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The Teaching Research of Enhancing Students' Artistic Expression through emotional Resonance in Dance Education

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SUMMARY: *Dance education has been continuously promoted from standardized movement training to emotional experience, artistic expression and intelligent evaluation. Focusing on the optimization of dance teaching driven by emotional resonance, this paper constructs an intelligent analysis model that integrates multimodal data preprocessing and synchronous alignment, posture recognition, emotional feature coding, resonance gating fusion and sequential attention aggregation, and designs teaching intervention and intelligent feedback mechanisms. The verification was carried out on the basis of 64 students and 8 weeks of teaching experiment. The results showed that the comprehensive expression of the experimental group increased from 70.26 to 86.57, and the emotional resonance increased by 19.39. The Accuracy of the model reaches 91.42%, the F1-score reaches 90.73%, and the average response time of the system is controlled at 2.8 s. The research shows that this method can improve the accuracy of emotion recognition, performance evaluation and feedback guidance in dance teaching, and provide an operable and interpretable technical path for the cultivation of artistic expression.*

KEYWORDS: *Dance education; Emotional resonance; Artistic expression; Multimodal intelligent Instruction*

1 Introduction

Dance education has multiple attributes such as skill training, aesthetic experience and emotional expression. The formation of students 'artistic expression depends not only on whether the movements are standardized and the rhythm is accurate, but also on whether they can understand the context of the work, mobilize emotional experience, and complete the internal transformation of body language. In practical teaching, many classes still focus on movement decomposition, combination cohesion and formation control, and the evaluation criteria also focus on limb Angle, movement range, beat consistency and technical completion. This teaching method helps to consolidate the basic skills, but it is also easy to make students focus on learning in imitation and reproduction. Although some students can complete the movement process completely, the emotional level is not clear enough during the performance, and there is a disconnection between the appearance and internal expression of the movement, which eventually presents a state of acceptable technology but insufficient appeal.

From the perspective of artistic generation mechanism, dance is not a linear concatenation of a group of movements, but a comprehensive presentation after the joint action of music, rhythm, body control and emotional experience. Only when students truly enter the situational structure of the work and establish the connection with the music content, the role psychology

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and the stage atmosphere in the process of action execution, can the external action gradually transform into the artistic expression with tension and temperature. Emotional resonance is the key link in this process, which not only affects the depth of students' understanding of the connotation of the work, but also affects the overall effect of attitude control, movement texture, rhythm breathing and stage performance. At present, dance teaching still relies more on teachers' experience, oral inspiration and demonstration in emotional training. This method is direct, but it also has obvious limitations: on the one hand, it is difficult for teachers to continuously observe the emotional input and performance changes of each student in the collective classroom; On the other hand, small deviations in students 'emotional expression are often difficult to be stably recorded, and teaching adjustment depends more on stage display results, lacking process basis.

In recent years, the development of computer vision, multimodal perception, affective computing and intelligent education technology has provided new method support for dance teaching research. With the help of video acquisition and posture recognition technology, the joint point trajectory, action expansion amplitude, center of gravity migration and rhythm stability in the training process of students can be extracted. Combined with facial expression recognition, speech emotion perception and learning behavior records, it can further analyze students 'engagement degree, emotional fluctuations and feedback responses in practice. Compared with the traditional teaching observation that only looks at the results, this kind of methods pay more attention to the continuous perception and data expression of the training process, which is helpful to establish a more complete analysis framework from three levels of action performance, emotional state and learning behavior. For dance education, the value of computer technology is not to weaken the role of teachers, but to transform the classroom details that are difficult to quantify into traceable, comparable, and feedback-able information, so as to improve the fineness of teaching diagnosis.

Based on the above background, this paper focuses on the problem of improving students 'artistic expression through emotional resonance in dance education, tries to introduce posture recognition, emotional feature analysis and intelligent feedback mechanism into the teaching scene, and constructs an intelligent dance teaching model for classroom training and performance improvement. The research content includes the preprocessing and synchronous alignment of multimodal emotion and action data, the design of artistic expression representation model integrating posture features and emotional features, and the construction of teaching intervention and feedback methods for the improvement of emotional resonance. On this basis, combined with the teaching experiment, the changes of students 'artistic performance, model recognition performance, intervention effect differences and system application value were comprehensively analyzed, hoping to provide a more operational, interpretative and technical support research path for the emotional cultivation in dance education.

2 Related Research

In recent years, the research on the digitization of art teaching, emotional guidance and intelligent feedback has gradually increased, and the relevant results provide the basis for this paper to discuss the emotional resonance in dance education from the perspective of computer aided. In order to facilitate the sorting of the existing research context, the main literature content is shown in Table 1.

Table 1: Related research contents and directions for reference in this paper

Reference	Research Topic	Main Content	Implications for This Study
[1]	AI Immediate Feedback and Dance Learning	Introduces mobile interaction and AI feedback into blended learning	Intelligent feedback can be embedded into the dance training process
[2]	Digital Empowerment and the Cultivation of Teaching Sensitivity	Emphasizes the role of digital technology in promoting instructional adaptation	The cultivation of emotional resonance should pay attention to situational adaptation
[3]	Situational Teaching and Music Appreciation	Stimulates expressive interest through situational organization	Emotional engagement in dance should rely on specific situations
[4]	Value Shaping in Music Education	Focuses on the emotional influence of art courses	Artistic expressiveness includes the construction of internal emotion
[5]	Emotion-Conditioned Generative Models	Enhances content resonance with emotion labels	Emotional features can participate in dance performance modeling
[6]	Dance Video Teaching in Digital Environments	Discusses the characteristics and limitations of video-based imitation learning	It is necessary to move beyond motion replication toward deeper expression
[7]	Comparison Between Autonomous Learning and Lecture-Based Teaching	Compares the effects of different teaching organization methods	Intervention design should balance guidance and autonomy
[8]	AI for Improving Higher Education Teaching Quality	Emphasizes feedback efficiency and management precision	Provides support for introducing intelligent evaluation into the classroom
[9]	Development of Dance Videos in the New Era	Analyzes the teaching and dissemination functions of dance videos	Video data are suitable for motion analysis
[10]	Practical Teaching in Performance-Oriented Courses	Emphasizes practical training and process feedback	Dance teaching also requires continuous evaluation

From the perspective of the combination of dance teaching and intelligent feedback, Xu et al.(2025) combined mobile interaction, blended learning and AI timely feedback, discussed the changes of students 'dance performance, learning motivation and classroom participation under intelligent support conditions, and showed that the timeliness of feedback had a direct impact on performance courses [1]. Although the research object of Ni(2025) is English education in higher vocational colleges, its analysis of digital empowerment to improve teaching adaptability and perceived engagement shows that technological intervention not only expands resource supply, but also changes the way students enter the learning situation

[2]. Wu(2025) studies children's music appreciation activities from the perspective of situational teaching, and points out that situational organization can promote the connection between feeling, understanding and expression, which has obvious reference value for emotional arouse in dance classroom [3]. Ye et al.(2024), starting from the comprehensive education function of music education, emphasizes the role of art courses in emotional shaping, suggesting that the improvement of artistic expression itself cannot be discussed without internal emotional construction [4].

