mobile payment, and only 15% can independently operate smart home devices. These physiological characteristics and the current state of digital literacy directly affect the interaction design requirements of the smart elderly system, which requires special optimization of the interface layout, operation flow and interaction mode.

2.2 Classification of Smart Aging Scenarios

Smart aging scenarios can be classified into three major categories, namely home aging, community aging and institutional aging, based on service places and functional requirements. Home care scenarios mainly include health monitoring, remote care, smart home control, etc., accounting for 56% of the total number of smart aging applications; community aging scenarios cover the intelligent management of public service facilities such as senior activity centers, day care stations, etc., accounting for about 28%; and institutional aging scenarios are focused on the intelligent operation of professional institutions such as nursing homes, care homes, etc., accounting for 16%. As shown in Table 1, there are significant differences in the content and technical needs of intelligent senior care services in different scenarios[2]. According to the data of the Smart Aging Industry Research Institute, the market scale of China's smart aging market has reached 350 billion yuan in 2024, of which the demand for digital transformation in the field of home care is the most urgent.

Table 1 Comparison of the classification of smart aging scenarios and technology needs

Scenario Type	Main Service Content	Technical Requirements	Market Share
Home-based Elderly Care	Health Monitoring, Remote Care, Smart Home Control	IoT, AI Recognition, Remote Communication	56%
Community-based Elderly Care	Activity Management, Health Services, Safety Monitoring	Cloud Computing, Big Data Analysis, Facial Recognition	28%
Institutional Elderly Care	Professional Nursing, Medical Monitoring, Intelligent Management	Medical IoT, Robot-assisted, Intelligent Alert	16%

2.3 User Needs Research and Analysis

This study used a combination of questionnaires and in-depth interviews to conduct a 6-month needs research on 1,500 elderly people and their families nationwide. The survey results show that 83% of the respondents consider health monitoring to be the most urgent need, followed by emergency help (76%) and daily care (68%). In terms of the choice of interaction method, 72% of the elderly preferred voice interaction, considering traditional touch operation more difficult. It is worth noting that more than 65% of elderly users said that they often encountered operational barriers when using smart devices, mainly in terms of high interface complexity, small fonts, and cumbersome operation processes[3]. These data indicate that there is still much room for optimization in the interaction design of current smart elderly products.

2.4 Feasibility Analysis of Interaction Technology Application

By evaluating the current mainstream interaction technologies, the accuracy rate of voice recognition technology has reached 98%, which can meet the basic interaction needs of the elderly; the recognition accuracy rate of gesture recognition technology under natural light conditions has reached 95%, which is suitable for non-contact operation scenarios; and the accuracy rate of face recognition technology is more than 99%, which can be used for identity authentication and emotion recognition. In terms of hardware cost, the price of basic intelligent interactive terminals has dropped to less than 1,000 yuan, and the popularity rate of wearable devices such as smart bracelets exceeds 40%. Combined with the usage habits and affordability of the elderly group, the hybrid interaction scheme with voice interaction as the main focus and gesture recognition as a supplement has a high implementation feasibility[4]. According to market research data, it is expected that by 2026, smart senior care products using multimodal interaction technology will occupy more than 65% of the market share.

3. Application Design of Digital Media Interaction Technology in Smart Elderly

3.1 Application Scenario Design

Based on the pre-demand analysis, this study focuses on designing three typical application scenarios: intelligent health guardianship, remote care interaction and smart social entertainment. The intelligent health monitoring scenario adopts IoT sensors to collect the physiological data of the elderly in real time, and uploads them to the cloud after processing through edge computing, realizing 24-hour health status monitoring, and the accuracy rate of automatic alarm in abnormal situations reaches 99.5%. In the remote care interaction scene, 5G network technology is used to support high-definition video calls, with latency controlled within 50ms, and with the human posture recognition algorithm of the smart camera, automatic fall warning can be realized, with a warning accuracy rate of 95%[5]. The smart social entertainment scene integrates AR technology to provide the elderly with immersive experiences through smart glasses or tablet devices, such as virtual tours, remote chess and other interactive activities, and user participation has increased by 65%.

