Research on AIGC-Driven Automated Generation Methods for Interaction Design in the Metaverse

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Keywords: AIGC, Metaverse, interaction design, automation, generative models, virtual reality, UX

Abstract: With the rapid development of Artificial Intelligence Generated Content (AIGC) and the Metaverse, new opportunities and challenges have emerged in the field of interaction design. Traditional interaction design methods are time-consuming, labor-intensive, and often fail to meet the complex demands of immersive, personalized, and real-time interactive experiences. This study explores a novel approach to automating interaction design generation using AIGC technologies. It investigates the core principles, technical frameworks, and key application scenarios of AIGC in the Metaverse, and proposes a systematic methodology for integrating AI-driven generative models with user-centered design paradigms. The findings aim to provide technical references and theoretical support for future intelligent and scalable interaction design systems in virtual environments.

1. Introduction

1.1 Research Background and Significance

The emergence of the Metaverse has brought about a paradigm shift in how users interact with digital environments. No longer limited to flat screens and static interfaces, users now expect deeply immersive, adaptive, and responsive experiences that closely mimic or even surpass physical-world interactions. These evolving expectations place significant pressure on traditional interaction design workflows, which are often linear, labor-intensive, and unable to rapidly respond to the complexity and dynamism of the Metaverse. At the same time, the development of Artificial Intelligence Generated Content (AIGC) has opened new possibilities for automating and enhancing creative processes. AIGC refers to the use of AI algorithms—such as generative adversarial networks (GANs), large language models, and reinforcement learning agents—to autonomously generate text, images, audio, 3D models, and interactive elements. When applied to interaction design, AIGC has the potential to not only reduce the time and cost of content production but also to unlock new levels of creativity, personalization, and scalability. Therefore, exploring how AIGC can be integrated into interaction design for the Metaverse is both timely and of significant theoretical and practical value.

1.2 Research Objectives and Questions

This research aims to explore how Artificial Intelligence Generated Content (AIGC) can be effectively integrated into the interaction design workflow for the Metaverse, focusing on its potential to enhance creative output, design efficiency, and user engagement. As the Metaverse evolves into a highly complex, interactive, and immersive environment, traditional design approaches struggle to keep up with the demands of real-time adaptability and personalization. In response to this challenge, the study seeks to establish a framework for automated design generation powered by AIGC technologies, examining how tools such as generative models, natural language processing, and machine learning can support the creation of responsive and dynamic interaction systems. The research further investigates whether AIGC-driven workflows can scale effectively to accommodate a wide range of user contexts and preferences, and how such systems influence the quality and depth of user experience. Ultimately, it aims to offer theoretical insights and practical strategies for embedding AI into the core of immersive interaction design.

  DOI: 10.25236/gemmsd.2025.027

1.3 Research Methodology and Structure

To achieve these objectives, the study employs a multi-method approach that combines theoretical inquiry, system modeling, and empirical validation. It begins with a comprehensive review of existing literature in interaction design, AI content generation, and immersive media environments, identifying critical gaps and opportunities at their intersection. Building on this foundation, a cross-disciplinary framework is proposed that merges principles from computer science, UX design, and artificial intelligence to outline how AIGC can be systematically integrated into the design process. A functional prototype based on this framework is then developed to demonstrate practical implementation. Through a series of case studies and user-centered experiments, the research evaluates the prototype's effectiveness in generating adaptive, scalable, and engaging interaction designs. Metrics related to usability, user satisfaction, system adaptability, and creative potential are analyzed to assess the model's performance. Structurally, the paper is organized into six main sections, including the introduction, literature review, theoretical framework, system development, empirical evaluation, and a concluding discussion that summarizes findings, limitations, and directions for future research.

