Research Article

Application and Deconstruction of Visual Communication in Art Design Based on Linear Operator Theory

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With the continuous development of society, information transmission can be seen everywhere, and various forms of visual communication with artistic design such as posters, periodicals, and electronic screens appear one after another. Visual communication is the effective communication of information through various visual elements. Visual communication of art design can promote the exchange of information and promote the development and progress of society. However, in the process of visual communication of artistic design, there are many problems of unclear images such as halo and inconsistent brightness, which brings bad visual experience to the information receiver. The linear operator theory has the ability to transform parameters and generalize to find the optimal solution, and the linear operator theory is applied to the visual communication of art design, which can effectively solve the problem of unclear images in traditional visual communication. This paper compares and analyzes the information entropy and mapping similarity between the visual communication of art design based on the linear operator theory and the traditional visual communication of art design by setting up an experimental group. The results showed that, among the four communication methods of art design visual communication, that is, figures, videos, animations, and movies, the mapping information entropy of art design visual communication based on linear operator theory in 6 different scenarios is 1.55 more than the traditional visual communication mode on average, and the average mapping similarity is 0.10 more. Therefore, the visual communication of artistic design based on the linear operator theory can convey more information and more accurate information and improve the effect of visual communication.

1. Introduction

Visual communication is a way of information transmission. Initially, visual communication mainly conveyed information through newspapers and letters. Later, people were not satisfied with simple visual communication and added artistic design while communicating information. The paintings and sculptures that appeared could bring better visual impact, which make visual communication more artistic. With the rapid development of information technology, new media technology has been applied to visual communication of art design, and various electronic products such as figures and videos have made visual communication more and more convenient. In the information age, people are not satisfied with only accepting visual information and pay more attention to the quality of visual information. The visual communication brought by new media is relatively rough in the processing of many figures and videos. Although visual communication can be carried out in time, the effect of visual communication is not good. Linear operator theory is a spatial mapping method that can effectively improve image compression capability, image color continuity, and image clarity. Applying linear operator theory to visual communication of art design can improve the quality of visual communication. Therefore, this paper has research significance.

The transmission of visual information has an important impact on social production and life, and relevant personnel conduct research on visual communication of art design. Among them, Jaenichen research shows that the way of
visual communication of art design has developed from primitive words to diversified images, which promotes the exchange of information in society [1]. Wijaya said that visual communication of art design can accelerate the exchange of information, which can promote the development of society [2]. Shi compared and analyzed the visual communication of art design and traditional visual communication and found that visual communication of art design can transmit information more effectively [3]. Li research aimed to illustrate that optimizing the visual communication of artistic design can improve the development of visual information [4]. Bleiker pointed out that the visual communication of art design is influenced by new media such as images and videos, which can improve the speed of information dissemination [5]. Although artistic design visual communication can promote the exchange of information, the effect of visual communication is not very good.

The linear operator theory can effectively deal with the mapping relationship between different dimensions, and the linear operator theory is applied to the visual communication of art design. Among them, the research of Murean and Murean showed that the linear operator theory can optimize the image quality of visual communication and make the visual communication of art design more effective [6]. Hariyanto applied the semigroup algorithm in the linear operator theory to the visual communication of art design, which improved the problem of unclear image quality in visual communication [7]. Altmann and Zimmer utilized the boundary control of linear operators to improve the image quality of visual communication, which make visual communication more effective [8]. Ghanim applied linear operators to visual communication of artistic design and used linear transformation to change the image into the clearest mode [9]. Yan used linear operators to optimize the image quality in visual communication of art design and improve the effect of image information communication [10]. Although the application of linear operator theory to visual communication of artistic design can improve the effect of image information communication, the mapping algorithm used is not optimal.

The linear operator theory can realize spatial generalization mapping, and the use of linear changes can make visual images convey more clearly. The linear operator theory is applied to the visual communication of art design. By comparing it with the traditional visual communication of art design, the advantages of the linear operator theory in the visual communication of art design are highlighted. The innovations of this paper are as follows: (1) combine the linear operator theory with the visual communication of art design. (2) Compare the visual communication of art design based on linear operator theory with the traditional visual communication of art design.

2. Application of Linear Operator Theory in Visual Communication of Art Design

Visual communication is a way of public information dissemination. The early visual communication methods were mainly newspapers, books, and posters. Although information can be spread intuitively, the amount of information spread is small and cannot bring intuitive visual impact [11]. With the continuous development of new media technology, visual communication uses new media as a medium, and many artistic design elements are added to the way of visual communication, mainly displayed in multimedia such as figures, videos, and movies. The model of visual communication of art design is shown in Figure 1.