In terms of the combination of computer methods and artistic emotional expression, Sun et al.(2024) proposed the idea of music generation under emotional constraints, indicating that emotional labels can enhance the emotional consistency of generated content after entering the model, which provides ideas for extracting emotional features and engaging in expressive modeling in this paper [5]. Dimitrakopoulou(2022) points out that video has advantages in action demonstration when discussing dance video teaching in digital environment, but students are easy to stay at the imitation level, and it is difficult to naturally complete emotional investment [6]. Arora et al.(2025) compared autonomous learning and lectual-style teaching and found that different teaching organization methods would bring different learning effects, which indicated that the intervention design in dance teaching should not only emphasize one-way demonstration, but also reserve the space for students to actively experience and adjust [7]. Ta(2024) pointed out from the perspective of artificial intelligence improving teaching quality in colleges and universities that the value of intelligent technology lies in improving feedback efficiency and process management accuracy, which provided a realistic basis for introducing intelligent evaluation into dance classroom [8]. When Lu and Hao(2025) studied the development trend of dance videos, they believed that the video medium has changed from a simple communication tool to a teaching support carrier, which provides an available data basis for motion capture, expression analysis and behavior recording [9]. Yu(2025) further pointed out in the research of vocal music practice teaching that the ability improvement of performance courses is inseparable from continuous training and process feedback, which is also applicable to the cultivation of dance artistic expression [10].

In general, the existing research has involved digital platforms, situational teaching, emotion modeling and intelligent feedback, but most of the results still stay in a single link, and few put emotional resonance, action performance and computer-aided assessment in the same framework for overall analysis. On this basis, this paper tries to introduce multi-modal data processing, posture recognition and emotional feature analysis into dance teaching, so as to explain the formation process of students 'artistic expression in more detail.

3 The construction of an intelligent dance teaching model for improving students 'artistic expression based on emotional resonance

3.1 Data preprocessing and synchronization alignment of multimodal emotion and action in dance teaching

The emotional resonance in dance teaching is not only reflected in the student's facial state, but also reflected in the body trajectory, rhythmic breathing, voice feedback and practice behavior. If the artistic expression of students is judged only by a single video image, it is easy to miss information. Therefore, in the construction stage of the teaching intelligence model, this paper firstly preprocesses the classroom video, accompaniment audio, facial expression and interaction log, and completes cross-modal time synchronization, so as to provide a computable data basis for subsequent artistic expression representation. Fig. 1 shows the process of multimodal data preprocessing and synchronous alignment for dance teaching.

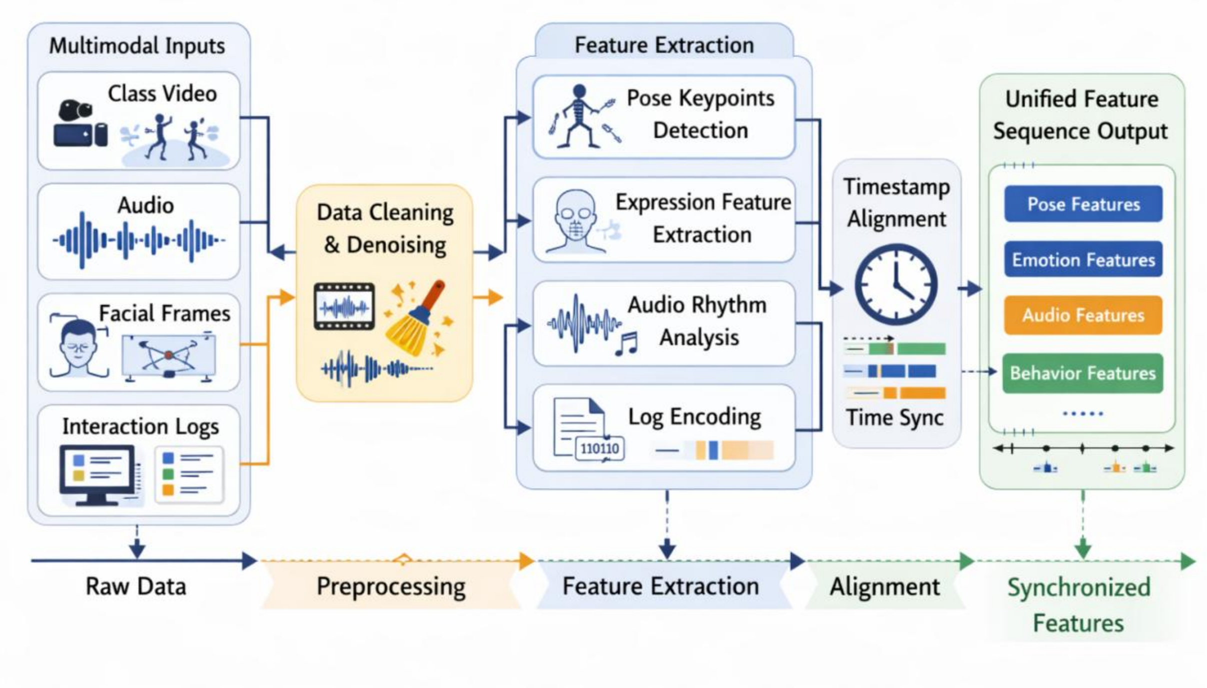

Figure 1: Flow chart of multimodal data preprocessing and synchronization alignment for dance teaching

In order to ensure that all kinds of data can enter the same analysis space, the collected multi-modal information is segmented according to a fixed time window. Let the sequence of video frames be $V = \{v_1, v_2, \dots, v_n\}$, the audio frame sequence is $A = \{a_1, a_2, \dots, a_m\}$, the behavior log sequence is $L = \{l_1, l_2, \dots, l_k\}$, under the condition of window length Δt the synchronization result of the i time slice is denoted as follows.

$$S_i = \{V_i, A_i, L_i\}, i = 1,2, \dots, T \quad (1)$$

Here, T represents the total number of time slices after partitioning. This processing method can convert continuous classroom data into comparable discrete segments, which is convenient for the model to recognize students 'emotional changes and action fluctuations in different practice stages.

