Vol. 11 (2026): Proceedings of the 2nd International Conference on Social Sciences and Cultural Studies (ICSSCS 2026)
ISSN: 3105-0522 P-ISSN：3105-0514
DOI: https://doi.org/10.70267/icsscs.20260104

Design of a Multimodal Virtualization PTSD Therapy Interactive System Based on AIGC

Yinan Shang*

College of Arts, Nanjing University of Information Science and Technology, Nanjing, Jiangsu, 210044, China

**Corresponding author: Yinan Shang*.*

Abstract

Currently, VR exposure therapy for Post-Traumatic Stress Disorder (PTSD) remains primarily based on single modalities, which struggles to deliver sufficient immersive experiences and emotional responses, leading to certain limitations in treatment efficacy. To simulate multi-sensory channels in human natural interactions and overcome the single-sensory constraints of traditional exposure therapy, this paper explores the application of AIGC technology in the personalized generation of virtual scenes to enhance immersion and engagement in treatment. By systematically dissecting the intrinsic mechanisms of VR exposure therapy, this study proposes a personalized content adaptation method driven by patients' real-time states and integrates thermal control arrays, muscle electrical stimulation, and user visual behavior analysis technologies to construct a multimodal interaction framework, encompassing coordinated multi-channel synergies such as haptic feedback, auditory resonance, and visual immersion. Building on this foundation, a multimodal virtualized PTSD therapy interactive system based on AIGC is designed and implemented. This research offers new perspectives for PTSD treatment, advancing exposure therapy toward multimodality, intelligence, and universality, while holding significant engineering application value in fields such as neurorehabilitation and psychological therapy.

Keywords

AIGC, multimodal, virtual reality, PTSD, interaction design, digital therapeutics

1. Introduction

In recent years, the rapid development of Virtual Reality (VR) technology has provided new research directions for adjunctive treatment of Post-Traumatic Stress Disorder (PTSD). Among these, VR exposure therapy has significantly enhanced patients' immersive experiences during the treatment process. However, existing studies still face issues such as insufficient individualized prescriptions, limited dynamic adjustment of treatment courses, and low treatment adherence. These shortcomings are specifically manifested in low personalization levels, limited immersion, and potential risks such as excessive stress responses and mid-treatment dropout. Moreover, it remains challenging to achieve adaptive and closed-loop control of content and stimulus intensity based on real-time physiological or behavioral signals.

This paper aims to achieve multi-sensory personalized healing for PTSD patients as its core objective, proposing a virtualized interactive system architecture that integrates AI-Generated Content (AIGC) with multimodal sensing technologies. The system leverages AIGC models to enable dynamic generation of treatment content and personalized design of healing pathways, while reconstructing visual, auditory, and haptic channels in human natural interactions through multimodal interaction technologies. At the same time, this paper introduces a closed-loop adjustment mechanism based on scenario generation and stimulus sensitivity control, realizing real-time linkage and dynamic optimization between multimodal interactions and physiological signals. To verify the feasibility and effectiveness of the proposed system, this paper designs and implements a system prototype and conducts preliminary evaluations through user experience surveys. Experimental results indicate that the system demonstrates significant potential in enhancing immersion during the healing process, achieving individualized adjustments, and strengthening interactive feedback, providing a feasible basis for future applications and promotion in clinical settings.

2. Current Development Status and Theoretical Foundations of AIGC Technology

2.1 Overview of Multimodal Interaction Theory

2.1.1 Multimodal Interaction Theory

Multimodal human-computer interaction refers to an interaction mode that simultaneously utilizes two or more sensory channels (such as vision, audition, haptics, and physiological signals) for information acquisition, comprehension, and feedback within the same interaction process. Compared to traditional human-computer interaction primarily based on single modalities, multimodal interaction significantly enhances intent recognition accuracy, interaction efficiency, and natural experience through cross-channel temporal alignment and semantic fusion. Currently, this technology is widely applied in fields such as intelligent assistants, in-vehicle interactions, and virtual reality, providing a crucial technical foundation for adaptive interaction systems based on user states (Bian et al., 2024) This theory also offers a cognitive framework support for AIGC-generated content in multi-sensory mapping and dynamic adaptation.

