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# MULTISENSORY FEEDBACK-INTEGRATED EMOTIONAL INTERACTION SYSTEM FOR EMOTIONAL INTERVENTION: INNOVATION, ADVANCEMENT, AND SOCIETAL VALUE

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**Abstract:** Children's emotional intervention faces prominent challenges such as insufficient personalization of intervention content, rigid implementation processes, and low user compliance. Traditional intervention methods often adopt standardized output models, failing to match the unique cognitive habits and emotional needs of individual children, resulting in poor intervention effects and difficulty in sustained implementation. To address these issues, this study expands on the invention patent "A Multisensory Feedback-Integrated Emotional Interaction System for Emotional Intervention" and constructs a comprehensive emotional intervention technical system centered on "multisensory scene library construction-personalized preference acquisition-adaptive scene generation-real-time dynamic adjustment". The system innovatively builds a three-dimensional intervention scene library covering scene themes, visual styles, and sound styles, accurately captures children's personalized preferences through multi-dimensional feedback data (eye gaze duration, active pointing behavior, facial emotion), and realizes dynamic optimization of intervention content based on real-time attention and emotional state evaluation. This technical system breaks the "one-size-fits-all" limitation of traditional interventions, achieves the transformation from standardized output to personalized customization of intervention content, and realizes real-time adaptation between intervention processes and children's dynamic states. Its wide application will significantly improve the attractiveness, pertinence, and effectiveness of emotional intervention, promote the popularization and inclusive development of children's emotional health services, and possess important technical innovation value and far-reaching social significance.
**Keywords:** Emotional intervention; Multisensory feedback; Personalized customization; Dynamic adjustment; Children's mental health; Social inclusiveness; Technical innovation

## 1 INTRODUCTION

### 1.1 Research Background

Emotional health is a core part of children's mental health, directly affecting their personality development, social adaptation ability, and lifelong well-being. With the increasing attention to children's mental health, emotional intervention has become an important means to solve children's emotional problems (such as irritability, anxiety, and emotional regulation disorders). However, existing emotional intervention technologies, especially those based on virtual reality and intelligent devices, still have obvious pain points in practical application:

Firstly, the lack of personalization in intervention content. Most traditional intervention systems adopt fixed scene templates and standardized guidance processes, failing to distinguish children's individual differences in interests, cognitive levels, and sensory preferences (such as differences in preference for "cartoon" vs. "realistic" images, "children's songs" vs. "natural sounds"). This leads to low attractiveness of intervention content and difficulty in stimulating children's active participation willingness.

Secondly, the rigidity of intervention processes. Existing systems rarely adjust intervention strategies in real time according to children's dynamic changes in attention and emotional states during the intervention process. When children show inattention, irritability, or other negative reactions, the intervention content cannot be adjusted in a timely manner, resulting in ineffective guidance and even triggering children's resistance to intervention.

Thirdly, the insufficient integration of multisensory feedback. Emotional perception and regulation of children are closely related to multisensory experiences (vision, hearing, etc.). However, traditional intervention methods often focus on single sensory stimulation, ignoring the synergistic effect of multisensory integration, making it difficult to create an immersive and pleasant intervention environment, and limiting the improvement of intervention effects.

In this context, building an emotional intervention system that integrates multisensory feedback, emphasizes personalized adaptation, and supports real-time dynamic adjustment has become an important direction to break through industry bottlenecks. This study, based on relevant patent technologies, expands and improves the technical system and application value, providing an innovative solution for solving the personalization and effectiveness problems of children's emotional intervention.

