

Research on VR Content Generation and Services from the Perspective of Embodied Intelligence

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ABSTRACT

VR publishing, as a new business model of immersive knowledge services created by publishing houses relying on virtual reality technology, generally faces practical bottlenecks such as superficial embodied interaction, fragmented service chains, and the separation of body and mind while reshaping users' physical presence experience. Based on the theory of embodied intelligence, this paper defines the core connotation of VR publishing services and user experience, and proposes an evolutionary theoretical model of VR publishing services from the perspective of embodied intelligence, revealing the collaborative evolution mechanism of physical body, surrogate body, avatar, and inner body. On this basis, the paper proposes optimization paths for publishing houses' VR publishing services from four dimensions: perception coupling of the four bodies, emotional state adaptation, cognitive load regulation, and risk prevention and control system. The research can provide theoretical support and practical reference for breaking the bottleneck of VR publishing experience, improving service mechanisms, and enhancing the core competitiveness of digital publishing.

Keywords: Embodied intelligence (EI), Virtual reality publishing (VRP), Service mechanism, User experience, Media narrative.

1. INTRODUCTION

Embodied Intelligence (EI) breaks through the cognitive limitations of traditional Artificial Intelligence (AI), which is detached from the body and isolated from the environment. It emphasizes the implementation of intelligence through real-time interaction between physical carriers and the environment, providing a new theoretical perspective for the deep integration of virtual reality technology and the publishing industry.[1] Virtual Reality Publishing (VRP), as a new business model in which publishing institutions rely on virtual reality technology to transform traditional knowledge content into immersive, interactive, and embodied digital publishing products, and provide full-process services such as content experience, knowledge learning, and interactive communication, is reshaping the production mode, interaction logic, and user experience form of digital publishing. In the VR publishing scenario, users are no longer passive recipients of abstract symbols, but participate in the narrative process and meaning construction through

physical actions, highly aligning with the core viewpoint of embodied intelligence that "cognition originates from the coupling of the body and the environment"[2].

Although China's virtual reality (VR) content creation market reached a value of 8.452 billion yuan[3] in 2024, and VR publishing has demonstrated diverse narrative forms and vast application prospects in fields such as education, children's content, science popularization, and cultural tourism, publishing houses still face significant experience bottlenecks and service shortcomings when scaling up their VR publishing operations. Currently, many VR publishing products still suffer from issues such as superficial embodied interaction, short average user dwell time, low flow state trigger rate, incomplete service chains, prominent physical and mental disconnection, insufficient experience coherence, and weak user stickiness.[4][5][6][7] These issues directly hinder the industrial implementation and value release of VR publishing.

The existing related research mostly focuses on single technical dimensions such as VR hardware upgrade and visual presentation optimization,[8] or directly applies the general media experience model, and fails to carry out systematic analysis based on the VR publishing business scenario and service logic of the publishing house. The existing achievements have not clearly defined the four-dimensional functional boundaries and coordination mechanisms of body, avatar, avatar and inner body from the perspective of embodied intelligence, nor have they revealed the evolution law of virtual reality publishing services from basic embodied perception to deep flow experience. Moreover, there is a lack of targeted service optimization framework, which is difficult to effectively solve the core problem of the separation of body, mind and environment in virtual reality publishing, and cannot provide accurate support for publishers to build a high-quality virtual reality publishing service system.

Against the background of deep reconstruction of virtual reality publishing service logic and user interaction mode by embodied interaction, how to open up service links and enhance experience depth with four-body collaboration has become the key for publishers to promote virtual reality publishing business. Based on this, based on the theory of embodied intelligence, this paper defines the core connotation of virtual reality publishing service, constructs the evolution model of virtual reality publishing service and user experience from the perspective of embodied intelligence, reveals its internal mechanism, and proposes the optimization path of virtual reality publishing service from the four dimensions of perceptual coupling, emotional adaptation, cognitive regulation and risk prevention and control, aiming at expanding the application boundary of embodied cognition theory in the field of publishing, and providing theoretical support and practical guidance for publishers to break the bottleneck of virtual reality publishing experience, improve service mechanism and enhance core competitiveness.

