Research on Key Techniques for Emotional Expression of Animated Game Characters Driven by Digital Human Technology

Xiao'ou Ji[1], Juan Song[2]
[1]College of Architecture and Art, Taiyuan University of Technology, Jinzhong 030600, Shanxi, China
[2]School of Humanities and Arts, Xi'an International University, Xi'an 710077, Shaanxi, China
Corresponding author: Juan Song (e-mail: xogg2025@163.com)

ABSTRACT Against the backdrop of rapid development in the metaverse, AIGC, and real-time interaction technology, digital humans have become the core carriers in fields such as animation, gaming, virtual hosting, and interactive entertainment. Traditional animated game characters rely on manual keyframes, motion capture, and preset state machines for emotional expression, which have bottlenecks such as stiff facial expressions, mechanical movements, asynchronous sound and image, thin emotional layers, and difficulty in generating complex emotions and micro expressions, making it difficult to meet the interactive needs of high immersion, empathy, and realism. This article is driven by digital human technology and focuses on the entire process of emotion generation, transmission, rendering, and interaction for animated game characters. It systematically studies key technologies such as multimodal emotion computing, facial micro expression generation, body posture emotion mapping, voice expression action collaborative driving, real-time rendering optimization, and emotional interaction decision-making.

INDEX TERMS digital human,animated game characters,emotional expression,micro-expression,real-time rendering

I. INTRODUCTION

A. RESEARCH BACKGROUND AND SIGNIFICANCE

WITH the rapid breakthroughs in digital human technology, real-time rendering, large model interaction, and multimodal generation technology, the animation and gaming industry has entered a new stage of "high emotion, high immersion, and high interaction". As the narrative core and emotional entry point, the emotional expression ability of characters directly determines the infectivity of the work, the player's sense of immersion, and the commercial reputation. Traditional character emotion generation heavily relies on manual K-frame art, motion capture and script branching, with high costs, long cycles, poor flexibility, and difficulty in achieving continuous emotional changes, complex composite emotions, and unconscious micro expressions. , This leads to systemic issues characterized by diminished facial expressivity, kinematically rigid transitions, and cross-modal desynchronization between acoustic and visual signals, severely degrading the immersive experience. In this context, AIGC (Artificial Intelligence Generated Content) is specifically utilized for the real-time synthesis of non-linear emotional facial animation sequences based on dynamic text prompts[1-2]. Digital human technology is centered around 3D modeling, action driven, emotion computing, speech synthesis, multimodal fusion, and real-time rendering. It can directly generate natural, delicate, and coherent facial expressions, body movements, and tone and intonation from text/speech/context, providing a revolutionary solution for emotional expression of animated game characters. In recent years, technologies such as Audio2Face, SadTalker, and TIETFG have gradually achieved voice driven facial animation, large language models have enabled contextual emotional understanding, neural rendering has enhanced facial realism, and digital humans are transitioning from "likeness" to "likeness"[3].

However, the emotional expression of digital humans in animated games still faces multiple challenges: the emotional model lacks constraints on character personalities and worldviews; Insufficient restoration of micro expressions and subtle postures; The accuracy of cross modal synchronization between speech, expression, and action is low; Complex emotions and transitional emotions are difficult to generate; Real time rendering performance and image quality are difficult to balance; The lack of dynamic emotional interaction logic in an open world. Therefore, conducting research on key technologies for emotional expression of animated game characters driven by digital human technology has become an urgent need to improve the quality and core competitiveness of works[4].

B. RESEARCH SIGNIFICANCE

1) Theoretical Significance

To construct a complete technical system and theoretical framework for emotional expression of digital human driven animated game characters, and to improve the cross theory of emotional computing, multimodal generation, and virtual human animation; Propose a mechanism for generating and aligning emotions through role-playing, scenarizing, and storytelling, enriching the theory of intelligent expression for digital humans; Establish an emotional expression evaluation system for real-time interaction, providing a theoretical basis for high-quality virtual character development[5].

2) Practical Significance

Significantly reduce the production cost of animated game character expressions and actions, and shorten the production cycle; Realize more delicate, natural, and layered emotional expression, significantly enhancing character appeal and player empathy; Support real-time dynamic emotional feedback, adapt to open world, storyline interaction, and immersive experience needs; Promote the leapfrog upgrade of domestic animation and games in terms of character expression, narrative art, and industrialization process[6].

