Application of Computer-Aided Technology in Digital Graphic Design

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Graphic design emphasizes constructing visual aesthetics using computer-aided platforms, effectively shaping various design elements. A wavelet-based image processing technology solution is proposed for graphic design in response to the increasing demand for image-denoising quality in graphic design. The wavelet decision process transforms the two-dimensional image structure, enhancing the threshold for generating wavelet coefficients, and evaluating them. To enhance image removal and restoration, the author developed an adjustment model based on the wavelet decomposition scale, enabling the setting of a threshold for robust paper data collection. Simulation verification and data analysis results indicate that the image restoration performance of the wavelet and adaptive thresholding methods is nearly equivalent, surpassing both hard and soft thresholding methods. When compared to other methods, the adaptive wavelet threshold setting method employed by the author can enhance the peak signal-to-noise ratio by over 1.3 dB based on the adaptive threshold. Furthermore, the mean square error in image restoration has been reduced in comparison to existing methods, and the structural similarity has improved by more than 5% when contrasted with existing methods. It has been demonstrated that the proposed algorithm is superior in denoising and image restoration in comparison to existing algorithms, with adaptive thresholds effectively elevating the quality of image restoration.

Povzetek: Članek raziskuje uporabo računalniško podprte tehnologije v digitalnem grafičnem oblikovanju s poudarkom na algoritmih za izboljšanje kakovosti slik, odstranitev šuma in restavracijo, ter optimizacijo z valovnimi transformacijami.

1 Introduction

With the development and popularity of the Internet, computer technology is widely used in many fields. Computer-aided technology refers to the process of using a computer platform to complete product design and testing, commonly used in graphic design. The use of technology to show the beauty of graphic design allows designers to gain more knowledge about graphic design while also making the design work clearer [1]. In recent years, computer-aided technology has achieved rapid development under the leadership of computer popularization. Among them, computer-aided technology, as a new technology, has developed the fastest and has made certain contributions to the development of graphic design. With the support of computer-aided technology, graphic design has achieved a good design platform. On this platform, the visual aesthetics of graphic design have been greatly developed, and the support of geometric design functions has made graphic design works more visually diverse.

The integration of computer-aided technology in digital graphic design is depicted in Figure 1. It draws attention to the difficulties that traditional design approaches present for designers, the potential for increased productivity and creativity that comes with technology, and the key goals of this research that are meant to close the gap between these realms. By utilizing computer-aided technology, this research seeks to maximize graphic design's potential while streamlining workflows and encouraging creative innovation. Geometric visual beauty is one of the important pursuit points in graphic design, mainly including important elements such as symmetry and golden sections. Based on this, the most important point in constructing an aesthetic vision in graphic design is the integration and reasonable combination of different geometric elements. The ability of geometric elements to present harmony is a key factor affecting the viewer's evaluation of the work [2].

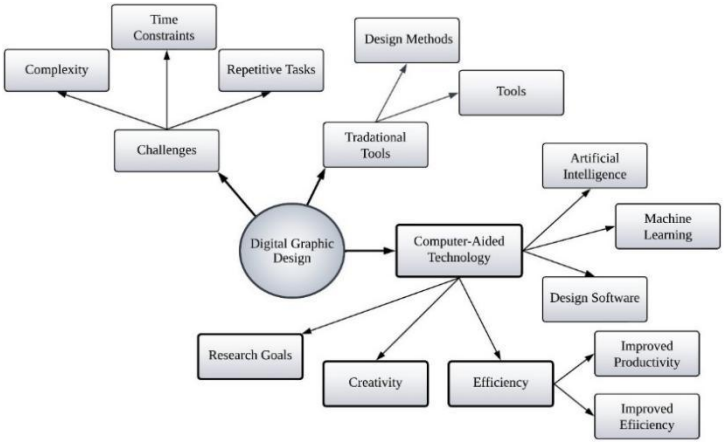

Figure 1: Computer-Aided technology integration in digital graphic design

Therefore, designers need to pay attention to the construction of geometric elements in the process of designing their works, and this process needs to be carried out using computer-aided technology. Designers should use computer-aided technology to process and design elements in their works in order to achieve a balance between the proportions and positional relationships of various design elements and achieve the goal of visually appealing works to the viewer.

