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Study on the Gestalt-Based Approach to Optimizing 3D Game Interface Layouts

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Abstract: As virtual reality (VR) technology continues to evolve, the user interfaces of 3D games are progressively shifting from conventional two-dimensional paradigms towards immersive, multi-dimensional environments, thereby substantially enriching the realism and experiential depth for users. However, this shift has also brought about design challenges such as complicated spatial layout, decreased interaction efficiency, and insufficient device adaptability. In this regard, there is an urgent need to introduce a scientific visual perception theory to guide the design. This paper takes the Gestalt principle as the theoretical basis and aims to explore its applicability and optimisation value in 3D game user interface design. Through a combination of literature review and typical case analysis, relevant findings from recent years are systematically sorted and analyzed. It is found that the laws of proximity, similarity, closure and continuity in Gestalt principles have significant guiding significance in the layout of 3D interfaces, which can effectively improve the order of interface structure and the efficiency of information conveyance, and boost the user's sense of immersion and smoothness of operation. Moreover, it proposes a set of optimization strategies for 3D game interface design based on Gestalt principles, offering a feasible reference for enhancing the rationality of interface layout and the convenience of user interaction.

Keywords: Gestalt Principles, Interface Layout Optimization, 3D Game Interfaces, Virtual Reality, User Experience

1. Introduction

With the rapid advancement of virtual reality (VR) technology, 3D game interfaces are gradually transitioning from traditional two-dimensional screen interactions to immersive, multi-dimensional interactive environments. This shift significantly improves the sense of reality and participation of user experience, but it is also accompanied by a series of new design challenges such as the increase in interface spatial complexity, the appearance of differences in equipment adaptability, and the decrease in user operating comfort. In this context, the effective organization and communication of information within 3D interfaces has emerged as a pressing issue in interaction design. Gestalt psychology, as a classic theory of visual perception, stresses that human beings tend to integrate separated elements into an orderly whole based on the principles of similarity, proximity, continuity and closure in the perception process. This theory has been widely used in 2D user interface design to enhance information readability and interface logic. However, the application of this concept in 3D game interface design is still in its nascent stage, with existing research being sparse and lacking comprehensive exploration and practical direction. Thus, this study aims to explore the applicability

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and optimisation potential of Gestalt principles in 3D game interface design. By analyzing relevant literature and comparing typical game cases, it summarizes the adaptive features and expressions of Gestalt principles in 3D environments, exploring their strategic applications in optimizing interface layout, guiding user attention, and thus improving interaction efficiency. This paper may serve as a reference for game interface design and advancing related design methods.

2. Gestalt principles and user perception

2.1. The theoretical basis of Gestalt principle

Gestalt, derived from German, refers to a concept of wholeness and structure. Known as Gestalt psychology, it examines visual perception, emphasizing the holistic nature of stimulus interpretation [1,2]. Humans naturally organize visual information into coherent wholes [3]. In interface design, Gestalt principles, based on the laws of visual perception, provide a scientific cognitive framework for information organization. Key principles include proximity, similarity, continuity, closure, and figure-ground relationship. In particular, the proximity principle holds that elements close to each other are perceived as a group. For example, in 3D games,task icons are clustered in the lower right corner to help players quickly locate key information. The similarity principle aids classification via consistent shapes or colors. For example, in the character skill bar, attack skills are represented by uniform angular icons and a red color, making it easier for players to distinguish between functions. The continuity principle directs visual flow through lines or curves. For example, in an open-world scene, river or mountain outlines guide the exploration path. The closure principle encourages users to complete incomplete figures. For example, a task prompt may appear as translucent fragments that blend into a full information panel when approached, improving the interactive experience. The figure-ground principle uses contrast to distinguish the subject from the background. In a battle interface, an enemy’s health bar in low contrast helps players quickly identify the target. These principles streamline information structure, guide user actions, and reduce cognitive load in 3D interfaces, providing a framework for dynamic interaction design and interface optimization.