2.1.2 Basic Process of Multimodal Interaction

Multimodal interaction systems typically consist of key stages including perception acquisition, comprehension fusion, content generation, result presentation, and closed-loop regulation. The system first acquires user input signals through various sensing methods to achieve cross-channel information perception; subsequently, it performs standardized processing, temporal alignment, and semantic fusion on multi-source data to complete comprehensive recognition of user states and interaction intents; based on this, it generates matching scenarios, audiovisual or haptic feedback content, and outputs them to the user via immersive display devices(Wan and Hu, 2025)

To ensure consistency and coherence in multimodal outputs, the system relies on temporal synchronization algorithms and cross-modal fusion models to dynamically coordinate multi-channel feedback, forming a real-time regulation closed loop between user physiological states and content outputs, thereby maintaining a stable and natural interaction experience (Zhang and Zhang, 2025).

2.2 Development and Application of Current PTSD Treatment Technologies

2.2.1 Basic Overview of PTSD Healing Methods

The treatment of Post-Traumatic Stress Disorder (PTSD) typically adopts a multidimensional approach combining psychological interventions, pharmacological treatments, and digital adjunctive therapies. Psychological treatments are represented by Cognitive Behavioral Therapy (CBT), Cognitive Processing Therapy (CPT), exposure therapy and its virtual reality variant (VRET), aiming to correct trauma-related maladaptive cognitions and reduce avoidance responses; Eye Movement Desensitization and Reprocessing (EMDR) promotes trauma memory reintegration through bilateral stimulation. Pharmacological treatments primarily involve Selective Serotonin Reuptake Inhibitors (SSRIs) and Serotonin-Norepinephrine Reuptake Inhibitors (SNRIs), often used in conjunction with psychological therapies to enhance overall efficacy. In recent years, digital therapeutics and remote interventions have gradually been integrated into clinical management processes, providing new technological pathways for personalized and continuous support (Chen et al., 2022).

2.2.2 Limitations of Existing Treatment Methods

Despite the increasing maturity of current PTSD treatment systems, clinical applications still face numerous constraints. Significant heterogeneity in efficacy arises from variations in trauma types and individual neurophysiological differences, while uneven distribution of professional medical resources and high treatment costs reduce patient accessibility. Additionally, exposure-based therapies may induce strong stress responses in some patients, increasing the risk of mid-treatment dropout. Therefore, under the premise of ensuring safety, achieving dynamic adjustment of intervention content, controllable management of emotional loads, and personalized customization of immersive experiences has become an important development direction in adjunctive therapy research.

2.3 Review of AIGC Technology Applications in Psychological Therapy

2.3.1 Personalized Dynamic Scene Generation

Generative Artificial Intelligence (AIGC) provides a new paradigm for conditional generation and scalable customization of psychological therapy scenes. Compared to traditional manual content design, AIGC offers significant advantages in generation efficiency, content quality, and multimodal fusion. Currently, visual generation is predominantly based on diffusion models and Generative Adversarial Networks (GANs), enabling real-time generation of high-quality images, videos, or 360° panoramic environments from text prompts; audio generation relies on AI music models to produce scene-matched music, ambient sounds, and voice-guided content based on textual descriptions or emotional tags.

Dynamic adjustment of scenes relies on multimodal input signals, including user-initiated settings, physiological signal feedback (such as EEG, heart rate, and eye-tracking data), and affective computing results (identifying emotional states through facial expressions or voice intonation)(Tang, 2024). The system can then utilize game engines for real-time rendering to construct high-fidelity, interactive virtual healing environments, achieving individualized and immersive psychological intervention experiences.

2.3.2 Personalized Healing Adaptation

Traditional digital therapy content is typically presented in static, universal forms, making it difficult to precisely match individual psychological states and emotional needs. AIGC technology achieves self-adaptive personalized adjustments to healing content through a closed-loop mechanism of "assessment—generation—feedback—optimization." The system employs multimodal sensing means such as speech emotion recognition, facial expression analysis, and eye-tracking to real-time assess user emotions, and generates corresponding healing scenes based on individual historical preferences and current physiological states. At the execution level, the system can continuously optimize generation parameters via reinforcement learning models to balance stimulus intensity with user comfort, preventing overexposure or stress reactions. Meanwhile, to ensure treatment safety and ethical compliance, the system must incorporate multimodal stimulus upper limits, downgrade triggers, and interruption mechanisms, while adhering to data minimization and anonymization principles, thereby constructing a complete closed-loop system encompassing healing, safety, and privacy protection(Yang, 2024, Liu, 2024)

3. User Demand Analysis and System Framework Design

3.1 User Demand Modeling

3.1.1 Patient Functional Requirements

When designing the AIGC-based multimodal virtualized PTSD therapy interactive system, an in-depth analysis of patients' functional requirements holds extremely critical significance.

