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Computer-Aided Design AND APPLICATIONS

Interactive Creation Method and Implementation of Printmaking with Image Segmentation Technology

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Abstract. The use of new media art has gradually become one of the distinctive features of contemporary art creation, and the figure of new media art has also emerged in contemporary printmaking art. In today's society, digital images dominate the new media era, and new media technology has quietly penetrated into our visual culture. People's aesthetic and thinking patterns are also undergoing significant changes. This article focuses on the diversified transformation of contemporary printmaking under the development of new media art, mainly analyzing works using 3D technology. To grasp the development trend of future printmaking art and the correct integration of printmaking and new media art methods through image segmentation. A detailed analysis and demonstration of the transformation of contemporary printmaking in terms of artistic concepts, work forms, and creative media under the development of new media, using research methods such as comparative argumentation. The article affirms the positive transformation and impact that the development of new media art has brought to printmaking while also analyzing the areas for improvement in its integration with contemporary printmaking. Strive to expand the expressive power of printmaking art language while promoting its wider dissemination and development.

Keywords: Image Segmentation; Printmaking CAD Creation; High Precision; High Efficiency; Artistic Creation
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1 INTRODUCTION

In recent years, due to the impact of emerging media such as mobile Internet and smartphones, more and more artistic talents have gradually been labeled as print art with new media attributes, which is no exception [1]. Contemporary printmaking artists should not only be limited to traditional concepts and frameworks of artistic creation but also need to seek a new perspective of artistic creation and break the thinking mode of graphic creation. In the context of the increasing public aesthetic power, we can find that some printmaking artists are no longer satisfied with the traditional path of printmaking and are beginning to seek new ways of expression [2]. In addition, with the outstanding performance of new media technology in other fields, contemporary printmaking techniques naturally begin to undergo transformation, just like other art categories. Therefore, it has become an urgent and important issue to deeply consider the changes that have occurred in contemporary printmaking under the development of new media art, the artistic characteristics, and how to use new media and other methods to present more comprehensive art [3]. Compared with traditional printmaking in the past, printmaking art in the context of new media has a new form of artistic expression and characteristics. A small number of artists attempt to utilize the basic characteristics and technological advantages of information technology to combine new media technology with printmaking art, attempting to form a new display method that is multi-angle and more aesthetically pleasing [4]. Therefore, in order to better keep up with the times and further promote printmaking art.

At the same time, educators and participants can provide personalized guidance and feedback to help students discover and solve problems encountered in learning [5]. At the same time, through personalized guidance and extensive interactive communication, students' learning interests and creativity have been fully stimulated, laying a solid foundation for their future artistic path. Compared to traditional teaching methods, it is more intuitive and efficient and can help students gain a deeper understanding of the essence and essence of printmaking art [6]. As a unique form of art, printmaking often contains rich textures and details. In the process of printmaking, artists will use different knife techniques, lines, and colours to express the connotation of their works. However, when printmaking works are affected by certain factors (such as ageing, pollution, or poor shooting conditions), their texture and details may become blurry and difficult to observe and analyze clearly. At this point, image segmentation-based techniques can come in handy. Similar to handling fog images, we can develop a printmaking analysis system based on image segmentation technology. The study analyzed the limitations of the FCM clustering centre initialization method and similarity measurement and proposed an improved FCM algorithm based on parameter initialization. Simultaneously affecting the convergence speed of the algorithm. To ensure that the FCM algorithm can quickly converge to a more accurate and stable cluster centre, this paper combines the statistical characteristics of the image grayscale histogram to initialize the cluster centre [7]. To enhance the robustness of the improved algorithm to clustering structures, a high-dimensional spatial distance function is introduced using a Gaussian kernel function; Provide an estimation method for the radial width of Gaussian kernel function. The random initialization of FCM clustering centres has a significant impact on segmentation, which may cause the objective function to fall into local minima, resulting in inconsistent clustering results obtained by the algorithm in different execution processes. This algorithm has improved the image segmentation effect and efficiency to a certain extent. The texture of printmaking is one of the sources of its unique charm, which includes the texture, colour distribution, and lighting effects of the image [8]. Through texture segmentation, we can distinguish different areas in printmaking works (such as background, main body, details, etc.), in order to analyze the artistic characteristics and style of the work more deeply. After implementing these two parts, we can combine them to form a complete printmaking analysis system.