(1) Video data cleaning and action sequence normalization

Video data mainly carries student body movement, formation change and facial expression information, which is the main mode of dance teaching analysis. Considering the illumination changes, partial occlusion and camera jitter in the classroom shooting environment, this paper firstly denoised the original video, stabilized the image and extracted key frames, and then used the pose estimation algorithm to extract the coordinates of key nodes such as shoulder, elbow, wrist, hip, knee and ankle. In order to reduce the influence caused by the height difference of students and the change of camera distance, the coordinate sequence is normalized:

$$\hat{p}_{ij} = \frac{p_{ij} - p_j^{min}}{p_j^{max} - p_j^{min}} \tag{2}$$

Here, p_{ij} represents the original coordinate of the j joint point in the i frame, and $\hat{p}_{ij}$ is the normalized result. After processing, the scale differences of action trajectories are compressed to a uniform range, which is more conducive to comparing the differences in movement amplitude and rhythmic cohesion among different students.

(2) Audio and expression feature extraction

Emotional resonance in dance often changes with music rhythm and facial expression. Therefore, in addition to video processing, this paper extracts audio and expression features synchronously. The audio part mainly retains the beat intensity, short-term energy and spectrum center of gravity to reflect the relationship between music advancement and action response. In the expression part, the emotion vector is generated according to the eyebrow and eye opening and closing, the tension of the mouth corner and the change of the facial muscle group. To reduce the interference of transient outliers, moving average smoothing is applied to continuous expression features:

$$e_t{'} = \frac{1}{w} \sum_{t=i-w+1}^{i} e_t \tag{3}$$

Here, $e_t{'}$is the smoothed sentiment feature and w is the length of the sliding window. In this way, it can avoid excessive amplification of emotional judgment caused by single frame expression jitter, and make students 'emotional engagement state present more stable.

(3) Behavior log encoding and cross-modal alignment

The behaviors such as pause, look back, repeat exercise and teacher comment response automatically recorded by the classroom platform can supplement the learning engagement information that is difficult to reveal by action images alone. In order to make different modalities correspond in time, this paper uses the video frame timestamp as the benchmark, and maps the audio and log to a unified timeline. Let the video timestamp be tiv and the audio timestamp be tja, then the alignment error is defined as follows.

$$\delta_{ij} = |t_i^v - t_j^a| \tag{4}$$

When $\delta ij < \varepsilon$, it is considered that the two modalities have completed the alignment within the same teaching segment, where ε is the allowable error threshold. Through this method, the motion peak, music downbeat and mood fluctuation can be put into the analysis at the same time, and the judgment bias caused by information dislocation can be reduced.

To facilitate the illustration of how the data of each modality is processed in the preprocessing stage, the relevant Settings are shown in Table 2.

Table 2: Multimodal data preprocessing with synchronous alignment Settings

Data Modality	Original Form	Core Extracted Content	Preprocessing Operations	Aligned Output
Classroom Video	30 fps video stream	Joint point coordinates, motion trajectories, and amplitude changes	Denoising, stabilization, keyframe extraction, and normalization	Pose temporal vector
Accompaniment Audio	16 kHz audio stream	Beat intensity, short-time energy, and spectral features	Noise reduction, framing, endpoint detection	Audio rhythm vector
Facial Expression	Local regions of video frames	Pleasure level, tension level, and engagement level	Face detection, expression encoding, and smoothing filtering	Emotion feature vector
Behavioral Log	Platform interaction records	Pause, replay, repeated practice, and feedback response	Deduplication, encoding, and time mapping	Learning behavior vector

(4) Unified feature sequence generation

After alignment, we concatenate action, emotion, audio, and behavior information into a unified input vector:

$$X_i = [P_i; E_i; A_i; L_i] \tag{5}$$

Here, P_i represents the posture feature of the i time slice, E_i represents the emotion feature, A_i represents the audio rhythm feature, and L_i represents the behavior log feature. After this process, the classroom information originally scattered in different carriers is transformed into a multi-modal feature sequence with a unified structure, which provides a stable input for subsequent gesture recognition, emotional resonance analysis and artistic expression modeling. On the whole, this link is not a simple data splicing, but retains the dynamic relationship between movement, emotion and learning behavior in dance teaching, so that the model can be closer to the performance generation process in the real classroom.

3.2 Design of artistic expression representation model integrating gesture recognition and emotional features

After multi-modal data preprocessing and synchronous alignment are completed, the core problem is to represent students 'body control, emotional investment and paragraph expression in dance learning in the same framework. Traditional classroom grading relies on teachers' experience and judgment, which can grasp the overall feeling, but does not fully explain the corresponding relationship between action details and emotional ups and downs. Therefore, under the idea of computer-aided analysis, this paper constructs an artistic expression representation model that integrates posture recognition and emotional features, so that the model can not only retain the structural information of dance movements, but also depict the emotional entry degree and resonance state of students in the performance process.

In order to illustrate the data flow and scoring path inside the model more intuitively, the artistic expression representation model integrating posture recognition and emotional features is shown in Fig. 2.

