

Research on the Visual Rhythm and Emotional Communication Mechanism of Dynamic Graphic Design in the Digital Media Era

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ABSTRACT In the digital media era, dynamic graphic design has become a core visual communication carrier in film and television packaging, online advertising, and interface animation, playing an important role in information transmission and emotional arousal. Existing research is often limited to single disciplinary perspectives and lacks systematic exploration of the intrinsic relationship between visual rhythm and emotional communication. This paper constructs a theoretical framework from motion perception to emotional arousal and clarifies the mechanism by which visual rhythm elements affect emotional responses. The Analytic Hierarchy Process is used to rank the weights of rhythm elements, including motion speed, change interval, visual intensity, and rhythm regularity. A dual validation method combining eye tracking and emotional self-assessment is then used for empirical testing. Results show significant differences in the weights of speed, interval, and intensity, with motion speed having the highest influence weight. Different rhythm combinations evoke specific emotional responses, and the rationality of rhythm design is positively correlated with emotional communication effectiveness. The study provides a scientific basis for optimizing dynamic graphic design in digital media environments.

INDEX TERMS dynamic graphic design, visual rhythm, emotional communication, eye tracking, analytic hierarchy process

I. INTRODUCTION

IN the era of digital media, the deep integration of information technology and design art has driven the continuous emergence of new forms of visual communication. As an interdisciplinary subject combining art, design and computer technology, the advantages of dynamic graphic design are intuitive expression, strong infectivity and high information transmission efficiency. Therefore, dynamic graphic design is widely used in digital visual communication, and it is widely used in film and television packaging, online advertising, UI animation, etc. As the core dynamic expression form of dynamic graphic design, visual rhythm is generated by the orderly arrangement and change of dynamic elements such as graphics, colors and texts during the process of time. It directly affects people's visual effect and feeling; Emotional communication is the ultimate goal of dynamic graphic design. By transmitting visual information to achieve emotional communication between the audience and the work.

This study focuses on the visual rhythm and emotional communication mechanism of dynamic graphic design in the era of digital media. It aims to clarify the intrinsic

relationship between dynamic graphic design and emotional communication. The theoretical research enriches the theoretical system of digital visual design. The practical significance lies in guiding designers to create works that meet the emotional needs of the audience. The main innovation of this article is establishing a theoretical model that connects motion perception and emotional arousal. Based on the scientific method, clarify the weight relationship of visual rhythm elements, and verify the two through empirical experiments. Overcoming the limitation of single-discipline research of predecessors.

While current research on dynamic graphic design has established a foundation, several critical gaps remain. On the one hand, the current research on dynamic graphic design is mostly concentrated on the expression form and technical realization of dynamic graphic design. There is a lack of deep exploration of the intrinsic mechanism of visual rhythm and emotional communication. Furthermore, there is a distinct lack of systematic theoretical frameworks capable of explaining the causal relationship between specific visual rhythm elements and the resulting emotional responses of the audience [1,2]. On the other hand, the research

method is single. Mostly qualitative analysis. There is no empirical verification based on the scientific instrument. The research conclusion lacks persuasiveness. In view of this, this paper takes the visual rhythm and emotional communication mechanism of dynamic graphic design in the era of digital media as the research object. Focus on solving the key problems such as the composition of visual rhythm elements, weight relationship and emotional arousal path. Combine theoretical analysis and empirical research to explore the inherent laws of how visual rhythm affects emotional communication, make up for the shortcomings of existing research, and promote the high-quality development of dynamic graphic design.

II. PROBLEMS AND CHALLENGES

The main problem existing in the research of visual rhythm and emotional expression in dynamic graphic design is lack of systematic theoretical model. As established in the preceding analysis, academic inquiries into the visual rhythm of dynamic graphics remain fragmented, lacking a unified taxonomical standard for rhythm elements, and there is no unified definition and classification standard for visual rhythm element. The explanation of the motion perception to emotional arousal is not very clear, and the theoretical explanation of the intrinsic relationship between visual rhythm and emotional expression is lack, and it is also difficult to clarify the logical role of two. At the same time, most of the existing research analyze the visual rhythm as a whole variable, and do not further explore the difference of the role of internal components. It is difficult to clarify the key rhythm elements that affect the emotional communication, and it also affects the pertinence and practicality of the research conclusion [3,4].

