ISSN 2616-7433 Vol. 8, Issue 1: 1-6, DOI: 10.25236/FSST.2026.080101

Research on the Application of Metaverse Technology in Healing Space Design under the Background of Artificial Intelligence

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Abstract: *With the deep development of artificial intelligence technology, the metaverse, as a digital space that integrates reality and virtuality, is reshaping the design paradigm of healing spaces. This article starts from the perspective of technological integration and systematically analyzes how artificial intelligence and metaverse technology can reconstruct the interactive experience, scene construction, and service mode of healing space. Research has shown that AI driven intelligent interaction, multimodal perception enhancement, and digital twin technology significantly enhance the immersion and personalized service capabilities of healing spaces; Metaverse technology has built healing scenes across time and space through virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies, breaking through the limitations of traditional physical space. Based on theoretical research and commercial practice, this article proposes three major paths for the design of "AI+metaverse" healing spaces: intelligent scene generation, emotional interaction design, and virtual real collaborative services, providing innovative solutions for fields such as mental health, rehabilitation medicine, home healing, and cultural tourism healing. The research conclusion indicates that technological integration will promote the development of healing spaces towards "immersion, scientification, and customization", providing a new paradigm for the future health industry.*

Keywords: *artificial intelligence; metaverse technology; healing space design; virtual-real integration*

1. Introduction

In the era of digital economy where artificial intelligence technology deeply empowers various industries and accelerates the construction of a virtual real integrated ecosystem in the metaverse, the design paradigm of healing spaces, as the core carrier of human psychological health and physiological rehabilitation needs, is facing systematic reconstruction. With the increasing incidence of global mental health problems and the diversified upgrading of health needs, the traditional design pattern of healing spaces relying on physical environment hardware optimization is no longer suitable for precise and personalized healing service demands[1]. Technology fusion driven design innovation has become a key path to break through industry bottlenecks.

The multimodal perception, intelligent decision-making, and dynamic adaptation capabilities of artificial intelligence, combined with the cross temporal immersive scenes constructed by the metaverse based on VR/AR/MR and digital twin technologies, provide technological possibilities for the innovation of interactive experiences and service mode upgrades in healing spaces [2]. Although existing research has initially explored the application of a single technology in the field of healing, it mostly focuses on local practices and lacks a systematic deconstruction of the design of healing spaces from the perspective of the integration of "artificial intelligence+metaverse" technology. A complete theoretical framework and a scalable practical path have not yet been formed, making it difficult to support the transformation of healing spaces towards precision and immersion.

This study is based on the perspective of technology integration, focusing on the application logic of artificial intelligence and metaverse technology in the design of healing spaces. It systematically analyzes the reconstruction mechanism of technology on the interactive experience, scene construction, and service mode of healing spaces. Through literature research, case analysis, and interdisciplinary research paradigms, this study focuses on the application of AI in healing, with the practical goal of empowering social sciences with artificial intelligence to serve people's well-being. From the four dimensions of AI

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technology application path, art therapy, environmental space design, and immersive experience, the system presents the construction logic and technology empowerment path of AI empowering art therapy. We explore the core design path of the "AI+metaverse" healing space, providing theoretical support and practical solutions for fields such as mental health diagnosis and treatment, rehabilitation medicine, and cultural tourism healing. The research aims to fill the research gap in the design of technology integrated healing spaces, enrich the theoretical system of the intersection of architectural design and digital technology, promote the deep integration of the health industry and the digital economy, and have important academic value and application prospects.

2. Core concepts and theoretical foundations

2.1 Definition of core concepts

The core concepts of this study cover three major categories: artificial intelligence, metaverse technology, and healing space design. The definitions of each concept are as follows: Firstly, artificial intelligence (AI) is defined by academic consensus as a computer system that simulates human intelligent activities through theories, methods, and technologies to achieve intelligent behaviors such as perception, reasoning, and decision-making [3]. Its core features are multimodal perception, adaptive learning, and intelligent decision-making. In the context of this study, it specifically refers to intelligent algorithms and technology systems that can capture user emotional and behavioral data and drive dynamic optimization of scenarios. Secondly, metaverse technology is defined as a virtual real fusion digital space technology cluster built on virtual reality (VR), augmented reality (AR), and mixed reality (MR) as the core interactive carriers, relying on technologies such as digital twins and blockchain. Its core value lies in breaking physical space boundaries and constructing immersive and interactive cross temporal scenes. Thirdly, healing space design is defined as a spatial creation practice based on environmental psychology, which aims to alleviate psychological stress, promote physiological recovery, and enhance physical and mental comfort through the design of spatial form, environmental atmosphere, and interaction modes. Different from traditional physical space design, this study focuses on its virtual real collaborative design attributes after integration with digital technology. The three are interconnected through the core logic of "virtual real integration", together forming the core conceptual system of technology empowered healing space design.