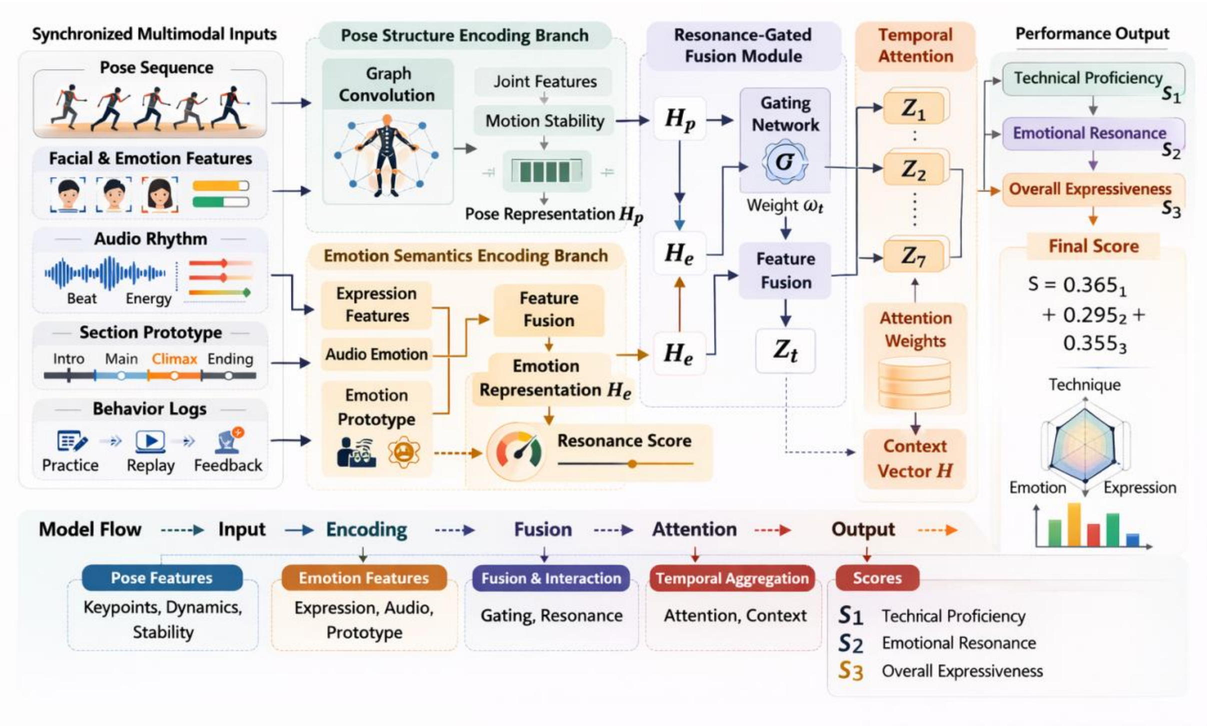

Figure 2: Structural diagram of artistic expressiveness representation model fusing pose recognition and emotional features

(1) Design of pose structure encoding branch

The artistic performance of dance movements is related to the path of movement expansion, the quality of joint connection and the stability of body control. Based on this feature, we represent each human skeleton frame as a graph structure $G_t = (V_t, E_t)$, where V_t represents the set of joint points and E_t represents the skeleton connection relationship. Let the joint feature matrix of frame t be X_t, then the pose coding result is denoted as follows.

$$H_t^p = \mathrm{ReLU}\left(\hat{A} X_t W_p + b_p\right) \tag{6}$$

Here, $\hat{A} = D^{-1/2}(A + I)D^{-1/2}$ is the normalized adjacency matrix and Wp is the learnable parameter. The function of this formula is not simply to extract coordinates, but to incorporate the spatial dependence between the joint points such as shoulder, elbow, hip, and knee into the calculation, so that the overall expansion relationship of the action is preserved. Considering that movement fluency and control are equally important in dance performance, this paper further defines the movement stability term:

$$c_t = \frac{1}{J}\sum_{j=1}^{J} \| q_{t,j} - 2q_{t-1,j} + q_{t-2,j} \|_2 \tag{7}$$

Here, $q_{t,j}$ represents the position of the j joint point in frame t, and ct reflects the degree of mutation of the action at successive moments. The smaller the value is, the smoother the movement connection is, and the closer it is to the consistent force and natural contraction and contraction often mentioned in dance performance.

(2) Emotional semantic coding branch design

In dance teaching, students' emotional state is affected by music paragraphs, rhythm strength and work context. Therefore, in this paper, expression features, audio emotion cues, and prototype vectors of works passages are jointly input into the emotion branch. Let the expression feature be ft, the audio emotion vector be at, and the emotion prototype corresponding to the current paragraph be pk, then the emotion encoding result is as follows.

$$H_t^e = \tanh(W_f f_t + W_a a_t + W_k p_k + b_e) \tag{8}$$

This formula can associate the student's immediate emotional state with the emotional direction of the work, so that the model does not only recognize the expression itself, but also judge whether the expression matches the emotional atmosphere of the current dance. In order to measure the matching degree, this paper constructs the emotional resonance coefficient:

$$r_t = \frac{H_t^e \top p_k}{|H_t^e|_2 | |p_k|_2} \tag{9}$$

When the value of rt is high, it means that the emotion output of the student in the current segment is closer to the prototype of the work. Conversely, it indicates that although the action is completed, the emotional entry is insufficient, or the expression direction is offset.

(3) resonance gated fusion and key segment aggregation

The formation of dance artistic expression is not the mechanical addition of posture information and emotional information. A common situation in actual teaching is that students' movement technology is relatively standard, but the emotion is insufficient. There are also students with strong expression involvement, but the body control and rhythm support are not enough. In order to let the model automatically judge the weight of different modalities in different segments, this paper designs the resonance gated fusion module. Its gating weight is defined as follows.

$$\omega_t = \sigma(W_g[H_t^p, H_t^e; c_t; r_t] + b_g) \tag{10}$$

where [·] is the concatenation of vectors and σ(·) is the Sigmoid function. The fused segments are characterized as follows.

$$Z_t = \omega_t \odot H_t^p + (1 - \omega_t) \odot H_t^e \tag{11}$$

In this way, the model can dynamically balance between technical support and emotional expression. If a segment is more dependent on posture tension, the gating value will be biased towards the posture branch. If a segment is more prominent in emotional advancement, the gating value will retain more emotional branch information. Considering that dance works often have different passages such as beginning, unfolding, climax and bandha, this paper continues to introduce the time attention mechanism to aggregate the key moments:

$$\alpha_t = \frac{\exp(v^\top Z_t)}{\sum_{\tau=1}^{T} \exp(v^\top Z_\tau)}, H = \sum_{t=1}^{T} \alpha_t Z_t \tag{12}$$

Here, αt represents the importance of the t-th time slice to the overall expressiveness judgment. In this way, instead of viewing all segments equally, the model will pay more attention to key moments with obvious emotional turns and concentrated action tension.

To illustrate the input sources, feature dimensions, and output forms of each part of the model, the relevant Settings are shown in Table 3.