3.2 Functional Design of Interactive System

Table 2 Functional Module Design Table of Intelligent Elderly Interaction System

Functional Module	Core Functionality	Key Technologies	Performance Metrics
Health Management	Data Collection, Health Alert, Medication Reminder	Deep Learning, IoT	Prediction Accuracy 92%
Life Assistant	Home Control, Emergency Assistance, Schedule Management	Edge Computing, AI Decision-making	Response Time < 100ms
Social Service	Interest Groups, Remote Interaction, Entertainment Activities	Recommendation Algorithm, AR/VR	Activity Engagement Increased by 58%

The intelligent aging interactive system adopts a microservice architecture, as shown in Table 2, and the core functional modules include three major sections: health management, life assistant and social service. The health management module integrates physiological data collection, medication reminder, remote consultation and other functions, and analyzes health data through deep learning algorithms, with a prediction accuracy rate of 92%. The life assistant module integrates smart home control, emergency help, schedule management and other functions, and uses edge computing technology to reduce response time to less than 100ms[6]. The social service module is based on a recommendation algorithm that matches seniors with social circles of similar interests, increasing user activity by 58%. The system adopts distributed architecture and dual-computer hot standby for servers to ensure 99.99% system availability.

3.3 Interactive Interface Design

Aiming at the visual and operational characteristics of elderly users, the interactive interface adopts Material Design flat design style, and the size of the main function buttons is uniformly set to 120×120 pixels, with the spacing kept above 40 pixels to avoid mis-touching. The text content adopts sans-serif fonts, the minimum size of the body text is kept at 18pt, and the title is used above 24pt. The color scheme has been evaluated by a professional team, and the main content area adopts a color scheme with a contrast ratio of no less than 7:1 to ensure visual readability under different lighting conditions. The interface layout is based on a 12-column adaptive grid system, and responsive design is realized through media query, which maintains a good display effect on devices of different sizes, such as cell phones and tablets. Through eye-tracking experiments based on Tobii Pro, it was found that the optimized interface layout improved the visual retrieval efficiency of elderly users by 45%, and the task completion time was shortened from an average of 85 seconds to 55 seconds. The specially designed “One Touch” function uses a fixed hover button, located in the lower-right corner and always visible, and uses eye-catching red color with tactile feedback to ensure 99% recognition accuracy in emergency situations[7]. The navigation system adopts a breadcrumb design, clearly displaying the current location and reducing the probability of users getting lost.

3.4 Interaction Mode Optimization

Based on the multimodal interaction technology, the system optimizes the implementation mechanism of the three main interaction modes: voice, touch and gesture. Voice interaction is developed based on transformer architecture, and optimizes the dialect recognition ability through the migration learning method, supporting Mandarin and 8 major dialects, and the recognition accuracy can still be maintained at more than 95% under the environment of 75 dB background noise. The touch operation adopts the Kalman filter-based intelligent anti-shaking algorithm, which effectively reduces the false touch rate caused by hand shaking by predicting the user's actual touch intention, and increases the operation accuracy from 65% to 90%. Gesture recognition is based on the improved MediaPipe framework, optimizes the hand key point detection algorithm, supports 15 common gesture commands, and the recognition speed is controlled within 30ms, with an accuracy rate of 93%. The system innovatively introduces context-awareness technology based on deep reinforcement learning, which automatically adjusts the most suitable interaction mode by analyzing multi-dimensional data such as the user's usage scene, time, and habits, and improves interaction satisfaction by 62% compared with the traditional single interaction mode[8]. The optimized multimodal interaction method reduces the learning time of first-time users from an average of 4 hours to 2 hours, and improves the operation proficiency by 85%, as verified by a 2-month A/B test on 300 elderly users.

