Journal of Autonomous Intelligence (2024) Volume 7 Issue 3
doi: 10.32629/jai.v7i3.1452

ORIGINAL RESEARCH ARTICLE

Optimization of regional cultural modern liquor packaging design based on computer vision algorithm

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ABSTRACT

In alcohol packaging, graphics, colors and text are social symbols. This article first uses the relevant principles of visual grammar to conduct a multimodal discourse analysis on the packaging pattern of Fen Liquor blue and white vases from multiple angles. Then, this paper uses human visual characteristics to improve product packaging styling effects. At the same time, a Gaussian filter is used to denoise the noisy wine packaging image, and then the image is used as an input image for grayscale transformation to obtain the guidance image. Research shows that in the multimodal discourse of Fen Liquor blue and white bottles, various forms such as images, text and colors can constitute and convey product information, mapping the history and culture of the product. This stimulates consumers' visual senses and arouses consumers' spiritual resonance to achieve the goal of promoting consumption.

Keywords: blue and white porcelain fen liquor; human visual characteristics; multimodal discourse analysis; guided filtering; product packaging design; image processing algorithm

ARTICLE INFO

Received: 21 November 2023
Accepted: 15 December 2023
Available online: 19 January 2024

1. Introduction

In human civilization's long history, wine is an objective material form and a cultural symbol. Studying the art of wine packaging will help us discover the rich culture and national character in more things so that people can better understand and recognize the wine brand. Domestic and foreign research on alcohol packaging primarily focuses on cultural symbols, cultural connotations, consumer psychology, development trends, etc.[1]. Applying interdisciplinary ideas to alcohol packaging is the future development direction. The multi-channel discourse analysis method based on systemic functional linguistics extends the concept of three meta-functions to a visual model. In this way, a visual syntax theory with image analysis as its basic structure is constructed. Some scholars use multimodal language as the starting point to combine multidisciplinary research on wine packaging[2]. Enriching and developing related theories of wine packaging is of great significance.

Good packaging design plays a crucial role in product development. Choosing appropriate packaging materials and pattern designs based on full consideration of product function, appearance and materials, coupled with exquisite production skills, can make the overall visual effect better. Packaging design is a way to improve the relationship between products and customers. Excellent packaging design can significantly increase the product's value and brand awareness. Make it stand out among similar products[3]. Graphics

have the most significant proportion in product packaging design. Enhancing the visual effect of graphics in graphic design is an urgent topic that designers need to study.

With the rise of social networking and video sites in recent years, image-processing methods have gradually matured. Image processing algorithms are often used for image quality analysis[4]. By calculating the structural similarity of images and comparing the differences between images, the quality of the images can be judged. Some researchers have begun to use image analysis methods for target recognition. Existing research primarily focuses on image enhancement. People obtain information about target images through their two eyes, thus forming a complete visual system[5]. Computer vision technology uses two cameras to collect images of the measured target from multiple perspectives. Use parallax theory to restore the 3D stereoscopic image of the target. Therefore, visual technology is widely used to achieve target positioning in three-dimensional space[6]. According to the human physiological structure and the working mechanism of the imaging system, some scholars have proposed a method of using human visual attention to construct a grayscale image of the image. So that it can highlight meaningful images. After the image is systematically acquired, various noises, such as impulse noise during transmission, will interfere. This will reduce the quality of the image and allow for in-depth inspection of problematic liquor packaging[7]. To restore the original image from a noisy image, we must first remove the noise while maintaining the details and correlation of the original image. Traditional filtering methods include median filtering, box filtering and average filtering. These filtering methods will blur the image boundaries and cause the loss of image details. Among them, the Gaussian and bilateral filters are commonly used smooth filters for boundary protection and detail enhancement[8].

For this reason, this article takes blue and white liquor as a case. Use the principles of visual grammar to analyze multimodal speech. Then, a guided filtering method based on Gaussian filter fusion is proposed to denoise wine packaging images.