Table 3: Main modules and parameter Settings of artistic expressiveness representation model

Module Name	Input Content	Input Dimension	Output Dimension	Main Function
Pose Structure Encoding Branch	Coordinates and velocity features of 17 joint points	51	64	Extracts skeletal topological relations and motion control features
Motion Stability Term Calculation	Joint point positions in 3 consecutive frames	17×3	1	Reflects movement continuity and the degree of abrupt change
Emotional Semantic Encoding Branch	Facial expression features, audio emotion vectors, and segment prototype vectors	48	64	Represents the student's current emotional state and the matching degree with the performance piece
Emotional Resonance Coefficient Module	Emotional encoding vector and prototype vector	64	1	Measures the consistency between emotional expression and the intended meaning of the performance piece
Resonance-Gated Fusion Module	Pose features, emotional features, stability term, and resonance coefficient	130	64	Dynamically allocates the weights of pose information and emotional information
Temporal Attention Aggregation Module	Fusion vectors of 32 time slices	32×64	64	Strengthens climax segments and key expressive fragments
Scoring Output Layer	Aggregated global representation	64	3	Outputs technical completion, emotional resonance, and overall expressiveness

(4) Interface design of multi-dimensional scoring output and teaching explanation

In order to make the model results directly serve teaching and not stay at a single score level, this paper sets the output to three interrelated but separately interpretable indicators, namely, technical completion degree S1, emotional resonance degree S2 and artistic expression comprehensive score S3. The output is of the form:

$$[\mathrm{S}_1, \mathrm{S}_2, \mathrm{S}_3] = \mathrm{Softplus}(\mathrm{W_o H} + \mathrm{b_o}) \tag{13}$$

Based on this, the overall score is further written as follows.

$$\mathrm{S} = 100(0.36S_1 + 0.29S_2 + 0.35S_3) \tag{14}$$

This design has two benefits, one is to facilitate teachers to distinguish whether students' problems are in the quality of action, emotional engagement or overall presentation, and the other is to provide a clear basis for the subsequent intelligent feedback module. For example, if the technical completion is high and the emotional resonance is low, the system is more suitable for pushing contextual arousal, character experience, and music passage prompts. If the emotional involvement is strong but the movement stability is insufficient, the feedback should be focused on control training and rhythm modification. On the whole, by means of computer modeling, the model puts body control, emotional expression and paragraph resonance into a unified space for calculation, which provides a traceable and interpretable quantitative basis for subsequent teaching intervention.

3.3 The Construction of teaching intervention Mechanism and intelligent Feedback Method for the Improvement of Emotional Resonance

After multi-modal feature extraction and artistic expression representation are completed, if the model output only stays at the scoring level, its teaching value is still limited. What the dance classroom really needs is not only to know what level the students are currently performing at, but more importantly to identify where the problem occurs, how to adjust, and whether the adjustment has produced effective improvement. Therefore, after the representation model, this paper continues to construct the teaching intervention mechanism and intelligent feedback method for the improvement of emotional resonance, so that the system can convert the recognition results into executable classroom suggestions.

(1) Intervention target recognition and deviation localization

In order to improve the pertineness of feedback, this paper compares the current performance state of students with the target performance template to construct the priority value of teaching intervention, which is used to judge which kind of problems the system should give priority to. Let action deviation be dt, emotional mismatch be et, and behavioral fluctuation be bt, then the intervention priority value in the T time slice is defined as follows.

$$I_t = \alpha d_t + \beta e_t + \gamma b_t \tag{15}$$

Here, α, β, γ are the weight coefficients, and α+β+γ=1. When It is high, it indicates that the segment has both insufficient performance and is more likely to affect the overall emotional resonance effect, so it needs to be prioritized into the feedback module. Compared with the way of only looking at the score of a single item, this processing is more in line with the reality of the classroom, because teachers usually do not correct a certain action point, but to determine whether the student most needs action modification, emotional arousal, or training rhythm adjustment.

(2) Multi-level feedback strategy generation method

In view of the characteristics of obvious differences between students and large changes in work styles in dance teaching, this paper divides the feedback into four types: movement correction type, rhythm coordination type, emotional arousal type and comprehensive guidance type. Among them, the motion correction type is mainly oriented to the situation of insufficient joint deployment and large deviation of center of gravity. The rhythm coordination type is mainly oriented to the segments where the movement is inconsistent with the music advancement. The emotional arousal type corresponds to the situation of single expression, slow emotional entry, or mismatched paragraph atmosphere. In order to realize feedback automatic matching, the feedback selection function is set as follows.

$$G_t = \arg\max_{k \in \{1,2,3,4\}} (w_k^T z_t + c_k) \tag{16}$$

Here, zt represents the comprehensive state vector of the current segment, k corresponds to the four types of feedback templates, and wk and ck are the classification parameters. The purpose of this formula is to let the system automatically select the most suitable type of prompt based on the state characteristics, rather than mechanically pushing in a unified language. For example, when the emotional mismatch is obvious and the movement score is acceptable, the system will not repeatedly prompt the body Angle, but will guide the students to pay attention to the music passage, the character psychology and the breathing change, so as to focus the feedback on the emotional resonance.

To illustrate the trigger conditions and intervention directions of different feedback types, the relevant rules are shown in Table 4.

Table 4: Intelligent feedback types versus instructional intervention rules

Feedback Type	Trigger Condition	System Prompt Content	Teacher Intervention Method	Expected Improvement Direction
Action Correction Type	Motion deviation value ≥ 0.35, emotional mismatch degree < 0.20	Indicates problems in key joint angles, center-of-gravity position, and movement amplitude	Decomposed demonstration and targeted local re-practice	Improve technical completion
Rhythm Coordination Type	Rhythm synchronization error ≥ 0.30	Indicates inconsistency between movement timing points and musical downbeats	Segmented follow-up practice and beat reinforcement training	Improve consistency between movement and music
Emotional Arousal Type	Emotional mismatch degree ≥ 0.32, insufficient facial expression fluctuation	Indicates paragraph emotion, character atmosphere, and breathing treatment	Situational guidance, role experience, and semantic explanation	Improve emotional resonance
Comprehensive Guidance Type	Both motion deviation value and emotional mismatch degree are high	Provides dual-channel prompts for both movement and emotion	Individual teacher guidance and key-segment replay	Enhance overall artistic expressiveness

(3) Collaborative intervention mechanism with the participation of teachers

This paper does not set intelligent feedback as an independent substitute for teachers, but designed it as an auxiliary tool for classroom judgment. The system first outputs the problem type, deviation position and suggested path, and then the teacher decides whether to adopt and how to adjust according to the work style, student foundation and classroom rhythm. To this end, this paper introduces the collaborative intervention gain coefficient, which is used to measure the correction effect after the joint effect of system feedback and teacher intervention:

$$Q = \frac{R_{t+1} - R_t}{1 + \exp(-u_t)} \tag{17}$$

Here, R_t represents the overall performance rating of the current round, R_{t+1} represents the new rating after the intervention, and ut represents the intensity of teacher participation. This coefficient takes the teacher's role in the correction process into account, so the system can gradually learn which kind of feedback is more easily absorbed by students after the teacher's demonstration, and which kind of prompts need to be further adjusted in expression, so as to reduce vague, repetitive and even inappropriate prompts in the classroom context.