2. Theoretical Foundations of AIGC and Metaverse Interaction

2.1 Evolution and Principles of AIGC

AIGC (Artificial Intelligence Generated Content) refers to advanced AI systems capable of autonomously generating various forms of content, including text, images, sounds, videos, and even 3D models [1]. These systems are primarily built on cutting-edge technologies such as deep learning, natural language processing (NLP), and multimodal generative models, including Generative Adversarial Networks (GANs) and diffusion models. The evolution of AIGC has transformed machines from passive tools that follow predefined instructions into active creators that can autonomously produce high-quality, human-like outputs. This shift has redefined the relationship between humans and machines in creative processes, opening up new possibilities for automated design generation and content creation across various fields such as entertainment, marketing, and virtual environments. Through advanced algorithms, AIGC systems are capable of analyzing patterns, understanding context, and even emulating artistic or writing styles, offering a new era of creative potential and automation.

2.2 Interaction Design in the Metaverse Context

Interaction design in the Metaverse represents a significant departure from traditional user interface (UI) and user experience (UX) paradigms. While traditional UI/UX focuses primarily on user interactions with 2D screens and graphical interfaces, the Metaverse introduces the complexity of 3D spaces, mixed-reality environments, and immersive technologies [2]. In the Metaverse, interaction design encompasses a range of innovative and dynamic features such as embodied interaction, where users engage with virtual worlds through avatars or immersive gestures, multimodal inputs that integrate touch, voice, and haptic feedback, and real-time responsiveness that adapts to a user's movements and behaviors. The continuous evolution of virtual reality (VR), augmented reality (AR), and extended reality (XR) technologies has made it necessary for designers to create environments that are not only intuitive but also adaptive and immersive. This complexity demands new approaches that can scale with the diversity of user behaviors, preferences, and interactions, and that can dynamically adjust to the changing needs of users within these virtual spaces. Interaction design in the Metaverse thus challenges designers to rethink human-computer interaction (HCI) principles, creating engaging, immersive, and responsive experiences that blur the lines between the physical and digital worlds.

2.3 Design Automation and Computational Creativity

Design automation, powered by computational creativity, highlights the growing role of AI in shaping design processes. Computational creativity refers to the ability of AI systems to generate

original and valuable content by mimicking and innovating upon human-designed patterns. Through learning from vast datasets, user interactions, and existing design frameworks, AIGC models can understand and replicate the creative processes that have traditionally been associated with human designers. These models are trained on enormous repositories of design elements, artistic works, and even user-generated content, enabling them to generate new, complex designs that align with specific objectives or creative briefs [3]. This ability to automate design tasks not only alleviates the repetitive aspects of creative work but also enables the generation of highly complex and novel design solutions that may not have been conceived by human designers alone. In virtual environments, AIGC's capacity to handle the intricacies of design complexity is particularly beneficial in generating dynamic interaction schemas, new forms of user engagement, and personalized content that responds to the evolving needs of users. Computational creativity empowers designers to expand the boundaries of what is possible, opening new doors for innovation and automation in areas like virtual world building, game design, digital art, and user experience in interactive environments

3. Technical Architecture of AIGC-Driven Design Generation

3.1 System Framework and Modular Composition

An effective AIGC interaction design system is built on a modular architecture that integrates key components such as input analysis, content generation, interaction logic modeling, and real-time rendering [4]. These modules work together within a layered structure, enabling the system to efficiently process user inputs, generate dynamic content, and deliver immersive, interactive experiences. Input analysis interprets user actions, whether through voice, gestures, or text, while content generation leverages advanced generative models to create designs like avatars, objects, and environments. Interaction logic modeling ensures that these generated elements respond appropriately to user behavior, establishing seamless interactions within the virtual space. Real-time rendering displays the generated content in an immersive, interactive manner, ensuring responsiveness and fluidity. This modular framework supports iterative design, allowing for continuous feedback and optimization, ensuring that the system adapts and improves over time based on user engagement and performance metrics.

3.2 Model Selection and Training Strategies

An effective AIGC interaction design system relies on carefully selected generative models tailored to specific tasks, such as GPT for dialogue systems, StyleGAN for avatar generation, and NeRF for scene synthesis [5]. These models are trained on extensive datasets, including interaction data, design libraries, and multimodal user behaviors, to ensure that the generated content is context-aware, functional, and aesthetically aligned with user preferences. GPT models are used to facilitate natural language interactions, producing coherent and relevant dialogues based on user input. StyleGAN is employed for creating highly detailed and diverse 3D avatars, while NeRF models generate photorealistic 3D environments by synthesizing complex visual scenes. Training these models involves exposure to large amounts of data to enable them to adapt to the specific context of user interactions. This approach ensures that the AI can generate designs that are not only visually appealing but also responsive and relevant to the user's needs and actions, ultimately enhancing the overall experience in virtual environments.