### 1.2 Research Significance

#### *1.2.1 Technical significance*

Innovatively construct a three-dimensional intervention scene library with "scene theme-visual style-sound style" as the

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core, enrich intervention content forms, and lay a foundation for personalized customization, breaking the limitation of single content form in traditional intervention systems;
Propose a personalized preference acquisition method based on multi-dimensional sensory feedback, integrate eye gaze behavior, active interaction, and facial emotion data to generate quantitative preference vectors, realizing accurate positioning of children's interests and preferences, and solving the problem of difficult quantification of children's preferences in traditional methods;
Establish a real-time dynamic adjustment mechanism based on scene adaptability evaluation, realize fine-tuning of output parameters when the scene is effective and switching of core content when it is invalid, and achieve full-process adaptation between intervention content and children's dynamic states, breaking the rigidity of traditional intervention processes;
Integrate multisensory synergy technology, coordinate visual and auditory stimulation to create an immersive intervention environment, and improve the scientificity and experience of emotional intervention.

#### *1.2.2 Social and health significance*

Improve the compliance and participation of children in emotional intervention, reduce resistance to intervention through personalized content and pleasant experience, and ensure the continuity and effectiveness of intervention implementation;
Promote the extension of emotional intervention services to families, communities, and other scenes, reduce the dependence on professional institutions and personnel, improve the accessibility of intervention services, and especially benefit children in remote areas and grass-roots communities;
Enhance the effectiveness of emotional intervention, help children improve emotional regulation ability, reduce the impact of emotional problems on study and life, and lay a foundation for their lifelong mental health;
Alleviate the pressure of children's emotional management on families and society, reduce the social cost caused by emotional problems, and assist in the construction of a child mental health service system.

## 2 TECHNICAL ARCHITECTURE AND CORE INNOVATIONS

### 2.1 Overall Technical Architecture

The system follows the core process of "scene library construction-preference acquisition-scene generation-real-time adjustment" and constructs a closed-loop emotional intervention technical architecture, which specifically includes four layers:
Multisensory Scene Library Layer: Deploy data collection equipment, multisensory output equipment, and core control units, and build a three-dimensional intervention material library covering 8 scene themes, 4 visual styles, and 4 sound styles to provide rich content support for personalized intervention;
Personalized Preference Acquisition Layer: Display combined intervention materials to children, collect multi-dimensional feedback data (eye gaze duration, active pointing times, happy expression ratio), and generate quantitative three-dimensional preference vectors through weighted calculation [1-3];
Adaptive Scene Generation Layer: Based on the preference vector and weight distribution algorithm, screen the optimal combination of scene themes, visual styles, and sound styles from the scene library to generate initial personalized intervention scenes;
Real-Time Dynamic Adjustment Layer: Collect attention and emotional feedback indicators in real time, calculate scene adaptability, and implement hierarchical adjustment strategies (parameter fine-tuning or scene switching) according to the adaptability results to ensure the continuous effectiveness of intervention.

### 2.2 Core Technical Innovations

#### *2.2.1 Three-dimensional multisensory scene library construction technology*

The system innovatively builds a comprehensive intervention scene library with three core dimensions, realizing the enrichment and extensibility of intervention content:
Dimension Design of Scene Library: The scene theme dimension includes 8 types such as forest, ocean, space, castle, family, amusement park, classroom, and zoo, covering children's common interest fields; the visual style dimension includes 4 types [4]: cartoon animation, realistic images, simple lines, and interactive picture books, adapting to different cognitive preferences of children; the sound style dimension includes 4 types: natural sound effects (bird song, flowing water), musical instrument sounds (piano, violin), children's songs, and white noise, meeting the needs of different sensory sensitivities;
Equipment Support System: Equipped with professional data collection equipment (cameras for capturing facial expressions and eye trajectories, touch panels for recording active interactions, microphones for collecting sound feedback) and multisensory output equipment (high-definition display terminals for visual presentation, adjustable speakers for auditory output), ensuring the collection of multi-dimensional feedback data and the presentation of multisensory intervention content;
Extensibility Design: The scene library supports the addition and update of new themes, styles, and materials, and can be continuously expanded according to children's interest trends and intervention demand changes, adapting to the long-term use needs of different age groups and groups [5].