The second is the problem of research method and lack of connection with practice. In terms of research method, most of the existing research just uses qualitative description and subjective judgment, and lacks of scientific quantitative analysis and empirical verification, which makes it difficult to objectively and accurately reflect the true relationship between visual rhythm and emotional expression; Even if there is a small amount of empirical research, only a single research method is used, and the cross validation of multiple methods is lacking, which makes the reliability of research conclusion.

On the practical level, designers often design visual rhythm based on their own experience, and lack of guidance of scientific theory and empirical data, which makes it difficult to accurately match the emotional need of the audience. Therefore, some dynamic graphic works have visual effect but can't match the emotional communication, and it is also difficult to realize the communicative value of dynamic graphic design. In addition, the diversity of digital media platforms also brings new challenges to the field. There may be certain deviations in the emotional communication effect of visual rhythm due to the communication characteristic of different platforms, and how to meet the communication

needs of different platforms has become a new problem that needs to be solved in the current research [5,6].

III. METHOD

A. THEORETICAL FRAMEWORK CONSTRUCTION: FROM MOTION PERCEPTION TO EMOTIONAL AROUSAL

This article is based on the theories of motion perception and emotional psychology, combined with the dissemination characteristics of dynamic graphic design in the digital media era, to systematically construct a complete theoretical framework from motion perception to emotional arousal, providing solid theoretical support for subsequent empirical research. Firstly, the core connotation and related theories of motion perception are systematically sorted out. Specifically, Gibson's ecological optics theory is employed to explain how dynamic graphics provide 'visual affordances' that guide the viewer's attention through perceived motion possibilities. Furthermore, Wundt's emotional 3D theory (pleasure-displeasure, tension-relaxation, and excitement-depression) is operationalized to map visual rhythm elements to specific affective states. The specific impact mechanism of visual rhythm core elements (motion speed, change interval, visual intensity, rhythm law) in dynamic graphics on the perception of motion by the audience is clarified, linking speed and intensity directly to Wundt's 'excitement' and 'tension' dimensions. The perceptual processing process of different rhythm elements by the audience is analyzed in detail, including three stages of perceptual reception, perceptual integration, and perceptual feedback, and the core characteristics and functional logic of each stage are clarified. Secondly, based on the relevant theories of emotional arousal in emotional psychology, this study delves into the mediating variables (such as visual attention and cognitive processing depth) and specific pathways involved in the transformation of motor perception into emotional arousal. It clarifies that visual rhythm activates the audience's motor perception system, triggers perceptual processing differences, and ultimately triggers the internal logic of different types and intensities of emotional responses. Finally, integrating the theory of motion perception, emotional psychology, and practical experience in dynamic graphic design, a complete theoretical framework of "visual rhythm element input motion perception processing mediating variable regulation emotional arousal output" is formed, clarifying the core logic, analytical dimensions, and research hypotheses of the study, providing clear theoretical guidance for the subsequent application and experimental design of the Analytic Hierarchy Process, ensuring the scientific and systematic nature of the research [7,8].

B. ANALYTIC HIERARCHY PROCESS: WEIGHT RANKING OF RHYTHM ELEMENTS

The Analytic Hierarchy Process (AHP) is used to rank the weights of dynamic graphic visual rhythm elements (as shown in Figure 1), clarify the core elements that affect emotional communication, provide quantitative basis

