

Health Service-Oriented Implementation Dilemmas and Intelligent Innovation Paths for Hotel Robots

Qinghan Zhang

Beijing International Studies University, Beijing, 100000, China

ABSTRACT

The application of robots in health service hotels faces a triple dilemma of technology, service, and industry. The blurred responsibility boundaries between medical and nursing institutions and hotels lead to service gaps, the lack of unified cross platform protocol standards restricts equipment collaboration, and regulatory policies lag behind, exacerbating compliance risks. The innovation path focuses on technological breakthroughs, service upgrades, and ecological reconstruction, achieving secure sharing of medical data through federated learning, optimizing dynamic service strategies through reinforcement learning, and building a data ownership system using blockchain technology. The upgrade of service mode is centered on aging friendly interaction, tripartite collaborative warning, and temperature quantification evaluation, while the reconstruction of industrial ecology relies on government enterprise research and application collaboration, certification standard formulation, and RaaS business model innovation. Research has revealed that it is necessary to promote the transformation of the health service robot industry towards value operation through collaborative innovation between technology, institutions, and models, in order to solve the problems of responsibility allocation, cost sharing, and policy fragmentation.

KEYWORDS

Health service robot; Industrial synergy; Federated learning; Aging friendly services

1 Introduction

Driven by the acceleration of population aging and the upgrading of health consumption, health service hotel robots, as innovative carriers of medical and elderly care integration scenarios, are facing multiple challenges in technology implementation, service adaptation, and industry collaboration. Existing research mostly focuses on a single technological dimension, lacking systematic integration of technology fusion, service models, and industrial ecosystems. This article explores the core mechanisms of multimodal perception, proactive intervention services, and integration of medical and elderly care resources from three dimensions: technological features, service innovation, and industry collaboration. It reveals the practical difficulties of data security, responsibility allocation, and policy lag, and proposes an innovative path of technology service institutional collaboration. This provides a theoretical framework and practical strategies for promoting the transformation of the health service robot industry from equipment sales to value operation.

2 Technical characteristics and service advantages of health service hotel robots

2.1 Characteristics of technology fusion

The technological integration characteristics of health service hotel robots present a triple innovation dimension ^[1]. By integrating multimodal perception technologies such as biosensing, environmental monitoring, and behavior recognition, a three-dimensional data collection network covering physiological indicators, spatial environment, and behavior patterns is constructed; Based on the hybrid architecture of edge computing and cloud computing collaboration, it realizes the dynamic balance between local real-time processing and cloud based deep learning, which not only ensures the timeliness of health data, but also improves the decision-making intelligence of complex scenarios; Building user health profiles based on digital twin technology, mapping multi-source heterogeneous data into interactive virtual models, and driving the generation of personalized health management solutions. The coupling of the three forms a technological loop of "perception calculation intervention", significantly improving the accuracy and continuity of health services.

2.2 Service model innovation

The service mode innovation of health service hotel robots presents a triple leap ^[2]. By using a health risk prediction model to achieve a paradigm shift from symptom monitoring to trend analysis of physical signs, a proactive service loop of "warning intervention tracking" is constructed; Deconstructing the service process based on user health profiles, breaking down the data barriers of room monitoring, catering allocation, and health rehabilitation, and forming a cross scenario service chain covering the entire hotel stay cycle; By using a dynamic visualization interface to convert physiological indicators into interactive charts, combined with remote diagnosis and treatment interfaces, real-time

collaboration between doctors and patients can be achieved, breaking through physical space limitations and constructing a virtual presence mechanism of "monitoring decision-making treatment", significantly improving the continuity of health services and the efficiency of medical resource access.

2.3 Industrial synergy effect

The industrial synergy effect of health service hotel robots is reflected in the triple coupling mechanism^[3]. Medical and elderly care resources are integrated across domains through robot nodes, forming a closed-loop service chain of "monitoring intervention referral"; The data connectivity mechanism relies on standardized interface protocols to build a data center for building status management, service scheduling, and health record linkage; Under the standardized process framework, a rule engine based on health profiles is used to dynamically adapt service solutions, forming a supply model that combines rigidity and flexibility. The three parties work together to promote the evolution of the health service industry from functional superposition to ecological symbiosis.

3 The practical difficulties and deep-seated contradictions in the implementation process

3.1 Technical implementation bottleneck

The technological implementation of robots in health service hotels faces triple structural bottlenecks, with ethical review mechanisms for medical grade data collection lagging behind technological application scenarios, and legal gaps in biometric data anonymization and medical liability definition exacerbating privacy leakage risks, resulting in data compliance dilemmas. In complex service scenarios, algorithm models often suffer from abnormal behavior misjudgment and decision delay due to insufficient dynamic environment perception ability, especially in multi-agent collaborative scenarios, which exposes the risk of emergency response failure. At the level of device interconnection, the fragmentation of communication protocols and data formats between heterogeneous systems has led to technical barriers between service robots, medical terminals, and hotel management platforms, forming a "data island" that significantly restricts the collaborative efficiency of the entire process of health services.

