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From 2D Plane to 3D Space: Virtual Reality's Spatial Reconstruction of Visual Communication Ontology

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Abstract:

With the rapid advancement of digital technology, virtual reality has revolutionized visual communication design. Traditional graphic design, limited to two-dimensional representation, is now redefined by virtual reality, which offers a three-dimensional immersive environment that redefines the presentation and dissemination of visual information. This study focuses on how virtual reality technology overcomes the spatial limitations of graphic design, aiming to construct a visual communication system with deep perception. By analyzing the spatial narrative logic and interaction mechanisms of virtual environments, it is found that multi-dimensional spaces can enhance the effectiveness of visual information expression and improve the audience's real perceptual experience. Virtual reality extends visual elements in depth, motion, and time through spatial reconstruction, opening up new possibilities for visual communication design. This technological innovation not only broadens design techniques but also profoundly influences the audiences' cognitive methods and aesthetic experiences.

Keywords: Virtual reality; visual communication; spatial reconstruction; dimension; ontology

1. Introduction

The rapid advancement of digital technology has brought unprecedented opportunities for transformation in visual communication design. Traditional graphic design, long constrained by two-dimensional representation, struggled to fully convey the three-dimensional layers and dynamic interactivity of information. With the maturation of virtual reality (VR) technology, its three-dimensional immersive capabilities have provided the necessary technical support to overcome these limitations. This technology creates a virtual environment with depth perception, enabling visual elements to dynamically extend across spatial dimensions, thus revolutionizing the traditional flat presentation of information.

The current field of visual communication is at a critical stage of transitioning from static surfaces to dynamic spaces. Virtual reality technology, supported by hardware such as head-mounted displays and spatial positioning systems, combined with methods like parallax gratings and integrated imaging, enables design works to achieve realistic depth effects. This transformation is not only technical but also fundamentally transforms design thinking—— Designers need to rethink the organization of visual information from new perspectives, such as spatial storytelling and user perspective shifts. Current achievements primarily focus on superficial improvements in technical implementation and user experience, lacking a deep exploration of the ontology of visual communication. AR (Augmented Reality) technology creates interactive scenes that blend the virtual and the real, but most research remains at the level of functional implementation, failing to systematically reveal the coding logic and cognitive patterns of visual elements in three-dimensional space.

Digital technology is driving a transformation in visual communication design, while traditional graphic design is constrained by its two-dimensional nature. Virtual reality technology, with its three-dimensional immersive capabilities, overcomes these limitations by creating a deep perception virtual environment, thus extending the spatial dimensions of visual elements. The field is currently transitioning from static two-dimensional layouts to dynamic spaces, yet most existing research focuses on the surface aspects of technology and experience, lacking a deeper exploration of the fundamental principles of visual communication.

2. Theoretical Basis of Virtual Reality and Visual Communication

2.1 The Ontological Evolution of Visual Communication

The ontological evolution of visual communication reflects the deep interaction between media technology and human cognitive methods. From traditional print media to the virtual reality environments of the digital age, the essential attributes of visual communication have undergone a qualitative transformation from static symbols to dynamic spaces. In the era dominated by printing technology, visual communication primarily relied on two-dimensional media such as paper and posters, characterized by a fixed graphic symbol system. As Wang Yiwen noted, this medium acts like a mirror, reflecting the designers intentions unidirectionally, with audience participation strictly limited to the visual perception level. At this time, the essence of visual communication emphasized the principles of formal aesthetics, such as grid systems and color contrasts, which are key elements of graphic design.

The rise of digital technology has, for the first time, challenged this traditional ontological foundation. Computer interfaces have expanded visual communication to a window mode, allowing users to engage in the information acquisition process through simple interactions like clicking and sliding. This shift has given visual communication its initial interactive features, though its spatial representation remains confined to the two-dimensional plane of the screen. The introduction of new media art language has further propelled the evolution of this ontology. Zhou Meng notes that visual communication is gradually moving towards virtual reality and interactive communication. For instance, hover effects and dynamic charts in web design have begun to show the potential for multidimensional space-time expression, but due to the physical limitations of display media, their perception of spatial depth remains significantly limited.