2. Methods

2.1. Visual grammar analysis of multi-channel discourse on liquor packaging

"Multi-channel" is the integration of multiple interactive methods, such as text, images, and sounds, to achieve the purpose of interactive communication. The theory was initially applied in linguistics and gradually expanded to other disciplines, such as social semiotics and education[9]. This article conducts a relatively in-depth study of multimodal discourse. Systemic functional grammar believes that a social "symbol" is a social symbol with a specific social role. When expressing an event, there must be a sure way to achieve the meaning it wants to convey. Based on the perspective of cognitive linguistics, this article expresses some obscure concepts in images to help readers better understand and recognize them. Later, the "meta-function" of linguistics was recognized by multimodal discourse analysis[10]. This deepens the understanding of systemic functional grammar theory and a basic theory under a multimodal discourse analysis framework. It belongs to the relationship between inclusion and being included (**Figure 1**). Like "systemic functional linguistics," "visual" grammar also has three levels, which correspond to the three significant meta-theories in "systemic functional linguistics."

"Multimodality" is a complex discourse that interactively transmits text, images, sounds and other forms of communication. The systematic functional grammar theory comprises three major subsystems, and the packaging of Fen Liquor is a multimodal chapter composed of words, images, meanings and colors. The method of conceptual metaphor is used to integrate the spirit of Chinese philosophy and aesthetics into the product packaging design. Multimodal discourse is a new form in a multimedia environment[11]. Studying its multimodal semantic construction can further improve the understanding of multimodal discourse.

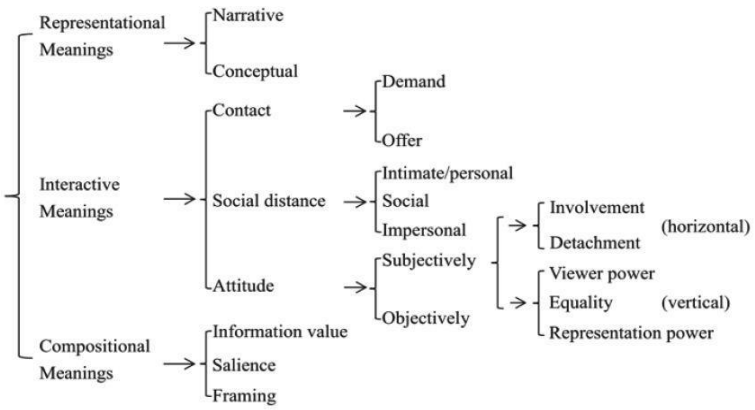

Figure 1. Visual grammar parses multi-channel discourse.

2.2. Analysis of human visual characteristics and packaging design

2.2.1. Perceptual characteristics of images by human eyes

The human eye's recognition of images can be divided into three steps: image signal capture, retinal imaging, signal transmission and recognition. The human eye's imaging of images directly affects the accuracy of subsequent visual perception analysis. Human vision is a very complex visual experience and image, and its contrast sensitivity depends on its spatial frequency band. The specific relationship is shown in **Figure 2**[12].

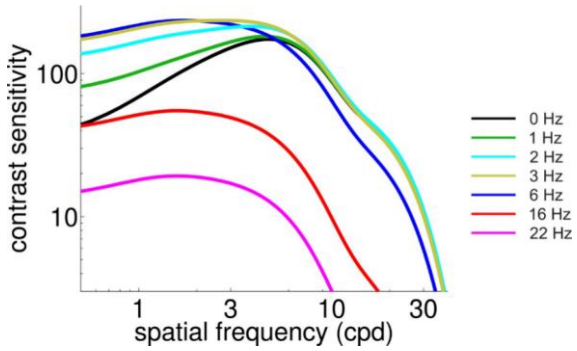

Figure 2. Human eye contrast sensitivity and spatial frequency relationship curve.