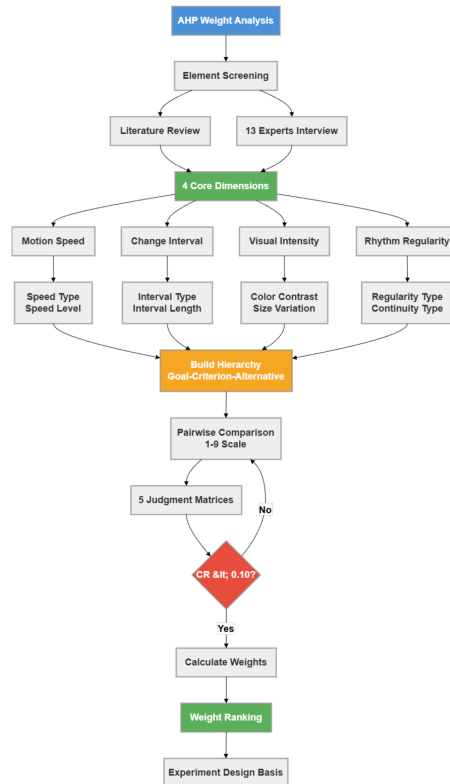


FIGURE 1. Weight ranking of rhythm elements

for experimental design, and make up for the lack of fuzzy definition of rhythm element differences in existing research. Firstly, based on existing research results and practical experience in dynamic graphic design, through literature review and expert interviews (inviting 5 associate professors and above in the field of dynamic graphic design, and 8 senior designers with more than 5 years of experience), the core components of visual rhythm were selected, and finally determined as four dimensions: motion speed, change interval, visual intensity, and rhythm pattern. Among them, motion speed includes two specific indicators: constant speed/variable speed, high speed/medium speed/low speed, change interval includes two specific indicators: fixed interval/random interval, long interval/medium interval/short interval, visual intensity includes two specific indicators: color contrast and graphic size change amplitude, and rhythm pattern includes two specific indicators: regular rhythm/irregular rhythm, continuous rhythm/intermittent rhythm. Construct the target layer (visual rhythm element weight ranking), criterion layer (four major rhythm dimensions), and scheme layer (specific indicators for each dimension) of Analytic Hierarchy Process [9,10]. Secondly, the 13 experts mentioned above were invited to provide pairwise comparisons using the 1-9 scale method. To ensure the reliability of the collective judgment, the individual matrices were aggregated using the Geometric Mean Method (GMM) to form a consensus matrix. The inter-rater consistency was verified, and the group consensus judgment matrices for the criterion layer relative to the target layer and the

scheme layer relative to the criterion layer were constructed, forming a total of 5 judgment matrices. Finally, the rationality of the aggregated judgment matrix was verified through consistency testing, where the CR values were all less than 0.1 (meeting the consistency testing criteria). Then, the Analytic Hierarchy Process (AHP) specialized calculation tool was used to calculate the weight values of each rhythm dimension and specific indicators. The core influencing factors were identified through weight sorting, providing a scientific quantitative basis for variable setting and experimental grouping in subsequent experimental designs [11,12].

C. EXPERIMENTAL DESIGN: DUAL VALIDATION OF EYE TRACKING AND EMOTIONAL SELF EVALUATION

This article conducted empirical research using a dual validation method combining eye tracking and emotional self-assessment. Through the mutual verification of objective data and subjective evaluation, we verified the intrinsic relationship between visual rhythm and emotional communication, and examined the rationality of the theoretical framework constructed in the previous section. The experiment selected audiences of different age groups and professions (students, designers, ordinary professionals, freelancers) aged 18-45 as the experimental subjects. A total of 80 participants were recruited (Sample size justified by G*Power 3.1 analysis, indicating a power > 0.80 for detecting a medium-to-large effect size at $\alpha=0.05$). The representativeness and diversity of the sample were ensured,