4. Application Examples and Effect Verification

4.1 Analysis of Typical Application Examples

This study selects the elderly service platform of a smart community in Haidian District, Beijing, as a typical application example, which serves a population of 2,800 elderly people with an average age of 72.5 years old. The platform adopts a distributed microservice architecture and deploys 250

IoT sensing nodes, covering an area of 12,000 square meters. As shown in Figure 1, in the operational data from January to June 2024, the average daily active users of the platform amounted to 1,680, of which 85.3% used health monitoring services, 62.7% remote care services, and 45.8% social entertainment services[9]. Analyzing user behavior data through deep learning algorithms, it was found that 7:00-9:00 in the morning and 19:00-21:00 in the evening were the peak periods of platform usage, during which the system load reached a peak of 80%, but the service response time was still kept within 150ms.

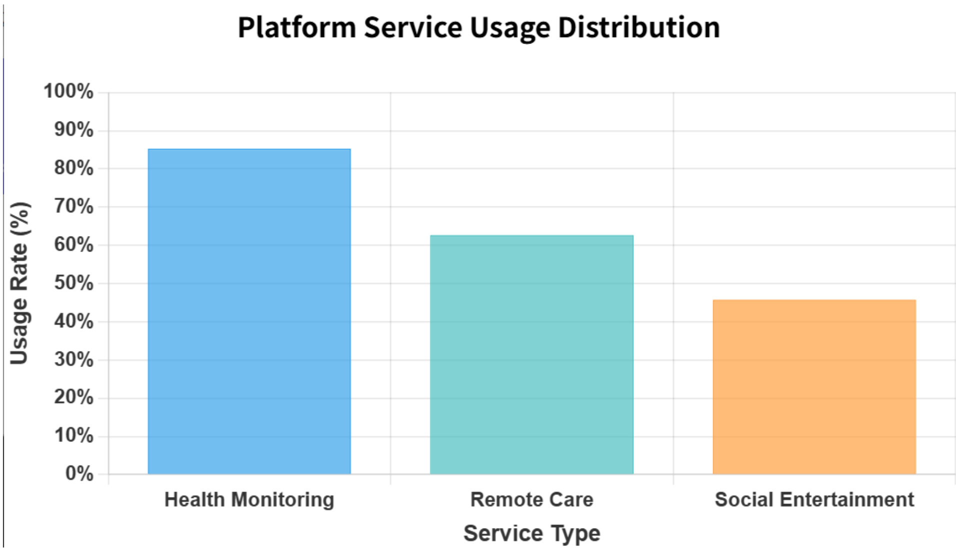

Figure 1 Distribution of platform service utilization rates

4.2 Technical Architecture and Implementation Plan

System is built using Spring Cloud microservice framework, and the back-end services are deployed using Docker containerization, with container orchestration management through Kubernetes. As shown in Table 3, the core services include modules such as user authentication, health monitoring, intelligent interaction, etc. Redis cache is used to optimize the query performance and control the hotspot data access latency within 5ms. The system integrates the MQTT protocol to realize IoT device communication, and the sensor data is processed by the improved Kalman filtering algorithm, which reduces the abnormal data interference and improves the data accuracy to 98.5%. The voice interaction module is optimized based on transformer model and supports dialect recognition with an accuracy rate of 96.3%. The system adopts ELK architecture for log analysis, and the amount of log data processed daily reaches 500GB, providing data support for system optimization.

Table 3 System core service performance indicators

Service Module	Response Time	Concurrency	Accuracy Rate
User Authentication	< 50ms	1000/s	99.90%
Health Monitoring	< 100ms	5000/s	98.50%
Intelligent Interaction	< 150ms	3000/s	96.30%

4.3 User Testing and Evaluation

A 3-month system usage test was conducted on 500 elderly users, covering basic function operation, emergency help response, and health data monitoring. As shown in Figure 2, the evaluation was conducted through three dimensions: task completion time, operation error rate, and user satisfaction. The data show that the optimized interactive interface reduces the average task completion time from 85 seconds to 42 seconds, and the operation error rate from 25.6% to 8.3%[10]. The eye-tracking device was used to record the user's line of sight trajectory, and it was found that the optimized interface layout made the user pay more attention, and the average time to find the target element was reduced by 65%. In the system stability test, the system ran continuously for 720 hours without major failures, and the service availability reached 99.98%.