However, in the process of visual communication of artistic design, there are many problems of poor image visual effect, and the linear operator theory can optimize the image through the color scale mapping, so as to make the visual effect of visual communication better.

2.1. New Mediatization of Visual Communication of Art Design

There are many forms of expression of art design. In the information age, new media is the most important way of expression of art design. In traditional forms of artistic expression, information is disseminated in the form of words, statues, paintings, etc., but information dissemination is very limited by space. New media technology makes art design no longer affected by factors such as region and flow of people through informatization [12].

Visual communication is to transmit information through vision. In the design process of visual communication, it is usually combined and transmitted in new forms such as text or figures. However, under the influence of new media technology, the design method of visual communication is constantly changing, adding information elements to make visual communication more rendering [13]. The new mediatization of art design visual communication makes visual communication have the advantages of strong memory, strong impact, and strong orientation and play a very positive role in the dissemination of public information. The new mediatization of visual communication of art design has made visual communication have a new development trend, mainly as follows: digital communication, humanized communication, and diversified communication. The new media model of art design visual communication is shown in Figure 2.

2.1.1. Digital Communication. With the continuous development of digital technology, digitalization is the main development direction of visual communication. Combining digital and artistic design visual communication makes visual communication more multimedia features, promotes the development of visual communication, and enables people to come into contact with visual communication in many ways through digital channels. Digital communication is more conducive to rapid multichannel dissemination of public information [14].

2.1.2. Humanized Communication. The visual communication of art design ultimately wants traditional information to be seen by people. Traditional visual communication pays more attention to traditional content, only rigid input content, and ignores humanized communication. Humanized visual communication is also a form of artistic design.
Traditional visual communication cannot meet people’s needs for visual information. Adding human factors to visual communication can improve people’s sensitivity to visual information, which is conducive to the dissemination and reception of visual communication [15].

2.1.3. Diversified Communication. The new mediatization of visual communication in art design has diversified the ways of visual communication, and the design of visual communication has also changed. Adding new media elements such as videos and moving figures in the process of visual communication can mobilize people’s interest in visual information, which is conducive to the dissemination and reception of visual communication [15].

2.2. Linear Operator Model. An operator is a mapping relationship between two spaces, and a linear operator indicates that the mapping between two spaces is a linear relationship. In the process of visual communication of artistic design, linear operators are used to map image information to the screen, and information is conveyed through vision [17]. The use of linear operators can represent different image qualities. Let the brightness of the image at high dynamic time be $L_h$ and let the image compression operator be $g(\cdot)$, and then the image brightness at low dynamic time is expressed as

$$L_d = g(L_h). \quad (1)$$

In formula (1), $L_d$ represents low dynamic image brightness.

In the process of converting a high dynamic image into a low dynamic image, let $r$ be the degree of compression, and then the curve of the image change can be expressed as

$$L_d(j) = rL_h(j) + k_i. \quad (2)$$

In formula (2), $j \in \nu$, $k$ represents the initial brightness of the image.

The image change is transformed by the window $\nu$ centered on the pixel $i$. By controlling the values of $r$ and $k$, different degrees of linear operators can be realized; that is, different degrees of image compression transformation can be realized. Image transformation is mainly divided into two types in the degree of compression:

When $r > 1$, the image can be displayed more clearly in areas with low color intensity. When $0 < r < 1$, the image can be displayed more clearly in the area with higher chroma.

The different mapping effects of the linear operator in the process of image change are shown in Figure 3.

In Figure 3, different mappings based on linear operators present different visual image effects. The brighter area on the left can better display the figure information,
and the darker area on the right can better transmit the figure information. Therefore, the linear operator can make the visual communication of artistic design more visually impactful.

2.3. Tone Mapping Algorithm. The level mapping algorithm is to process the brightness and color of the image. There is the process of mapping a high dynamic image to a low dynamic image through a linear operator, and each pixel in the high dynamic image needs to undergo color scale transformation, and then the cumulative result of the color scale of all pixels in the image is expressed as

\[
    T_i \cdot [r'_i k'_i]^T = E_i.
\]

In formula (6), \( r'_i \) and \( k'_i \) represent the optimal solution of the tone scale transformation, which is expressed in the form of a matrix.

The transformation of formula (6) is solved to get

\[
    [r'_i k'_i]^T = T_i^{-1} \cdot E_i.
\]

In formula (4), \( A \) represents the constraint parameter \( A = 0.1, \) and \( B \) is the pixel contrast.