The maturation of virtual reality technology has ultimately achieved a spatial reconstruction of the essence of visual communication. As media forms transition from windows to doors, the fundamental nature of visual communication has undergone a significant transformation: Firstly, information carriers have expanded from two-dimensional surfaces to three-dimensional environments with depth coordinates, allowing visual elements to be arranged hierarchically based on their spatial positions. For instance, in a virtual exhibition hall, key exhibits can be given visual prominence through z-axis depth settings, which aligns better with human spatial perception than size comparisons in flat designs. Secondly, the interaction dimension has evolved from simple gestures to full-body movements, enabling users to interact with the virtual space through natural behaviors like head turns and limb movements, thereby integrating the visual communication process with the users physical experience.

This ontological evolution has also profoundly transformed the logic of visual information organization. Traditional graphic design relies on the linear guidance of visual flow, whereas in virtual environments, information presentation follows the non-linear principles of spatial storytelling. Designers need to create a cognitive map for three-dimensional scenes, enabling users to discover the connections between information nodes through self-exploration.

From a philosophical perspective, virtual reality has redefined the relationship between the subject and object in visual communication. In the era of flat media, there was a clear boundary between creators and audiences; however, in immersive virtual environments, users continuously alter the visual presentation through their interactions, thereby participating in the process of information recreation. This enhancement of inter-subjectivity shifts the

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focus of visual communication from the author-centered to the experience-centered approach, where its intrinsic value is not only in the visual form itself but also in the dynamic interaction between users and the virtual space. Zhou Linxi emphasis on the trend towards interactive communication is fully reflected here, indicating that the essence of visual communication has evolved from material visual symbols into a composite system encompassing behavior, space, and cognition[1].

The current ontological framework of visual communication exhibits multidimensional integration: in the technical dimension, it integrates 3D modeling, real-time rendering, and spatial positioning; in the perceptual dimension, it unifies visual, auditory, and somatosensory inputs; in the cognitive dimension, it coordinates spatial memory, logical reasoning, and emotional experiences. This comprehensive ontological attribute signifies that visual communication has transcended traditional aesthetic boundaries, evolving into a medium bridge connecting physical space with digital experiences.

2.2 Spatial Characteristics of Virtual Reality Technology

The core feature of virtual reality technology is its construction of a three-dimensional space, which completely transforms the limitations of traditional visual communication on a two-dimensional plane. Through computer-generated simulated environments, virtual reality creates a three-dimensional space with depth, breadth, and height, allowing visual elements to extend freely in all three dimensions. Unlike traditional two-dimensional planes, this three-dimensional characteristic enables visual elements to be arranged and move according to the physical laws of the real world, providing a more realistic means of visual communication.

Virtual reality technology simulates the depth perception mechanism of human eyes in the real world through the parallax effect and binocular parallax principle. When users wear head-mounted display devices, there are subtle differences between the images received by the left and right eyes, and the brain produces stereoscopic vision by processing these differences, so as to perceive the depth information of virtual space [2]. This kind of depth perception ability is not available in traditional graphic design, which makes visual communication from simple graphic representation to three-dimensional expression with spatial hierarchy (Figure 1).

The spatial characteristics of virtual reality are also evident in its dynamic interactivity. Users are not just passive observers; they can interact with visual elements in the virtual space in real time through controllers, gestures, or eye tracking. This interaction breaks the traditional one-way communication model of visual information, making the process more active and personalized. Designers can leverage this feature by incorporating interactive visual elements into the virtual space, such as rotatable 3D models and disassemblable mechanical structures, allowing users to gradually acquire information as they explore. This spatially interactive approach to visual communication significantly enhances the clarity and memorability of the information.

The spatial characteristics of virtual reality have introduced a new dimension to visual communication. Designers are no longer confined to the rules of flat composition but must consider three-dimensional design elements such as visual flow, line of sight guidance, and interaction hotspots within the space. This shift not only broadens the possibilities of visual expression but also demands that designers acquire new spatial thinking and skills. In virtual spaces, visual elements can be arranged according to the importance of the information, distributed across different depth levels, and their logical connections can be implied through spatial positioning. This approach is more intuitive and efficient compared to traditional flat layout methods [3].