3.2 Service adaptation challenge

The service adaptation of robots in health service hotels is facing a triple rupture. The elderly population forms a technology acceptance barrier due to differences in digital literacy, and the mismatch between interface interaction complexity and cognitive decline leads to service delivery failure, forming a negative cycle of "technology availability user agency"; In sudden health emergencies, robots are limited by the rigidity of preset protocols and the complexity of dynamic scenarios, making it difficult to break through the programmatic response framework and implement effective interventions, exposing deep conflicts between algorithmic decision-making and medical ethics; The excessive pursuit of technological efficiency leads to the objectification of service processes, and the formal design of emotional interaction modules weakens empathy expression, alienating health management into a data collection tool, exacerbating the value imbalance between "technological rationality human care", and ultimately constraining service accessibility and user trust building.

3.3 Obstacles to industrial synergy

The industrial collaboration of health service hotel robots faces deep structural contradictions, and there is a lack of institutional framework for the division of rights and responsibilities between medical and nursing institutions and hotel entities, resulting in a "responsibility vacuum" for the attribution of medical intervention responsibilities and privacy protection obligations, which restricts the depth of cross domain cooperation. The cost of equipment procurement and operation and maintenance forms a "cost externalization" game among the main players in the industrial chain, and the high investment and sustained technical maintenance costs exacerbate the economic game dilemma. The more fundamental constraints stem from the lag of cross industry regulatory policies, the institutional mismatch between medical equipment admission standards and hotel service norms, coupled with fragmented regulation in areas such as data security and professional qualifications, giving rise to compliance risks and "institutional arbitrage", ultimately forming a vicious cycle of "innovation suppression" and "responsibility shifting".

4 Intelligent innovation path and implementation optimization strategy

4.1 Technological innovation breakthrough

The technological innovation breakthrough of health service hotel robots is reflected in the collaborative evolution of the three-layer architecture. The federated learning framework achieves cross institutional knowledge sharing while ensuring medical data privacy through distributed model training and encrypted parameter aggregation, breaking the

data island dilemma. Reinforcement learning algorithms are used to construct a dynamic service optimization engine, which adaptively adjusts strategy parameters such as exercise intervention intensity and medication reminder frequency based on real-time environmental feedback and user health profiles, forming a closed-loop system of "perception decision optimization". The blockchain technology reshapes the paradigm of health data governance, realizing the full process of data collection, use, and profit distribution through smart contracts, and combining distributed storage mechanisms to build tamper proof health records, which not only guarantees user data sovereignty but also provides a trustworthy foundation for cross scenario service connection. The collaboration of the three promotes the transition of service mode from functional implementation to value creation ^[4].

4.2 Service mode upgrade

The service model upgrade of health service hotel robots focuses on triple interaction optimization. The aging friendly interaction interface simplifies operation levels, enhances voice interaction sensitivity, and adapts to large font display, effectively bridging the digital divide among the elderly population. It is supplemented by tactile feedback and gesture recognition technology to build a multimodal service channel. The tripartite collaborative early warning system integrates robot health monitoring data, professional judgment of medical staff, and remote monitoring needs of family members, forming a real-time data sharing network, and triggering a graded early warning response chain in case of emergencies. The service temperature quantification mechanism uses emotional computing models to analyze user emotional characteristics, and constructs a dynamic evaluation system based on parameters such as service duration and response speed to drive flexible adjustments in service strategies, ensuring a deep integration of technical rationality and humanistic care.

4.3 Industrial ecological reconstruction

The industrial ecological reconstruction of health service hotel robots requires the construction of a three-dimensional support system ^[5]. The innovation consortium of government enterprise research and application collaboration forms an innovative synergy through policy guidance, resource integration, and technological transformation, breaking through the constraints of single subject resources. The development of certification system and grading standards should cover dimensions such as safety performance, service effectiveness, and ethical compliance, and draw on the experience of medical equipment certification to construct a multi-level access framework. The innovation of insurance intervention mechanism and RaaS model reduces the application threshold through risk sharing. The Robo-as-a-Service model converts procurement costs into operational expenses, and combines health insurance products to monetize service value, forming a closed-loop ecosystem of "technology service guarantee" and promoting the transformation of the industry from equipment sales to value operation.

5 Conclusions

The development of health service hotel robots needs to break through multiple constraints of technology, service, and system. On the technical level, precise health management is achieved through multimodal perception, edge cloud computing collaboration, and digital twin technology; Innovative service models have established a new paradigm of proactive intervention, cross scenario linkage, and remote collaboration between doctors and patients; Industrial collaboration relies on the integration of medical and elderly care resources, data connectivity mechanisms, and a balance between standardization and personalization to promote ecological reconstruction. Research has revealed that only through the three-dimensional collaborative innovation of technology, services, and institutions can we overcome bottlenecks such as data privacy, cost sharing, and policy lag, accelerate the transformation of the health service robot industry from functional overlay to value operation, and ultimately achieve the popularization of health services and sustainable development of the industry.

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