The wavelet-based image processing technology relies on the principles of wavelet transforms, which decompose an image into different frequency components, each corresponding to different scales. The wavelet decision process involves selecting the appropriate wavelet function and decomposition level to optimally represent the image's features. This transformation allows for efficient denoising and restoration by isolating noise components in high-frequency sub-bands while preserving essential image details in low-frequency sub-bands. The process transforms images into two dimensions by applying the wavelet transform separately in the horizontal and vertical directions, resulting in a hierarchical multi-resolution representation. Most designers use the principle of composite graphics as a theoretical support in graphic design, and some beautiful applications use hot spots and numerical values so that the work can have a good visual effect, give more visibility to the audience, and improve it. visual performance of the work. gain experience and improve work-related visual performance [3]. The use of visualizing beauty in computer graphic design, on the one hand, comes from the understanding and recognition of aesthetic elements, which further enhances the value of the work. Digital graphic design is a constantly changing subject, and producing visually striking and functional designs presents many obstacles for designers. An increasingly sophisticated and efficient method is required due to the growing complexity of design software and the need for creative design solutions. These needs may outgrow the capabilities of traditional design techniques, so it's critical to investigate the use of computer-aided technology in digital graphic design. The need to increase graphic artist's output and inventiveness is what spurred this research. Because of the limits of traditional tools, designers frequently struggle with tedious, repetitive chores and may miss out on exploring creative design possibilities. It can transform the design process, expedite workflows, and enable designers to achieve unprecedented levels of efficiency and artistic expression by using the power of computer-aided technology. The goal of this study is to offer a thorough grasp of the possible advantages and difficulties of incorporating computer-aided technology into digital graphic design. Through the identification of useful applications, investigation of new trends, and resolution of any drawbacks, the research will offer significant contributions to the design sector and technology developers. In the end, this research aims to close the gap between technology and creativity, opening the door to more inventive and effective digital graphic design solutions.

2 Literature review

With the development of modern computer technology, computers have become auxiliary platforms in various fields. Computer-assisted technology refers to the technical process of designing and testing products based on computer platforms. In computer-aided technology, emphasis is placed on human subjectivity, especially in the visual aesthetics of graphic design. Based on computer-aided technology, geometric design can be effectively carried out. Graphic tools in computer-aided technology are the main design platform for designers, and through computer technology, various elements of product design can be better controlled [4]. With the development of computers, computer-aided technology has made rapid progress, especially in the planning of computer-aided processes, which has promoted the development of new technologies. Moreover, the development of this new technology has, to some extent, been incorporated into the development of graphic design. Computer-assisted technology has built a good platform for graphic design. Based on the design platform, it can provide functional support for visual aesthetics, especially geometric design, making the visual elements of graphic design more diverse. This is one of the biggest characteristics of modern graphic design. The application of computer-

assisted technology in digital graphic design is shown in Figure 2.