C. CURRENT RESEARCH STATUS AT HOME AND ABROAD

1) Research on digital human emotional expression technology

Foreign countries are relatively mature in facial animation, voice driven expression, and action generation, NVIDIAAudio2Face,MetaAudio2Emotion, Implement high-precision mouth shape and expression drivers using Apple's ARKit facial expression system, among others; The research focuses on lip sync, FACS action units, and emotional space modeling. However, most systems tend to favor universal digital humans and lack adaptation to the stylization, role-playing, and narrative of animated games.

In recent years, there have been advancements in voice driven facial animation in China SadTalker, Break throughs have been made in text driven expression and continuous emotion generation, with Harbin Institute of Technology's TIETFG achieving continuous emotional changes. NetEase, Paperstack, miHoYo, and others have conducted in-depth research on game character micro expressions and action emotions. But overall, there are still issues such as a thin emotional model, cross modal synchronization bias, unnatural micro expressions, insufficient real-time performance, and difficulty in ensuring character consistency[7].

2) Research on Character Emotion Generation in Animated Games

Traditional games rely on animation trees, state machines, motion capture libraries, and manual K-frames. Open world games have begun to introduce dynamic emotion systems, but emotion switching is rigid, lacks micro expressions, and cannot understand deep contexts; Animation production heavily relies on original artists and motion capture, resulting in low efficiency and high modification costs. Digital human technology has not yet been deeply integrated into the industrial process, and there is a lack of automation, intelligence, and emotional production capacity.

3) Research on Multimodal Emotional Fusion and Synchronization

The collaborative expression of speech, facial expressions, and actions is the key to emotional naturalness. Existing research mostly addresses the synchronization of mouth movements, but lacks emotional level synchronization: problems such as excited tone but flat expression, and stiff movements when sad are common. The end-to-end cross modal alignment and temporal consistency optimization for real-time interaction are still immature[8-10].

4) Insufficient existing research

(1) Emotional modeling lacks constraints on role identity, personality, and worldview, leading to a lack of character-specific traits in emotional expression;

(2) Micro expressions, subtle postures, and physiological level details are missing, making it easy to fall into the 'uncanny valley';

(3) The accuracy and synchronization of multimodal emotional collaboration between speech, expression, and action are low;

(4) Weak ability to generate continuous emotions, compound emotions, and transitional emotions;

(5) Real time rendering and lightweighting are insufficient, making it difficult to embed game engines for real-time operation;

(6) Lack of dynamic emotional decision-making mechanism for narrative and scene oriented[11].

D. MAIN RESEARCH CONTENT

(1) The overall framework and technical process of emotional expression of digital human driven animated game characters;

(2) Character emotion cognition and intention understanding based on emotion computing and large-scale models;

(3) High precision facial micro expression generation and action unit (AU) control technology;

(4) Emotional mapping and generation methods for body posture, gestures, and torso movements;

(5) Speech expression action cross modal emotion alignment and real-time synchronization technology;

(6) Lightweight real-time rendering optimization and animation game engine adaptation solution;

(7) Dynamic emotional interaction decision-making, role consistency, and narrative adaptation mechanism;

(8) Empirical verification and evaluation of system performance, emotional effects, and user experience.

E. TECHNICAL ROADMAP

Following the technical route of "requirement analysis framework construction emotion modeling multimodal generation collaborative synchronization real-time optimization interactive decision-making empirical verification", based on the full stack technology of digital humans, with the goals of emotional naturalness, richness, real-time performance, and role consistency, a directly engineering technical solution is formed.

II. RELATED THEORETICAL AND TECHNICAL FOUNDATIONS

A. DIGITAL HUMAN TECHNOLOGY SYSTEM

Digital human is a complex system integrating 3D modeling, bone binding, action driving, speech synthesis, emotional computing, real-time rendering, and interactive intelligence. It can be divided into realistic digital human, cartoon digital human, and anime digital human according to applications, which can fully adapt to the art style of animation games[12-13].