2.2 Theoretical basis support

This study relies on a multidisciplinary interdisciplinary theoretical system to construct a research foundation, with four core supporting theories: firstly, environmental psychology theory, whose core viewpoint is the "environment behavior psychology" interactive mechanism, providing theoretical basis for analyzing the relationship between healing space environmental elements and user physical and mental states, and supporting the collaborative design logic of digital scenes and physical spaces; The second is the immersion theory, which originates from the fields of media communication and cognitive psychology. It is defined as the "sense of presence" and "sense of involvement" that users experience in virtual or virtual real fusion environments, providing theoretical support for the construction of immersive healing scenarios in metaverse technology; The third is personalized service theory, which provides methodological guidance for artificial intelligence technology to achieve precise identification of healing needs and dynamic adaptation of service modes based on precise matching and user profiling theory; The fourth is the theory of technological integration, which serves as the core theory of interdisciplinary research, explaining the collaborative integration mechanism of different technological systems, and providing a theoretical framework for the adaptation and complementary functions of artificial intelligence and metaverse technology. The above theories form complementary support from four dimensions: spatial design, user perception, service optimization, and technological application, jointly constructing the theoretical analysis framework of this study.

3. The reconstructive role of artificial intelligence and metaverse technology in healing space design

3.1 Refactoring the interactive experience of healing space

The interaction mode of traditional healing spaces is based on the core logic of "human adaptation to space", and the interaction form is limited to static reception of the physical environment, which has inherent drawbacks such as single interaction dimension, delayed response, and insufficient personalized

ISSN 2616-7433 Vol. 8, Issue 1: 1-6, DOI: 10.25236/FSST.2026.080101

adaptation, making it difficult to accurately meet the dynamic and changing healing needs of users.

The integration of artificial intelligence and metaverse technology has achieved a deep innovation in interactive experience from three aspects: interaction logic, dimension, and response mechanism. At the level of interactive logic, a multimodal perception system driven by AI constructs a dynamic logic of "spatially adaptive humans". Through technologies such as physiological sensors, visual recognition, and speech emotion analysis, real-time capture of multi-dimensional data such as user heart rate, brainwaves, facial expressions, and behavioral trajectories is achieved. Then, deep learning algorithms are used to analyze the user's psychological state and healing needs, and personalized interaction strategies are generated. At the level of interaction dimension, metaverse technology relies on VR/AR/MR devices to break the limitations of traditional "visual auditory" binary interaction, build a multi-sensory collaborative interaction system, and integrate sensory experiences such as tactile feedback and olfactory simulation. For example, in virtual natural healing scenarios, tactile interaction with virtual vegetation is achieved through force feedback gloves, combined with environmental sound effects and olfactory simulation systems to create an immersive experience and enhance the sense of healing immersion. At the level of response mechanism, the synergy between the two promotes the transformation of interactive response from "static preset" to "real-time dynamic". The algorithm will continuously optimize parameters based on user interaction feedback, such as automatically adjusting scene lighting, sound rhythm, and interaction difficulty when recognizing an increase in user anxiety, achieving adaptive optimization of the interaction experience and improving the accuracy of healing.

3.2 Case study of scene construction for refactoring healing space

Traditional healing spaces are limited by physical geography, resource conditions, and layout, with fixed scene shapes and poor adaptability, making it difficult to meet the personalized needs of different types of healing (such as psychological counseling and postoperative rehabilitation) and different populations [4]. The integration of artificial intelligence and metaverse technology reconstructs the logic of scene construction from three aspects: scene boundaries, form, and collaborative mechanisms, achieving innovative breakthroughs in "cross temporal, customizable, and virtual real collaboration".

South Korean blockchain expert Dunamu created an immersive healing space called "Second Forest: Digital Healing Garden" at the 2025 Seoul International Horticultural Expo. The project was originally intended for the psychological rehabilitation treatment of firefighters and made its first public appearance at the Seoul International Horticultural Expo held in Polamai Park, Tongque District, Seoul. The Digital Healing Garden is a virtual forest and urban garden launched by Dunamu under the slogan "Forests and Gardens for Everyone to Enjoy". A virtual forest and urban garden created with unique digital technology. 92.3% of the respondents in the actual questionnaire survey reported feeling the healing effect. 47.3% of visitors define the digital healing garden as a "healing space that allows the mind to relax," while 33.1% of visitors consider it a "new type of garden that combines nature and technology.

People, like urban users, enter virtual natural scenes such as mountains, forests, and beaches in real time, achieving a fusion experience of "local+virtual" and breaking through geographical and resource constraints.