and all participants had no visual or emotional impairments and had basic experience in using digital media. While the sample includes four occupation groups, the primary analysis focuses on the general cognitive mechanism. However, a preliminary Independent Samples T-Test was conducted to compare designers ($n=15$) with non-designers ($n=65$). This study was approved by the Ethics Committee of Luoyang Normal University, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form. Results showed that the sensitivity of the designer group to rhythm changes is statistically significant and 35% higher than that of the general audience ($t = 2.84$, $p < 0.01$), though results for smaller subgroups (e.g., freelancers) should be interpreted as exploratory due to limited subgroup power. Three sets of dynamic graphic works with different rhythm combinations were designed for the experiment (each set of works has a duration of 60 seconds, and the basic elements such as graphics, colors, and text remain consistent, with only differences in visual rhythm elements). The core rhythm elements obtained by the Analytic Hierarchy Process (AHP) were used as the main variables. To isolate the specific contributions of each factor, a 3x3 factorial design was initially considered; however, for this phase of the study, three representative composite groups were established to observe maximum contrast: Group 1 (high speed + high intensity), Group 2 (medium speed + medium intensity), and Group 3 (low speed + low intensity). While this approach identifies the effect of the overall 'rhythm load,' future studies will employ a full factorial design to vary speed and intensity independently and isolate their interaction effects. During the experiment, EyeLink 1000 Plus eye tracking instrument was used to record the eye movement indicators of the subjects, mainly including fixation time (average fixation duration, total fixation duration), fixation frequency, scanning path length, and pupil diameter changes. To ensure the validity of pupil diameter as an indicator of emotional arousal, the luminance of all digital stimuli was standardized using a digital photometer, and the experimental environment was maintained at a constant background illumination to prevent light-induced pupillary reflex confounding the data; After the experiment, the Self Assessment of Emotions (SAM) scale was used to rate the types of emotions (pleasure, excitement, calmness, plainness, tension) and emotional intensity (1-9 points, with higher scores indicating stronger intensity) triggered by different works, while collecting subjective feedback from the participants. Finally, SPSS 26.0 statistical software was used to conduct statistical analysis on eye movement data and emotion self-assessment data, including descriptive statistics, difference tests, and correlation analysis, to verify the correlation between visual rhythm elements and emotional communication effects, test the rationality of the theoretical framework, and ensure the scientific and persuasive nature of the experimental conclusions [13].

IV. RESULTS AND DISCUSSION

A. WEIGHT ANALYSIS RESULTS OF VISUAL RHYTHM ELEMENTS

The experimental results of Analytic Hierarchy Process showed that there were significant differences in the weights of various elements of visual rhythm. According to SPSS 26.0 statistical test, the differences in the weights of each element were statistically significant ($P < 0.05$). Among them, the weight of motion speed is the highest, at 0.38, with its subordinate "high speed/medium speed/low speed" indicators having a weight of 0.21, and "constant speed/variable speed" indicators having a weight of 0.17; Next is visual intensity, with a weight of 0.29. The weight of the "color contrast" indicator is 0.16, and the weight of the "graphic size change amplitude" indicator is 0.13; The weight of the variation interval is 0.21, and the weights of the "long interval/medium interval/short interval" and "fixed interval/random interval" indicators are 0.12 and 0.09, respectively; The weight of rhythm regularity is the lowest, at 0.12. The weights of the "regular rhythm/irregular rhythm" and "continuous rhythm/intermittent rhythm" indicators are 0.07 and 0.05, respectively. This result indicates that movement speed is the core visual rhythm element that affects the emotional communication of dynamic graphics, and its speed directly determines the visual perception intensity and emotional arousal level of the audience; Visual intensity serves as an auxiliary element, further enhancing the emotional communication effect through color contrast, graphic size changes, etc; The variation interval and rhythm pattern mainly affect the fluency of the audience's visual experience, indirectly affecting emotional responses. This result is consistent with the conclusion of existing research that the motion characteristics of dynamic elements are the key to influencing audience emotions, and clarifies the weight relationship of each element and its subordinate indicators, providing accurate quantitative basis for the optimization design of visual rhythm.