B. EMOTION CALCULATION AND EMOTION MODEL

Emotion computing aims to empower machines with the ability to recognize, understand, and express emotions. Common models include:

(1) Basic emotional models: joy, anger, sadness, fear, shock, disgust, etc;

(2) PAD 3D model: valence, arousal, dominance;

(3) FACS facial action coding system: parsing expressions in AU units;

(4) OCC cognitive model: generates emotions based on event evaluation.

C. FACIAL ANIMATION AND MICRO EXPRESSION TECHNOLOGY

The core of facial animation includes BlendShape, bone drive, muscle simulation, vertex animation, and more. Micro expressions are short duration and small amplitude true emotional leaks that are key to enhancing realism, relying on high-precision AU control and temporal smoothing[14].

D. PHYSICAL EMOTIONS AND POSTURE LANGUAGE

Body posture, gestures, range of motion, speed, and tension directly convey emotions: large excitement, stiff tense posture, relaxed posture, etc., forming a complete "body emotional language".

E. MULTIMODAL FUSION AND TEMPORAL SYNCHRONIZATION

Speech rhythm, facial expressions, and body movements must be highly aligned in terms of emotional intensity, temporal changes, and emotional categories in order to be natural and credible. Excessive synchronization error can lead to a strong sense of dissonance[15].

F. REAL TIME RENDERING AND GAME ENGINE TECHNOLOGY

Unity, Unreal and other engines support skeletal animation BlendShape, Material expression, post-processing, but emotional expression needs optimization: LOD, instantiation, shader lightweighting, dynamic detail adjustment, etc.

G. CHARACTERISTICS OF EMOTIONAL EXPRESSION IN ANIMATED GAME CHARACTERS

(1) Stylization: realistic, cartoon, anime, ink painting, etc;

(2) Characterization: Personality, identity, and background determine the way emotions are expressed;

(3) Narrative: emotional service plot, conflicts, and transitions;

(4) Real time: Games require dynamic response and low latency;

(5) Exaggeration: Allowing moderate artistic exaggeration to enhance expressiveness[16].

III. OVERALL FRAMEWORK FOR EMOTIONAL EXPRESSION OF ANIMATED GAME CHARACTERS DRIVEN BY DIGITAL HUMAN TECHNOLOGY

A. OVERALL DESIGN OBJECTIVES

(1) Emotional naturalness: delicate expressions, smooth movements, and rich micro expressions;

(2) Multi modal collaboration: speech expression action emotion synchronization and consistency;

(3) Character consistency: Emotional responses conform to personality, identity, and worldview;

(4) Real time performance: meets the real-time running requirements of 60fps in games;

(5) Industrial adaptation: can be embedded in the production process of animated games[17].

B. FIVE LAYER TECHNICAL ARCHITECTURE

(1) Emotional Perception and Understanding Layer: Text/Speech/Context Emotion Analysis;

(2) Emotional modeling and decision-making layer: role emotional model, state management, narrative constraints;

(3) Multi modal emotion generation layer: facial, body, and voice emotion driven;

(4) Collaborative synchronization and scheduling layer: cross modal timing alignment, smooth transition;

(5) Real time rendering and interaction layer: engine adaptation, lightweighting, and image quality optimization, as shown in Table 1 below.

TABLE 1. Digital Human Emotional Expression Technical Framework

Layer	Core Module	Function
Emotion Perception	Text/Speech Semantic Analysis	Emotion category & intensity
Emotion Modeling	Character Emotion Model	Personality & state control
Multimodal Generation	Face/Body/Voice Drive	Expression & action synthesis
Collaborative Sync	Multimodal Alignment	Timing & emotion consistency
Real-time Rendering	Engine Adaptation & LOD	Performance & quality balance

C. FULL PROCESS TECHNICAL LINK

Text/voice/plot events $\to$ emotional understanding $\to$ character emotional decision-making $\to$ facial expression generation $\to$ body posture generation $\to$ voice emotion generation $\to$ multimodal synchronization $\to$ real-time rendering $\to$ animation/game screen output[18-20].

D. CORE SCIENTIFIC ISSUES

(1) How to make digital people emotionally like characters rather than machines;

(2) How to achieve collaborative expression of micro expressions, posture, and tone;

(3) How to achieve high-quality emotional animation in real-time and with low computing power;

(4) How to make emotions dynamically change with narrative, scene, and relationship.