These technologies are crucial for a wide range of image understanding applications, especially in the field of printmaking art. In order to better understand and apply image segmentation techniques to printmaking, some scholars have proposed a systematic classification method for image segmentation research in printmaking analysis [9]. It is called the "Print MFHIST Multi-level Image Segmentation Classification Method." At the level of image representation methods, we explored how to represent these features best so that algorithms can effectively process them. It is not necessarily necessary to incorporate digital media in current printmaking creation, but it is also entirely possible to use certain digital media methods in the process. The main purpose is to clearly express that the application of digital media has played a positive role in the development of contemporary printmaking and has a unique artistic form and aesthetic value [10]. The use of digital media combined with contemporary printmaking art does not necessarily require labeling or specifying the specific variety. The excellence of a printmaking work depends not on how flexible and fast digital media is used but on whether the creator can use the tools in their hands to appropriately express their thoughts, mental state, and attitude towards the world. However, the consensus is that digital media can indeed be used to enrich, support, and develop printmaking rather than dissolve it [11]. From the different stages of printmaking development, it can be seen that each development is closely related to technology, and printmaking will continue to advance with the development of technology. The application of digital media in printmaking is an extension and expansion of traditional printmaking, which can expand the concept of printmaking, stimulate the pursuit of new spiritual levels in printmaking, and change the aesthetic concept of printmaking. It is then printed with the cooperation of printing machines, independently completed by artists, and is a purposeful artistic creation activity for people. The development trend of modern printmaking is to use digital cameras, scanners, computers, output machines, and digital laser engraving machines to create or participate in the printing process, which is the result of the combination of printmaking art and digital technology. In the traditional sense, printmaking is mainly in the form of two-dimensional paper, using tools such as knives and brushes to draw on specific media materials. The involvement of digital media in printmaking is a cross-fusion of science and art, and the development of technology has brought tremendous updates to printmaking [12].

The central focus of this article is to investigate the collaborative creative method of printmaking CAD, aided by image segmentation, and validate its feasibility and efficacy through rigorous simulation experiments. More specifically, our investigation will centre around the following:

(1) In-depth analysis of the theoretical basis of printmaking CAD creation and image segmentation technology, and clear the research scope and focus.

(2) Design and implement an interactive creative system of printmaking CAD with image segmentation technology, including image input, preprocessing, image segmentation, element extraction, creative editing, and output.

(3) The performance and effect of this method are verified by simulation experiments, and the differences and reasons between the experimental results and the expected goals are analyzed and discussed.

(4) Summarize the research achievements and shortcomings, and put forward the future research direction and improvement suggestions.

The innovations presented in this article are highlighted by the following points:

(1) The integration of image segmentation technology into print CAD creation enables precise extraction of crucial elements from intricate images, offering a novel, efficient, and accurate approach to print creation.

(2) Through the application of image segmentation technology, this study identifies the optimal image segmentation algorithm tailored for printmaking CAD, thereby enhancing the precision and efficiency of the segmentation process.

(3)The proposed creative method for printmaking CAD, incorporating image segmentation technology, encompasses not only technological advancements but also aligns with artistic creative needs and aesthetic standards. This holistic approach focuses on both technological implementation and its seamless integration with the artist's creative workflow, embodying the harmonious blend of technology and art.