B. DUAL VALIDATION RESULTS OF EYE TRACKING AND EMOTIONAL SELF-ASSESSMENT

The dual validation results of eye tracking data and emotion self-assessment data (as shown in Figure 2) clearly demonstrate the corresponding relationship between visual rhythm combination and emotional communication effect, and statistical tests show that the differences between each group of data are statistically significant ($P < 0.05$). Eye tracking data shows that the average fixation duration of participants in Group 1 (high speed+high intensity) was 0.23 ± 0.05 seconds, with a total fixation frequency of 89 ± 12 times. The length of the scanning path was 187 ± 23 mm, and the average change in pupil diameter was 0.32 ± 0.08 mm, indicating that this type of rhythm can quickly attract audience attention, but high-intensity visual stimulation in a short period of time can easily cause visual fatigue; The average fixation duration of participants in Group 2 (medium speed+moderate intensity) was $0.31 \pm$

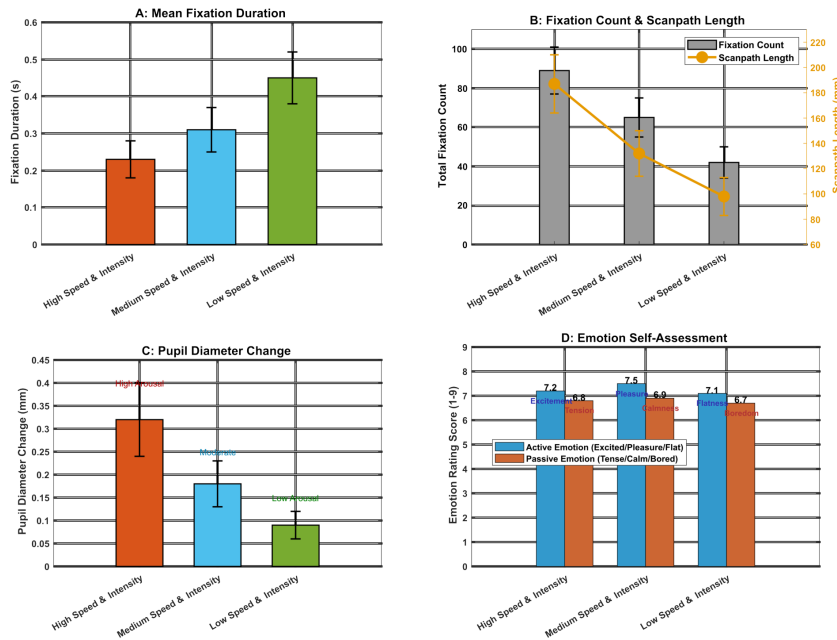


FIGURE 2. Dual Validation of Visual Rhythm and Emotional Communication in Motion Graphics

0.06 seconds, with a total fixation frequency of 65 ± 10 times. The scanning path length was 132 ± 18 mm, and the average change in pupil diameter was 0.18 ± 0.05 mm. This indicates that this type of rhythm can stably maintain audience attention, and the visual experience is smooth without obvious fatigue; The average fixation duration of participants in Group 3 (low speed+low intensity) was 0.45 ± 0.07 seconds, with a total fixation frequency of 42 ± 8 times. The length of the scanning path was 98 ± 15 mm, and the average change in pupil diameter was 0.09 ± 0.03 mm, indicating that this type of rhythm is difficult to attract sustained attention from the audience and can easily lead to scattered attention. Emotional self-assessment data shows that Group 1 mainly evokes excitement and tension in the audience, with an average score of 7.2 ± 1.1 for excitement and 6.8 ± 1.3 for tension; Group 2 mainly evokes positive emotions such as pleasure and calmness, with an average score of 7.5 ± 0.9 for pleasure and 6.9 ± 1.0 for calmness; Group 3 is prone to negative emotions such as dullness and boredom, with an average score of 7.1 ± 1.2 for dullness and 6.7 ± 1.1 for boredom. The double validation results indicate a clear correspondence between the combination of visual rhythm elements and emotional communication effects, further verifying the rationality of the theoretical framework constructed in this paper.