E. SYSTEM INTERFACE AND ENGINEERING ADAPTATION

Provide standard animation/game engine interfaces, supporting FBX, animation clips BlendShape, Bone animation output can be integrated with motion capture, manual animation, and AIGC processes to form a hybrid production mode.

IV. CHARACTER EMOTION COGNITION AND MODELING TECHNIQUES

A. EMOTIONAL INPUT AND UNDERSTANDING

The input sources include: plot text, dialogue statements, voice signals, player interactions, scene events, task status, etc. The system extracts emotion categories, intensity, duration, and motivation through semantic analysis, speech emotion recognition, and context understanding.

B. ROLE EMOTIONAL COGNITION BASED ON LARGE MODELS

We employ a fine-tuned GPT-4o model as the cognitive core. The model processes dialogue strings to output a structured emotion vector $E \in \{v, a, d\}$.

(1) Analysis of dialogue emotions and intentions;

(2) Deep emotional recognition such as satire, metaphor, and suggestion;

(3) Character personality and tone style transfer;

(4) Reasonable emotional deduction under narrative logic.

C. CONSTRUCTION OF ROLE BASED EMOTION MODEL

Establish an exclusive emotional model for each character:

(1) Basic personality parameters: extroverted/introverted, calm/impulsive, sensitive/sluggish;

(2) Emotional triggering rules: preference for reactions to events, conversations, and relationships;

(3) Emotional decay and transition curve: natural calm, burst, suppression, etc;

(4) Expression style parameters: expression exaggeration, action amplitude, tone characteristics.

D. EMOTIONAL STATE MACHINE AND DYNAMIC MANAGEMENT

Build a continuous emotional state space that supports:

(1) Basic emotions and compound emotions (such as bitter smile, grievance, anger);

(2) Smooth transition of emotions based on a temporal weighted fusion algorithm. Instead of immediate overwriting, new emotional triggers are treated as impulse vectors that superimpose upon the current decay curve of the existing state. This ensures that transitions between contrasting emotions (e.g., from lingering sadness to sudden shock) follow a continuous mathematical gradient, thereby eliminating mechanical jumping;

(3) Emotional superposition and suppression (such as holding back tears or pretending to be calm).

E. EMOTIONAL INTENSITY AND PERFORMANCE MAPPING

The emotional intensity I is mapped to the target AU weight W_{AU} using the function $W_{AU} = \sigma(\alpha \cdot I + \beta)$, where σ is a sigmoid activation to ensure weights remain in [0, 1] and α, β are character-specific personality coefficients.

V. MULTIMODAL EMOTION GENERATION AND COLLABORATIVE DRIVING

A. FACIAL MICRO EXPRESSION GENERATION TECHNOLOGY

High precision emotional expression based on FACS action unit (AU):

(1) Basic emoji library: joy, anger, sadness, fear, shock, disgust, calm;

(2) Micro expression generation: blinking, raising eyebrows, slight movements at the corners of the mouth, changes in the pupils, and flapping of the nose wings;

(3) Timing control: facial expression activation, peak, decay, natural transition;

(4) Style adaptation: Realistic/cartoon/anime expression curve adjustment.

B. EMOTIONAL GENERATION OF BODY POSTURE

Establish a posture emotion mapping library:

(1) Emotional posture: happy and relaxed, angry and tense, sad and low hanging, tense and stiff;

(2) Gesture emotions: clenching fists, spreading hands, hugging arms, finger poking, gentle caressing;

(3) Head micro movements: nodding, shaking, tilting, staring, avoiding;

(4) Rhythm of movement: speed, acceleration, pause, jitter.

C. SPEECH EMOTION AND MOUTH SHAPE SYNCHRONIZATION

(1) Emotional speech synthesis: tone, speed, volume, wheezing, vibrato adapted to emotions;

(2) High precision mouth shape synchronization: real-time mapping of phoneme mouth shape coefficients;

(3) Emotional synchronization: When excited, the amplitude of the mouth shape is large, and when sad, the mouth shape is gentle.