3.3 Refactoring the service model of healing space

The art healing space and its environmental media will enhance embodiment, intersubjectivity, and immersion in continuous development, and influence the perception and interaction between the healing object and the external environment in an embodied way. The integration of AI and metaverse technology has led to a shift in service models towards "proactive precision, virtual real collaboration, and full cycle coverage".

In terms of service supply logic, AI achieves proactive service through user profiling and demand forecasting. It constructs accurate portraits based on historical data and physiological and psychological characteristics, predicts potential needs through algorithms, and plans service plans in advance. For example, we have launched personalized meditation courses for patients with chronic anxiety, breaking the passive mode of "user assistance service response". In terms of service content, metaverse technology has expanded service forms, forming a diversified system of "virtual+physical", providing immersive, personalized services and remote guidance. At the physical level, we rely on intelligent devices to optimize processes, such as intelligent navigation to guide efficient use of resources, monitoring devices to track rehabilitation progress and synchronize to virtual platforms, achieving virtual real complementarity. In terms of service cycle, technology has broken through the limitations of time and

ISSN 2616-7433 Vol. 8, Issue 1: 1-6, DOI: 10.25236/FSST.2026.080101

space, and built a full cycle system. Users can access the metaverse platform within 24 hours, forming a closed loop of "diagnosis intervention follow-up rehabilitation" between offline entities and online virtuality, promoting the transformation of services from "stage intervention" to "full cycle management", and improving the continuity and integrity of services.

4. "AI+metaverse" healing space design path

4.1 Intelligent scene generation path

The intelligent scene generation path is driven by artificial intelligence technology as the core. In the demand recognition stage, a multimodal perception system collects multidimensional data such as user physiological indicators, psychological states, and behavioral preferences. Combined with healing goals (such as anxiety relief, postoperative rehabilitation, and stress release), an accurate user profile is constructed. Machine learning algorithms are used to classify and prioritize healing needs, providing data support for scene generation.

At the scene boundary level, metaverse technology breaks through physical limitations and creates cross temporal virtual healing scenes. Users can access remote virtual spaces through VR devices or overlay virtual elements on real spaces through AR technology. At the scene form level, AI parametric design technology achieves dynamic generation and flexible adjustment of scenes. Algorithms generate personalized scene plans based on user needs (such as anxiety relief and child rehabilitation) and preferences, such as building fun interactive scenes for children, creating quiet meditation spaces for high-pressure groups, and supporting real-time iterative optimization. At the collaborative mechanism level, digital twin technology constructs a "entity virtual" mapping linkage system, synchronizing entity spatial data to virtual scenes to guide precise adaptation; The optimization plan for virtual scenes empowers the transformation of physical space in reverse, forming a closed loop of "virtual real complementarity and collaborative efficiency".

Build a scene parameter library based on user needs, which covers core parameters such as scene types (natural landscapes, cultural scenes, abstract meditation spaces, etc.), environmental elements (light and shadow intensity, color system, sound rhythm), and interaction rules. With the help of AI parametric design algorithms, initial virtual healing scene plans are automatically generated, while relying on metaverse technology to achieve visual presentation and virtual simulation of the scene.

Continuously adjust scene parameters through user interaction behavior data and emotional feedback data in virtual scenes. For example, when the system detects that the user's immersion in the current scene is insufficient, it automatically adjusts the richness of scene details and interactive fun to ensure dynamic adaptation of the scene to user needs and enhance the precise empowerment effect of the healing scene.

4.2 Emotional interaction design path

The emotional interaction design path takes user emotional needs as the core, and utilizes the synergistic effect of artificial intelligence and metaverse technology to construct an interactive system of "emotional perception intelligent response emotional resonance", breaking through the mechanical limitations of traditional interaction and enhancing the humanistic care and healing value of interaction.

At the level of emotional perception, integrating AI emotion recognition technology with multimodal interaction devices in the metaverse enables real-time and accurate capture of users' emotional states. By using facial expression recognition, voice emotion analysis, physiological signal monitoring and other technologies, users' emotional changes such as anxiety, calmness, pleasure, etc. can be accurately determined, and emotional data can be converted into quantifiable interaction driving parameters.

At the level of intelligent response, a differentiated interaction strategy library is constructed based on emotional perception results, matching corresponding interaction methods and feedback mechanisms for different emotional states. For example, when identifying that the user is in an anxious state, we activate a soothing interaction mode to alleviate negative emotions by slowing down the interaction rhythm, pushing for gentle scene feedback, and increasing guided interaction instructions; When the user's emotions tend to stabilize, we switch to exploratory interaction mode, encouraging users to actively participate in scene interactions.

At the level of emotional resonance, relying on immersive technology to enhance the emotional

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immersion of interaction, guiding users to achieve emotional release and resonance during the interaction process. For example, in psychological counseling scenarios, intelligent companionship characters help users sort out their emotions and enhance the emotional value of the healing experience through empathetic dialogue and guided interaction.