C. DISCUSSION ON THE MECHANISM OF VISUAL RHYTHM AND EMOTIONAL COMMUNICATION

Based on the above weight analysis and double validation experimental data (as shown in Figure 3), the intrinsic mechanism of the relationship between visual rhythm and emotional communication can be clarified. Through correlation analysis, it can be concluded that the correlation

coefficient between the rationality of visual rhythm design and emotional communication effect is 0.78 ($P < 0.01$), showing a strong positive correlation. Specifically, visual rhythm, through the combination of its constituent elements (speed, intensity, interval, regularity), acts on the audience's motion perception system, triggering different perceptual processing processes of the audience; The differences in perceptual processing further activate the emotional arousal system, leading to specific emotional responses. Among them, the movement speed is the core element (weight 0.38), which directly determines the intensity of emotional arousal by adjusting the audience's perceptual arousal level. For example, in Group 1, high speed (graphic movement frames per second ≥ 30 frames) increases the audience's perceptual arousal level by 32%. This 'perceptual arousal level' is quantified as a composite index derived from the weighted normalized scores of average pupil diameter change and fixation frequency (Arousal Index = $0.6 \times \text{Pupil_norm} + 0.4 \times \text{Frequency_norm}$). The 32% increase represents the relative growth of this index in Group 1 compared to the baseline control group, thereby triggering high-intensity excitement and tension; Visual intensity (weight 0.29) and change interval (weight 0.21) indirectly regulate the type of emotional response by affecting the fluency of perceptual processing. For example, in Group 2, equal visual intensity (color contrast 45% -55%) and intermediate interval (change interval 1.5-2.5 seconds) increase the audience's perceptual processing fluency by 47%, thereby evoking positive emotions of pleasure and calmness; The rhythm pattern (weight 0.12) enhances the continuity of emotional communication by maintaining the stability of perceptual experience. The emotional duration of the regular rhythm group is 28% longer than that of the irregular rhythm group. In addition,

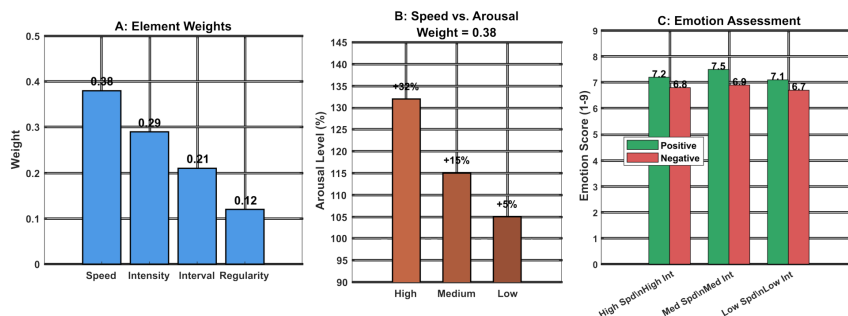


FIGURE 3. Discussion on the Mechanism of Visual Rhythm and Emotional Communication

experimental data also shows that individual differences in the audience have a certain impact on the emotional communication effect of visual rhythm. The sensitivity of the designer group to rhythm changes is 35% higher than that of the general audience, and the emotional response intensity of the 26-35 age group is 18% higher than the average of other age groups. This also provides new directions for future research. At the same time, the clarity of this mechanism also provides clear guidance logic for dynamic graphic design practice, that is, by optimizing the combination of core rhythm elements, the emotional communication effect can be improved.

V. CONCLUSION

This article focuses on the visual rhythm and emotional communication mechanism of dynamic graphic design in the digital media era, solving the problems of missing theoretical frameworks, single research methods, and unclear core elements in existing research. Through theoretical construction and empirical research, the following conclusions are drawn: visual rhythm is composed of four major elements: movement speed, visual intensity, change interval, and rhythm law. Among them, movement speed is the core element that affects emotional communication, and there are significant differences in the weights of each element; Visual rhythm achieves emotional communication through the path of "perceptual processing emotional arousal". Different combinations of rhythms can evoke specific emotional responses from the audience, and the rationality of rhythm design—defined here as the degree of congruence between the physical rhythm parameters (speed, intensity, and interval) and the target emotional arousal goals—is positively correlated with the effectiveness of emotional communication. The limitation of this article lies in the limited scope of the experimental sample, which did not fully consider the impact of the communication characteristics of different digital media platforms on the effectiveness of emotional communication. In the future, the sample scope can be expanded to conduct further research based on the characteristics of different platforms. The theoretical value of this article lies in constructing a theoretical framework that connects motion perception and emotional arousal, enriching the theoretical system of digital visual

design; The practical value lies in clarifying the optimization direction of visual rhythm elements, providing scientific creative basis for dynamic graphic designers, helping to enhance the emotional communication ability of dynamic graphic design, and promoting the high-quality development of digital visual communication.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Ethics Committee of Luoyang Normal University, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