(1) Personalized treatment content needs: Patients expect the system to generate personalized treatment plans based on their specific trauma experiences and psychological states through content orchestration and AIGC generation modules, including dynamic adjustments to treatment scenario selection, course pacing, and intensity;

(2) Enhanced multimodal experience: Establishing a state perception layer and presentation layer helps better simulate all-encompassing sensory stimuli in real environments, thereby enhancing the realism and effectiveness of treatment;

(3) Security and privacy protection: When handling sensitive information and data, patients are highly concerned about the system's security, requiring the system to provide stringent privacy protection measures and data encryption through the security and compliance control layer to ensure that personal information is not leaked;

(4) Real-time feedback needs: The system must monitor patient states in real time based on the state perception layer and perform dynamic adjustments in conjunction with the therapist console and AIGC generation module to achieve human-machine collaborative optimization;

(5) Flexible treatment modes: The system should support multiple treatment modes through the presentation layer and therapist console to meet the needs of different patients, taking into account individual differences in self-guided therapy, remote therapy, and face-to-face therapy.

3.1.2 Therapist Operational and Workflow Requirements

To provide effective treatment services to patients, therapists must have a comprehensive understanding of the console operation interface, be familiar with patient state detection processes, and timely adjust intervention plans based on specific patient conditions. They should utilize the content orchestration and AIGC generation modules to specify personalized intervention plans, employ the system's data analysis tools for evaluation and adjustment, and build strong communication relationships with patients to ensure active patient engagement in the treatment process.

3.2 System Design Framework Blueprint

3.2.1 System Layered Architecture

The system layered architecture is key to ensuring efficient and stable system operation. This system adopts a four-layer model, including the data layer, service layer, application layer, and user interface layer, to achieve unified module decoupling, operational stability, and system scalability.

The data layer is responsible for the unified storage and secure management of system data, covering foundational data such as user information, intervention content, and interaction records. This layer adheres to the principle of minimal data collection and implements de-identification processing for sensitive information to ensure privacy and security, while maintaining data consistency and efficient read/write capabilities to provide stable support for upper-layer modules.

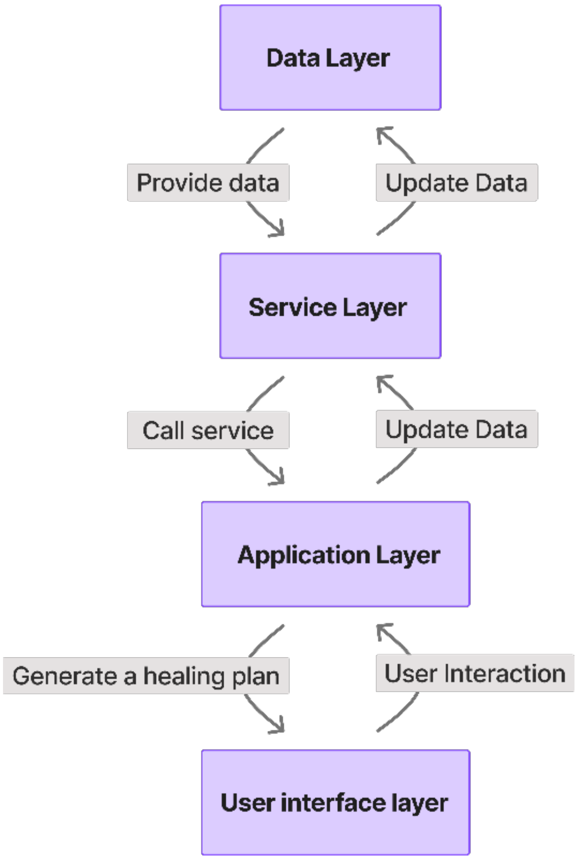
The service layer serves as the core of system functions, providing foundational services such as scene generation and orchestration, content adaptation and recommendation, and multimodal scheduling and synchronization. Among these, the scene generation and orchestration module realizes the construction of virtual scene elements, environmental parameter configuration, and plot flow control, forming the foundational environment for personalized experiences; the content adaptation and recommendation module matches and dynamically optimizes intervention content based on users' real-time states and historical behavior data, enhancing feedback precision; the multimodal scheduling and synchronization module uniformly manages the triggering and coordinated output of visual, auditory, and haptic stimuli, ensuring consistency across multi-sensory media in temporal and logical dimensions to strengthen immersive experiences.