2. CONCEPTS OF VRP SERVICES AND USER EXPERIENCE FROM THE PERSPECTIVE OF EMBODIED INTELLIGENCE

The philosophical foundation of embodied cognition theory originates from Merleau-Ponty's body phenomenology. Its core lies in breaking the traditional cognition that cognition is limited to the

symbolic operation of the brain, establishing the body as the cognitive subject, and generating the core logic of perception, judgment and meaning through dynamic interaction with the environment.[9] Clark et al.'s extended mental theory further expands this cognitive boundary, incorporates external tools such as digital devices into the cognitive system, and forms a closed-loop cognitive architecture of body, tool and environment, which provides theoretical support for the interaction mode among body, device and content in VR publishing.[10] In the theory of narratology, the theory of narrative transmission further reveals that when the audience is deeply involved in the narrative world, their cognition and emotion will be highly integrated with the narrative content. This process is significantly amplified by the deep involvement of the body in the VR publishing environment.[11] With the evolution of artificial intelligence technology, embodied intelligence transforms abstract intelligence into perceptible and actionable practical ability through real-time interaction between physical carrier and environment, which provides support for the upgrading of VR publishing service from sensory stimulation to meaning construction.

The core connotation of user experience is the comprehensive cognitive impression and emotional response formed by people when using or expecting to use products, systems and services.[12] In the field of digital publishing, how to transform the user-centered concept into a practical solution has always been a key proposition for publishers to break through the bottleneck of experience[13] and build core competitiveness.[14]. This proposition is endowed with new connotation in VR publishing from the perspective of embodied intelligence due to the innovation of technical form and interactive logic. Compared with traditional digital publishing, VR publishing reconstructs the experience mode with the presence of the body. Its user experience is no longer a simple content reception and tool operation, but a complex system that deeply integrates the characteristics of the body.[15]

Therefore, this paper believes that VR publishing service and user experience from the perspective of embodied intelligence refers to the reader's dynamic coupling mode of body, equipment and publishing content. Through the organic coordination and dynamic adaptation of the four-dimensional elements of body, avatar, avatar and inner body, the essence of experience is raised from instrumental interaction to the meaning construction process of body participation. This

process is highly consistent with the three-element interactive framework of user, narrative and system in interactive narratology.[16] In the process of VR publishing service, users are not only the recipients of content, but also the subjects involved in content generation and meaning construction through body movements. That is to say, VR publishing service and user experience from the perspective of embodied intelligence are not simple digital reproduction of traditional content, but the publishing house constructs the cognitive coupling field of body and virtual content through technology, so that users can complete the transition from passive sensory stimulation to active meaning generation in the four-body coordination, and finally achieve the service value of the integration of sense, emotion, thinking and action.

3. EVOLUTION MECHANISM OF VRP SERVICES FROM THE PERSPECTIVE OF EMBODIED INTELLIGENCE

In order to break the dilemma of separation of body, mind and environment in VR publishing service, based on the essence of VR publishing service from the perspective of embodied intelligence, this paper constructs a theoretical model of VR publishing service evolution with “user experience advanced stage” as the vertical axis and “embodied intelligence dimension” as the horizontal axis as shown in “Figure 1”. The model includes four advanced stages: physical presence, task focus, value identity and flow integration, which provides theoretical support for publishers to break through the bottleneck of VR publishing experience, optimize and intervene in realistic precision experience. The specific evolution mechanism is as follows:

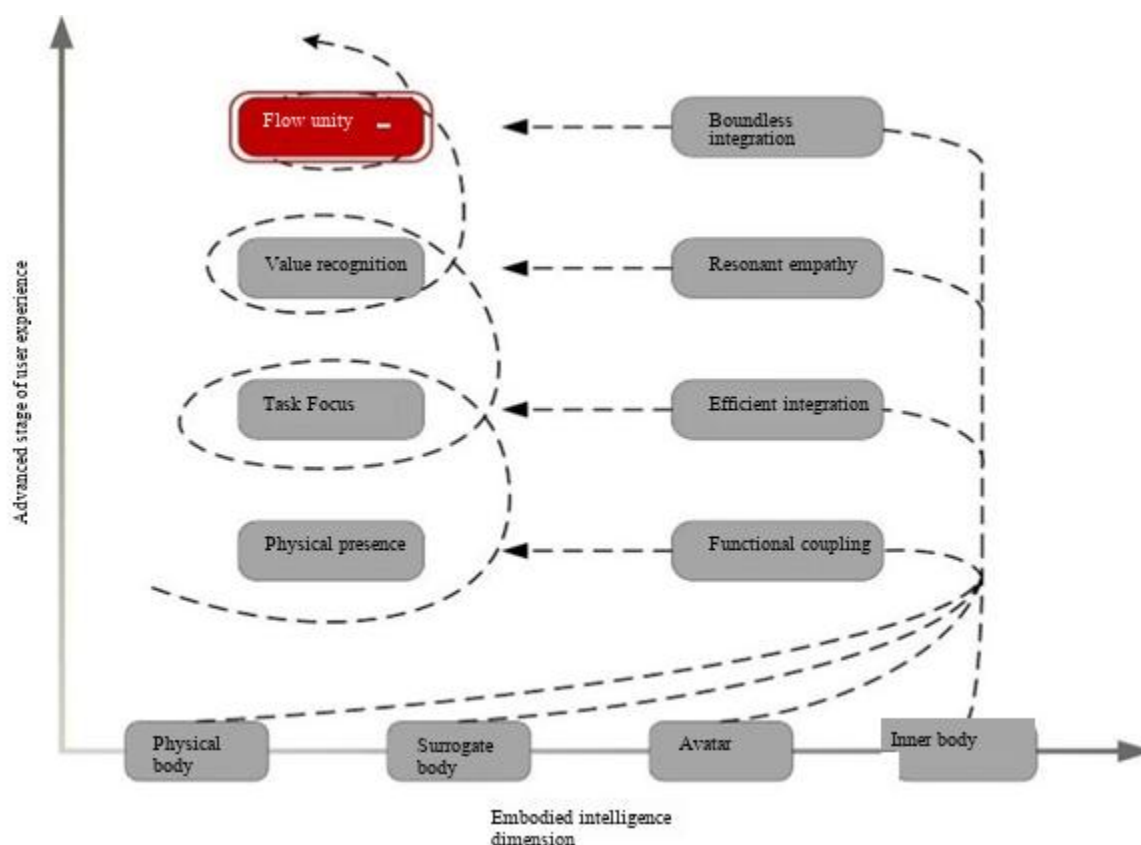


Figure 1 Theoretical model of VRP services evolution from the perspective of embodied intelligence.

Firstly, the model constructs physical presence through the coupling of four bodily functions, laying the physical and cognitive foundation for VR publishing services. From the perspective of

embodied intelligence, the core value of physical presence lies in completely breaking the cognitive separation of "body-mind duality" in traditional publishing.[17] Instead of viewing the body as a

spectator of cognition, it transforms the service experience from brain decoding of symbols to interactive generation between the body and the scene through the deep binding of the body and virtual publishing content, achieving an essential leap from instrumental interaction to existential participation. In this stage, the physical body uses physiological actions such as walking and touching as entry points for experience, reducing users' psychological resistance to unfamiliar virtual environments and providing perceptual anchors for virtual scenes. The surrogate body undertakes the core responsibility of bidirectional adaptation and translation, accurately solving the problem of adaptation between physical body movements and virtual feedback through technical means such as tactile gloves, establishing a perceptual pathway between reality and virtuality. The avatar completes user identity anchoring with an image that deeply fits the publishing content scene, synchronizing movements with the physical body in real time, strengthening the concrete cognition of "I am acting in the virtual scene". Under the dual drive of scene immersion and action feedback, the inner body completes the shift of attention from the real world to the VR publishing content environment, actively filters the real interference, and forms a preliminary trust in the virtual publishing scene.

Secondly, the model deepens the cognitive experience of VR publishing services by guiding the focus of tasks through four efficient integrations. From the perspective of embodied intelligence, task concentration is the cognitive basis of flow experience. Through four-body collaboration, VR publishing service experience rises from passive reception of sensory stimulation to active participation in meaning construction.[18] At this stage, the users' attention is highly concentrated on the core learning and experience tasks of the published content, and the operation and cognition achieve a smooth integration state. The time perception is distorted, and the interference factors are effectively filtered, which provides the necessary conditions for the subsequent emotional resonance and flow state formation. Among them, the physical body movement is upgraded from exploratory to goal-oriented, and the muscle memory is formed through the high-frequency feedback of the surrogate body, and the movement is gradually automated. The surrogate body is upgraded from a simple signal translator to a cognitive burden reliever, which reduces cognitive consumption by dismantling complex publishing tasks and filtering redundant signals; the avatar is

deeply designed around the content role, binding knowledge and skills with physical movements, and strengthening the cognitive association of "physical body is role"; the inner body relies on task structured disassembly and interference shielding to achieve deep focus and improve task controllability and service immersion.