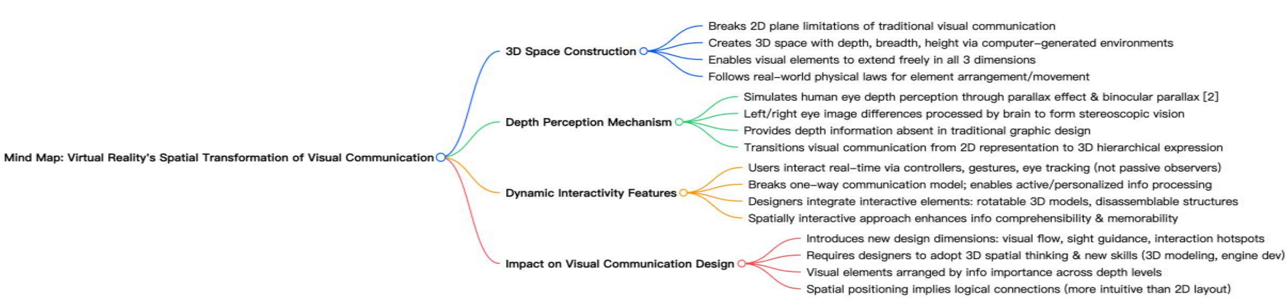

Fig.1. VR's spatial transformation of visual communication framework (Picture credit: Original)

3. Organizational Logic of Visual Information Narrative in Three-dimensional Space

3.1 The Construction of Hierarchical System Dominated by Deep Clues

In traditional two-dimensional design, the hierarchy of visual information is primarily achieved through color contrast, size differences, and positional arrangements. While this method can establish a basic visual order, it tends to lead to confusion when the information becomes more complex. In three-dimensional space, the construction of visual hierarchy benefits from richer dimensions and a more natural logic, with depth cues becoming the core element in constructing the information hierarchy.

Binocular disparity is the fundamental physiological mechanism for perceiving three-dimensional space. When users wear virtual reality devices to observe scenes, the images received by their left and right eyes differ slightly due to the angle of view. The brain interprets these differences to determine the distance of objects. Designers can leverage this principle by placing key interactive elements, such as function buttons and important operation prompts, in the foreground to create a stronger sense of depth in the users visual system, making them the natural focal point. Meanwhile, background environments and auxiliary information are placed in the middle and background, with their depth reduced by adjusting the disparity parameters, allowing users to subconsciously distinguish the importance of the information [4]. Adjusting convergence is also crucial for constructing information hierarchies. When the human eye observes objects at different distances, the lens must change shape to achieve clear focus, and both eyes will converge. In virtual scene design, the content that requires the users attention is set at an appropriate focus distance to ensure a clear and sharp visual effect, while secondary content is blurred, simulating the visual differences experienced when observing objects at different distances. This approach physiologically guides users to prioritize key information.

The atmospheric perspective effect arises from the scattering of light by the atmosphere in the real world. The farther an object is, the thicker the atmospheric layer that blocks its light, leading to a decrease in color saturation, reduced contrast, and blurred outlines (Figure 2). In virtual scenes, this principle is replicated by using low-saturation, high-blurriness visual treatments for decorative elements and background landscapes in the distance, suggesting to users that these elements are secondary. In contrast, the main elements in the foreground are kept high in saturation and detail, creating a stark contrast that establishes information priority in the users mind. Occlusion relationships are also crucial for conveying depth. In three-dimensional space, fully exposed objects are perceived as closer to the observer and are more likely to attract attention. By adjusting the spatial relationship between objects, designers can place core information at the center of the view, free from occlusion, while designing auxiliary information to be partially obscured. This approach leverages the human visual systems natural preference for complete objects, guiding the distribution of users attention.

These deep insights are not isolated but work together to form a comprehensive hierarchical system. For instance, in the design of virtual museum exhibits, the core artifact model is placed in the foreground, highlighted by large parallax and clear focus. The textual information about the artifact is displayed as semi-transparent floating panels slightly behind the artifact, using atmospheric perspective to reduce its visual impact. The historical scenes in the background are blurred and low-saturated, with some elements partially obscured by the foreground, ensuring that the display space remains rich in information while clearly presenting the hierarchy of artifact-introduction-background. Users can naturally perceive the importance of each part without deliberate effort