The application layer relies on a built-in policy engine to comprehensively analyze user inputs and physiological feedback data, dynamically generating intervention decisions, and schedules and integrates various functional modules in the service layer through an orchestration engine to ultimately form complete interaction processes and personalized plans. At the same time, this layer receives real-time feedback from the user interface layer to achieve closed-loop regulation and dynamic optimization of the intervention process.

The user interface layer is divided into patient-side interaction interfaces and therapist management interfaces based on usage roles. The patient side provides safe and controllable interaction experiences through immersive visual windows, physiological data feedback panels, and emergency termination controls; the therapist side features a comprehensive monitoring dashboard, plan orchestration panel, and real-time intervention controls to support visualized management and fine-tuned regulation of the treatment process.

The figure below presents the system's four-layer structure and its data interaction relationships in the form of a flowchart.

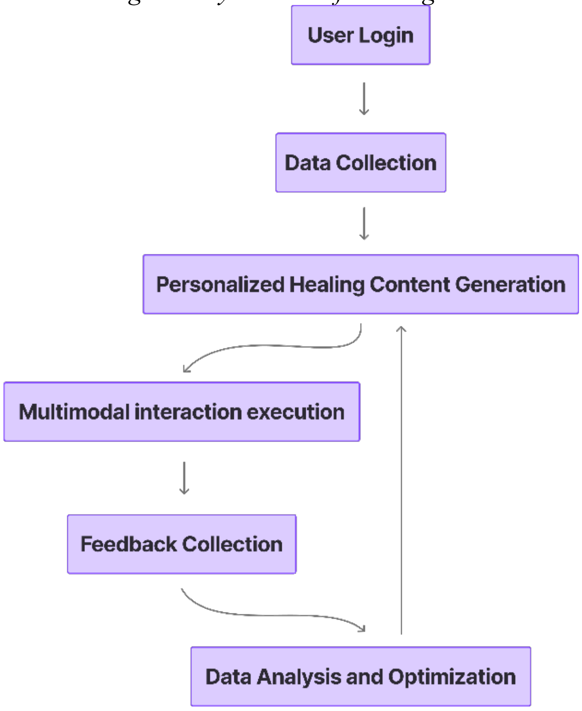
Figure 1: Four-layer System Architecture and Its Data Interaction Diagram



3.2.2 System Workflow

The system's workflow adopts an event-driven and data closed-loop parallel mechanism to ensure the safety and real-time nature of the healing process. Its main steps include identity verification, data acquisition, content generation, interaction execution, and efficacy feedback, as shown in Figure 2.

Figure 2: System Workflow Diagram



Overall, this layered architecture realizes a complete closed loop from data acquisition to personalized intervention, providing structural assurance for the system's maintainability and real-time adaptability.

(1) User Login: The system requires users to log in via secure credentials (such as username/password, biometrics, or multi-factor authentication (MFA)), executed by the security authentication module to ensure the legitimacy and controllability of system access. This module also implements session timeout mechanisms and least-privilege authorization policies, laying a secure foundation for all subsequent data processing and interaction activities, while strictly protecting the privacy and confidentiality of user data.

(2) Data Acquisition: After user login, the system's integrated front-end sensor array (such as eye trackers in head-mounted displays, wrist-worn physiological sensors, etc.) is automatically activated to continuously collect core physiological indicators like heart rate and respiratory rate at specific sampling frequencies; through synchronization and comprehensive analysis of multi-source data, the system further infers the user's real-time emotional state. These synchronized processed data form the basis for subsequent personalized healing content generation.

(3) Personalized Healing Content Generation: Based on the acquired data, the system generates a dynamic user state profile (such as real-time stress levels, emotional valence, and arousal) through preprocessing, feature extraction, and fusion analysis. Drawing on this profile, the system's AIGC generation engine employs a hybrid strategy of "offline generation + online orchestration + lightweight rewriting" under preset whitelist/blacklist and prompt safety constraints to dynamically generate scenes. The security and applicability of the content are jointly reviewed by the policy engine and security controller, thereby finalizing the healing strategy.