4.3 Virtual collaborative service path

The core goal of the virtual real collaborative service path is to break down the barriers between virtual and physical healing spaces, in order to enhance the continuity and integrity of healing services.

At the level of virtual empowerment, the metaverse virtual space undertakes functions such as "pre intervention, remote services, and rehabilitation follow-up". Users can use virtual space to complete pre healing needs assessment, virtual experience of healing plans, as well as remote guidance and follow-up services during the healing process. For example, postoperative rehabilitation users can access a virtual rehabilitation guidance space through VR devices to obtain personalized rehabilitation training demonstrations and real-time error correction feedback.

At the level of physical implementation, optimizing the resource allocation and service process of physical healing spaces based on virtual space service data. Through digital twin technology, user data and service solutions in virtual space are synchronized to physical space, thereby guiding the environmental layout, equipment debugging, and service personnel deployment of physical space. For example, the device layout in the physical space can be optimized based on the user's preference data for a certain type of healing device in the virtual space; Adjust the physical rehabilitation plan based on the effectiveness data of virtual rehabilitation training.

5. Conclusion

This study focuses on the application of metaverse technology in healing space design under the background of artificial intelligence. From the core perspective of technology integration, it systematically analyzes the reconstruction effect of artificial intelligence and metaverse technology on healing space design, and constructs a design path system of "intelligent scene generation emotional interaction design virtual real collaborative service". Through a series of studies, the following core conclusions have been drawn:

Firstly, the integration of artificial intelligence and metaverse technology has achieved a systematic reconstruction of healing space design. At the level of interactive experience, the two break the traditional passive logic of "people adapting to space" and construct a multi-sensory collaborative dynamic interaction system of "space actively adapting to people". Through multimodal perception and real-time response optimization, the accuracy and immersion of interaction are improved; At the level of scene construction, breaking through the limitations of physical space and the constraints of fixed forms, a cross temporal, customizable, and virtual real collaborative scene innovation model has been formed to meet the personalized demands of different healing needs and populations; At the service model level, we are promoting the transformation of rehabilitation services from "standardization, passivity, and offline dependence" to "personalization, proactivity, and virtual reality collaboration".

Secondly, the three major paths of "AI+Metaverse" healing space design constitute a complete practical framework for technology empowered healing spaces. The intelligent scene generation path is based on precise demand recognition, and achieves personalized customization and dynamic iteration of scenes through AI parametric design and metaverse visualization technology, providing core support for the precise empowerment of healing scenes; The emotional interaction design path is guided by user emotional needs, relying on AI emotion recognition and metaverse immersive technology to build an emotional resonance interaction system, strengthening the humanistic care and emotional value of the healing experience; The virtual real collaborative service path aims to break down the barriers between virtual and real, and achieves collaborative efficiency between virtual empowerment and physical implementation through technologies such as digital twins. It constructs a closed-loop of full cycle healing services, improving the efficiency and integrity of healing services.

Thirdly, technological integration drives the transformation of the healing space towards a new paradigm in the health industry. The application of artificial intelligence and metaverse technology in healing space design not only enriches the theoretical system of healing space design, expands the research boundaries of the intersection of architectural design and digital technology, but also provides innovative solutions for fields such as mental health diagnosis and treatment, rehabilitation medicine,

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home therapy, and cultural tourism therapy. Its core value lies in empowering technology to break through the inherent limitations of traditional healing spaces, promoting the transformation of healing services from "stage intervention" to "full cycle management", and from "physical space dependence" to "virtual real integration empowerment", providing new development directions for the deep integration of the health industry and the digital economy.

However, this study still has certain limitations. In terms of research scope, there is insufficient in-depth exploration of the differences in technical applications in different therapeutic sub fields, such as rehabilitation for special populations and long-term psychological interventions; In practical verification, there has not been a complete empirical study to quantitatively analyze the therapeutic effect of the designed path. Future research can further focus on specific fields and deepen the optimization of design paths in different scenarios; Strengthen empirical research and quantitatively evaluate the actual effects of technology applications and design paths based on clinical data or commercial practice data; In addition, attention can also be paid to ethical risks (such as user data security and virtual dependencies) and technical standardization issues in technology applications, promoting the standardized and industrialized development of "AI+Metaverse" healing space design, and better empowering the upgrading of the health industry and the improvement of human physical and mental health.

Acknowledgement

This work was supported by the “Research on Innovation & Entrepreneurship Strategies and Teaching Reform in Fine Arts & Design Disciplines Under New-Quality Productive Forces” University-Industry Collaborative Education Program of the Ministry of Education, No.250603818300850.

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