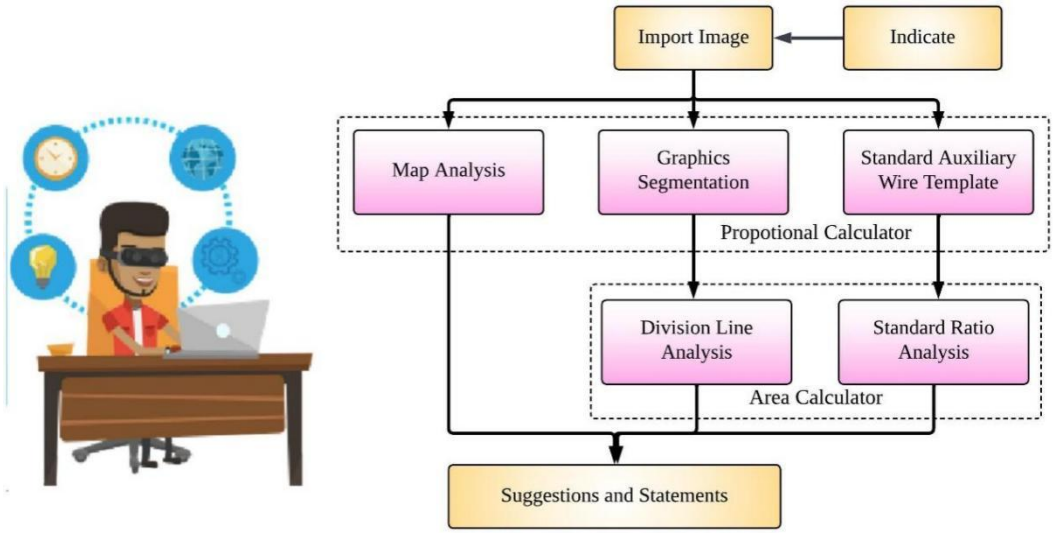

Figure 2: Application of computer-aided technology in digital graphic design

Table 1: Summary of the several studies in the area of digital graphic design

References	Contribution	Technique Used	Benefits	Drawbacks	Solutions
[8]	Contribution of AI in automating design tasks.	Machine Learning, Neural Networks	Increased productivity, reduced manual labor.	Lack of human touch and creativity in designs.	Combining AI with human input for design personalization.
[9]	Exploration of user-centered design principles.	User-Centered Design, Usability Testing	Enhanced user satisfaction and engagement.	Time and resource-intensive.	Streamlining testing processes through automation.
[10]	Impact of Virtual Reality (VR) on graphic design.	Virtual Reality, 3D modeling	Immersive design experiences, new perspectives.	High equipment costs and accessibility challenges.	Develop more cost-effective VR solutions and software.
[11]	Study on the integration of Augmented Reality (AR).	Augmented Reality, Mobile Apps	Enhanced interactivity, real-world design applications.	Limited AR device adoption and fragmentation.	Standardization of AR platforms for consistency.
[12]	Analysis of the role of generative design algorithms.	Generative Design, Algorithms	Automated generation of design variations.	Potential loss of designer's control over the final product.	Balancing automation with designer input for control.
[13]	Investigation of the implications of blockchain in design.	Blockchain Technology	Enhanced security for design assets and intellectual property.	Complex implementation and adoption challenges.	Simplified blockchain integration for designers.
[14]	Study on the importance of sustainability in design.	Sustainable Design Practices, Eco-friendly materials	Reduced environmental impact and social responsibility.	Limited material choices and potentially higher costs.	Research into more sustainable materials and processes.
[15]	Exploration of cross-disciplinary design collaboration.	Collaboration Tools, Design Thinking	Diverse perspectives and innovative problem-solving.	Communication challenges in diverse teams.	Enhanced cross-disciplinary training and communication tools.

[16]	Investigation of cultural influences in design.	Cross-cultural Design, Ethnography	Culturally sensitive and globally relevant designs.	Complexity in understanding diverse cultural contexts.	Cross-cultural design guidelines and frameworks.
[17]	Analysis of the psychology of color in graphic design.	Color Psychology, Neuromarketing	Improved visual appeal and brand communication.	Subjectivity in color perception and context-dependency.	Guidelines for effective use of color in different contexts.

With the rapid development and popularization of the media technology industry, the application scope of graphic design is gradually expanding. The design level has gradually increased its requirements, leading designers to significantly improve the clarity and resolution of images, try to remove noise in the images, and thus improve the quality of the images [5–7]. However, due to limitations at a professional level, the image processing technology of graphic design has not been updated in a timely manner, resulting in stagnant quality of graphic images and difficulty in producing original-level innovative results.