(4) Feedback results update and closed-loop optimization

The emotional resonance in dance teaching is obviously dynamic, and the feedback acceptance effect of the same student in different dance segments and different classroom states is not consistent. Therefore, this paper sets up the feedback effectiveness update mechanism to modify the feedback strategy according to the improvement of students in the next round of training. Let the effectiveness of the NTH round of intervention be En, then the update mode is as follows.

$$E_{n+1} = \rho E_n + (1 - \rho)\Delta_n \tag{18}$$

Here, ρ is the historical retention coefficient and Δ_n is the actual improvement rate after this round of intervention. If the effect of a certain type of feedback is weak in successive rounds, the system will automatically reduce its call priority. If a certain type of feedback improves significantly in a specific student or a specific work, its subsequent weight is increased.

On the whole, the teaching intervention and intelligent feedback method constructed in this section concatenates performance recognition, problem localization, feedback generation, teacher collaboration and effect update into a complete closed loop. It not only retains the advantages of computer model in speed and consistency, but also takes into account the practical characteristics that it is difficult to completely standardize emotional expression in dance teaching, which provides a method basis for subsequent experiments to verify the teaching assistant effect of the system.

4 Experimental setup and teaching implementation plan

4.1 Experimental environment Configuration and realization conditions of dance teaching platform

In order to ensure that the process of emotional resonance recognition, action analysis and teaching feedback can run stably in the same platform, this paper builds a teaching platform environment for dance classroom in the experimental stage. The whole platform adopted a three-layer structure of "collection end-processing end-feedback end". The collection end was responsible for obtaining classroom videos, accompaniment audio and learning behavior logs, the processing end completed posture recognition, emotional feature extraction, multi-modal alignment and score calculation, and the feedback end showed movement deviation, emotional state and exercise suggestions to teachers and students. Considering that the dance teaching scene has high requirements for video fluency, timing synchronization and interactive response speed, the experiment uses medium and high performance graphics computing equipment as the core computing node, and the visualization page is deployed in the front end to ensure that the two tasks of classroom demonstration and after-class review can be completed successfully.

In terms of system implementation, the back-end of the platform uses Python as the main development language, combines PyTorch to complete model training and reasoning, the front-end uses Vue to build the teaching interactive interface, and MySQL is used as the database to store student training records, scoring results and feedback logs. The video processing part integrates OpenCV, the human keypoint detection module is used for posture recognition, and the audio analysis part uses Librosa to extract beat and energy features. When the platform runs, the data of different modalities are uniformly mapped to the timeline, and the technical completion, emotional resonance and comprehensive performance scores are output by the representation model. The experimental environment configuration and platform implementation conditions are shown in Table 5.

Table 5: Experimental environment configuration and realization conditions of dance teaching platform

Category	Configuration Item	Specific Parameter or Condition	Main Function
Hardware Environment	Processor	Intel Core i7-12700F	Supports parallel multitask computing
Hardware Environment	Graphics Processing Unit	NVIDIA RTX 4060 8GB	Performs model training and inference acceleration
Hardware Environment	Memory	32 GB DDR4	Ensures stable video and feature caching
Hardware Environment	Storage	1 TB SSD	Stores classroom videos and experimental data
Acquisition Terminal	Video Capture	1920×1080, 30 fps, two HD cameras	Captures motion trajectories and facial expression frames
Acquisition Terminal	Audio Capture	16 kHz wireless microphone and accompaniment input module	Extracts rhythm and emotional cues
Software Environment	Operating System	Windows 11 64-bit	Provides the basic runtime environment
Software Environment	Programming Language	Python 3.10, JavaScript	Supports model and front-end development
Software Environment	Deep Learning Framework	PyTorch 2.1	Completes model training and deployment
Software Environment	Supporting Libraries	OpenCV, Librosa, NumPy	Implements video processing and audio analysis
Platform Implementation	Front-end Interface	Vue 3 + ECharts	Displays scoring results and feedback information
Platform Implementation	Data Storage	MySQL 8.0	Stores logs, features, and evaluation results

4.2 Dataset Construction Experimental grouping and teaching implementation process design

In order to ensure the comparability of the experimental results, this paper constructs a teaching dataset with students in two parallel classes of a university dance course as the object, and carries out group experiments in the same teaching cycle. A total of 64 students were included in the experiment, which were evenly divided according to the basic level of the class and the pre-test scores, including 32 students in the experimental group and 32 students in the control group. The two groups were taught by the same teacher, using the same dance material, training time and assessment standards. In the three stages of pre-test, mid-test and post-test, a unified evaluation index was used to record students 'technical completion, emotional resonance and comprehensive expression. In order to ensure the consistency of the results analysis, the platform synchronously collected video, audio, expression frames and behavior logs for the two groups of classroom processes, and formed multimodal samples for model training and effect evaluation after slicing, cleaning and screening. The difference between the two groups was only reflected in the teaching intervention mode, that is, the experimental group was connected with the emotional resonance recognition and intelligent feedback module on the basis of conventional teaching, and the control group completed the training by teacher demonstration, decomposed explanation and after-class comment. The whole experiment lasted for 8 weeks, with two classes per week and 90 min each time. Table 6 shows the design of experimental grouping and teaching implementation process for dataset construction.