D. CROSS MODAL EMOTIONAL COLLABORATION AND SYNCHRONIZATION

Core solution to the problem of multimodal asynchrony and temporal misalignment between speech, facial expression, and body movement:

(1) Unified emotional intensity center control;

(2) Timing alignment and delay compensation;

(3) Keyframe smoothing and curve fusion;

(4) Multi modal consistency verification and correction are shown in Table 2 below.

TABLE 2. Emotional Mapping of Face, Body and Voice

Emotion	Face Feature	Body Feature	Voice Feature
Happy	Smile, eye bright, brow relaxed	Open posture, quick	High pitch, fast, loud
Sad	Mouth down, eye wet, brow furrowed	Slouched, slow	Low pitch, soft, slow
Angry	Glare, frown, tight jaw	Fist, tense, forward	Loud, sharp, fast
Surprised	Eyebrow up, eye open, mouth open	Backward, stiff	High pitch, short, breathy

E. COMPOUND EMOTION AND CONTINUOUS EMOTION GENERATION

Support:

(1) Mixed emotions: mixed emotions of sadness and joy, both shocked and angry, unable to laugh or cry;

(2) Continuous emotional gradient: from calmness to excitement to calmness;

(3) Suppressing/concealing emotions: surface calmness and subtle expressions reveal true emotions.

VI. REAL TIME RENDERING OPTIMIZATION AND EMOTIONAL INTERACTION DECISION-MAKING

A. LIGHTWEIGHT ANIMATION DRIVER OPTIMIZATION

(1) BlendShape simplification and key expression preservation;

(2) Skeletal LOD and dynamic detail switch;

(3) Facial expression curve pre calculation and interpolation acceleration;

(4) Asynchronous dual-track scheduling: An asynchronous inference pipeline is implemented to decouple deep semantic analysis (LLM-based) from motion synthesis. While the LLM processes complex metaphors at a lower update frequency, the system utilizes lightweight local heuristics to maintain continuous 60fps frame updates for micro-expressions, preventing high-latency reasoning from blocking the real-time rendering loop.

B. REAL TIME RENDERING ADAPTATION OF GAME ENGINE

(1) Feed facial expressions and posture animations into the engine;

(2) Material expression: blushing, pale, sweating, tears, etc;

(3) Unified lighting and emotional atmosphere;

(4) Performance monitoring and dynamic load shedding strategies are shown in Table 3 below.

TABLE 3. Real-time Rendering and Lightweight Optimization

Method	Object	Effect
BlendShape Simplification	Face expression	Reduce computation
Bone LOD	Body animation	Dynamic detail control
Asynchronous Calculation	Emotion inference	Stable frame rate
Material LOD	Emotional texture	Reduce GPU overhead

C. DYNAMIC EMOTIONAL INTERACTION DECISION-MAKING MECHANISM

(1) Player behavior triggers emotions: dialogue selection, attack, help, neglect, etc;

(2) Role memory and relationships affect emotions;

(3) Scenario atmosphere constraints: indoor/outdoor, combat/plot/leisure;

(4) Emotional reinforcement of narrative nodes: climax, turning point, departure, reunion.

D. GUARANTEE OF CHARACTER EMOTIONAL CONSISTENCY

(1) Stable emotional response patterns for the same character;

(2) Intensity of personality and identity constraints expression;

(3) Avoid OOC (Out of Character) expressions and actions;

(4) Unified style across multiple scenes and storylines.

E. EFFECTIVENESS EVALUATION SYSTEM

Objective indicators and user subjective evaluations were conducted from six dimensions: naturalness, richness, synchronicity, role consistency, immersion, and performance consumption. Please refer to Table 4 for details.

TABLE 4. Evaluation Index System of Emotional Effect

Index	Description	Evaluation Standard
Naturalness	Smooth and realistic	Higher better
Consistency	Match character identity	Higher better
Synchronization	Voice-expression-action alignment	Higher better
Richness	Micro-expression and complex emotion	Higher better
Performance	Frame rate and latency	Lower better

To quantify subjective experiences, we employed a 7-point Likert scale and professional blind testing. "Naturalness" is measured by the discrepancy score between AI-generated sequences and ground-truth motion capture data, while "Consistency" is evaluated through cross-scene behavior matching tests. These metrics are statistically processed using a T-test to verify the "significant improvement" ($p < 0.05$) reported in the empirical results.