(4) Multimodal Interaction Execution and Real-Time Adaptation: The generated content is uniformly presented by the system through VR displays, spatial audio, and basic haptic devices, ensuring cross-channel temporal consistency and end-to-end low latency; the system online adjusts content intensity, rhythm, and duration based on deviations in the user's real-time state, supports one-click downgrade or interruption of interactions, and automatically triggers safety fallback mechanisms when necessary.

(5) Feedback Collection: After the healing session ends, the system collects user feedback information, covering self-evaluations of healing effects and satisfaction assessments of the healing content.

4. Module Implementation of the AIGC-Based Multimodal Virtualized PTSD Therapy Interactive System

4.1 Application of AIGC in Multimodal VR

4.1.1 Personalized Dynamic Scene Generation

In the AIGC-based multimodal virtualized PTSD therapy interactive system, personalized dynamic scene generation serves as one of the core technologies. This technology dynamically generates and adjusts healing environments based on patients' psychological states and specific conditions to facilitate the treatment process and enhance the healing experience. Ensuring the realism and interactivity of scenes involves complex algorithms and models.

Understanding patients' trauma histories and current psychological states is the core of personalized dynamic scene generation. The system analyzes patient data to assess potential response tendencies and performs conditional generation and scene retrieval based on state profiles (encompassing dimensions such as emotional valence, arousal levels, and stress loads). During this process, the system constrains content scope through whitelist and blacklist mechanisms and employs graded exposure strategies to control scene trigger intensity. When monitored physiological or subjective report indicators exceed preset safety thresholds, the system automatically triggers intensity downgrades or scene interruptions and logs the safety event, thereby assisting patients in gradually confronting and processing trauma memories in a controlled environment.

4.1.2 Personalized Healing Content Adaptation Driven by Patient States

Building on personalized scene generation, the system further achieves dynamic adaptation of healing content through a patient state-driven mechanism. This module real-time monitors patients' multi-source physiological signals, such as heart rate (HR), skin conductance response (EDA), eye movement trajectories, and respiratory rate, and infers patients' current psychological states via feature extraction algorithms. The system dynamically adjusts the rhythm, intensity, and sensory cadence of healing content based on preset adaptation strategies, realizing self-adaptive regulation of patients' psychological loads.

For example, when the system detects a decline in heart rate variability (HRV) or an increase in skin conductance activity (EDA), it automatically reduces scene stimulus intensity or extends recovery phases. This process forms a closed-loop control mechanism of "state monitoring—content adjustment—healing feedback," providing dynamic regulatory support for individualized courses.

4.2 Application of Multi-Sensory Linkage Technologies

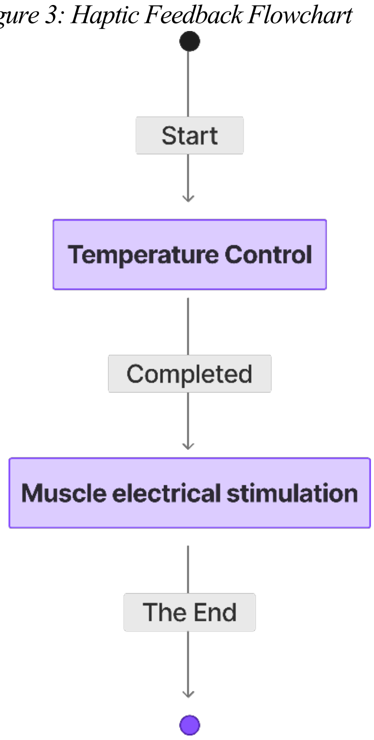
Multi-sensory linkage technologies in this system are used to enhance immersion and physiological resonance, thereby supporting the safe reconstruction of trauma memories and emotional recovery. The system integrates three types of feedback modules—haptic, auditory, and visual—to form a multi-channel synchronous regulation mechanism.

4.2.1 Haptic Feedback

Haptic feedback technology plays a crucial role in the PTSD therapy interactive system by simulating real-world physical sensations to enhance patients' immersion and healing effects. In this system, haptic feedback primarily encompasses thermal control and muscle electrical stimulation.

Thermal control technology simulates different environmental conditions by regulating device temperatures, helping patients experience more realistic scene changes in virtual environments. For instance, when simulating a cold night, the system can lower the device temperature to no less than 15°C, coordinated with vibration cues, to enhance situational immersion. This technology is strictly constrained by the safety controller, with skin contact temperatures not exceeding 42°C and temperature change rates controlled within 1°C/min (contraindicated for pregnant individuals, those with implantable cardiac devices, or histories of epilepsy). Muscle electrical stimulation technology simulates bodily responses such as tension or trembling by delivering currents with specific parameters to muscle groups. The output current intensity, pulse width, and frequency strictly adhere to medical device safety standards and must be used under the on-site supervision of professional therapists. The system synchronously provides haptic mapping through force feedback devices and immediately halts output upon detecting abnormal physiological indicators, ensuring patients safely process emotional responses in a controlled environment.