Table 6: Dataset construction experiment grouping and teaching implementation process design

Item	Experimental Group	Control Group	Unified Conditions
Number of Students	32	32	Dance majors from the same grade
Teaching Duration	8 weeks	8 weeks	2 sessions per week, 90 min per session
Teaching Method	Conventional Teaching + Intelligent Feedback	Conventional Teaching	Same instructor, same dance segment
Data Collection	Video, audio, facial expression frames, and behavioral logs	Video, audio, facial expression frames, and behavioral logs	Pre-test, mid-test, and post-test data recorded synchronously
Sample Size	640 valid segments	640 valid segments	1,280 valid segments in total
Evaluation Content	Technical Completion, Emotional Resonance, and Overall Expressiveness	Technical Completion, Emotional Resonance, and Overall Expressiveness	Unified scoring criteria

5 Result analysis and performance evaluation

5.1 Analysis of the effect of emotional resonance teaching on the improvement of students 'artistic expression

In order to test the actual role of emotional resonance teaching in dance classroom, this paper compares and analyzes the artistic expression scores of the experimental group and the control group in the pre-test, mid-test and post-test stages under the unified data collection and unified scoring standards. The basic level of the two groups of students before the start of the experiment was relatively close, and the differences in technical completion, emotional resonance and comprehensive expressiveness were small, indicating that the subsequent results were comparable. With the advancement of teaching, the experimental group showed a continuous upward trend in the three dimensions, and the improvement was more obvious in the middle and late stages. The control group also improved in the conventional teaching condition, but the overall increase was relatively limited. The comparison of artistic expression scores between the experimental group and the control group under emotional resonance teaching is shown in Table 7.

Table 7: Comparison of artistic expression scores between experimental group and control group under emotional resonance teaching

Group	Test Stage	Technical Completion	Emotional Resonance	Overall Expressiveness
Experimental Group	Pre-test	71.84±4.12	68.95±4.36	70.26±4.21
Experimental Group	Mid-test	78.63±3.98	79.42±4.05	79.01±3.87
Experimental Group	Post-test	84.76±3.65	88.34±3.72	86.57±3.54
Control Group	Pre-test	72.11±4.08	69.27±4.19	70.54±4.13
Control Group	Mid-test	75.26±3.94	73.68±4.01	74.39±3.89
Control Group	Post-test	78.42±3.81	76.15±3.93	77.21±3.76

As can be seen from Table 7, the comprehensive expression of the experimental group reached 86.57 points in the post-test, which was 16.31 points higher than that in the pre-test, and the increase was 23.20%. The emotional resonance score increased from 68.95 to 88.34, with an increase of 19.39. In contrast, the control group only increased the overall expressiveness by 6.67 points and the emotional resonance by 6.88 points. It can be seen that emotional resonance teaching has a more obvious role in promoting students 'artistic expression, especially in emotional expression and stage appeal.

5.2 Performance evaluation of multimodal emotion recognition and action analysis models

In order to verify the recognition ability of the built model in dance teaching scenes, this paper selects the posture feature only model, emotion feature only model, and posture and emotion direct splicing model as comparison methods, and evaluates them from four dimensions of accuracy, precision, recall and F1 value. The experimental results show that although the single modal model can complete the basic recognition, there are still shortcomings in the collaborative description of movement changes and emotional fluctuations in dance performance. After adding multi-modal fusion, the model was more stable in the discrimination of students 'artistic performance state. Table 8 shows the performance evaluation results of different models.

Table 8: Comparison of performance evaluation results of different models

Model Type	Accuracy	Precision	Recall	F1-score
Pose-Only Feature Model	83.27	82.65	81.94	82.29
Emotion-Only Feature Model	80.94	80.36	79.88	80.12
Direct Concatenation Model of Pose and Emotion Features	87.18	86.74	86.03	86.38
Proposed Model	91.42	90.96	90.51	90.73

It can be seen from Table 8 that all the indicators of the proposed model are better than the other comparison methods. The Accuracy reaches 91.42%, which is 8.15 percentage points higher than that of the posture feature only model, and the F1-score reaches 90.73%, which is 4.35 percentage points higher than that of the direct splicing model. It shows that the combination of posture recognition, emotional features and timing fusion mechanism can more effectively identify students 'action performance and emotional investment state in dance teaching.

5.3 Comparison of students' artistic performance under different teaching intervention strategies

In order to further compare the differences in the effects of different teaching intervention strategies on the improvement of students 'artistic performance, this paper selected four types of strategies: action modification type, rhythm coordination type, emotional arousal type and comprehensive guidance type, and counted the changes of comprehensive expression after four rounds of intervention. Fig. 3 shows the changing trend of students' artistic performance under different teaching intervention strategies.

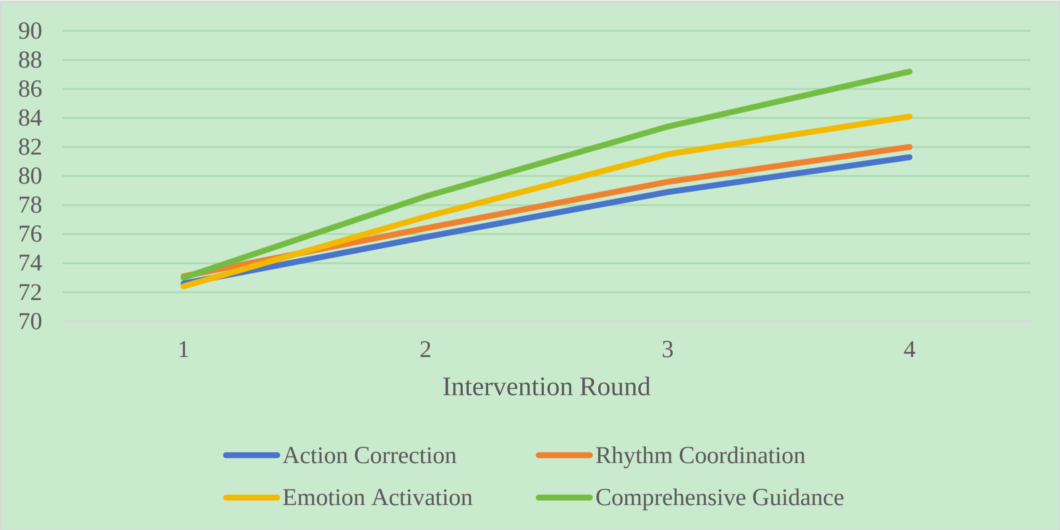

Figure 3: Line chart of changes in student artistic performance under different instructional intervention strategies

On the whole, the four types of strategies can bring a certain degree of improvement, but there are obvious differences in the growth speed and final effect. The action modification strategy is more stable in the early stage, which is more conducive to consolidating the technical foundation. The rhythm coordination strategy performed better in the middle stage, and the coordination between movement and music was improved significantly. The emotional arousal strategy has a greater improvement in the latter two rounds, indicating that it has a more direct promotion effect in strengthening emotional engagement and stage appeal. In contrast, the comprehensive guided strategy always maintained the highest growth curve, increasing from 73.0 points in round 1 to 87.2 points in round 4, a cumulative increase of 14.2 points. During the same period, the emotional arousal score increased from 72.4 to 84.1, an increase of 11.7. Rhythm coordination and motion modification improved by 8.9 and 8.7 points, respectively. The results show that the combination of movement correction, rhythm adjustment and emotional guidance is more conducive to the overall improvement of students 'artistic expression, especially in the later stage, showing a stronger continuous promotion effect.