This article is structured into six sections, outlined as follows: The introductory section elucidates the research background, significance, current research status, objectives, content, and the overall structure of the article. The second section delves into related works. The third section provides an overview of printmaking CAD creation and image segmentation technology. The fourth section details the design of a printmaking CAD creation method that integrates image segmentation technology. The fifth section presents the simulation experiments and analyzes the results. The final section offers conclusions and future prospects.

2 RELATED WORK

Li et al. [13] focused on exploring the application and development of digital media in contemporary printmaking art. Printmakers should make full use of the advantages of digital media in their artistic practice, embrace the new media brought by the new era, and create art that belongs to this era. In today's rapidly changing science and technology, digitization brings many possibilities to printmaking creation. It is also based on this relatively new technological means to explore its possibilities in the development of printmaking art, aiming to explore how digital media and contemporary printmaking can interact and develop healthily. Only those who approach technology calmly are serious artists, because they are experts in perceiving and perceiving changes. Liu et al. [14] sorted out the art classification and conceptual definition of printmaking under traditional concepts and then analyzed the update and development status of concepts after the intervention of digital media. The significance and influence of digital media in contemporary printmaking creation, and the integration of digital media provide a new path for the development of contemporary printmaking. They then explore how the two can interact and develop healthily, and introduce the humanistic spirit required after the intervention of digital media in printmaking creation. However, it also brings many temporary problems, analyzing the advantages and disadvantages of digital media in printmaking creation. Continuing from the previous text, relevant examples in contemporary printmaking art at home and abroad were cited to explore the application status of digital media further and analyze digital media. Liu and Yang [15] mainly explored the relationship between the humanistic spirit and the application of digital technology in printmaking art, pointing out that the humanistic spirit is the core of digital media application in printmaking creation. The humanistic spirit carries the emotions of digital media applied to printmaking creations and is an important factor in determining whether printmaking can enter the depths of people's hearts. Clarifying the humanistic spirit is the key to continuously enriching the charm and vitality of digital media applications in printmaking creation. This in-depth analysis can help us better understand the artistic value and style characteristics of works, providing strong support for the inheritance and development of printmaking art.

In the field of printmaking art, interaction is not only a part of the artist's creative process but also an important way for public users to understand and appreciate printmaking works deeply. By analyzing these vector models, it is possible to predict the regions that users may be interested in and, based on this, propose interaction suggestions such as zooming in, highlighting, or providing relevant background information. This challenge mainly stems from the lack of professional knowledge and analytical ability in printmaking works and their technical background. This method is particularly useful in printmaking works based on image segmentation technology. In the field of computer vision, image segmentation refers to dividing an image into different regions, aiming to simplify or transform the representation of the image, make its meaning clearer, and facilitate analysis. The quality of image segmentation results directly affects the accuracy of target representation, description, and feature extraction, which in turn affects the research of pattern recognition and computer vision. There are many algorithms for image segmentation, but there is no universal method or strategy, so it has always been regarded as a bottleneck in the field of computer vision, inspiring people to conduct in-depth research. Image segmentation has a pathological characteristic. On the one hand, uneven lighting or other external factors make the boundaries of image features vague and difficult to distinguish clearly. On the other hand, the subjective characteristics of human knowledge cognition and visual perception often result in non-unique or uncertain criteria for classification. The fuzziness and uncertainty of such concepts cannot be effectively modelled using classical set theory but can be well addressed through fuzzy set theory. The theoretical method based on fuzzy sets provides a solid theoretical foundation for the analysis of fuzziness in image segmentation. The fuzzy membership function can effectively characterize the fuzzy characteristics of the membership relationship of image pixels. To address this issue, Ma et al. [16] proposed a machine learning-based approach aimed at providing personalized and insightful interactive recommendations for novice users. Taking a traditional Chinese printmaking visualization system based on image segmentation technology as an example, the system not only displays the overall image of the printmaking but also presents different elements in the work (such as characters, scenery, patterns, etc.) through segmentation technology. For example, if the user frequently clicks and zooms in on the character area, the model can suggest that the user view detailed background information or related art comments about the character.