The value of \( B \) is related to various factors of image change. The generic expression of \( B \) is

\[
    B = (L_h, L_d, c, d).
\]

In formula (5), \( c \) represents the standard deviation of the brightness of the high dynamic image, and \( d \) represents the mean value of the brightness of the high dynamic image.

After constraining the color scale mapping function, the optimal solution of the color scale transformation is obtained, and the optimal solution is expressed as

\[
    \sum \sum (L_d(j) - rL_h(j) - k_j)^2.
\]

In formula (3), \( i \) represents the \( i \)-th pixel in the image.

The process of mapping the high dynamic level of the image to the low dynamic is the process of solving the minimum value of formula (3). But when \( r \) takes 1 and \( k \) takes 0, \( L_d = L_h \), there is a trivial solution to formula (3) in this case. Therefore, the solution process of the minimum value cannot be directly carried out for formula (3), and some restrictive factors need to be added in the process of image change solution, so that there is an optimal solution for the transformation of high dynamic to low-dynamic images [19].

After adding the limiting factor, the formula (3) is transformed into

\[
    g = \sum \sum (L_d(j) - rL_h(j) - k_j)^2 + AB^2 (r - B)^2.
\]

In formula (4), \( A \) represents the constraint parameter \( A = 0.1, \) and \( B \) is the pixel contrast.

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After constraining the color scale mapping function, the optimal solution of the color scale transformation is obtained, and the optimal solution is expressed as

3. Experimental Design

3.1. Experimental Data. In order to analyze the application of linear operator theory in visual communication of art design, it is necessary to carry out a comparative experiment based on linear operator theory and traditional mode for different visual communication methods of art design [21]. To compare and analyze the ways of visual communication of art design, it is necessary to investigate the common ways of visual communication of art design. Therefore, the experiment will randomly investigate 50 art and design visual communication workers by means of questionnaires to investigate the common visual presentation methods in the process of visual communication and the proportion of each visual communication method. The results of the visual communication method of the questionnaire are shown in Table 1.

In Table 1, figures, videos, animations, and films occupy most of the visual communication methods of art design, and these four methods belong to the communication methods under new media, while the statues, paintings, and words occupy very little visual communication. Therefore, when comparing the visual communication of art design based on the linear operator theory and the traditional visual communication of art design, people mainly compare figures, videos, animations, and movies [22].
When comparing the visual communication of art design based on the linear operator theory and the traditional visual communication of art design, it is also necessary to consider the scene of the comparison content, because scenes with different degrees of complexity will cause different degrees of interference to the visual communication. Investigate the scenes under the visual communication of new media art design from 2020 to 2021, and investigate common visual communication scenes, and their respective proportions. The survey results of the visual communication scenarios are shown in Table 2.

### Table 1: Visual communication results table.

| Serial number | Medium of visual communication | Number of people | Proportion (%) |
|---------------|-------------------------------|------------------|---------------|
| 1             | Figure                        | 50               | 100           |
| 2             | Video                         | 48               | 96            |
| 3             | GIF                           | 45               | 90            |
| 4             | Movie                         | 44               | 88            |
| 5             | Statue                        | 12               | 24            |
| 6             | Painting                      | 24               | 48            |
| 7             | Word                          | 12               | 24            |

### Table 2: Visual communication scenario survey results table.

| Serial number | Visual communication scene | Proportion (%) |
|---------------|---------------------------|---------------|
| 1             | Building                  | 15            |
| 2             | Weather                   | 15            |
| 3             | Figure                    | 16            |
| 4             | Animal                    | 14            |
| 5             | Apparel                   | 22            |
| 6             | Furniture                 | 18            |

3.2. Experimental Design. The hardware conditions of the experimental environment in this paper are Inter core i7 processor, 8 GB memory, the software configuration is Win10 system, and the simulation environment used is VS 2010. The experiment will compare and analyze the visual communication of art design based on linear operator theory (visual communication A) and the traditional visual communication of art design (visual communication B) [23].

The art design visual communication based on the linear operator theory adopts the color scale mapping algorithm, while the traditional art design visual communication adopts the traditional mapping method. The experiment will compare the visual communication effects of art design in different scenarios in different visual communication methods. The evaluation indicators are mainly divided into two parts, that is, the information entropy and similarity of the mapping. The information entropy is the representation of the information amount of the image information. The larger the value of the information entropy is, the more information the mapped image covers. The similarity of the map represents how similar the mapped image is to the original image. The larger the similarity value, the higher the similarity with the original image [24].