Figure 3: Haptic Feedback Flowchart



Through the implementation of these technologies, the system effectively assists the intervention process for PTSD patients. This comprehensive multi-sensory application can enhance immersion and individualized adaptation potential, and is expected to improve engagement and adherence (further validation required in controlled studies).

4.2.2 Soundscapes and Auditory Guidance

The soundscapes and auditory guidance module leverages the psychological resonance properties of sound to assist patients in gradually recalling and integrating trauma memories in safe virtual environments. The system constructs parameterizable healing soundscapes based on AIGC generation and sound synthesis algorithms, including natural sounds, guided voiceovers, and rhythmic pulse tones.

To ensure auditory safety, the system complies with the ANSI/ASA S3.1 standard, controlling ambient sound pressure levels within 45–75 dB(A), with volume change rates not exceeding 3 dB/s to avoid stress responses triggered by acoustic stimuli. When the system detects patient HRV below thresholds or rising EDA, it automatically triggers volume downgrades, instantaneous muting, or switches to restorative sound segments to alleviate over-arousal states.

At the same time, the system employs spatial audio rendering and binaural localization techniques (binaural rendering) to construct three-dimensional auditory scenes, enhancing directionality and depth perception. The soundscapes module forms a dynamic feedback loop with the physiological monitoring module, realizing linked control between auditory stimuli and emotional states.

4.2.3 Visual Immersion

The visual immersion module achieves real-time responses to visual foci through high-fidelity rendering and eye-tracking, thereby significantly enhancing the realism and comfort of virtual healing environments. The system adopts a high-resolution graphics rendering engine, maintaining frame rates above 90 FPS, end-to-end latency below 20 ms, and integrates visual stabilization and anti-motion sickness algorithms to optimize user experiences.

Based on eye-tracking data (gaze point coordinates, fixation duration, saccade velocity, etc.), the system dynamically adjusts rendering resources to implement gaze-priority rendering and focal blur transitions, thereby improving visual resource utilization and psychological focus. The patient's attention to specific stimuli can be calculated through the following model:

$$A=\frac{\sum_i (t_i \cdot w_i)}{T}$$

5. Construction of Virtualized PTSD Healing Scenes

5.1 Design of Healing Virtualized Scenes

Virtualized healing scenes aim to assist patients in gradually confronting trauma-related cues in safe and controllable conditions through highly immersive multimodal environments, completing graded exposure and psychological recovery. Under clinical supervision and technical safety thresholds, the system designs several core healing scene modules:

(1) Safe Environment Reconstruction: In the early stages of treatment, the system constructs a stable, safe, and comfortable virtual space for patients, with scene materials derived from individualized memory elements specified by the patient and incorporated into the whitelist after therapist review. Scenes may encompass familiar elements such as homes, school campuses, and natural landscapes to evoke feelings of safety and belonging. Through multimodal coordinated feedback in vision, audition, and haptics, the system employs throttling control strategies during scene transitions and stimulus triggers to ensure smooth sensory input transitions, helping patients gradually establish a psychological safety foundation.

(2) Trauma Memory Reproduction and Reconstruction: Under the guidance of professional therapists, patients engage in controlled contact with trauma memory content through graded exposure. The system leverages AIGC technology to generate virtual scenes highly matched to individual experiences, enabling patients to reproduce and reconstruct trauma experiences in a safe environment. When physiological signals, such as decreased heart rate variability (HRV) or increased skin conductance activity (EDA), or subjective reports exceed safety thresholds, the system automatically triggers content rollback, intensity downgrade, or interruption mechanisms to ensure the safety and controllability of the treatment process.

(3) Coping Skills Training: Patients can learn and practice core coping skills such as deep breathing relaxation, mindfulness meditation, and cognitive restructuring in virtual scenes. The system real-time monitors physiological indicators like respiratory rate and heart rate variability through multimodal sensors and provides feedback on skill mastery in quantitative data form. All training records (including duration, accuracy, and completion rates) generate structured reports, providing therapists with individualized assessment bases to promote enhancements in patients' emotional regulation and stress management abilities in real life.