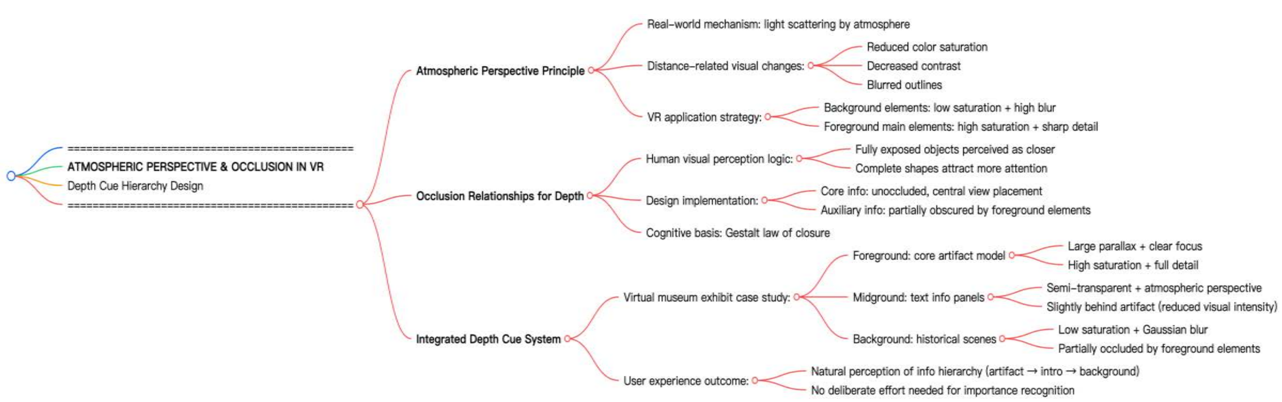

Fig.2. Atmospheric perspective & occlusion in VR framework (Picture credit: Original)

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3.2 Narrative Structure Design Driven by Motion Trajectory

The three-dimensional space breaks the static limitation of the two-dimensional plane, so that visual elements can move freely in space, and the movement trajectory becomes the key element to drive information narrative. In the virtual reality environment, the user's movement and the movement of visual elements are intertwined with each other, and a dynamic narrative structure is constructed together [5].

The coupling of spatial movement and visual flow forms the foundation of narrative through motion. The path users take in virtual spaces directly influences the sequence and pace of information presentation. For instance, on a virtual city tour, designers can connect key points such as landmarks and historical sites using ground light trails or aerial guidance beams, creating a clear and coherent spatial path. As users follow this path, information about attractions and historical stories is presented sequentially based on their location, making the experience as natural and smooth as a real-life tour. Additionally, the spatial movement.

The design of the line can also incorporate suspense and surprise elements, such as setting up turns and hidden passages in the path. When users explore these areas, special visual effects or hidden information are triggered to increase the interest and exploration of the narrative.

The sequential arrangement of dynamic elements adds rhythm and emotion to the narrative. Different types of information can convey distinct narrative intentions through variations in movement speed, direction, and duration. For crucial core information, such as key data and main arguments, a slow-in and slow-out animation effect can be used, with a slower movement speed and longer display time to draw users attention for an extended period. For secondary information like supplementary explanations and background details, faster and smoother movements, such as quick pans and flickers, can be employed to convey information without distracting from the core content. In virtual product launches, the core functions of the product can be showcased through dynamic effects like slow rotation and partial enlargement[6]Users can observe in detail from all aspects; while the auxiliary content such as product parameters and technical highlights is briefly presented in the form of scrolling subtitles and flashing icons, which are clearly divided into primary and secondary, so as to ensure the integrity of information and avoid user fatigue due to information overload.

The construction of multi-dimensional narrative spaces further expands the possibilities of storytelling. In traditional flat or linear video narratives, users can only receive information in a predetermined sequence. However, in virtual reality, users can trigger parallel narrative lines or branching stories through various movement paths. For instance, in a virtual historical story experience, as the main plot unfolds, if a user chooses to explore a specific room or touch an object, they might trigger a side story about the background of that scene. This multi-dimensional narrative approach transforms users from passive recipients of information into active participants in the narrative. Every action choice by the user can influence the storys development and the information they receive, greatly enhancing the fun and depth of the information conveyed. It also meets the personalized information needs of different users [7].

4. Cognitive Impact: Re-examine the Visual Communication Effect of Immersive Experience

4.1 Reconstruction of Information Reception Cognitive Paradigm

In the era dominated by traditional two-dimensional graphic design in visual communication, the information reception model exhibited a flat focus characteristic. Designers guided users attention through carefully designed visual focal points and clear visual flows, leading users to passively follow the preset paths to receive information. However, the three-dimensional spatial perception provided by virtual reality has completely transformed this model, shifting users from passive viewers to active explorers, thus forming a new paradigm of three-dimensional exploration in information reception [8].

In the VR environment, users enjoy unprecedented control over their viewpoint. They can freely explore every corner of the virtual space by turning their heads and moving their bodies, actively searching for and obtaining the information they need. This autonomous exploration mode breaks the limitations of fixed visual focal points in flat design, allowing users to choose what they focus on based on their needs and interests. For instance, in virtual building design presentations, users can not only view the buildings exterior from a standard angle but also move inside to freely examine the room layout, decorative details, and even zoom in on specific structures to gain a deeper understanding of the design process. This active cognitive process, compared to passive viewing, helps users form a deeper memory of the information because they invest more attention and cognitive resources during exploration, significantly enhancing the depth of information processing.