Zhang and Wang, Johnson and Lee, latest advancements in the image processing techniques [18, 19]. Li and Wang offer special models to enhance the experience of complex 3D graphics and visual environments. This course combines virtual reality technology with computer design; VR is an educational platform. Virtual reality technology aims to extend 2D computer graphics (CG) into a realistic 3D experience. Virtual reality technology can be used to support student engagement and learning. Transform educational content through VR education. To see this, there is no user interaction, and it is necessary to create the real world or think in the world [20]. Li et al. proposed the use of the classical FP development algorithm to solve the most common technology problems. The FP processing algorithm has the widest range of applications. It injects the data transfer into the FP tree for processing. It also uses the Apriori algorithm, which improves efficiency by eliminating the need to generate complex candidate frequency components. In addition, this paper uses two main technologies, namely data mining technology and data integration technology, which are the further power of technology to use science in the work of university departments in the information age [21]. The rapid development of new technologies has had a significant impact on graphic design. It not only supports the rapid development of the graphic design industry but also accelerates the change and development of all communication design education. While traditional graphics teaching strategies may not meet the needs of students, graphic design in digital materials can enhance the experience of students who are happy with glowing faces. Therefore, it is important to study the adaptation of new graphic design standards in the digital media environment. Liu analyzed the development of digital media art and graphic design, then explored the relationship between graphic design and digital technology, and finally explored the value and changing importance of digital media technology in graphic design [22]. Table 1 presents the literature in the area of digital graphic design which are briefly summarized, together with information on their contributions, methods, advantages, disadvantages, and possible remedies. This literature addresses a wide range of subjects, including user-centered design, sustainability, and cross-cultural influences, as well as the integration of artificial intelligence and developing technologies. These developments come with drawbacks as well, such as loss of the personal touch, high implementation costs, and cultural complexity, even though they also yield significant advantages like improved productivity, higher user satisfaction, and creative design possibilities. In an effort to overcome these shortcomings, researchers are actively working on solutions that include standardizing new technologies for better application in the graphic design industry, automating processes while allowing for human input, and expediting testing procedures. In response to this issue, the author introduced the technical method of wavelet transformation. The author proposes a wavelet-based graphic design image processing technology solution. On the basis of two-dimensional image modeling, it is proposed to use discrete wavelet technology for image denoising. In response to the significant impact of global thresholds on denoising performance, the author has designed an adaptive wavelet threshold setting method that can be adjusted based on the wavelet decomposition scale.

3 Methods

The methodology employed for this research is depicted in Figure 3, which includes applying wavelet-based approaches in a methodical manner to image restoration.

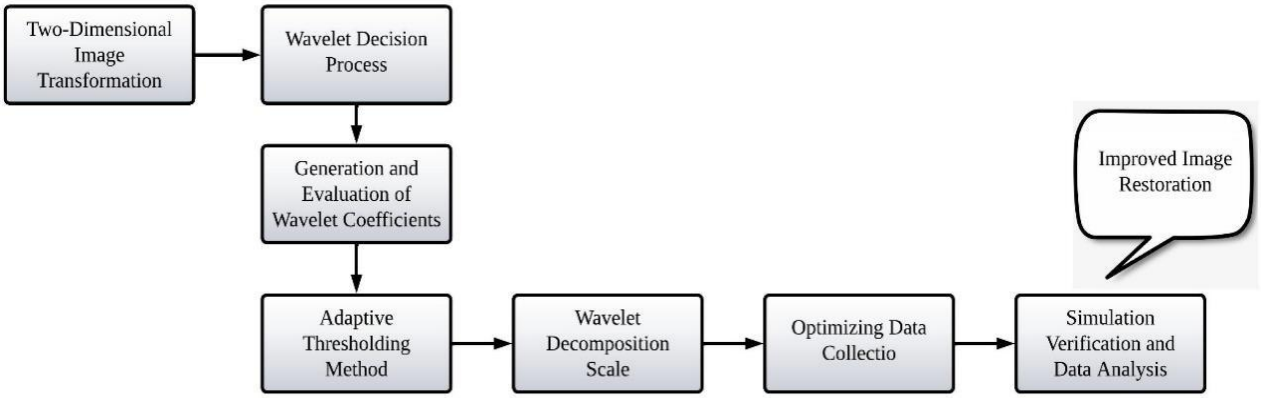

Figure 3: Methodology for adaptive wavelet thresholding image restoration

First, the wavelet decision process was used to transform images into two dimensions. Wavelet coefficients were then produced and assessed by the application of an adaptive thresholding technique. After that, a wavelet decomposition scale was included in the study to determine the threshold and maximize the acquisition of high-quality picture data. In order to evaluate the efficacy of adaptive thresholding over wavelet thresholding, simulation verification, and data analysis were carried out, emphasizing the latter's ability to produce better picture restoration outcomes.