2.2. Gestalt and visual perception

The application of Gestalt principles in visual perception can effectively solve common problems in 3D game interface design like information overload, visual confusion and difficulty in identifying key information. For example, in dynamic scenes, dense interface elements greatly increase visual load, making it difficult for players to quickly locate task prompts or health bars. The interactive nature of multi-dimensional spaces can also lead to operational confusion, raising cognitive costs. To address these issues, Gestalt principles offer systematic solutions through scientifically-based visual organization strategies. Information overload can be alleviated via the principle of proximity, which groups similar elements using consistent colors or shapes, thus reducing visual clutter and cognitive load. For example, placing the skill bar and inventory button close together creates logical groupings, reducing interface fragmentation. In Genshin Impact, the shortcut menu is placed at the screen edge to minimize visual distractions. The principle of similarity addresses visual confusion by standardizing the attributes of similar elements. In Cyberpunk 2077, main quests are highlighted in yellow, contrasting with gray side quests, which simplifies categorization. The figure-ground principle addresses the difficulty in identifying key information by enhancing the separation of the subject from the background. In Death Stranding, pulse lighting highlights important cargo, making it stand out against the dark terrain and preventing players from missing their target due to visual clutter. These strategies reduce visual load and cognitive conflict, transforming complex interfaces into intuitive cognitive wholes, with proximity optimizing organization, similarity speeding decision-making, and figure-ground focusing visual attention.

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2.3. The use of Gestalt theory in design

The Gestalt principle boosts the functionality, aesthetics, interactive experience, and spatial layout by translating perceptual laws into design language. In visual communication design, the principle of closure stimulates the psychology of completeness by simplifying graphics, for example, the use of incomplete graphics in logo design triggers brand associations; the principle of figure-ground relationship highlights the core information by contrasting and layering, for example, the separation of the highlighted blood bar and the low-saturation background in the battle interface to avoid visual confusion. In UI/UX design, the similarity principle strengthens categorization logic through uniform colors and shapes like red and blue icons for attack and defense skills to distinguish attack and defense skills in a character attribute panel, reducing cognitive load. The continuity principle uses dynamic light trails or path outlines to guide the direction of interaction, replacing traditional arrow indicators and enhancing intuitive navigation. In spatial navigation design, the unity principle builds spatial order through coherent arrangement of environmental element, such as evenly spaced torches in a dungeon that form a visual rhythm to naturally guide player movement. By simplifying the hierarchy of elements, implying logical connection and guiding the flow of attention, a complete cognitive picture is constructed in the limited visual information. For 3D game interfaces, Gestalt principles shape a complete cognitive framework through minimal visual cues, supporting design logic, aesthetics, and practical application.

3. Features and challenges of 3D game interface design

3.1. Features of 3D game interface design

Powered by VR and intelligent interaction technologies, 3D game interface design transcends flat screen limitations, thus emphasizing spatial logic and immersive multi-dimensional perception. By streamlining information hierarchy, leveraging natural interaction methods like gestures, voice, and eye tracking, integrating dynamic visual cues with multisensory feedback to balance immersion and functionality, and expanding VR interaction through artificial intelligence, these trends collectively shape an immersive gaming ecosystem.

3.1.1. Spatial multidimensionality and dynamic interaction

In 3D game interfaces, spatial multidimensionality relies on a hierarchical layout of elements within a three-dimensional coordinate system, using depth relationships to convey information priorities and operation paths. Dynamic interaction involves user interaction with the interface during spatial and temporal transformations, such as viewpoint switching, object movement and state feedback. Together, they define the core dimensions of 3D interface interaction, surpassing the limitations of 2D interfaces and revealing more complex structures and dynamics. For example, in the inventory interface of The Elder Scrolls V: Skyrim, items are displayed as rotating 3D models, allowing users to view equipment details from different angles. And this enhances the intuitiveness of information retrieval while boosting the interface’s sense of hierarchy and realism. Free camera rotation and zooming as dynamic interactions allow users to select their focal points, thereby improving spatial exploration and reducing cognitive overload caused by information clutter. In addition, spatial navigation mechanisms are crucial in complex scenes. For example, in the navigation system of No Man’s Sky, the interface dynamically suggests the target orientation and path through spatial arrows, distance scales, and perspective distortion, guiding users to efficiently complete tasks in 3D space. Prior studies showed that 3D perspective shifts and spatial transition animations greatly boost users’ cognitive consistency of interface structure [4]. Together, spatial multidimensionality and dynamic

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interaction mechanisms expand information organization, increase user autonomy, and strengthen control, laying the foundation for an immersive interactive experience.