5.4 Model training convergence and system operation stability analysis

In order to verify the convergence characteristics of the model in the training phase and the stability of the platform during operation, this paper tracks the changes of training loss and validation loss, and combines the results of multiple rounds of system operation to observe its response fluctuations. The training convergence curve of the built model is shown in Fig. 4.

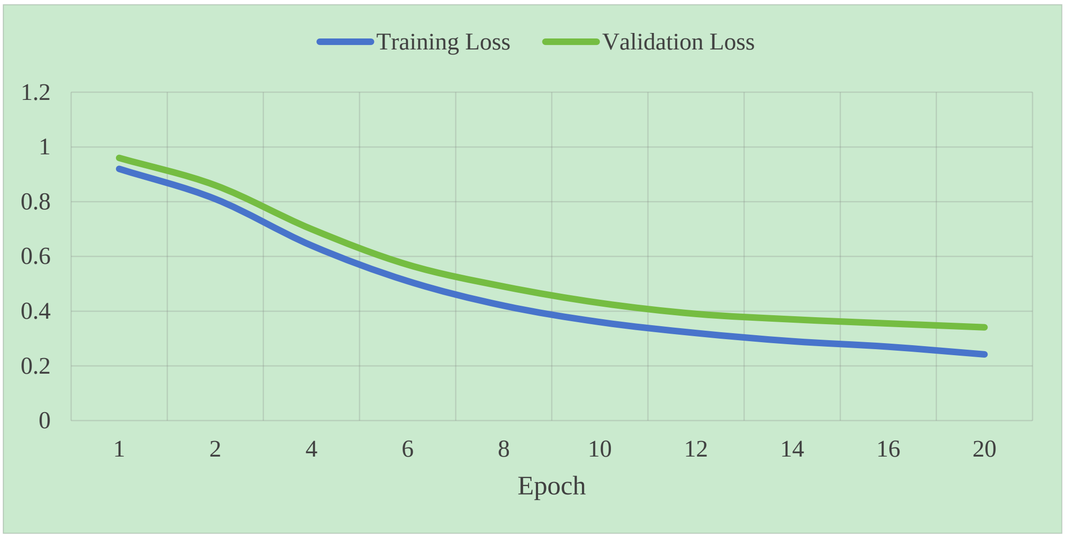

Figure 4: Training convergence curve of the built model

It can be seen that the two curves decline rapidly in the early stage of training, indicating that the model can quickly complete the preliminary learning of the joint features of action and emotion. After entering round 10, the downward trend gradually slows down, indicating that the parameter updates start to stabilize. By the 20th round, the training loss is reduced from 0.92 to 0.242, and the validation loss is reduced from 0.96 to 0.341. There is no obvious separation between the two, indicating that the model does not have serious overfitting, and the overall convergence state is relatively stable. On the other hand, in consecutive rounds of classroom sample testing, the average response time of the platform is kept at about 2.8 s, the fluctuation of single section sample processing is controlled within ±0.21 s, and the deviation of recognition results is less than 1.5% under repeated running conditions. This shows that the model not only has good training convergence, but also can maintain stable output in the dance teaching scene, which provides reliable support for subsequent teaching feedback and classroom application.

5.5 Evaluation of the overall application effect and practical value of the teaching assistant system

After completing the model performance test and the comparison of teaching interventions, this paper further evaluates the actual value of the teaching assistance system from the classroom application level. The evaluation objects included the students of the experimental group and the teachers involved in the teaching. The evaluation mainly focused on the timeliness of feedback, the understandability of results, classroom adaptability, the effectiveness of emotional guidance and the willingness to continue to use. On the whole, the system can not only output the results of action and sentiment analysis quickly, but also convert the complex recognition information into easier to understand prompt content, so it shows good applicability in classroom training, segmentation correction and after-class review. The evaluation results of the overall application effect of the teaching aid system are shown in

Table 9.

Table 9: Evaluation results of the overall application effect of the teaching aid system

Evaluation Dimension	Student Rating	Teacher Rating	Overall Mean
Timeliness of Feedback	4.62	4.71	4.66
Result Interpretability	4.48	4.56	4.52
Classroom Adaptability	4.41	4.63	4.52
Effectiveness of Emotional Guidance	4.57	4.68	4.62
Willingness for Continued Use	4.53	4.60	4.56

It can be seen from Table 9 that the comprehensive mean of the five dimensions are all higher than 4.50, among which the feedback timeliness reaches 4.66, and the emotional guidance effectiveness reaches 4.62, indicating that the system not only has good technical usability in dance classroom, but also can directly support students to enter their emotions and improve their artistic performance. Students scored 4.48 for the intelligibility of the results, and teachers scored 4.56, indicating a good cohesion between the system output and the classroom language. In general, the system takes into account the recognition efficiency, teaching adaptation and practical operation value, and provides a feasible technical support for the process cultivation of emotional resonance in dance education.

6 Conclusions

Starting from the problems that emotional resonance is difficult to identify, artistic expression is difficult to quantify, and teaching feedback is biased to experience in dance classroom, this paper introduces multi-modal perception, posture structure coding, emotional semantic modeling and intelligent feedback mechanism into the teaching process, and forms a more complete technical support framework. The experimental results showed that the emotional resonance teaching could significantly improve the comprehensive performance of students. The comprehensive expression of the experimental group reached 86.57 points in the post-test, which was significantly higher than that of the control group 77.21 points. At the same time, the proposed model performs stably in the joint recognition of action and emotion, with the Accuracy and F1-score reaching 91.42%and 90.73%respectively, and the average score of system application evaluation is higher than 4.50. It shows that this study not only improves the process diagnosis ability of dance teaching, but also enhances the pertinence and practicality of classroom intervention, which has practical value for promoting the transformation of dance education evaluation from single technical judgment to collaborative analysis of emotion and performance.

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