3.1 Image modeling

Image removal and enhancement using wavelet theory requires modeling the image first. In general, a two-dimensional plane image can be modeled as a two-dimensional array F(x,y) described as presented in Equation 1.

$$F = \begin{bmatrix} f(1,1) & \cdots & f(1,N) \\ \cdots & \cdots & \cdots \\ f(N,1) & \cdots & f(N,N) \end{bmatrix} \quad (1)$$

A binary image can be represented as a two-layer set of 0s and 1s, where 0 is black and 1 is white, as shown in Figure 4. For more complex grayscale images, they can be represented as 8-bit binary numbers. 0 is black, 255 is white, and the remaining numbers represent different levels of gray, as shown in Figure 5 [23].

0	0	0	1	1
0	0	1	1	1
0	1	1	1	1
1	1	1	1	1
1	1	1	1	1

Figure 4: Schematic diagram of binary images

0	20	60	90	120
20	60	90	120	150
60	90	120	150	180
90	120	150	180	210
120	150	210	210	255

Figure 5: Schematic diagram of grayscale image

Additive and multiplicative noise can easily affect images during the transmission and processing of images. After being affected by noise, the pixel values can be expressed as presented in Equation 2.

$$F(x,y) = f(x,y) \cdot (1 + n(x,y)) + N(x,y) \quad (2)$$

In the formula: n(x,y) represents multiplicative noise; N(x,y) represents additive noise.

3.2 Wavelet-based image denoising

Wavelet transforms can perform local transformations in the time and frequency domains for multi-scale analysis. The wavelet transformation method is defined as presented in Equation 3.

$$W_f(a,b) = \int_{-\infty}^{+\infty} f(t) a^{-\frac{1}{2}} \varphi\left(\frac{t-b}{a}\right) dt \quad (3)$$

In the formula: f (t) represents the original sequence; φ(·) represents the Fourier transform. The inverse wavelet transform can be expressed as presented in Equation 4.

$$f(t) = \frac{1}{C_\varphi} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} a^{-2} W_f(a,b) \varphi_{a,b}(t) da db \quad (4)$$

$$C_\varphi = \int_{-\infty}^{+\infty} \frac{|\varphi(w)|^2}{w} dw < \infty \quad (5)$$

Frome Equation 5, the wavelet coefficients obtained after wavelet transformation require threshold quantization processing. Perform denoising on multiple scales, removing the wavelet coefficients of the noise. The setting of the wavelet threshold function has a direct impact on the processing of wavelet coefficients, thereby determining the denoising effect of the image. Considering that the discontinuity of traditional wavelet thresholding in the defined domain can cause image distortion, the author improves the traditional wavelet thresholding with the expression as presented in Equation 6.

$$\widehat{w}_{ij} = \begin{cases} sgn(w_{ij})\left(|w_{ij}| - \dfrac{\lambda}{exp\left(p\sqrt{w_{ij}^2 - \lambda}\right)}\right), |w_{ij}| \geq \lambda \\ 0, |w_{ij}| < \lambda \end{cases} \quad (6)$$

In the equation, p is an adjustable parameter, usually taken as a positive integer. When p = 0, it degenerates into a general threshold function; λ is the global threshold. The wavelet threshold function used by the author does not have breakpoints, which can effectively preserve valid information and avoid retaining redundant noise information [24].

3.3 Adaptive wavelet image processing

The traditional global threshold is generally set using the threshold setting method proposed by Donoho.

$$\lambda = \sigma_n\sqrt{21g(MN)} \quad (7)$$

In Equation 7, σ_n represents the variance of noise; M and N represent the size of the image. In actual operation, σ_n cannot be estimated and is generally calculated using empirical estimates by using Equation 8.

$$\sigma_n = \frac{m(|w_{ij}|)}{0.6745} \quad (8)$$

In the equation, $m(|w_{ij}|)$ represents taking the middle number. The use of fixed thresholds cannot meet the requirements of the multi-wavelet decomposition scale, and using thresholds that are too large or too small may lead to excessive removal of effective information or the inability to effectively remove noise. To meet the requirements of different wavelet decomposition scales, adaptive global thresholds need to be used which is presented in Equation 9.

$$\lambda_j = \frac{\sigma_n\sqrt{21g(MN)}}{\log_2(J+1)} \quad (9)$$

The steps of the wavelet based graphic design image processing technology proposed by the author are as follows:

Input: Image two-dimensional matrix F; The threshold adjustable coefficient p.