3.1.2. Immersive experience and natural interaction

The key to 3D game interface design is achieving an immersive experience via the integration of visual, auditory, and motion perceptions, thus creating a seamless and realistic virtual environment. Natural interaction is the core mechanism for achieving immersion, focusing on controlling virtual objects via real-world actions to minimize the gap created by intermediary devices. By integrating multiple input methods, this approach enhances the intuitiveness and immersion of user operations. Head tracking synchronizes perspective and gaze direction, gesture recognition supports grabbing and rotating, eye tracking aids interface response focus, and voice input provides a quick command channel. The synergy of these technologies creates a low-latency, responsive interaction system. For instance, in the VR game Half-Life: Alyx, users control their view through head movements and interact with objects by picking them up or throwing them using hand gestures. The system offers immediate physical feedback like object collision sounds or vibrations, creating a closed-loop of perception, action, and response. The reality principle plays a crucial role in such interfaces by simulating physical laws, such as gravity and inertia, as well as object behaviors like door opening or object collisions, which boost the user's ability to anticipate interaction outcomes. For example, the simulated acceleration of falling virtual objects replicates real-world gravity, enhancing the naturalness and credibility of interactions. From a cognitive psychology standpoint, immersive experiences depend on the continuity of the interaction loop, where user intentions are validated through multisensory feedback, thus enhancing the sense of presence and immersion. This process not only boosts game engagement but also optimizes interface interactions and user satisfaction.

3.1.3. Multimodal input and multichannel feedback

Multimodal input refers to the interface supporting various interaction methods like voice, gestures, touch, and eye tracking to meet the needs of different operating contexts. Multichannel feedback conveys interaction results and system status through sensory channels like visual, auditory, and haptic feedback. Together, they collaborate to create a more flexible and inclusive 3D interface interaction system. Each input modality has distinct advantages and applicable scenarios: voice is ideal for quick commands, gestures for spatial operations, touch for precise selections, and eye tracking for focus determination and menu activation. Reasonable redundancy design enhances the fault tolerance of the system, for example, when gesture tracking is affected by occlusion or lighting, speech can replace the same operation to ensure that the task is not interrupted [5]. At the output end, multi-channel feedback strengthens action confirmation and environmental understanding. For example, in a VR scenario, when a user activates a mechanism, the system simultaneously triggers a button color change (visual), a gear sound effect (auditory), and controller vibration (haptic), thereby enhancing perceptual consistency and immersion. In high-paced, multi-tasking settings, cross-modal cues like voice alerts and flashing indicators help reduce visual strain and prevent cognitive overload. The essence of sensory synergy is to manage information density and pacing, ensuring that each modality complements rather than duplicates, preventing information overload. Research has shown that moderate multimodal synergy can improve the user's operational efficiency and reaction speed, especially for complex 3D task environments. Therefore, the synergy of multimodal input and multichannel feedback enhances the flexibility and closed-loop sense of interaction, and lays the foundation for the intelligence and immersion of 3D game interfaces.

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3.2. The challenges of 3D game interface design

3.2.1. The absence of standards and the reconstruction of design syntax

At present, 3D game interface design lacks a framework of design standards and a universal syntax, failing to establish a mature framework that matches the established system for 2D interfaces. In comparison to the well-established standards 2D interfaces, 3D interfaces are still experience-driven and lack unified standards to guide the design practice of spatial hierarchy, operation logic, visual metaphors, and other design elements. Due to the characteristics of different platforms, designers often have to reconstruct the visual language. For example, they may need to design new interface elements such as spatial menus, floating buttons, and 3D icons, which increases the trial-and-error cost during the design process and requires designers to possess cross-disciplinary skills, such as spatial modeling, motion path planning, and knowledge of perceptual psychology [6]. In addition, the lack of unified interfaces and specifications between platforms makes it difficult to migrate 3D interface designs across platforms, especially the huge challenge of design sharing between devices such as VR and AR, which hinders the realisation of multi-platform converged experiences. To cope with this dilemma, it is crucial to develop unified design standards and guidelines, alongside the promotion of modular interface component libraries, to enhance design reusability, streamline collaboration, and improve cross-platform compatibility. Through this systematic reconstruction of design syntax, 3D game interfaces can achieve higher scalability and consistency, laying the foundation for collaborative multi-platform development [7].