Thirdly, the model realizes value recognition through four-body resonance empathy and promotes the emotional sublimation of VR publishing services. From the perspective of embodied intelligence, value identity is an emotional bridge to build flow.[19] When users recognize the value of VR publishing content, they will form strong participation motivation and emotional engagement, providing key emotional motivation for the triggering of flow state. At this stage, the user experience changes from "want me to experience" to "I want to experience", and the attention automatically shifts from task execution to content meaning, creating conditions for the final flow of unity. At this time, the feedback received by the physical body is sublimated from task-related to emotional-related, and the surrogate body conveys a physiological perception of pleasure or empathy through vibration; The surrogate body strengthens the emotional reality while capturing the physiological signals of the body to reversely regulate the emotional intensity of the scene; Through the expression and action, the avatar concretizes the emotion and becomes the visual bridge of the inner body emotional resonance; The inner body integrates atmosphere, expression and physiological feedback, completes the transformation from understanding emotion to investing emotion, recognizes the value of VR publishing content, and forms the motivation of active service participation.

Finally, the model achieves the unity of heart and flow through the integration of the four-body unbounded fusion, and realizes the ultimate value of VR publishing service. From the perspective of embodied intelligence, the state of mind flow is the deep fit between the body and the meaning construction of virtual publishing content,[20] which is the higher-order form of VR publishing service. In the state of flow, users are no longer passive recipients of published content, but actively participate in the generation of content meaning through four-body unbounded integration, realizing the upgrade from functional satisfaction to spiritual pleasure and knowledge internalization. At this time, the fusion of body and avatar is extremely perfect, and the action and emotion are seamlessly

connected to form the identity cognition of "I am the avatar"; The surrogate body is completely invisible, and the sense of existence of the device disappears, becoming a natural extension of body perception; the inner body enters the optimal state of symbiosis between goals and processes, and the motivation shifts from completing the task to enjoying the experience itself, truly immersed in the immersive knowledge and emotional experience brought by VR publishing services, and achieves the high-level service state of "experience is self".

4. OPTIMIZATION PATH OF VRP SERVICES FROM THE PERSPECTIVE OF EMBODIED INTELLIGENCE

Based on the service evolution mechanism driven by the synergy of four bodies, combined with the core conditions triggered by flow state, this paper constructs an optimization system for VRP services in publishing houses from the perspective of functional adaptation of the four bodies, promoting a smooth transition of service experience to the flow unity stage, and solving the problem of the separation of body, mind, and environment.

4.1 Strengthening the Coupling of Four-body Perception and Building a Solid Foundation for Physical Presence

To alleviate the sense of disconnection from the digital body of VR publishing users, strengthen the cognitive coupling of physical presence, and lay a physical foundation for users' subsequent cognitive immersion and emotional resonance, publishing houses should enhance the natural mapping and perceptual synchronization of body movements in the development of VR publications from the following two aspects.

On the one hand, it is necessary to optimize action mapping and identity binding, and strengthen the coordination of physical body and avatar. The natural mapping and perceptual synchronization of body movements are the core foundation of VR publishing user experience. The consistency of perception and action can effectively eliminate the separation of virtual and real bodies and enhance the immersive experience.[21] Therefore, the VR publishing content of the publishing house should adopt high-precision and lightweight surrogate equipment to accurately capture the users' subtle actions, control the action mapping error in the senseless range, realize the millisecond linkage

between the avatar and the body, and strengthen the identity cognition of "I am the avatar". At the same time, it provides avatar customization and action sensitivity adaptation for users of different ages, reduces the sense of conflict in unfamiliar environments, and embeds an action fault-tolerant mechanism to filter unintentional misoperation, helping the inner body to build trust in the virtual scene.

On the other hand, a multi-modal perception closed-loop is constructed to strengthen the coordination of physical body and surrogate body feedback. Multi-sensory consistency feedback is the physiological basis for realizing the sense of reality of human-machine consubstantiality.[22] Publishing houses should build a multi-sensory feedback system dominated by the surrogate body with visual, tactile and auditory coordination as the core. For example, at the tactile level, the texture of the object is transmitted through gloves and vibrating cushions; at the auditory level, 3D spatial sound technology is used to accurately match the footsteps, environmental sounds and body movement trajectories. At the olfactory level, odor generators can be configured for specific scenarios to supplement the users' sensory dimension and enhance the cognitive realism of the human-machine interface. All of these can promote the deep coupling of physical body, surrogate body and publishing content through multi-sensory consistency feedback, and consolidate the foundation of embodied perception.