Spatial spectrum characteristics

It is decomposed into sinusoidal intensity components that vary with spatial frequency through Fourier transformation. However, the limitation of human visual perception is that when the visual signal contains many high-frequency components, the limit of human visual perception will be significantly reduced. This area must be modulated to increase its visibility.

multi-channel characteristics

The human visual mechanism realizes the transmission of image information through multiple channels. This achieves the separation of orientation and frequency division of visual channels. The number of channels has a qualitative relationship with visual information. Information from multiple channels simultaneously can better extract image features, and this information affects each other[13].

Masking effect

The masking effect refers to the effect of the disturbed object on the interfered object. When the object detection threshold is significantly higher than the occluded object, the disturbed visual information will not impact object detection. Under the same conditions, occlusion can eliminate certain detection thresholds and enhance detection resolution, but if the detection threshold of an object is lower than the contrast of the masker, it will be obscured by the line of sight of the interfering object.

Visually prominent features

This property reflects the satisfactory resolution of images by human vision. In the cognitive process of the human eye, image information with significant characteristics is first detected, then the image information is captured and processed; at the same time, relatively simple pictures are roughly collected.

2.2.2. Product packaging

When designing packaging for goods, the graphics selected should have the function of replicating the goods. That is, through graphics content, we can understand the relevant characteristics of the product so that customers are interested in it. Therefore, image processing is a very critical link. In conventional graphics processing, abstract or concrete designs can be performed on graphics, photos, and other materials by combining elements such as deformation, characterization, addition, and deletion. This approach has been very influential and has resulted in several models. However, this process is more from an aesthetic point of view, and the final result is not consistent with the characteristics of human visual cognition. Therefore, it is significant to introduce human visual characteristics into product packaging design.

3. Results

The liquor packaging visual inspection system consists of four parts: image acquisition, image processing, computer system and mechanical control rejection device. The image extraction device is used to extract the object to be detected from the wine packaging image, and the obtained object image is sent to the computer for processing. The machine chip removal device removes the defective packaging to achieve the purpose of inspection. Before sealing, a CCD camera is used to visually detect the wine liquid and convert it into image information. The image information is then transmitted to the processing device, which performs various operations on these signals and extracts characteristics. Finally, automatic identification of wine packaging is achieved. The structure of the liquor visual detection system is shown in **Figure 3** (picture quoted from Misalignment inspection of multilayer PCBs with an automated X-ray machine vision system)[14].

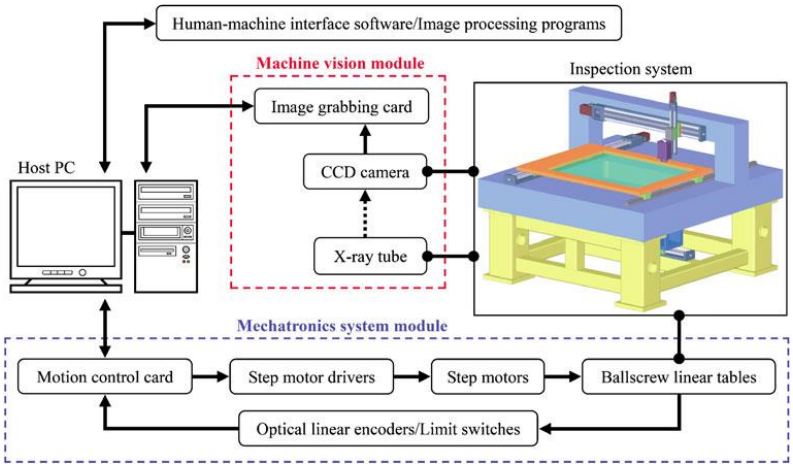

Figure 3. Visual inspection system structure diagram.