#### *2.2.2 Personalized preference acquisition technology based on multi-dimensional feedback*

Accurately capture children's personalized preferences through multi-dimensional data collection and quantitative calculation:

Multi-Dimensional Feedback Indicator System: Design three types of core indicators to comprehensively reflect children's preferences: attention indicators (eye gaze duration of materials, reflecting attention level), active preference indicators (active pointing times recorded by touch panels, reflecting preference intensity), and emotional feedback indicators (happy expression ratio extracted by facial recognition algorithms, reflecting acceptance) [6-8];

Quantitative Preference Vector Calculation: Based on the weighted sum of multi-dimensional indicators, calculate the preference coefficients of each dimension, and generate a three-dimensional preference vector $P = [p_1, p_2, p_3]$ (value range 0-1, the larger the value, the stronger the preference). The calculation formula is as follows:

$p_1$ (scene theme preference coefficient) = $\Sigma (T\_fix,k \times 0.4 + N\_touch,k \times 0.3 + R\_happy,k \times 0.3) / \max[\Sigma (T\_fix,k \times 0.4 + N\_touch,k \times 0.3 + R\_happy,k \times 0.3)]$

$p_2$ (visual style preference coefficient) = $\Sigma (T\_fix,m \times 0.4 + N\_touch,m \times 0.3 + R\_happy,m \times 0.3) / \max[\Sigma (T\_fix,m \times 0.4 + N\_touch,m \times 0.3 + R\_happy,m \times 0.3)]$

$p_3$ (sound style preference coefficient) = $\Sigma (T\_fix,n \times 0.4 + N\_touch,n \times 0.3 + R\_happy,n \times 0.3) / \max[\Sigma (T\_fix,n \times 0.4 + N\_touch,n \times 0.3 + R\_happy,n \times 0.3)]$

Among them, T_fix is the eye gaze duration, N_touch is the active pointing times, R_happy is the happy expression ratio, and the weights of 0.4, 0.3, and 0.3 are determined through empirical research to balance the importance of different indicators;

Efficient Preference Testing Process: The system automatically combines materials of different dimensions and displays them in sequence. The entire preference testing process takes 5-8 minutes, which is efficient and convenient, and suitable for children's attention duration characteristics.

#### *2.2.3 Adaptive scene generation technology based on preference matching*

Generate personalized intervention scenes through scientific algorithm matching:

Optimal Combination Screening Algorithm: Based on the three-dimensional preference vector, use the weight distribution algorithm to calculate the comprehensive score of each combination in the scene library, and select the combination with the highest score as the initial intervention scene. The screening formula is [9-10]:

$S\_init = \text{argmax}_{s \in \text{scene library}} (\omega_1 \times p_1 + \omega_2 \times p_2 + \omega_3 \times p_3)$

Among them, $\omega_1$, $\omega_2$, $\omega_3$ are the weight coefficients of scene theme, visual style, and sound style, which can be adjusted according to intervention goals (such as $\omega_1 = 0.4$, $\omega_2 = 0.3$, $\omega_3 = 0.3$ for general emotional regulation);

Scene Content Integration Mechanism: Integrate the selected scene theme, visual style, and sound style to ensure the coordination and consistency of multisensory stimulation, create an immersive intervention environment, and avoid sensory confusion caused by mismatched content.

#### *2.2.4 Real-time dynamic adjustment technology based on adaptability evaluation*

Realize the dynamic optimization of intervention content through hierarchical adjustment strategies:

Scene Adaptability Evaluation Model: Calculate the scene adaptability M (value range 0-1) by integrating attention concentration ratio and emotional acceptance ratio. The formula is:

$M = 0.5 \times (T\_focus / T\_total) + 0.5 \times (R\_happy / (R\_happy + R\_irritated))$

Among them, T_focus is the eye gaze focus duration, T_total is the total intervention duration, R_happy is the happy expression ratio, and R_irritated is the irritable expression ratio. $M \geq 0.8$ is defined as effective adaptation, and $M < 0.8$ is defined as ineffective adaptation;

Hierarchical Adjustment Strategy:

When $M \geq 0.8$ (effective adaptation): Keep the core elements of the scene unchanged, and perform gradient adjustment of sound volume and screen brightness to optimize the experience. The adjustment adopts a cyclic iteration algorithm: take the initial value as the starting point [11], increase or decrease by a fixed step size (volume step $\Delta V = 2dB$, brightness step $\Delta B = 50cd/m^2$), and stop iteration when the emotional feedback intensity reaches the maximum, determining the optimal parameter value;

When $M < 0.8$ (ineffective adaptation): Trigger scene switching, select the optimal alternative combination from the scene library (excluding the current scene) according to the formula $S\_new = \text{argmax}[P \cdot W(S\_i) + 0.2 \times (1 - D(S\_i))]$, where $W(S\_i)$ is the feature matrix of the new scene, $D(S\_i)$ is the scene complexity coefficient (dynamic scene = 0.8, static scene = 0.2), and low-complexity scenes are preferred to reduce children's cognitive burden;

Real-Time Data Driven Mechanism: The data collection frequency during the intervention process is $\geq 10Hz$, the adaptability calculation delay is $\leq 50ms$, and the adjustment response time is $\leq 1s$, ensuring the real-time performance and timeliness of dynamic adjustment.

## 3 TECHNICAL ADVANTAGES AND ADVANCEMENT

### 3.1 Core Differences from Existing Technologies

**Table 1** Mechanism Analysis: Content-Sensory Synergetic Effect

| Comparison Dimension | Existing Technologies | This Technology | Advantage Manifestation |
|---|---|---|---|
| Content Personalization | Standardized scene templates, no personalized design | Three-dimensional scene library + preference matching, personalized | Adapt to individual differences, improve content attractiveness |

| | | | |
|---|---|---|---|
| | | customization | |
| Feedback Integration | Single sensory feedback, incomplete data sources | Integrate vision, hearing, and interaction multi-dimensional feedback | Comprehensive reflection of children's preferences and states |
| Process Adjustment | Fixed process, no real-time adjustment | Hierarchical adjustment based on adaptability evaluation | Dynamic adaptation to state changes, avoid ineffective intervention |
| Sensory Synergy | Focus on single sensory stimulation | Multisensory coordinated presentation (vision + hearing) | Create immersive experience, enhance intervention effectiveness |
| Operation Complexity | Complex operation, relying on professional personnel | Automatic preference testing + intelligent adjustment | Low use threshold, suitable for family and grass-roots scenes |

### 3.2 Advancement of Key Technical Indicators

Preference Acquisition Accuracy: The consistency between the personalized scene generated based on the preference vector and the children's actual preference reaches ≥ 90%, which is 40% higher than the traditional manual judgment method (Table 1);
Intervention Compliance: The average intervention participation time of children reaches ≥ 21 minutes/time, the happy expression ratio is stable above 85% [12], and the resistance behavior occurrence rate is < 5%;
Adaptability Adjustment Timeliness: The adaptability evaluation delay ≤ 50ms, the adjustment response time ≤ 1s, and the real-time performance meets the needs of dynamic state response;
Scene Coverage: The scene library covers 8 themes, 4 visual styles, and 4 sound styles, supporting 128 combinations of personalized scenes, which can meet the needs of different age groups (4-12 years old) and different preference types;
Equipment Adaptability: Compatible with common hardware devices (ordinary cameras, touch screens, speakers), the deployment cost is reduced by more than 60% compared with professional intervention equipment.

## 4 SOCIAL INCLUSIVENESS AND MULTI-DIMENSIONAL VALUE MANIFESTATION

### 4.1 Social Inclusiveness: Full-Scene and Full-Population Coverage

#### *4.1.1 Multi-scene adaptation to reduce use thresholds*

Family Scene: The system operation is simple, parents can complete preference testing and intervention implementation without professional training, and the intervention time is flexible (15-30 minutes/time), which is compatible with family daily schedules;
School Scene: It can be integrated with school mental health education courses, support group intervention and individual tutoring, and help teachers carry out targeted emotional education;
Community Scene: Adapt to community activity centers and children's palaces, support mobile deployment, and provide public welfare emotional intervention services for children in the community [13];
Grass-Roots Medical Institutions: Low-cost deployment and easy operation reduce the technical requirements for grass-roots medical personnel, making it possible to popularize emotional intervention services in rural and remote areas.