4.2 Dynamically Adapting to Emotional States and Promoting the Sublimation of Value Recognition

The users' emotional state is the core variable that determines the depth and quality of VR publishing services. The publishing house should rely on the four-body resonance empathy logic to establish a deep connection between emotion and content through the collaborative operation of the capture of surrogate body emotion, the embodiment of avatar emotion, and the integration of inner body emotion, so as to provide emotional motivation for flow triggering.

Firstly, a non-invasive emotional perception system is built based on the surrogate body. When designing VR publishing services, publishing house should use the surrogate body as a technical carrier, integrate non-invasive modules such as eye tracking, skin electrical sensors, and heart rate monitoring, and build a multi-dimensional

physiological index collection system to provide data support for accurate identification of emotional states.[23] Specifically, the users' interest points and tension can be identified by eye tracking to capture data such as pupil expansion and gaze duration. The skin electrical sensor monitors the conductivity fluctuation in real time to capture the users' subconscious emotional changes; the users' emotional tone such as relaxation, calm, and stress can be distinguished by heart rate monitoring users' heart rate data. Furthermore, based on the above data, a multi-modal emotion recognition model is constructed to accurately quantify the users' core emotional states such as pleasure, anxiety, and boredom, providing an objective basis for subsequent dynamic adaptation and avoiding the one-sidedness of a single indicator.

Meanwhile, it is essential to achieve four-body collaborative emotional guidance and dynamic adaptation. When designing VR publishing services, publishers should take the closed-loop interaction between emotion and environment as the core, and achieve accurate response and guidance to users' emotional state through the collaborative linkage of surrogate body, avatar and virtual scene, so as to clear emotional obstacles for the triggering and maintenance of flow state. For instance, when recognizing the users' positive emotions, the surrogate body can strengthen the pleasure feedback through "soft vibration", and the avatar can simultaneously present expressions and actions that fit the emotions. The scene automatically advances to the high-value narrative node to deepen emotional resonance; When capturing users' negative emotions such as anxiety and boredom, the surrogate body can reduce the stimulus intensity, the avatar is guided in a soothing posture, the scene is switched to the low cognitive load buffer content, and the core narrative is returned after the emotion is stable. In addition, emotional state should be bound to task difficulty to form a positive cycle and maintain the continuity of emotional input.

4.3 Focusing on Cognitive Load Regulation and Deepening Task Focus Experience

Cognitive fluency is the core requirement of VR publishing service. Publishing houses should optimize content logic and task design, reduce cognitive consumption, and promote the integration of experience and cognitive fluency through the coordination of surrogate body burden reduction, avatar empowerment and inner body guidance.

On the one hand, the publishing houses can build a four-body driven dynamic content service framework. In order to enhance users' concentration, VR publishing should be supported by narrative cognition, embodied cognition and self-determination theory, and build a user-led dynamic content service framework driven by both embodied and narrative.[24] To this end, when designing VR publishing services, publishers should first rely on surrogate body to collect physical interaction frequency, gaze focus and other data, intelligently identify intrinsic interest preferences, and generate personalized plots to accurately meet intrinsic needs. Secondly, multi-level plot branches should be generated based on interest points, and the physical body movement feedback, avatar growth trajectory and plot should be deeply bound. Finally, the avatar should strengthen the identity with the image of the task role, so that the user can change from the content recipient to the content constructor, so as to activate the users' exploration motivation and reduce the users' cognitive conflict.

On the other hand, a step-by-step cognitive load regulation strategy is used to strengthen the focus of the inner body. When designing VR publishing services, publishers should achieve accurate regulation of inner body cognitive pressure through information filtering, task structured disassembly and dynamic load adaptation, so as to clear cognitive impairment for cognitive immersion and flow state. Specifically, complex tasks can be disassembled into stepped sub-tasks. After each sub-task is completed, the avatar feeds back the progress in real time through the visual progress bar, and the surrogate body synchronously provides tactile cognitive feedback such as vibration when the task is completed, so as to strengthen the task controllability of the inner body and reduce the users' external cognitive load. In addition, when the users' inner body cognitive overload is detected, the internal cognitive consumption can be reduced by filtering redundant sensory information, simplifying the operation interface, and hiding non-core function buttons, so as to avoid the users' attention distraction and cognitive immersion interruption caused by information overload.