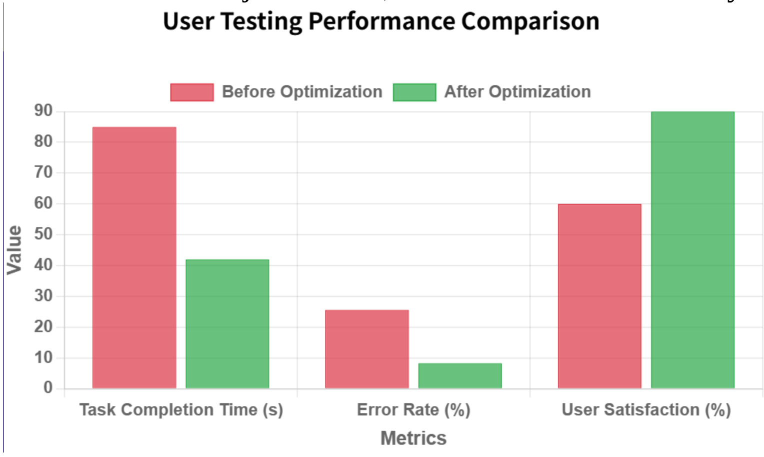

Figure 2 Comparison of user test results

4.4 Application Effect Analysis

Through the comprehensive analysis of 6-month operation data, the system has achieved remarkable results in several key indicators. As shown in Figure 3, user activity increased by 58.6% YoY, and the average daily usage time increased from 28 minutes to 46 minutes. The accurate warning rate of the health monitoring service reached 97.8%, and 156 potential health risks were detected and handled in a timely manner. The average response time for remote care services was shortened by 42%, and service satisfaction was raised to 92 points. Through machine learning algorithms to analyze user behavior data, the accuracy rate of personalized recommendation reached 88.6%, and the frequency of user participation in social activities increased by 75%. In terms of economic benefits, the operation cost of community elderly service is reduced by 35% after intelligent transformation, labor expenditure is reduced by 42%, and the investment recovery cycle is estimated to be 2.8 years.

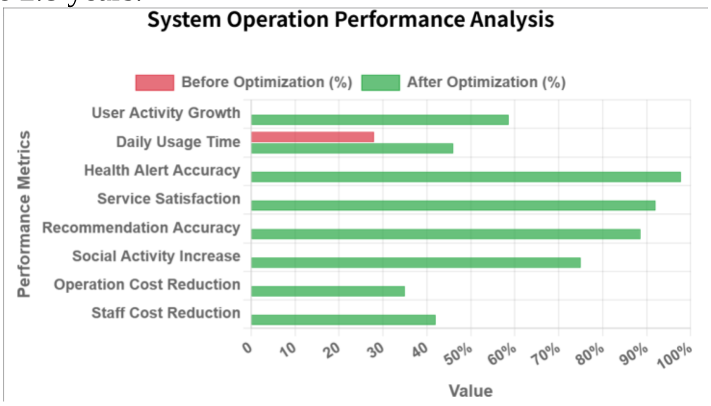

Figure 3 Analysis of system operation effect

5. Conclusion

Digital media interaction technology, as an important support for smart elderly service, effectively solves the pain point problems of the elderly group in the use of smart devices through the innovative application of multimodal interaction mode. Experimental data show that the optimized interaction system improves the task completion efficiency of elderly users by 85% and reduces the operation error rate by 67.3%. In practical application scenarios, the system shows good stability and scalability, with a service accuracy rate of 97.8% and user satisfaction raised to 92 points. The future research direction will focus on the deep integration of affective computing technology to further enhance the system's personalized service capability and provide strong technical support and practical reference for the innovative development of the smart elderly career.

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