The guided filter is a local linear filtering method with local multi-point filtering characteristics. It cannot only effectively retain the boundaries of the image but also ensure that the boundaries of the image do not undergo gradients. It is used in image enhancement, image defogging, and image matting. Figure, HDR image compression and other aspects have essential research value. Assume that the output of the guided filtering function and the image input are linear:

$$g_i = \lambda_t R_i + \varepsilon_t, \forall i \in \Theta_t \quad (1)$$

g will be used to output pixels. R is the guide image. i and t are pixel indices. λ and ε are the coefficients of this linear function when the center of the window is at t. The minimum window function is expressed as follows:

$$W(\lambda_t, \varepsilon_t) = \min_{\lambda_t \in K, \varepsilon_t \in K} \left(\sum_{i \in \Theta_t} ((\lambda_t R_i + \varepsilon_t - q_i)^2 + \mu \lambda_t^2) \right) \tag{2}$$

q is the imported image. The first term is the quadratic fidelity term. When the difference between g and q is the largest, the model is locally linear. The second item is the rule item. μ is the adjustment factor that makes λ_t more significant. μ in the formula must be greater than 0. Since the guide image E is the image F to be filtered when $\mu = 0$, the result is $g = q$. λ_t andε_t can be obtained using the least squares method:

$$\lambda_t = \frac{\frac{1}{|\zeta|}\sum_{i \in \Theta_t} R_i q_i - \phi_t \bar{q}_t}{\delta_t^2 + \mu}, \varepsilon_t = \bar{q}_t - \lambda_t \phi_t \tag{3}$$

Smoothing or maintaining the image of a particular area in the guidance filter is mainly determined by the two parameters λ_t and ε_t. These two parameters are the key to guided filtering. When the parameters of the local window are determined, the window will be overlapped to the position of each pixel. The mean method was used to calculate each parameter value, which reduced calculation errors and improved the method's robustness. This filter can be expressed as $g_i = \sum_j F_{ij}(R) q_j$, where $F_{ij}(R)$ is the core weight that guides the filter. Its definition is:

$$F_{ij}(R) = \frac{1}{|\zeta|^2} \sum_{(i,j) \in \Theta_t} \left(1 + \frac{(R_i - \phi_t)(R_j - \phi_t)}{\delta_t^2 + \mu} \right) \tag{4}$$

$$\frac{\partial g_i}{\partial q_j} = \frac{1}{|\zeta|^2} \sum_{(i,j) \in \Theta_t} \left(1 + \frac{(R_i - \phi_t)(R_j - \phi_t)}{\delta_t^2 + \mu} \right) \tag{5}$$

It can effectively prevent the reverse gradient effect produced by the bidirectional filter. By comparing traditional filtration methods, it was proved that this method can be better applied to the filtering pretreatment of alcohol packaging samples[15].

The feasibility of this method is demonstrated through detecting low-contrast and blurry images. In the experiment, the image enhancement technology introduced in the article was compared with the image enhancement technology provided in the literature[5]. It was evaluated from the test results, which are shown in **Table 1**. The image enhancement algorithms given in the literature[5] and the text in **Table 1** can enhance and improve the quality of the original image. From the four evaluation criteria, this paper uses human visual characteristics to improve the quality of the image. **Figure 4** shows the original and highlighted images of blue and white porcelain. Experimental results show that compared with the original image, this method can better highlight the critical information in the image. It can effectively suppress smooth areas and enhance contrast.

According to the brightness relationship of the blue and white porcelain wine bottle model, normalization is performed to obtain the information entropy. Image contrast may be slightly greater than 1 when the image is relatively small. The further the wine bottle packaging design deviates from the original graphic, the greater the contrast. The method in this paper has obvious advantages in misclassification rate and shape ratio. The results are shown in **Table 2**.

Table 1. Image quality evaluation comparison results.

Comparison algorithm	Contrast	Contrast	Information entropy/bit
Original picture	20.26	0.77	6.60
Literature[5]	41.09	0.82	7.88
Algorithm	47.11	0.84	8.31

Figure 4. Comparison between the original image and the salient image.

Table 2. Comparison of misclassification rates and shape degrees of various threshold segmentation results.