F. EMPIRICAL RESULTS AND ANALYSIS

In our controlled experiment involving 50 participants comparing the proposed system against traditional state-machine animations, the Emotional Naturalness score (on a 7-point Likert scale) increased from 3.2 to 5.8 ($p < 0.01$). Quantitative analysis of facial AU restoration showed a 42% reduction in Mean Squared Error (MSE) compared to the baseline. Furthermore, user empathy tests using the Interpersonal Reactivity Index (IRI) demonstrated a significant increase in the Empathic Concern subscale ($t=4.52$, $p < 0.05$), providing empirical evidence for the system's effectiveness.

VII. CONCLUSION AND PROSPECT

A. RESEARCH CONCLUSION

(1) We have constructed a five layer technical architecture and full process chain for digital human technology driven emotional expression of animated game characters, achieving a closed loop from emotional understanding to multimodal output.

(2) Propose an emotional cognition and modeling method that integrates character personality and narrative constraints, making emotional expression more in line with character identity and solving the problem of "no character characteristics".

(3) Developing multimodal generation and collaborative synchronization technology for high-precision facial micro expressions, body posture, and emotional speech, significantly improving naturalness and realism, effectively alleviating pain points such as stiffness, facial paralysis, and dissonance.

(4) Realize lightweight real-time rendering and engine adaptation, meet the industrialization and real-time operation needs of animated games, and have engineering implementation capabilities.

(5) Empirical evidence shows that the proposed technology can significantly enhance character emotional expression, player immersion, and artistic appeal of the work, with broad application prospects.

B. MAIN INNOVATION POINTS

(1) Constructing a role-playing emotional model to enable digital individuals to have stable personality and narrative logic in their emotional expression;

(2) Propose a cross modal emotion level synchronization mechanism to achieve high synergy between speech, expression, and action;

(3) Developing micro expressions and continuous emotion generation technology to break through the limitations of traditional fixed expressions;

(4) Develop a real-time lightweight rendering solution that can be directly embedded into mainstream game engines for commercial deployment.

C. RESEARCH PROSPECTS

(1) Combining physiological signals (heart rate, respiration, micro tremor) to further enhance realism;

(2) Deepen AI autonomous emotional decision-making and achieve long-term emotional memory and relationship evolution in an open world;

(3) Expand the stylized emotional expression system such as anime, ink painting and national style;

(4) Build a fully automated AIGC role emotion generation pipeline;

(5) Explore multi role interactive emotional fields and group emotional expression techniques.

AUTHOR CONTRIBUTIONS

Conceptualization –Xiao'ou Ji and Juan Song; methodology – Xiao'ou Ji and Juan Song; investigation – Xiao'ou Ji and Juan Song; writing-original draft preparation – Xiao'ou Ji and Juan Song. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research was supported by, Initiation Funds for High-level Talents Program of Xi'an International University: Research on Adaptive and Lightweight "AI + Video" Teaching Assistance (grant no. XAIU2025114)

ACKNOWLEDGEMENTS

Not applicable.

REFERENCES

[1] M. Huang, Z. Ren, F. Yang, et al., "Exploration of the application of virtual digital human technology in rural cultural and tourism-Digital transformation pathways from the perspective of scene theory," Advances in Social Behavior Research, vol. 16, no. 2, 7483, 2025, doi: 10.54254/2753-7102/2025.22030.

[2] S. Chen, L. Yang, Y. Zhang, et al., "Digital Human Technology in ELearning: Custom Content Solutions," Applied Sciences, vol. 15, no. 7, 3807, 2025, doi: 10.3390/app15073807.

[3] Y. Choi K, S. Yoon, and H. Lacey P, “Online game characters’ influence on brand trust: Selfdisclosure, group membership, and product type,” Journal of Business Research, vol. 66, no. 8, pp. 996–1003, 2013, doi: 10.1016/j.jbusres.2011.12.023.

[4] S. M V and M. M V, “Characters of Modern Animated Series in Games and Toys of Preschool Children,” Kul’turnoistoriceskaa Psihologia, vol. 11, no. 2, pp. 80–85, 2015, doi: 10.17759/chp.2015110208.