Multimodal fusion further strengthens the innovation effect of this information receiving paradigm [9]. Virtual reality technology integrates visual, auditory, and tactile experiences, creating a richer and more realistic sensory experience for users. Visual elements provide intuitive images, auditory elements guide direction and create an atmosphere through spatial sound effects, and tactile feedback enhances the realism of interactions through controller vibrations and force feedback. In virtual game navigation systems, visual arrows at intersections, directional sound cues, and controller vibrations during turns work together to help users quickly and accurately understand navigation instructions, reducing the risk of misinterpretation or omission that can occur with single visual information. The integration of multiple modalities also reduces cognitive load by complementing and verifying different sensory inputs, making it easier and more efficient for users to process complex information, thus improving the efficiency and accuracy of information reception.

Animation movie conveys the connotation of animation to audience through visual symbols, and audience-oriented improves aesthetic ability diversifies creative design. This paper starts with analysis communication design technology in animated films, analyzes principle images, realizes production films by using multi-visual 3D modeling texture rendering technology. The Sobel edge operator is introduced optimize image data movies, so as improve quality movies. development trend discussed, characteristics for mutual influence between them are analyzed. In order explore expression methods quantitative was conducted current film works.

4.2 The Construction of Emotional Resonance from the Perspective of Embodied Cognition

According to the embodied cognition theory, human cognition, emotion and body experience are closely related, and body perception and movement experience will profoundly affect our understanding of the world and emotional response. In virtual reality environment, this theory has been fully verified and expanded, and users body participation becomes a key factor in the construction of emotional resonance.

The users body movements deeply engage in the narrative process, significantly enhancing emotional engagement. In traditional media, user interaction with content is often limited to basic actions like clicking and swiping, with minimal physical involvement and indirect emotional experiences. However, in virtual reality, users can interact fully with the virtual environment through real body movements. When users escape from a virtual disaster scene by dodging or touch replicas of cultural relics in a virtual historical setting, every movement interacts in real-time with the virtual environment. This embodied experience transforms the story from an abstract fictional plot into a reality that users can personally experience. The emotional engagement is far more intense than traditional viewing or reading, as the tension, excitement, and shock generated during the actions deeply integrate with the story content, creating lasting emotional memories [10].

The authenticity of the scene plays a crucial role in evoking emotional resonance. Virtual reality technology, through high-precision modeling, realistic lighting and shadow rendering, and detailed material representation, can create highly realistic virtual environments. In virtual public service advertisements, the lifelike fur texture of endangered animals, their sorrowful gaze, along with spatial sound effects that match their living environment, and the interactive responses of the animals when users approach, can quickly evoke users sympathy and desire to protect. Compared to the single visual presentation of traditional advertisements, this immersive experience is more impactful and emotionally resonant. Users are more likely to project their emotions onto virtual objects in highly realistic scenes, fostering a sense of resonance. Additionally, the authenticity of the scene enhances users trust and immersion, making them more willing to accept and identify with the information and values conveyed in the virtual environment, thus achieving more effective emotional communication and value transmission [11].

5. Conclusion

This study systematically explores the spatial reconstruction effects of virtual reality technology on visual communication design, revealing the transformation mechanism from two-dimensional to multi-dimensional and its impact on design practice. Through theoretical analysis, it shows that augmented reality, with its features such as three-dimensional coordinate systems, depth perception, and dynamic interaction, significantly expands the dimensions of visual communication and narrative possibilities. The static symbol system of traditional graphic design transforms into a composite expression system in the virtual environment, incorporating spatial positioning, motion trajectories, and interactive feedback, making information delivery more aligned with human natural cognitive habits. This transformation not only requires designers to master new spatial thinking and interaction design skills but also prompts adjustments in visual communication education, emphasizing the cultivation of 3D modeling and user experience.

Future research can delve into the following areas: First, the integration of VR and AR technologies is worth

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exploring. The complementary strengths of these two technologies could lead to more flexible mixed reality visual communication solutions. Second, studying the differences in visual communication effects across cultural backgrounds is of significant value. Different cultural groups may have distinct habits for receiving information in virtual spaces. Additionally, as hardware becomes lighter and display technology advances, optimizing the visual comfort of virtual environments and reducing physiological discomforts such as dizziness remain key challenges in the application of these technologies.

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