Various threshold segmentation methods					Inspected 1	Inspected 2	Inspected 4
1	overall situation	No grayscale compensation	Otsu	threshold	143.5	135.5	159.5
				Pixel error rate	22.50%	30.92%	10.13%
				shape ratio	0.66	0.745	0.442
2		Grayscale compensation	Otsu	threshold	116.96	106.92	140.05
				Pixel error rate	18.70%	20.77%	7.93%
				shape ratio	0.968	0.688	0.442
3			Iterate	threshold	118.4	107.72	141.14
				Pixel error rate	18.70%	20.77%	7.93%
				shape ratio	0.968	0.688	0.442
4			maximum information entropy	threshold	154	115	160
				Pixel error rate	19.90%	21.93%	5.39%
				shape ratio	0.294	0.694	0.468
5	local		hysteresis threshold	threshold	0.6	−0.8	22
				Pixel error rate	15.22%	22.09%	3.92%
				shape ratio	0.342	0.422	0.694
6			In-text methods	Pixel error rate	3.16%	3.97%	3.31%
				shape ratio	0.99	0.836	0.789

4. Discussion

The most distinctive feature of blue and white porcelain wine packaging is its unique blue and white small mouth round bottom bottle. This article conducts an in-depth discussion on the packaging of blue and white porcelain wine and a preliminary discussion. This article is based on the visual grammar of Kress and Verellen and explains the shape of the blue and white wine bottle from three levels: representational meaning, interactive meaning and compositional meaning.

4.1. Rewriting meaning

It refers to the visual connection between various elements in the image and the viewer. This is the reader's general understanding of the multimodal chapter of the picture[16]. This is a primitive cognitive state. Presenting semantics in visual grammar is also a polysemy phenomenon, which includes two levels: narrative expression and conceptual expression. Narrative re-enactment is when the image maker makes the "events" or "actions" recorded in the images available for the subjects to watch. Conceptual expression is a more stable image element. It is a method of classifying, analyzing and symbolizing images. There are apparent differences between the two, and whether there is a "vector" is the primary indicator to distinguish the difference between the two. "Vector" is a component that connects the animation work in the picture and the viewer of the picture,

which reflects the dynamic relationship between the two. The external observer, as the sender of the vector Liquorish, interprets what the picture is conveying through the orientation of the vector's behavior. Vectors guide the completion of the narrative, and the observer interprets the meaning and function of the behavior by reading the direction of the vector behavior[17].

In the blue and white wine bottle shape, the bottle image itself has no vector, so the image elements and the audience's expression of the image are completed through symbolic means. In terms of color, the bottle is indigo, and the overall color is blue and white. The dignified elegance echoes the Juanxiu cursive font on the bottle. In terms of materials, a soft porcelain texture was chosen. It matches the soft aroma and soft and mellow taste of blue and white porcelain wine. The audience's visual understanding and emotional recognition of Fen Liquor culture are enhanced through conceptual image expression. At the same time, the overall packaging also integrates Chinese traditional cultural elements and national spiritual symbols. It reflects the historical inheritance and cultural characteristics of Fen Liquor.

4.2. Interaction

Interactive semantics occupies an intermediary position in the study of visual grammar. This theory is based on observers' in-depth reflection on the reproduced meanings of multimodal texts. It is the primary understanding of the reproduced meaning of a text and the interaction and communication between creator and observer. Interaction semantics consists of four parts: contact, social distance, attitude, and modality.