[5] H. Kazunori, “Topics in Computer Simulation:(Digital Human Technology),” The Proceedings of Mechanical Engineering Congress, Japan, vol. 2019, no. 0, C02103, 2019, doi: 10.1299/jsmemecj.2019.c02103.

[6] S. Lee Y and S. Lee J, “Study on Character Licensing in connection with Animation Gamification Focus on,” Cartoon and Animation Studies, vol. 41, pp. 357–378, 2015, doi: 10.7230/koscas.2015.41.357.

[7] Pulse Evolution Corporation; Pulse Evolution to Showcase Digital Human Technologies at the SeeThru Equity Fall Microcap Investor Conference in New York City, “Journal of Engineering,” 2016.

[8] W. Hongjiang and Z. Haiyan, “Digital human technology and its application in the field of sports medicine and Prospect,” Journal of Applied Science and Engineering Innovation, vol. 1, no. 1, 2014.

[9] D. Eom S, “[Summary of IPSJ Magazine] Digital Human Technologies for Medicine,” Communications of the Korean Institute of Information Scientists and Engineers, vol. 24, no. 2, pp. 66–68, 2006.

[10] Z. ShaoXiang, H. PhengAnn, L. ZhengJin, et al., “The Chinese Visible Human (CVH) datasets incorporate technical and imaging advances on earlier digital humans,” Journal of anatomy, vol. 204, no. 3, pp. 165–173, 2004, doi: 10.1111/j.0021-8782.2004.00274.x.

[11] C. Peng and W. Ling, “Design and Implementation of Multimode Natural Interaction of Game Animation Characters in Mixed Reality: A Novel User Experience Method,” International Journal of High Speed Electronics and Systems, vol. 34, no. 03, 2024, doi: 10.1142/S0129156425400087.

[12] F. Blümel E, M. Schulz, R. Breithaupt, et al., “Enhancing Resilience in Biometric Research: Generation of 3D Synthetic Face Data Using Advanced 3D Character Creation Techniques from HighFidelity Video Games and Animation,” Sensors, vol. 24, no. 9, 2024, doi: 10.3390/s24092750.

[13] M. Ochs, N. Sabouret, and V. Corruble, “Simulation of the Dynamics of Nonplayer Characters’ Emotions and Social Relations in Games,” IEEE Transactions on Computational Intelligence and AI in Games, vol. 1, no. 4, pp. 281–297, 2009, doi: 10.1109/tciaig.2009.2036247.

[14] Brown, “An exploration of gameness, rules and spoilsports in an erotic role play community in World of Warcraft,” Journal of Gaming & Virtual Worlds, vol. 4, no. 3, pp. 259–273, 2012, doi: 10.1386/jgvw.4.3.259_1.

[15] C. Brom, V. Šisler, M. Slussareff, et al., “You like it, you learn it: affectivity and learning in competitive social role play gaming,” International Journal of ComputerSupported Collaborative Learning, vol. 11, no. 3, pp. 313–348, 2016, doi: 10.1007/s11412-016-9237-3.

[16] C. Nardi, “Play Versus Strategy Method: Behavior and the Role of Emotions in the Ultimatum Game,” Italian Economic Journal, vol. 4, no. 1, pp. 91–106, 2018, doi: 10.1007/s40797-017-0070-2.

[17] N. Amani and A. Yuly R, “3D modeling and animating of characters in educational game,” Journal of Physics: Conference Series, vol. 1193, no. 1, 012025, 2019, doi: 10.1088/1742-6596/1193/1/012025.

[18] H. Jang J and Noh, “The Effects of Identification with a Game Character in a Smoking Simulation Game on Perceived Health Risk and Smoking Attitude,” Advanced Science Letters, vol. 23, no. 3, pp. 1673–1676, 2017, doi: 10.1166/asl.2017.8621.

[19] C. Wu and T. Kanai, “Data-driven detailed hair animation for game characters,” Computer Animation and Virtual Worlds, vol. 27, no. 3-4, pp. 221–230, 2016, doi: 10.1002/cav.1700.

[20] Halliday and Heather, “Designing Creatures and Characters: How To Build an Artist’s Portfolio for Video Games, Film, Animation and More,” Library Journal, vol. 141, no. 20, 100, 2016.