3.3 Human-AI Collaboration Interface

To ensure that the design quality is maintained and that ethical standards are adhered to, the AIGC interaction design system incorporates a co-creation interface. This interface allows human designers to guide, modify, or fine-tune the AI-generated outputs, ensuring that the final product aligns with the designer's vision while taking full advantage of AI's generative capabilities [6]. The co-creation interface acts as a hybrid workflow between human creativity and AI efficiency. It empowers designers to intervene and make adjustments where necessary, providing them with a degree of control over the AI's output. This interface typically includes tools that allow for manual refinement

of designs, as well as the ability to provide feedback on the generated content. This feedback can then be used to inform future iterations, improving the AI's understanding of the designer's preferences and the project's requirements. This collaborative approach is critical for maintaining design integrity, as it ensures that AI's automated content generation process complements rather than replaces human expertise. It also supports ethical design practices, as it allows designers to prevent biases in AI-generated content and ensure that it adheres to ethical guidelines. Ultimately, this human-AI collaboration not only enhances the design process's efficiency and scalability but also ensures that the final output reflects the nuanced vision of human creativity.

4. Core Mechanisms of AIGC-Based Interaction Generation

4.1 Semantic Parsing and Intent Recognition

For meaningful and intuitive interaction design, it is essential for AIGC systems to grasp both the explicit requests and the underlying, often unspoken, intentions of users. This understanding is key to creating interactions that feel natural and responsive, fostering an environment where users can easily communicate with AI systems. Semantic parsing and intent recognition are central to this process, as they enable AIGC systems to decode complex user inputs and infer deeper meanings. Semantic parsing involves analyzing natural language input, transforming it into structured, machine-readable data that reflects the user's words, sentences, and phrases. This process allows the system to break down linguistic elements into discrete units such as keywords, phrases, and grammatical structures, which are then processed to understand the user's message. Intent recognition, on the other hand, goes beyond the surface-level text or commands. It identifies the user's underlying goals, desires, or objectives that drive the interaction, even when these are not explicitly stated. For instance, a user may say, "I want to create a character," but the intent recognition system will also consider the context of the conversation, user preferences, and prior interactions to determine the specific type of character they wish to design, or the context in which they want to use it. This deeper understanding allows the system to recognize when users are expressing frustration, curiosity, or other subtle emotions that might indicate a shift in their needs or engagement.

By combining semantic parsing with intent recognition, the AIGC system gains the ability to interpret not just the words spoken or typed, but also the user's broader objectives and emotions, enabling it to adapt dynamically. This allows the system to guide the interaction more effectively, tailoring responses, content, and the overall user experience in real time. For example, if a user's input suggests confusion or dissatisfaction, the system can adjust its responses to offer clarification or additional options, making the interaction smoother and more fluid. This nuanced understanding of user intent transforms AIGC systems into more than just reactive tools—they become proactive agents that anticipate and respond to user needs in a highly personalized manner. By ensuring that the AI system is continuously aware of both explicit commands and implicit desires, it fosters richer, more meaningful engagement in dynamic, immersive environments like virtual spaces or interactive simulations.

4.2 Behavior Modeling and Predictive Feedback

To further enhance the user experience, AIGC systems incorporate behavior modeling techniques that predict and adapt to user actions. Using reinforcement learning and behavioral clustering, the system can analyze patterns in user behavior, learning how individuals typically interact with the environment and respond to various stimuli. By understanding these patterns, the system can proactively adjust the interaction flow, anticipating user needs before they are explicitly expressed. For example, if a user frequently engages with certain types of content or tends to navigate virtual spaces in specific ways, the system can anticipate these behaviors and adjust the virtual environment or interface elements accordingly. This predictive feedback model enhances the immersion and engagement of users, creating a more intuitive and seamless experience by preemptively aligning the system's responses with user expectations.