In the field of printmaking art, with the flourishing development of computer vision and image processing technology, image segmentation technology has brought new creative possibilities and profound understanding. Threshold processing allows artists to accurately separate foreground and background based on the grayscale or colour distribution of printmaking images or extract specific colour regions to highlight the theme and details of printmaking further. In today's society, digital images dominate the new media era, and new media technology has quietly penetrated into our visual culture. People's aesthetic and thinking patterns are also undergoing significant changes. Siti et al. [17] focused on the diverse transformation of contemporary printmaking under the development of new media art. Grasp the development trend of future printmaking art and the correct integration of printmaking and new media art methods. Mainly using research methods such as work analysis and comparative argumentation, this paper provides a detailed analysis and argumentation of the transformation of contemporary printmaking in terms of artistic concepts, work forms, and creative media under the development of new media. Strive to expand the expressive power of printmaking art language while promoting its wider dissemination and development. Many of the studies are relatively broad and rough summaries, with little detailed exploration of the transformation and innovative development of contemporary printmaking under the development of new media art. The main purpose of selecting the topic of "The Diversified Transformation of Contemporary Printmaking under the Development of New Media" for research is to explore the development status and multifaceted transformation of contemporary printmaking under the development of new media art. The use of new media art has gradually become one of the distinctive features of contemporary art creation, and the figure of new media art has also emerged in contemporary printmaking art. Xiao and Ni [18] discussed the diverse transformation of contemporary printmaking in terms of artistic concepts, work forms, and creative media under the development of new media. The article affirms the positive transformation and impact that the development of new media art has brought to printmaking, while also analyzing the areas for improvement in its integration with contemporary printmaking. Finally, innovative aspects and future prospects for the development of printmaking art in the future were proposed. By properly integrating with new media, audiences can truly participate, and only in this way can we better promote the innovative development and widespread dissemination of printmaking art in the future. In the future development of printmaking art, it is necessary for artists to fully showcase the language characteristics of printmaking, as well as their current social life and humanistic sentiments, and selectively absorb cutting-edge culture and concepts.

In recent years, with the development of deep learning, image segmentation technology has made tremendous progress. The common neural network structures for image segmentation cannot produce good segmentation results, and the processing of lines and edges in ancient painting images is relatively rough. There are numerous cultural relics and painting images in China, which are of great significance in various fields such as cultural and creative industries, art appreciation and analysis. However, due to the particularity of cultural relic painting image data in terms of lines, colours, and the shape of character targets. In response to the above issues, Zhang [19] studied the image segmentation problem of ancient figure painting images based on deep learning. Simultaneously using a hypercolumn feature module to integrate shallow and deep-level features in convolutional neural networks. Propose an image segmentation neural network based on dilated convolution and hypercolumn features. Based on a fully convolutional neural network structure, introduce dilated convolution. Based on large-scale kernel convolution, a pixel classification module was designed to process the hyper-column features and achieve good segmentation results. Aiming at the problem of rough lines and edges in ancient painting images processed by neural networks, the Graph Cut algorithm is improved by combining image segmentation neural networks. We achieved better performance than neural network models such as SegNet, which proves the feasibility of the image segmentation network model proposed in this paper. The improved algorithm can correct the segmentation results of image segmentation neural networks and obtain refined segmentation results of ancient figure painting images. The algorithm has also been tested on art image datasets mainly based on ancient figure painting and has achieved very good results, proving the effectiveness of the segmentation algorithm in solving the problem of ancient figure painting image segmentation.