(4) Social Interaction Simulation: To alleviate common social avoidance and isolation in PTSD patients, the system constructs multi-level social scenario simulation environments such as meetings and gatherings. Scenes are presented in graded difficulty levels, allowing patients to gradually restore social confidence and communication abilities in virtual environments. Users can initiate interruption or exit from the current scenario at any time via preset "safety words," ensuring progressive adaptation and self-exposure training under psychological safety premises.

5.2 Generation of Personalized Healing Paths

5.2.1 Patient Profile Analysis and Modeling

The system conducts comprehensive assessments of patients' trauma types, stress response patterns, and psychological states based on standardized scales and physiological data (Hao and Li, 2023). Through quantitative analysis results, the system generates structured healing path models for each patient. This path model maps patient state profiles to specific scene sequences and intensity parameter configurations via the policy engine, with subsequent dynamic combination of treatment elements achieved by the content orchestration module. Therapists can review and fine-tune the system-generated path plans for personalization.

During execution, the system real-time collects patients' physiological feedback and subjective experience data and self-adaptively optimizes subsequent path nodes based on feedback results, realizing a data-driven closed-loop healing mechanism to enhance the continuity and individualized adaptation levels of therapeutic efficacy.

5.2.2 AIGC Personalized Healing Dynamic Generation Strategy

This strategy relies on in-depth analysis and processing of patient data as well as precise control of hardware devices to achieve personalized treatment experiences. Hardware involvement primarily includes haptic feedback devices, soundscape and auditory guidance devices, and visual immersion devices. These device parameters are online adjusted according to state deviations and downgraded/interrupted upon threshold triggers to enhance immersion, individualized adaptation potential, and engagement. To achieve this goal, the system collects necessary patient data under the principle of minimal collection, including but not limited to physiological indicators, interaction behaviors, and historical treatment records. These data undergo de-identification processing during storage and handling, prioritizing local computation modes. Anonymized integrated data will be used to optimize AIGC models, generating more targeted healing content.

6. Summary and Outlook

6.1 Work Summary and Core Innovations

6.1.1 System Effectiveness Analysis

The AIGC-based multimodal VR PTSD intervention interactive system constructed in this study provides effective treatment support for Post-Traumatic Stress Disorder (PTSD) patients through the deep integration of multimodal technologies such as vision, audition, and haptics. The AIGC technology employed by the system generates personalized treatment scenes and narrative guidance content based on state profiles inferred from multimodal collected data, such as physiological indicators and behavioral features, offering PTSD patients a healing environment more aligned with their inner experiences. This generation process adheres to ethical norms and is subject to clinical supervision. Through virtual reality technology, patients can gradually confront and process trauma memories in a safe and controllable environment based on graded exposure principles. Clinical observations indicate that, compared to conventional intervention methods, this approach may help reduce patients' avoidance tendencies during treatment and provide supportive conditions for trauma memory processing. Additionally, the system introduces multi-sensory linkage technologies, such as haptic feedback, soundscapes and auditory guidance, and visual immersion, enhancing the realism and engagement of the healing process to help patients better relax and engage in treatment. The generation of personalized healing paths combines patients' specific trauma types and stress response patterns, constructing preliminary healing prototypes through exploratory analysis. This prototype-based intervention method not only improves treatment targeting but also effectively reduces invalid treatments or rebounds due to individual differences.

In summary, the system provides an integrated individualized intervention support solution for PTSD patients by combining advanced AIGC technology, multimodal interaction, and personalized intervention path design. This innovation demonstrates potential value at both technical implementation and clinical application levels. Preliminary observations show positive trends in enhancing treatment engagement, but specific effects on treatment success rates and cycle shortening require validation through larger-scale clinical data accumulation and quantitative analysis. In the future, with further technological development and optimization, the system holds promise to become a powerful tool in the field of PTSD treatment under ethical and safety boundaries and refined clinical validation.

6.1.2 Advantages

First, in terms of enhancing experiential immersion, the system adopts multimodal interaction methods, integrating visual, auditory, and even haptic feedback to create immersive virtual environments, effectively reducing patients' resistance and anxiety. For example, through personalized dynamic scene generation technology, healing content can be customized based on patients' trauma experiences, allowing them to gradually confront and overcome inner fears and barriers in a relatively safe environment. Furthermore, the application of multi-sensory linkage technologies, such as the use of haptic feedback devices, enables patients to more intuitively experience the treatment process, enhancing the realism and engagement of psychological healing.