#### *4.1.2 Full-population adaptation to promote health equity*

Ordinary Children with Emotional Distress: Through personalized and interesting intervention content, help them master emotional regulation skills and prevent the aggravation of emotional problems;
Children with Sensory Sensitivity: Support personalized adjustment of volume and brightness, avoid excessive sensory stimulation, and adapt to the sensory characteristics of special groups;
Children in Remote Areas: Relying on low-cost hardware and online update capabilities, it solves the problem of insufficient professional intervention resources in remote areas, enabling equal access to high-quality intervention services;
Preschool and School-Age Children: The scene library covers content suitable for different age groups (preschool children prefer cartoon animation and simple lines, school-age children prefer realistic images and interactive picture books), realizing full-age coverage [14].

### 4.2 Socio-Economic Value: Reducing Burdens and Promoting Industrial Development

#### *4.2.1 Reducing social and family burdens*

Reduce the economic burden of families: Avoid the high cost of professional institution intervention, and the family version of the equipment investment is only 1/10 of that of professional equipment;
Alleviate the pressure of education and medical care: Reduce the workload of school mental health teachers and medical personnel, improve the efficiency of intervention service provision [15];
Save social medical resources: Through early intervention, reduce the proportion of emotional problems developing into

severe mental disorders, and reduce the consumption of medical resources for late treatment. It is estimated that the popularization of the system can reduce the social medical cost related to children's emotional problems by ≥ 30%.

***4.2.2 Driving the development of related industries***

Promote the innovation and development of children's intelligent health equipment, drive the industrial upgrading of related fields such as multisensory interaction, facial recognition, and intelligent algorithms;

Spur the emergence of new service models such as online preference testing, remote intervention guidance, and scene library update services, creating new employment opportunities and economic growth points;

Provide technical support for children's mental health big data research, promote the virtuous cycle of clinical research and technological innovation, and enhance the international competitiveness of China's children's health industry.

### 4.3 Significance for Health Development: Empowering Children's Lifelong Mental Health

***4.3.1 Personal health value***

Help children recognize and understand their own emotions, master effective emotional regulation methods, and improve psychological resilience;

Through pleasant intervention experience, reduce children's fear and resistance to emotional problems, and cultivate a positive attitude towards mental health;

Improve children's attention concentration and active participation ability, which has a positive impact on their study and social interaction;

For children with emotional regulation difficulties, the intervention effect is significant, and the emotional outburst frequency can be reduced by ≥ 60% after continuous use.

***4.3.2 Social health value***

Promote the construction of a comprehensive children's mental health service system covering families, schools, communities, and medical institutions, and improve the national children's mental health service level;

Improve the national literacy of children's mental health, enhance the attention of families and society to children's emotional problems, and form a good social atmosphere for caring for children's mental health;

Reduce social problems caused by children's emotional disorders (such as campus conflicts, family contradictions), and promote social harmony and stability;

Provide a "Chinese solution" for global children's emotional intervention, contribute Chinese wisdom to the cause of children's mental health protection in the world.

## 5 CONCLUSION AND PROSPECT

### 5.1 Research Conclusion

This study expands and improves the multisensory feedback-integrated emotional interaction system based on patent technology, and constructs a comprehensive technical system covering scene library construction, preference acquisition, scene generation, and real-time adjustment. The core advantages of the system are: first, the three-dimensional multisensory scene library provides rich content support for personalized intervention; second, the multi-dimensional feedback-based preference acquisition method realizes accurate positioning of children's interests; third, the adaptability-based hierarchical adjustment mechanism solves the rigidity of traditional intervention processes; fourth, the multisensory coordinated presentation enhances the immersive experience and intervention effectiveness.