3 OVERVIEW OF PRINT CAD CREATION AND IMAGE SEGMENTATION

3.1 Introduction of Print CAD Creation Technology

Digital media is widely used in printmaking today, which is closely related to the development of high-tech technology. This has also created a virtual "cyberspace" that stimulates the integration and collision of digital media technology and traditional printmaking techniques, expanding the artist's creative techniques. The breakthrough in printmaking in today's era is important for the new aesthetic features brought by new media to keep pace with the times and be accepted by people. Compared with other visual arts, printmaking art has its unique aesthetic characteristics, and upon careful analysis, each type has its own unique aesthetic characteristics. The creative process and key technical points of printmaking CAD are shown in Table 1:

Step	*Content*	*Key technical points*
1. Material acquisition	Artists get the basic image materials of prints by hand-drawing, scanning, or shooting.	Digital image technology (scanning or shooting)
2. Digital processing	Using CAD software to digitize the obtained material, including image restoration, color adjustment, line extraction, and other operations.	Image processing technology (restoration, adjustment, extraction)
3. Creative ideas	In CAD software, artists edit and modify images according to their own ideas and ideas to form preliminary prints.	Drawing and editing technology (accurate drawing and modification)
4. Output production	The print works in CAD software are exported to printers or engraving machines for entity production.	Output production technology (printing, engraving, etc.)

Table 1: Creative process and key technical points of printmaking CAD.

3.2 Fundamentals of Image Segmentation Technology

Image segmentation technology stands as a crucial aspect of digital image processing, involving the partitioning of images into distinct regions or objects sharing comparable characteristics. These areas or objects have certain similarities in visual characteristics, but there are obvious differences between different areas or objects. The basic concepts of image segmentation technology include (1) Pixel: The basic unit of an image, and each pixel has a specific colour or grey value. (2) Region: A set of pixels with similar properties, usually corresponding to an object or background in an image. (3) Edge: The boundary between different areas, usually formed by the sudden change of pixel grey value or colour value.

There are many methods for image segmentation. Table 2 lists several main methods:

Method name	*Method description*	*Examples of common operators/algorithms*
Threshold segmentation method	By setting the grey threshold or colour threshold, the image is divided into foreground and background.	Manual threshold segmentation, automatic threshold segmentation, adaptive threshold method, etc.
Regional growth method	Starting from a pixel, the adjacent pixels with similar properties are merged into a region.	Region growth is based on colour or grey level.

Edge detection method	Detect the edge information in the image and divide the image into different regions.	Robert operator, Prewitt operator, Sobel operator, Canny operator, etc.
Segmentation method based on clustering	The pixels in the image are regarded as data points, and the data points are divided into different clusters by the clustering algorithm, and each cluster corresponds to an image area.	K-means, fuzzy c-means, etc.
Segmentation method based on graph theory	The image is regarded as a weighted undirected graph, in which the nodes correspond to the pixels in the image, and the weights of the edges represent the similarity between adjacent pixels. The image is divided into different regions by algorithms in graph theory.	Minimum cut, maximum flow, etc

Table 2: Main methods of image segmentation.

4 PRINTING CAD CREATION METHOD

When designing the creation method of print CAD with image segmentation technology, the design idea of this article is to integrate image segmentation technology into the creation process of print CAD and realize efficient and accurate print creation by accurately extracting image elements, and providing flexible editing tools and optimization algorithms.

The specific steps of printmaking CAD creation method integrating image segmentation technology are as follows:

(1) Image acquisition and pre-processing: The artist first obtains the print image material that needs to be created, and carries out necessary pre-processing operations, such as denoising and enhancement, to improve the image quality.

(2) Image segmentation: Image segmentation technology is used to segment the preprocessed image and extract the required image elements. In this step, we can use a variety of image segmentation algorithms, such as threshold segmentation, region growth, edge detection, etc., and choose the appropriate algorithm according to the characteristics of the image and creative needs.

In this article, a neural network method for image segmentation based on hole convolution and super-column features is proposed to solve the shortcomings of traditional image segmentation algorithms in dealing with detailed information and spatial structure. Based on FCN (Fully Convective Networks), this article introduces the hole convolution and super-column feature module, aiming at better capturing the multi-scale information and local details in the image and achieving more accurate image segmentation.