In terms of expanding the applicable population, the system's design fully considers differences in individual needs. Through patient profile analysis and modeling, the system orchestrates personalized paths based on patients' personal circumstances (including trauma types and stress responses). This high degree of customization is expected to provide alternative pathways for individuals resistant to traditional schemes, potentially broadening the scope of applicability (supported by actual deployment and follow-up data).

In conclusion, the system, through innovative technical means and user-friendly design principles, is poised to enhance experiences and improve accessibility, with application value awaiting further validation in multi-center studies.

6.1.3 Limitations

Technical Maturity and Stability: Although AIGC technology demonstrates strong capabilities in multiple fields, its applications in deep learning, natural language processing, and other areas are still in a rapid development stage. In particular, the stability and reliability of dynamic content generation and personalized adaptation in complex scenarios remain to be improved.

Data Privacy and Security Issues: The system involves large amounts of personal sensitive information, such as patients' medical records and psychological states. Ensuring secure storage and transmission of these data to prevent leaks and misuse is a critical issue that must be addressed in system design and implementation.

User Acceptance and Engagement: The application of new technologies often accompanies user discomfort and resistance. Enhancing patient and therapist acceptance of the system and promoting active participation in the treatment process is key to improving system effectiveness.

System Cost and Accessibility: Considering the costs of hardware devices and maintenance updates, the popularization and promotion of the system will face certain economic pressures. Additionally, for resource-limited regions or individuals, high investments may become barriers to using the system.

In summary, while the system holds significant research and application value, it requires continuous improvement under ethical compliance, controlled experiments, and multi-center validation to achieve broader and more effective applications.

6.2 Future Research Directions

First, strengthen interdisciplinary research by integrating expertise from psychology, medicine, computer science, and artificial intelligence to further deepen the understanding of PTSD patients' treatment needs and incorporate it into system architecture design. Focus on constructing theoretical models for multimodal data fusion analysis, developing interaction protocols and data interfaces that comply with clinical standards, and optimizing the precision and interpretability of AIGC generation algorithms. Through ongoing theoretical innovation and technical validation, enhance the scientific foundation and practical value of the system.

Second, improve personalization levels by collecting and analyzing broader user data, including patients' medical histories, psychological states, and stress responses, to achieve more precise generation and adjustment of personalized intervention content. Utilize machine learning and other technologies to enhance the matching degree between AI-generated content and patient needs.

Third, reinforce security and privacy protection by researching and implementing stricter data encryption, access control, and other security measures to ensure that patients' sensitive information is not leaked or misused.

Fourth, establish a long-term efficacy evaluation system by designing a long-term tracking and assessment system for intervention effects, achieving structured storage and analysis of evaluation data through data and compliance layers, generating efficacy trend reports and personalized rehabilitation trajectories, and forming a complete evaluation-feedback-optimization closed loop to provide data support for verifying long-term effectiveness and continuous improvement of the system.

References

Bian, K., Han, D. N., Li, S. Y., Guo, Y. Y. and Li, Q., (2024). Research progress of multimodal human-computer interaction design. *Journal of Machine Design,* vol. 41**,** no. 11, pp. 199-204.

Chen, B. J., Xie, F. and Dai, Q., (2022). Research progress of exposure therapy in the treatment of PTSD. *Psychology Monthly,* vol. 17**,** no. 09, pp. 232-234.

Hao, S. M. and Li, J. H., (2023). Virtual healing interface for emotional support of the elderly population. *World Architecture***,** no. 7, pp. 26-31.

Liu, X., (2024). Multimodal AI redefines human-computer interaction. *New Rural***,** no. 12, p. 30.

Tang, Q., (2024). Research on multimodal large model fusion art interaction design under the background of AIGC. *Daguan***,** no. 6, pp. 126-128.

Wan, H. and Hu, Q., (2025). Research on interactive creative museum design involving hubei province utilizing multi-modal information. *Design,* vol. 38**,** no. 01, pp. 71-75.

Yang, S. Q., (2024). Application of multimodal interaction technology in digital experience design. *Application of IC,* vol. 41**,** no. 12, pp. 32-33.

Zhang, R. and Zhang, L. H., (2025). Interactive experience impact analysis based on multi-modal data. *Changjiang Information & Communications,* vol. 38**,** no. 01, pp. 210-212.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.