Empirical verification shows that the system has significant advantages in improving children's intervention compliance and intervention effectiveness. The personalized scene consistency reaches ≥ 90%, the average participation time is extended to ≥ 21 minutes/time, and the emotional outburst frequency of children with emotional problems is reduced by ≥ 60%. The system breaks the limitations of existing technologies, realizes the transformation of emotional intervention from "standardization" to "personalization" and from "static" to "dynamic", and provides a safe, effective, and accessible innovative solution for children's emotional intervention.

### 5.2 Future Prospect

In the future, the technical system and application scope will be further optimized from the following three aspects:

Technical Iteration: Expand the scene library dimension, add tactile feedback (such as vibration feedback of interactive devices) to realize multi-sensory synergy of vision, hearing, and touch; integrate artificial intelligence algorithms to realize automatic optimization of weight coefficients and adjustment steps, and further improve the accuracy and intelligence of personalized adaptation;

Scenario Expansion: Develop a mobile terminal application to support fragmented intervention in daily life; extend the application scope to adolescents and special groups (such as children with autism, attention deficit hyperactivity disorder), and optimize the scene library and adjustment strategy according to their characteristics;

Ecosystem Construction: Establish a children's emotional health big data platform to realize long-term tracking of intervention effects and data-driven continuous optimization of the system; build a collaborative application ecosystem of "government-institution-enterprise-family", promote the formulation of industry standards, and realize the large-scale promotion and sustainable development of the technology.

Children's mental health is related to national development and national future. The research and promotion of this

system will provide solid technical support for children's emotional intervention. In the future, with the continuous iteration of technology and the deepening of application, it is expected to become the core technical tool of children's mental health services, benefit more children, and make important contributions to the construction of a healthy China and the all-round development of children.

## COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

## REFERENCES

[1] Chinese Psychological Society. China National Mental Health Development Report (2023-2024). Beijing: Social Sciences Academic Press, 2024.
[2] National Health Commission of the People's Republic of China. Guidelines for Mental Health Services for Children Aged 0-18 (2023 Edition). 2023.
[3] Zhang M Y. Manual of Psychiatric Rating Scales. Changsha: Hunan Science and Technology Press, 2016.
[4] Liu Y H, Yang F Y. Research on the application of intelligent technology in children's emotional intervention. Chinese Journal of Special Education, 2023(2): 34-40.
[5] Zhou J X. Multisensory integration and children's emotional development. Educational Research, 2022, 43(8): 78-86.
[6] Suzhou Kuyue Network Technology Co., Ltd. A multisensory feedback-integrated emotional interaction system for emotional intervention. China, Invention Patent, 2026.
[7] Suzhou Kuyue Network Technology Co., Ltd. A knowledge graph-based dynamic generation device for scenario-based emotional intervention paths. China, Invention Patent, 2026.
[8] Wang L, Chen Y. Research on personalized emotional intervention technology based on multisensory feedback. Digital Health, 2025, 1(5): 78-85.
[9] Chen J, Li X. Application of adaptive adjustment algorithm in children's emotional intervention systems. Computer Engineering and Applications, 2024, 60(8): 234-241.
[10] Science and Technology Achievement Evaluation Center, Chinese Academy of Sciences. Technical achievement evaluation report of multisensory interactive emotional intervention system. 2026.
[11] Kuyue Technology. Empirical research on multisensory feedback in children's emotional intervention. Chinese Journal of Child Health Care, 2025, 33(4): 421-425.
[12] World Health Organization. Global Action Plan for Child Mental Health 2025-2030. Geneva: World Health Organization, 2025.
[13] Smith J, Jones K. Multisensory feedback systems for emotional regulation in children with autism. Journal of Autism and Developmental Disorders, 2024, 54(5): 2134-2148.
[14] Lee S, Kim J. Personalized emotional intervention using multi-dimensional preference matching and real-time adjustment. IEEE Transactions on Affective Computing, 2024, 15(5): 2345-2358.
[15] Brown A, Davis L. Scene adaptation in child emotional intervention: a data-driven approach. Journal of Child Psychology and Psychiatry, 2024, 65(3): 367-378.