"Contact" is the earliest subsystem of interaction. That is, the virtual connection formed by the interaction of sight between the image participant and the outside observer. Communication generally includes two components: "request" and "offer." From a packaging perspective, "request" refers to the most direct and effective interactive communication between the audience and the image. Does the packaging image have evident and direct eye contact with the audience? This method of communication usually conveys different information and effects. "Provide" means that there are special "visual receptors" among the various elements in the packaging image[18]. The most significant difference between the two is whether there is eye contact between the elements in the picture and the audience. If there is, then it is a "request". If not, then it is "offer". Starting from the bottle, the Chinese characters "fen" and "wine" are the primary packaging. In other words, there is no face-to-face contact and communication between the elements in the work and the viewer. Such a connection is called an "offer." If you look carefully, you will find many characters of different shapes on the bottle's main body. Among them, the image symbols of the word "wine" are mostly oracle bone inscriptions, bell and tripod inscriptions and small seal scripts. The font is small, the strokes are thin, the color is light, and the arrangement is loose. It is integrated with the blue and white porcelain pattern and complements each other. It complements the main graphic elements to make the theme elements appear more agile, elegant and accessible. In addition, different fonts set off each other, allowing people to appreciate Fen Liquor Company's century-old vicissitudes and exquisite brewing technology.

Social distance refers to the social relationship between the person in the image and the observer. The connection between the two is achieved through framed scenes. Frame landscapes can also be subdivided by elevation into close, middle, and long shots[19]. The bottle image with "Fen Liquor" as its main content is segmented at close range to achieve social distance. Graphic symbols are abstract and ambiguous. In terms of decoration, it is more accessible and flexible than oil painting, with appropriate merits. Subtle changes can show rich emotional connotations and vitality. Due to the enlargement of details, the font's texture, the ink color's undulations, the harmony of shades, and the character's personality and interest are all clearly expressed. The rarest thing is that the writing on these bottles was engraved on the spot after burning. Such a close situation shows the aesthetic realm of Chinese art of the unity of nature and man. In this way, the viewer can feel the profoundness of Fen Liquor, the ups and downs of Chinese culture, and the majestic artistic conception[20].

"Attitude" is looking at things from a specific perspective. It reflects people's views and emotions on things from the side. Posture is an immersive connection, which can be divided into two types: horizontal vision and vertical vision. The lateral view can be divided into two types: front and side. The front view refers to the sensibility of people in it; the lateral view refers to the objectivity and calmness, not in it. The longitudinal view is divided into three types: upward view, downward view and upward view. Looking from the bottom up indicates strength and superiority; the bird's-eye view conveys the message of "equal position." The angle of looking up represents the observation and worship of things. The blue and white porcelain bottle image uses horizontal and frontal angles to express the correspondence between the image and the viewer. This helps bring the viewer closer and more easily brings the viewer into the spiritual world shown in the image.

Modality reflects people's views on things. By adjusting the expression techniques of the picture, we can convey the life attitude and ideal beliefs hidden behind the picture. People's modality classification is divided into three levels: high, medium and low. The meaning contained in each level is also different. High modality refers to using more highly saturated colors in the picture, which are bright, exaggerated and high-key. Medium mode refers to the use of non-strong tones in the picture, which is soft, simple and stable; low profile means that the picture only uses black and white. This gives people a slightly depressing, heavy, but solemn feeling. Blue and white porcelain wine packaging uses indigo as the leading tone, a color with low unsaturation in the soul. It is refreshing, grand and luxurious and reflects Fen Liquor's open-mindedness and refreshing and elegant charm.

4.3. Meaning of composition

Compositional meaning is the ultimate aspect of visual grammar. "image" expresses "spatial structure," the interrelationship between various elements in multi-channel discourse. It is also the overall visual experience that the viewer can get. Its measurement indicators mainly include three dimensions: information value, significance and perspective.

4.3.1. Information value

The basis for judging the value of information is the location, degree, and centrality of the image elements in the work. Starting from the center of the image, it gradually decreases in importance. In addition, the transfer from the left to the right is also a layer-by-layer transformation from known to needs. The blue and white porcelain wine with "Fen" as the main body plays a significant role in the packaging. Whether viewed from a distance or up close, it is particularly conspicuous. The tone of the trademark is highly recognizable. The surrounding materials are also in the form of ancient Chinese calligraphy and painting inscriptions. The red lacquer and ink-blue calligraphy are integrated, highlighting the humanistic interest and poetic sentiment of this painting. This seal element makes the bottle image more balanced and the artistic conception more intense. It has a robust cultural connotation[21].