Step 1: Determine the dimensions M, N of the two-dimensional matrix;

Step 2: Determine the wavelet decomposition scale J;

Step 3: Calculate the wavelet decomposition coefficient Wf according to Equation 3;

Step 4: Calculate the noise variance estimator σ_n according to Equation 8;

Step 5: Calculate the adaptive global threshold λ_j according to Equation 9;

Step 6: Set the wavelet coefficient threshold $\widehat{w}_{ij}$based on the global threshold;

Step 7: Remove the decomposed wavelet coefficients based on the wavelet threshold;

Step 8: Reconstruct the image matrix $\hat{F}$ according to Equation 4.

Output: Reconstruct the graphic matrix $\hat{F}$ [25].

There are multiple crucial processes in the suggested wavelet-based graphic design image processing technology. First, it starts by determining M and N, the dimensions of the input picture matrix. The wavelet decomposition scale, J, which affects the procedure accuracy, is then determined. Next, using the input image matrix, the wavelet decomposition coefficients (Wf) are determined. For the next thresholding, a crucial parameter, the noise variance estimator (σ_n), is computed. Equation 9 is used to determine the adaptive global threshold (λ_j), which is the foundation for deciding which wavelet coefficients ($\widehat{w}_{ij}$) to keep or discard. The image is denoised when coefficients below this threshold are eliminated. Using Equation 4, the denoised image matrix ($\hat{F}$) is rebuilt in the last phase, yielding the output for graphic design applications. This methodology, which is based on particular equations, is a useful tool in graphic design processes since it successfully reduces noise and improves image quality.

4 Simulation verification and data analysis

To check the effectiveness of the waveform processing algorithm in the design plan proposed by the author. The author compares different denoising algorithms using the same image, comparing signal-to-noise ratio (PSNR), edge protection index (EPI), and similarity model (SSIM) [26]. Meanwhile, to test the effectiveness of the proposed algorithm, the author compared it with four existing image removal thresholding methods, comparing the signal-to-noise ratio, mean square error (MES), and the like models after image processing. To test the algorithm in the best way, the author usually uses a suitable filter method for comparison. By recording the interaction process, a complete comparison of the process with image processing based on the same experimental environment and experimental wavelet transform was performed.

Using the final results of these two algorithms, the author calculated and compared the signal-to-noise ratio and mean squared error results of the two algorithms, and the results are shown in Figure 6.

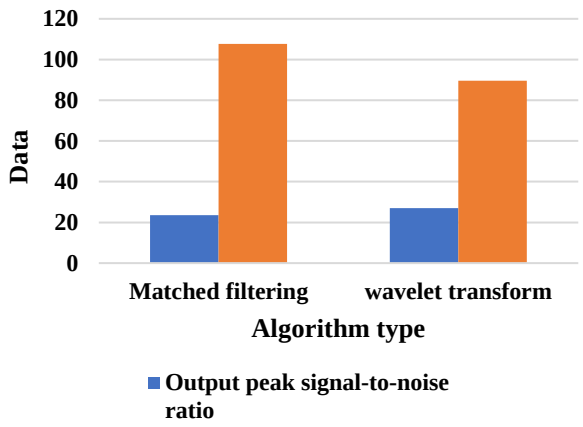

Figure 6: Parameter comparison of output results of two image processing algorithms

Figure 6 illustrates that the algorithm the author proposes has a higher signal-to-noise ratio and a lower mean square error [27] when compared to the matched filtering algorithm. This proves from the data level that the wavelet chaotic permutation algorithm has a better image denoising effect, and its execution stability is also better. As shown in Figure 7, different image-denoising algorithms are used to process the same image, and the PSNR, EPI, and SSIM indicators are compared. Among them, the performance based on the Frost denoising method is the worst, with the performance of median filtering and bilateral filtering being equivalent, and the bilateral filtering method is slightly better than the median filtering method [28]. Compared to the existing three algorithms, the algorithm proposed by the author has improved in all three indicators. Among them, the peak ratio increases by 6.4 dB compared to bilateral filtering, and the edge preservation index reaches 86%, which is more than 15% higher than existing algorithms. The structural similarity reaches 84%, which is more than 14% higher than existing algorithms.