4. Experiment Result Analysis

4.1. Comparison Results of Visual Communication Figure Methods in Art Design. The pictorial representation of the visual communication of art design is the most common way. Compare the mapping figures between the visual communication of art design based on the color scale mapping algorithm and the traditional visual communication of art design. When performing the tone-level mapping algorithm, the image needs to be linearly transformed, and the optimal figure mapping solution \( (r'_i, k'_i) \) is obtained by formula (7). By comparing the visual communication effects of the two visual communication methods in different figure scenarios, the comparison results of the two ways of visual communication of art design are shown in Figure 4.

In Figure 4, in terms of information entropy of mapping, the information entropy of visual communication of artistic design based on the color scale mapping algorithm is significantly more than that of traditional visual communication of artistic design. In terms of mapping similarity, the average mapping similarity of the two visual communication is 0.93 and 0.83, respectively. Therefore, the visual communication of artistic design based on the color scale mapping algorithm covers more information, and the similarity of the mapping is higher [25].

4.2. Comparison Results of Video Methods for Visual Communication in Art Design. The video presentation of visual communication of art design is the main way of new mediatization of visual communication. Compare the mapping video between the visual communication of artistic design based on the gradation mapping algorithm and the traditional visual communication of artistic design, and obtain the optimal video mapping solution \( (r'_i, k'_i) \) under the chromatic mapping algorithm through the mapping transformation of formula (7). Compare the visual communication effects of different visual communication methods of video scenes. Figure 5 shows the comparison results of the two visual communication video methods of art design.

In Figure 5, the average mapping information entropy of the art design visual communication based on the color scale mapping algorithm and the traditional art design visual communication is 8.10 and 6.34, respectively. In terms of the similarity of mapping, the visual communication of art design based on the color scale mapping algorithm is also better than the traditional visual communication of art design. The average mapping similarity for the two visual communication is 0.89 and 0.83.
4.3. Comparison Results of Visual Communication Motion Graphics in Art Design. Motion graphics are also a way of expressing new media in visual communication. Compare the dynamic map mapping of different scenes between the visual communication of art design based on the color scale mapping algorithm and the traditional visual communication of art design. The pros and cons of two visual communication methods are compared by analyzing the information entropy and mapping similarity of the mapping [26]. The comparison results of the two ways of visual communication animation of art design are shown in Figure 6.

In Figure 6, the average mapping information entropy and average similarity of the visual communication of artistic design based on the tone-level mapping algorithm are 8.15 and 0.90, respectively. The average mapping information entropy and average similarity of traditional art design visual communication are 6.91 and 0.83, respectively. Therefore, the visual communication of artistic design based on the color scale mapping algorithm depends on the traditional visual communication mode in the aspect of animation communication.

4.4. Comparison Results of Art and Design Visual Communication Film Methods. Film is also the main body of visual communication art design, and the two kinds of art design visual communication methods are compared for different scenes of film mapping [27]. The comparison results of the two artistic design visual communication film methods are shown in Figure 7.
In Figure 7, the average information entropy of the visual communication of artistic design based on the color scale mapping algorithm is 1.07 more than that of the traditional visual communication of artistic design, and the average of the mapping similarity is 0.16 more. Therefore, the visual communication of artistic design based on the color scale mapping algorithm has a better visual communication effect than the traditional mode in the way of film communication.

5. Conclusion

This paper compares the visual communication of art design based on linear operator theory and traditional visual communication in terms of figures, videos, animations, and films. By comparing the differences in the information entropy and similarity of the mapping between the two visual communications, the communication effect of the two visual communications is analyzed. The test results show that, in terms of image communication, the visual communication of artistic design based on the color scale mapping algorithm has an average of 2.11 more information entropy and an average of 0.10 more similarity than the traditional visual communication method. In the three aspects of video, animation, and film, the mapping information entropy and mapping similarity of visual communication of artistic design based on the color scale mapping algorithm are also better than those of the traditional visual communication mode. Applying the linear operator theory to the visual communication of art design can increase the amount of information conveyed, improve the accuracy of the information conveyed, and make the visual communication of art design have a better visual

Figure 6: Comparison result of the way of visual communication of art design. (a) Mapping information entropy. (b) Mapping similarity.

Figure 7: Comparison results of art and design visual communication film methods. (a) Mapping information entropy. (b) Mapping similarity.
communication effect. However, the visual communication methods using the linear operator theory studied in this paper are limited, so the extension of the linear operator theory to the visual communication method of art design will be the direction of future research.

**Data Availability**

The data used to support the findings of this study are available from the corresponding author upon request.

**Conflicts of Interest**

The authors declare no conflicts of interest.

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