3.2.2. Hardware heterogeneity and individual user differences

As 3D game interface design adapts to a variety of interaction terminals, such as VR headsets, AR glasses, somatosensory gloves, and haptic feedback devices, hardware heterogeneity becomes a major challenge in the design. These devices have obvious differences in performance, resolution, field of view, tracking accuracy and response time, which directly affect the interface display and response strategy. For example, the high resolution and large field of view of VR devices provide a more immersive visual experience, while low-resolution devices may result in a blurred interface and affect the quality of interaction; the accuracy and latency performance of somatosensory gloves also affect the perception of operation. Therefore, the design needs to be flexible to cope with these differences to ensure efficient and accurate interaction feedback under different devices. In addition, differences in users' physiological structures (e.g., pupil distance, hand length), cognitive abilities (e.g., spatial construction, task decomposition), and physical tolerance (e.g., tendency to motion sickness) make it difficult for a "universal interface" to satisfy the needs and comfort of all users [8]. For this reason, 3D interface design needs to introduce the principle of configurability in the design stage, combining parameter adjustment, adaptive layout and user profile analysis to find a balance between universality and individuality. This design strategy can not only improve the inclusiveness of the interface, but also enhance the user experience and satisfaction, and ensure that the needs of different user groups are effectively met.

3.2.3. High interaction density and physiological load control

In 3D games, players often juggle multiple windows, switch perspectives instantly, and manipulate objects, all demanding interfaces that pack more info and react lightning-fast. Without proper hierarchical management of task channels and visual focus, cognitive overload can easily occur. In addition, immersive experiences require users to maintain specific body gestures for a long period of time or frequently rotate their heads and eyes, which may cause physiological discomforts such as vertigo and muscle fatigue, especially when parallax processing and frame rate optimisation are

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insufficient [9]. In order to alleviate these problems, interface design needs to combine ergonomic and perceptual psychology principles, such as avoiding frequent forced viewpoint switching, optimising the information presentation tempo, and setting dynamic focus cues and other strategies. These designs improve interaction efficiency while simultaneously reducing users' physiological load. They maintain immersive interfaces without compromising comfort, minimizing discomfort from prolonged use. Through reasonable design adjustments, we can ensure the consistency of the immersive experience, avoid the impact of physiological load on user engagement, and achieve balance and sustainability in long-time interaction.

4. Optimization strategies for Gestalt principles in 3D game interfaces

4.1. The optimization in interface layout design

Interface layouts optimize information delivery and attention distribution through visual hierarchy and spatial perception in 3D virtual environments. For example, Overwatch adopts dual-coding via hue and shape to differentiate attack/defense skill icons, thus enhancing novice players' recognition accuracy; Eldon Ring highlights the objectives of the main quest through the golden ratio and the dynamic contrast hierarchy, which enhances the visual prominence; and Death Stranding makes use of the "soft containment" technique by employing translucent masks and closed strokes to divide the functional areas. Through the Gestalt principles of clustering, contrast and closure, the interface structure is optimized to reduce the cognitive burden and improve the efficiency of information retrieval. With the development of technology, the interface layout is gradually evolving towards intelligence, and AI-assisted design is beginning to be applied to interface dynamic adaptation and focus prediction, and personalised interface adjustment and operation path optimisation based on players' behavioural data. For example, Cyberpunk 2077 pushes contextual prompts based on the player's location and mission status. Future advancements in AR projection and screenless display technologies will dissolve interface constraints, integrating informational prompts directly into game worlds. This will give rise to ambient smart information fields that exist in symbiosis with the environment.