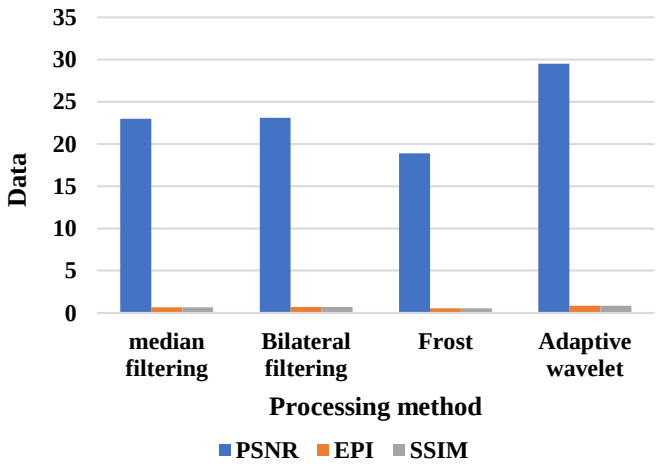

Figure 7: Comparison of image processing effects of different image denoising methods

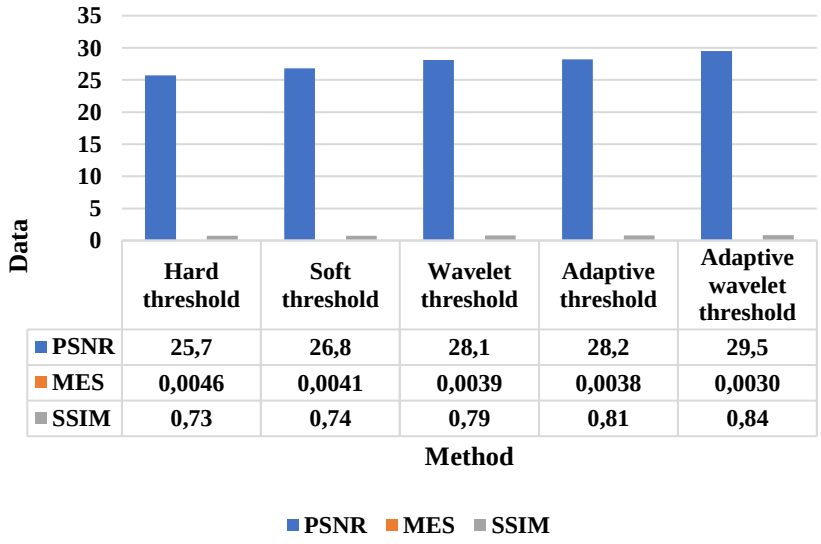

Figure 8: Comparison of image restoration quality under different threshold settings

Some of the techniques which gives good results are hard thresholding, soft thresholding and bilateral filtering. The hard thresholding method sets any wavelet coefficient below a certain threshold to zero. While it is simple and computationally efficient, it can lead to abrupt changes and artifacts in the processed image. Unlike hard thresholding, soft thresholding shrinks the wavelet coefficients by the threshold value. This approach provides smoother transitions but may blur important details in the image. The bilateral filtering technique combines domain and range filtering, preserving edges while reducing noise. It can handle a variety of noise types but may be computationally intensive. Through the experimental analysis of the proposed method, it is observed that the proposed method provides better results in comparison with these existing methods. As shown in Figure 8, the soft threshold method is slightly better than the hard threshold method. The image restoration performance of the wavelet thresholding method and the adaptive thresholding method is basically equivalent, both better than hard thresholding and soft thresholding methods [29-32]. Compared with other methods, the adaptive wavelet threshold setting method adopted by the author can improve the peak signal-to-noise ratio by more than 1.3 dB based on the adaptive threshold. Moreover, the mean square error of image restoration has been reduced compared to existing methods, and the structural similarity has been improved by more than 5% compared to existing methods.