4.4 Establishing a Risk Prevention and Control System, and Stabilizing the State of Flow Unity

The flow state is a high-order form of VR publishing service. It needs to rely on the four-body

collaboration to avoid the risks of experience interruption, emotional overload, cognitive dependence, etc., and ensure the smooth transition and stable maintenance of the service. Publishing houses should establish a full-link risk prevention and control system.

The first is to actively prevent and repair experience interruptions to ensure the continuity of user cognition. In the process of VR publishing user experience, experience interruption is often caused by equipment and other reasons. Therefore, when designing VR publishing services, publishers should build a multi-scenario interruption response system based on the principle of consistency between perception and action. At the device level, an emergency plan for the failure of the surrogate body equipment should be established. When the motion capture fails, it is automatically switched to a simplified mode such as voice control and line of sight control to avoid the experience fracture caused by technical failure. When facing external interference, the system should be able to automatically pause the experience and save the current state. After restarting, it can quickly wake up the cognitive memory of the inner body to the scene through means such as "avatar backtracking task progress and surrogate body reproducing key tactile feedback", repair the continuity of emotion and cognition, and help users quickly return to the immersive state.

The second is to actively prevent and control the users' emotional overload to buffer the users' emotional impact. Emotional overload is often caused when the emotional intensity caused by multimodal stimuli or published content in the virtual environment exceeds the individual's coping threshold.[25] Therefore, when designing VR publishing services, publishers should build a "preset threshold - real-time monitoring - collaborative buffering" prevention and control chain. Specifically, in the preset stage, the emotional security threshold customization function is provided, and the users can set the acceptance of the strong emotional scene; in the real-time stage, the buffer mechanism can be automatically started by capturing the emotional overload signal. In the execution stage, the negative emotional impact is alleviated and the flow rupture is avoided by means of "surrogate body filtering high-intensity emotional stimulation, avatar presenting soothing action, scene switching to low emotional load space".

The last is to balance the virtual and real cognitive boundaries and avoid cognitive dependence. Cognitive dependence refers to the state that the individual's independent cognitive ability is weakened and the individual has a continuous psychological dependence on the external carrier after long-term dependence on the virtual environment and other external carriers for cognitive activities.[26] For this, when designing VR publishing services, publishers must build a virtual and real cognitive boundary guidance mechanism to strengthen the reasonable guidance of users. For long-term use scenarios, users can be reminded of the boundary between virtual and reality by regularly displaying real time and real environment thumbnails. At the level of use duration control, the intelligent reminder function can be set. When the continuous use duration reaches the preset threshold, the user is guided to pause the experience through the avatar prompt and the surrogate body soft vibration, so as to avoid the excessive dependence of the inner body on the virtual identity and balance the cognitive and behavioral boundaries between the virtual experience and the real life.

5. CONCLUSION

The evolution of VR publishing services from the perspective of embodied intelligence is essentially a dynamic process where the collaborative relationship among the physical body, avatar, surrogate body, and inner body transitions from functional division to boundary dissolution, ultimately forming a boundaryless fusion state where "the physical body is the avatar, the surrogate body is an extension, and the inner body is the experience". This paper breaks through the shackles of traditional body-mind dualism, based on the practical scenario of publishing houses engaging in VR publishing business. With the collaborative framework of the four bodies as the core, it systematically reveals the progressive evolution mechanism of VR publishing services from embodied perception, task focus, value recognition to flow integration. It also constructs an optimized path for VR publishing services that adapts to the publishing industry, focusing on four dimensions: coupling of four-body perception, adaptation of emotional state, regulation of cognitive load, and risk prevention and control system. This provides theoretical support and practical guidance for addressing current practical bottlenecks such as superficial embodied interaction, separation of body, mind, and soul, and

incomplete service chains in VR publishing, while further expanding the application boundaries of embodied intelligence theory in the field of digital publishing.

In the future, with the deep integration of cutting-edge technologies such as brain-computer interfaces, generative artificial intelligence, and multimodal perceptual interaction with VR publishing, publishing houses can further open up the entire chain of content production, embodied interaction, knowledge services, and user operations by relying on the four-in-one collaborative mechanism. This will promote the upgrading of VR publishing from "immersive experience" to "cognitive fusion service", achieving a leap from content digital replication to knowledge embodied construction. At the same time, differentiated VR publishing service systems for niche areas such as educational publishing, professional publishing, children's publishing, and cultural tourism publishing will gradually be improved. While strengthening users' knowledge internalization, emotional resonance, and value recognition, they will continue to release the industrial and cultural value of VR publishing, injecting new impetus into the high-quality development of digital publishing in the new era.

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