4.3 Adaptive Content Rendering and Real-Time Integration

Once content is generated, it must be rendered and integrated into the Metaverse environment in a way that maintains continuity and immersion [7]. Adaptive rendering engines are crucial for this task, as they ensure that the content, whether it's visual elements, dialogues, or interactive components, is updated and displayed in real time, adapting to changes in the environment and user interactions. These rendering engines are designed to adjust the visual presentation based on factors like user behavior, contextual relevance, and system performance, ensuring that the virtual environment remains visually coherent and engaging. Real-time integration of content ensures that the interaction logic, from avatar movements to environmental changes, is consistent and responsive, preventing any disjointed or unnatural transitions. This capability allows the system to continuously adapt and evolve as users interact with the Metaverse, creating a dynamic and immersive experience that feels authentic and fluid.

5. Application Scenarios and Evaluation

5.1 Virtual Social Spaces and Avatar Interaction

In virtual social platforms, AIGC plays a crucial role in enhancing user interaction by dynamically generating various aspects of social engagement. It can generate realistic conversational scripts, allowing avatars to engage in meaningful dialogues with users, while also creating emotional expressions and gesture-based responses that mimic human behavior. This not only boosts the sense of social presence but also allows for more organic, diverse interactions that evolve in real time. As AIGC systems analyze user input and context, they are able to adjust avatars' behaviors, tone, and responses based on the flow of conversation, making interactions feel more natural and immersive. This approach eliminates the need for rigid, pre-scripted dialogues, allowing virtual environments to react flexibly to the nuances of each interaction. Users can engage with avatars or other participants in ways that feel spontaneous, thereby deepening emotional connections and enhancing the overall social experience in virtual spaces.

5.2 Smart Virtual Retail and Exhibition Spaces

AIGC technology also has transformative potential for virtual retail and exhibition environments within the Metaverse. By leveraging real-time content generation, AIGC can dynamically create personalized experiences that guide users through virtual spaces. Interactive guides can be tailored to individual preferences, helping users navigate complex retail or exhibition environments with ease [8]. This includes the generation of adaptive product showcases that adjust in real time based on user behavior, interests, or even past interactions. In e-commerce, for example, AIGC can create virtual shopping assistants that provide personalized product recommendations, virtual try-ons, or interactive demonstrations. In cultural exhibitions, AIGC can generate context-aware narratives, guiding users through the history and significance of exhibits, offering a customized tour experience. The ability to adapt content on the fly reduces the need for constant manual updates, increasing operational efficiency and keeping the virtual environment fresh and engaging for users, ultimately enhancing user satisfaction and engagement.

5.3 Education and Training in Immersive Contexts

In the realm of education and training, AIGC enables the creation of highly interactive and adaptive learning environments that can be tailored to the needs of individual learners. For educational content, AIGC can generate immersive, context-specific materials that respond to students' learning styles and progress [9]. This adaptability extends to training simulations, where AI can dynamically adjust difficulty levels, feedback mechanisms, and role-playing scenarios to provide a personalized learning experience. By monitoring user performance, AIGC systems can offer real-time feedback, adapt challenges to the learner's proficiency, and even modify scenarios to provide a more realistic or challenging environment. This flexibility not only enhances engagement but also maximizes learning outcomes by ensuring that each user receives the right level of challenge and support. Whether it's in

technical skills training, soft skills development, or subject-specific education, AIGC's ability to create a tailored, immersive learning experience makes it an invaluable tool for modern education and training programs.

6. Conclusion

This study demonstrates the transformative potential of AIGC in automating interaction design for the Metaverse. By integrating deep generative models with semantic understanding and behavioral prediction mechanisms, AIGC systems can autonomously generate adaptive, immersive, and user-centric interactive experiences. The research presents a structured framework and technical pathway for implementing AIGC in practical design workflows, while also highlighting the importance of human-AI collaboration to balance creativity, control, and ethical considerations. Future work will focus on refining AI co-creation interfaces, addressing data bias, and extending the system to support cross-platform Metaverse interoperability.

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