The soft threshold approach outperforms the hard threshold method by a small margin, as Figure 8 illustrates. Both the adaptive thresholding method and the wavelet thresholding method perform better at restoring images than hard and soft thresholding techniques, with nearly identical results [27–30].

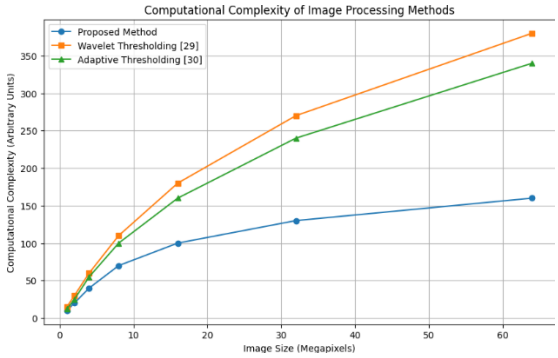

Figure 9: Computational complexity comparison

When compared to alternative approaches, the proposed method can increase the peak signal-to-noise ratio by almost 1.3 dB using the adaptive threshold. Additionally, the structural similarity has increased by more than 5% and the mean square error of picture restoration has decreased in comparison to current methods. The graph presents a comparative analysis of the computational complexity of three image processing methods across different image sizes which is depicted in Figure 9. The y-axis represents the computational complexity in arbitrary units, while the x-axis indicates the image size in megapixels. This visualization allows us to observe how each method's computational demands scale with increasing image sizes. The first line in the graph represents the computational complexity of the proposed wavelet-based image processing technology. It illustrates that, as the image size increases, the complexity of the proposed method also increases. However, the rate of increase is relatively moderate, demonstrating the method's efficiency in handling larger images. This efficiency is a key advantage, suggesting that the proposed method is scalable and suitable for high-resolution images commonly used in graphic design and related fields. The second line corresponds to the computational complexity of a traditional wavelet thresholding method. This line provides a baseline for comparison with the proposed method. As shown, the computational complexity of the traditional wavelet thresholding method increases significantly faster than that of the proposed method. This indicates that while traditional wavelet thresholding is effective, it demands more computational resources, particularly as image sizes grow. The third line represents the computational complexity of an adaptive thresholding method. This method also serves as a comparison point to highlight the efficiency of the proposed approach. Similar to the traditional wavelet thresholding, the adaptive thresholding method exhibits a steeper increase in computational complexity with larger image sizes, albeit slightly less pronounced. While the proposed algorithm demonstrates robust performance across various image types, certain limitations exist. For grayscale images, the algorithm performs efficiently due to the simpler data structure. However, for color images, the algorithm must be applied to each color channel (e.g., RGB) separately, potentially increasing computational complexity and processing time. High-resolution images benefit from the algorithm's ability to preserve fine details, but they require more computational resources.

5 Conclusion

With the use of computer-assisted technology, the development of clarity in graphics is more natural and social. In response to the demand for good image removal and restoration, the author proposes a wave-based planar image processing technology. Also, digital image modeling is used to get rid of decision wavelet transforms and improve wavelet coefficient threshold quantization ideas. This leads to the creation of a new spatial adjustment model based on the wavelet decomposition scale. This model improves the denoising effect and keeps the image information well. After testing, it was shown that the model developed by the author improved the ability to reject and recover images.

Compared with existing embedding methods, the original modification method not only improves image recovery but also has good performance. This research emphasizes how important computer-aided platforms are to improving graphic design's visual aesthetics. Wavelet thresholding techniques, especially the adaptive technique, show great promise for image restoration compared to conventional hard and soft thresholding techniques. The results show a significant improvement in mean square error, peak signal-to-noise ratio, and structural similarity, confirming the

proposed algorithm as a reliable way to denoise and restore images and improving the quality of the restoration process over current approaches.

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