Let the input be:

$$x = \left[x_0, x_1, x_2, x_3, \ldots, x_n\right]^T \tag{1}$$

The connection weight is:

$$W = \left[w_0, w_1, w_2, w_3, \ldots, w_n\right]^T \tag{2}$$

The output of the neuron is:

$$h_{w,b} = f \; W^T x + b \tag{3}$$

Where x is the input of the network, $h_{w,b}$ is the input of the network, and b is the offset.

For the convolution kernel K with dimension $m \times n$, $k_{u,v}$ represents the value at the convolution kernel coordinate u,v, where: $1 \le u \le m, 1 \le v \le n$. The convolution operation is as follows:

$$y_{i,j} = K * X = \sum_{u=1}^{m}\sum_{v=1}^{n} k_{u,v} x_{i-u+1,j-v+1} \tag{4}$$

In the formula, $y_{i,j}$ represents the output value corresponding to the pixel $x_{i,j}$ in the image X, where: $1 \le i \le M, 1 \le j \le N$.

The hop connection in FCN is shown in Figure 1.

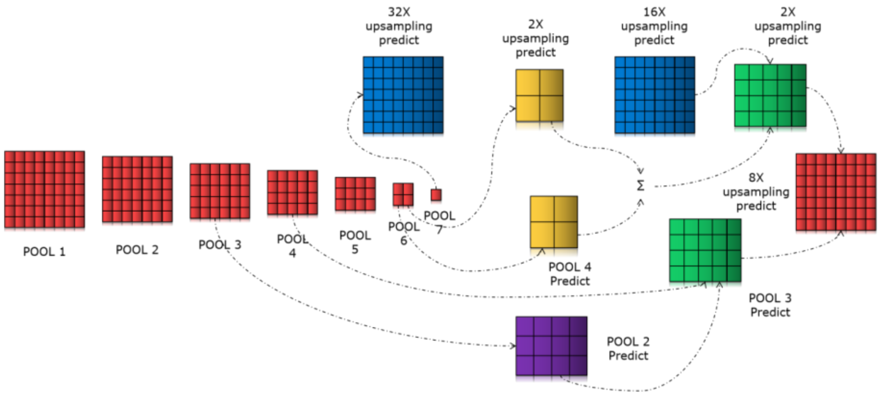

Figure 1: Jumping connection in FCN.

Hole convolution serves as an efficient approach to augment the receptive field of the convolution layer without augmenting the parameter count or computational load. This technique involves inserting zeroes into the convolution kernel, thereby enabling the expansion of the receptive field while preserving resolution. Consequently, it captures a broader context of information, which is particularly vital for image segmentation tasks. This is because segmentation often demands consideration of the spatial relationships and contextual information between pixels. Additionally, to blend shallow and deep features within a CNN (Convolutional Neural Network), this article incorporates a super-column feature module. Shallow features typically encompass richer details and edge data, whereas deep features exhibit stronger semantic information. The fusion of these diverse feature levels yields super-column features, encompassing both detailed and semantic data.

In this article, we design a pixel classification module based on large-scale kernel convolution to process the super-column features (Figure 2). Large-scale kernel convolution can further increase the receptive field while maintaining a high spatial resolution. Through this module, we can classify each pixel and get the final segmentation result.

Let $hp_{i,j}$ be the feature vector corresponding to the pixel $p_{i,j}$ in the super column feature, and its expression is shown in the following formula:

$$hp_{i,j} = \left[h_1\ i,j\ , h_2\ i,j\ , h_3\ i,j\ , \ldots, h_k\ i,j\ , \ldots, h_K\ i,j\ \right]^T \tag{5}$$

The super-column feature integration module designed in this article can generate its unique feature vector for each pixel. In this way, we can process these features more conveniently, so as to accurately obtain the category information of each pixel.