4.2. The optimisation in interaction design

The enhancement of cognitive flow in three-dimensional interactive environments necessitates compliance with biological attention allocation mechanisms and cognitive schema formation. The proposed tri-level model of guiding-simplifying-unifying, via synthesized environmental-interactive design, demonstrably improves dual metrics of interaction fluidity and systemic intelligibility. In guided interface design, The Legend of Zelda: Breath of the Wild utilizes the principle of continuity to achieve UI-free natural navigation through the dual-channel guidance of stone path spacing and dynamic light pillars; and the alchemy interface of Genshin Impact utilizes the principle of closure to activate the perfect mental shape through the animation closure of defective circles to enhance the coherence of operation. In terms of cognitive load management, Final Fantasy XIV combines Miller's Law and progressive expansion design to optimise complex information hierarchies; and It Takes Two strengthens the perception of operational causality through multi-modal feedback such as visual trails and tactile vibrations, verifying the effectiveness of cross-sensory synergy. In terms of cross-platform consistency, the three-layer hot zone structure of Minecraft adapts to multi-device input, maintains the topological constancy of spatial relationships, and ensures the coherence of interaction habit migration. In the future, next-generation interfaces will increasingly incorporate non-traditional inputs like voice commands, gestural controls, eye-tracking and BCI technologies, as pioneered by Half-Life: Alyx's revolutionary button-less interaction paradigm utilizing gaze tracking. And AI and big-model technology will dynamically generate operation guidance based on the player's mental model and behavioural prediction, thus creating adaptive cognitive interaction entities. This evolution signals a shift from static templates to responsive, empathetic co-processors that engage users in real-time spatial computing environments.

4.3. The optimisation in user feedback

In 3D games, effective feedback mechanisms require a careful balance between immediacy, gradual progression, emotional engagement, and tolerance for user error. In terms of immediacy, systems enhance immersion through synchronized multisensory feedback. For instance, Hades activates the reward circuitry with coordinated animation, sound effects, and haptic responses, while Sekiro enhances the realism of action feedback through particle effects and precise vibrations. Gradual feedback conveys risk and progress through incremental information delivery. In The Witcher 3, toxicity warnings employ expanding color gradients to convey escalating danger, while Ghost of Tsushima enhances the perception of progress via experience bars designed with flowing ink effects. Emotional feedback strengthens the player's affective connection. Animal Crossing fosters a sense of accomplishment through Gestalt experiences, while Devil May Cry 5 synchronizes animations with player rhythm to amplify neural feedback from operations. Fault-tolerant design improves reaction speed by optimizing visual cues and interaction rhythms: Deathloop alleviates anxiety from network latency, and Assassin's Creed: Valhalla enhances threat recognition by visually separating backgrounds. Looking ahead, feedback systems based on affective computing and neural mechanisms will offer personalized, dynamic responses, adjusting feedback intensity in real time through physiological signal monitoring to deepen immersion and aid emotional regulation. AI will construct emotional profiles based on player behavior, advancing feedback toward greater empathy and adaptability.

5. Conclusion

As virtual reality and 3D gaming technologies continue to evolve, a key challenge in game design is how to achieve orderly layouts and efficient information delivery within increasingly complex and multidimensional interactive environments. Thus, this paper investigates the applicability of Gestalt perception principles in 3D game interface design and explores optimization strategies based on these principles. Specifically, it demonstrates how core Gestalt laws, such as proximity, similarity, closure, and continuity, can be leveraged to structure spatial hierarchies, guide visual attention, and improve interaction efficiency. Based on both literature review and case studies, it integrates a set of practical strategies for optimizing 3D interfaces. These strategies highlight the importance of balancing immersive experience with cognitive clarity, thereby enhancing perceptual legibility and promoting more intuitive user interaction. The findings indicate that Gestalt principles not only simplify visual complexity in 3D environments but also establish a cognitively coherent order that supports users' understanding and willingness to engage with virtual systems. Looking forward, as multimodal perception and intelligent interaction technologies continue to advance, these principles are poised to become increasingly integral to 3D interface design, providing both a theoretical basis and practical strategies for crafting immersive, user-friendly, and visually compelling experiences.

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