4.3.2. Significance

Salience refers to the prominence of an image on the screen. The measurement of visual effect is mainly determined by the picture's size, position, shape, color and brightness. In other words, prominence makes design elements more prominent by enlarging the proportion, changing the position and shape, etc. In the blue and white porcelain wine, there are two prominent characters, "Fen Liquor" and a design of "smallmouth and pointed bottom" with "indigo" as the primary color. The shape of the smallmouth and the pointed bottom is derived from the smallmouth and pointed bottom of the painted pottery bottles unearthed in the early Yangshao Culture. According to experts, Chinese ancestors mastered the method of brewing wine 6,000 years ago. The bottle pattern of Fen Liquor is taken from this type to highlight its long history and mature wine-making technology[22].

4.3.3. Framing

Framing is to observe whether there are spatial separations or actual dividing lines in the picture. It reflects the interconnection of various elements in the picture at different positions. It can be seen from the picture that the bottle wall of the wine bottle can be divided into three sections: upper, middle, and lower, and it shows a shape that is narrow at the top and broad at the bottom. This concept of "separation" implies the contradiction and unity of the three talents of traditional Chinese "heaven, earth and man" and is a generally recognized way of thinking in Chinese literature, art and aesthetics. This has been China's spiritual essence and heritage for thousands of years. Judging from the appearance of this product, the two letters "fen" and "wine" are affixed to the side of the bottle. The audience only needs to turn the bottle to fully present the word "Fen Liquor." This movement, function and relationship are all based on the penetration, reconciliation, transfer and balance achieved by the interaction of yin and yang. This philosophical transmission puts the viewer in the tranquility and peace of the unity of nature and man.

The design of the blue and white bottle of Fen Liquor Yang Shao contains a dynamic construction process of multiple metaphors. First, the emotional symbolism with color as the main body creates an isomorphic relationship between people[23]. Green glaze is the color system of blue and white Fen Liquor. It has been understood or explained from the surface level of simple conceptual colors and identifying words. "Emotional symbols" refer to the profound combination of nature and life, nature and emotions. Secondly, we must take charm as the concept of life to achieve a state of unity between nature and man. As for the image of the bottle, it is mainly dry writing in cursive style, emphasizing the "charm" of "thinking white is black." It represents the highest artistic state of Chinese calligraphy and painting concepts. "Dilution" is a kind of detachment from the world. It has an air of nothingness and illusion. This immerses the viewer in contemplation and insight. In the end, countless emotions and fantasies are contained within the restricted bottle. The Blue and white porcelain Fen Distillery bottle is not limited to its shape. Its ethereal quality entirely depends on the imagination of the viewer and recipient. It reflects the aesthetic concept of Chinese painting of "putting no intention first, focusing on everything, and valuing stillness."

5. Conclusion

Multi-channel is the integration of multiple interactive methods, such as text, images, and sounds, to achieve the purpose of interactive communication. This structure includes "systemic functional linguistics" and "concept methodology." The theory consists of three parts. Blue and white packaging is a multimodal discourse that integrates words, images, connotations, and colors. The method of packaging patterns for liquor products based on human visual characteristics was studied. By comparing with traditional filtration methods, it is proved that this method can be better used for pretreatment before filtration of wine packaging. The experimental effect of this method is significantly better than the method proposed in the reference literature[5], and it can significantly improve the critical information in liquor packaging graphics.

Author contributions

Conceptualization, JW and YC; methodology, JW; software, JW and YC; validation, YC; formal analysis, JW; investigation, JW and YC; resources, JW; data curation, YC; writing—original draft preparation, JW; writing—review and editing, JW and YC; visualization, YC; supervision, JW; project administration, JW and YC; funding acquisition, JW and YC. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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