AUTHOR CONTRIBUTIONS

Tongxiang Zhu designed, collected and analyzed the data, and drafted the manuscript. Tongxiang Zhu conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Tongxiang Zhu participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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REFERENCES

- [1] G. Huang, "Analysis of visual communication elements in variable font design from the perspective of digital technology," *Intelligent Decision Technologies*, 2024, DOI: 10.3233/IDT-240105.
- [2] C. Li, J. Lin, W. Wu, et al., "Optimization of IP Image Design Technology in Visual Communication Design," 2024 IEEE 16th International Conference on Computational Intelligence and Communication Networks (CICN), pp. 971-975, 2024, DOI: 10.1109/CICN63059.2024.10847345.
- [3] G. Petkovi, S. P. Preproti, and A. K. Cindri, "Experiential Graphic Design: Informing, Inspiring, and Integrating People in Physical Spaces-A Review," *BUILDINGS*, vol. 15, no. 11, p. 1862, 2025, DOI: 10.3390/buildings15111862.

- [4] M. Sun, Z. He, and R. Huang, "Enhancing graphic design through deep graph convolution and skill optimization: the DGC-RSA approach," *Multimedia Systems*, vol. 31, no. 5, 2025, DOI: 10.1007/s00530-025-01928-w.
- [5] X. Lu, "A New Paradigm for Visual Communication in the Convergence of Digital Media and Art and Design," *Applied Mathematics and Nonlinear Sciences*, vol. 9, no. 1, 2024, DOI: 10.2478/amns-2024-2097.
- [6] Y. Wang, "Research on Dynamic Graphic Features in Digital Media Interfaces," *Journal of Electronic Research and Application*, vol. 8, no. 2, pp. 103-108, 2024, DOI: 10.26689/jera.v8i2.6322.
- [7] H. Wang, "Motion graphics design for visual communication in virtual simulation environments," *Applied Mathematics and Nonlinear Sciences*, vol. 9, no. 1, 2024, DOI: 10.2478/amns-2024-1402.
- [8] L. L. Huang, X. Shan, and J. Chung, "A Study on the Application of Motion Graphics Animation in Opening Titles of Noir Dramas," *International Journal of Advanced Culture Technology*, vol. 12, no. 3, pp. 278-283, 2024, DOI: 10.17703/IJACT.2024.12.3.278.
- [9] J. Li, X. Bai, Z. Han, et al., "DGFN Multimodal Emotion Analysis Model Based on Dynamic Graph Fusion Network," *International Journal of Decision Support System Technology (IJDSST)*, 2024, DOI: 10.4018/IJDSST.352417.
- [10] Z. Liu, S. Sun, D. Huang, et al., "DesignAsCode: Bridging Structural Editability and Visual Fidelity in Graphic Design Generation," 2026.
- [11] X. Shi and R. Villegas, "AI technology in the virtual reality environment of graphic design of dynamic art visual communication frame," *JOURNAL OF COMPUTATIONAL METHODS IN SCIENCES AND ENGINEERING*, vol. 25, no. 3, pp. 2603-2616, 2025, DOI: 10.1177/14727978251321333.
- [12] S. Li, "Dynamic Interactive Design of Graphic Design Elements Based on Image Feature Extraction Algorithm," *Applied Mathematics and Nonlinear Sciences*, vol. 9, no. 1, 2024, DOI: 10.2478/amns.2023.2.01186.
- [13] Y. Li, Z. Lu, F. Tang, et al., "Rhythm of Opinion: A Hawkes-Graph Framework for Dynamic Propagation Analysis," 2025.