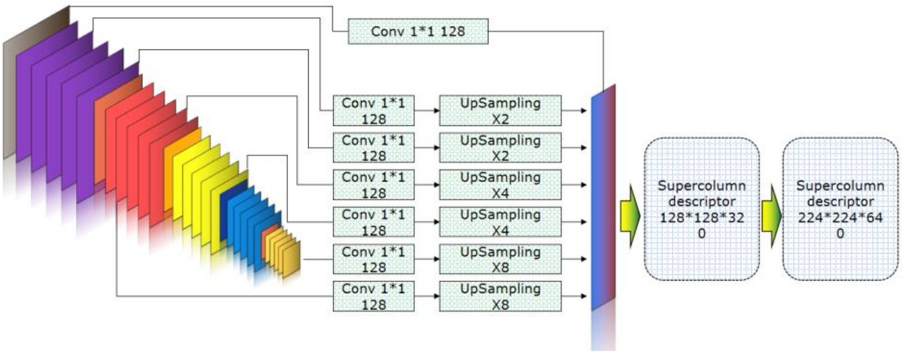

Figure 2: Supercolumn feature processing module.

The whole network structure consists of an encoder and a decoder. The encoder uses pre-trained CNN(ResNet) to extract multi-scale features through-hole convolution and pooling operation. The decoder integrates shallow and deep features by using a super-column feature module and classifies pixels by large-scale kernel convolution. Finally, the segmentation result map with the same size as the input image can be obtained.

ResNet structure is as follows:

$$F(x) = H(x) + x \tag{6}$$

Where $F(x)$ represents the output of the network, $H(x)$ is the result of processing through multiple convolution layers and pooling layers, and X is the input data. Feature extraction by hole convolution:

$$F_{atrous}(x) = Conv_{1\times1}(Conv_{atrous}(x)) \tag{7}$$

Among them, $Conv_{atrous}$ means using a hole convolution kernel to extract features, which is helpful in increasing the receptive field while maintaining the resolution. Feature pooling is used to reduce the spatial size of feature maps while maintaining information. The formula is as follows:

$$P(x) = MaxPooling(x) \tag{8}$$

Assuming $F_{encoder}$ is the output of the encoder, the super column feature module can be expressed as:

$$G(F_{encoder}) = Concatenate(F_{encoder}) \cdot W \tag{9}$$

Where W is a learnable weight matrix, and $Concatenate$ means connecting feature maps of different scales in the channel dimension. A large convolution kernel is used for fine pixel classification, where $Conv_{3\times3}$ stands for the large convolution kernel of 3×3. The formula for pixel classification by large kernel convolution is as follows:

$$C(x) = Conv_{3\times3}(x) \tag{10}$$

Element editing and adjustment: In CAD software, artists can edit and adjust the extracted image elements, including the modification of position, size, shape, and colour. CAD software provides rich editing tools and adjustment options to meet the individual needs of artists.

Creative conception and creation: After obtaining satisfactory image elements, the artist begins to carry out creative conception and creation. They can combine these elements to form unique prints. Furthermore, artists can also use the drawing tools of CAD software to add new lines, colours, and composition elements to enrich the expressive force of their works.

Output and production: After the creation is completed, the artist can output the work to the printer or engraving machine for physical production. In the production process, further adjustments and modifications can be made as needed to ensure the quality and effect of the final work.

In each of the above steps, this article adopts key technologies and algorithms to ensure the accuracy and efficiency of creation. For example, in the image segmentation step, this article adopts an advanced image segmentation algorithm to ensure that the extracted image elements are accurate. In the step of element editing and adjustment, this article uses the powerful function of CAD software to provide flexible editing tools and adjustment options. In the output and production steps, this article adopts high-precision printing and engraving technology to ensure the quality and effect of the final work.

5 SIMULATION EXPERIMENT AND RESULT ANALYSIS

5.1 Construction of Experimental Environment

The experimental environment includes the required hardware and software equipment and the corresponding software configuration.

Hardware environment: The hardware environment needed for the experiment mainly includes a high-performance computer, which should be equipped with enough memory and a high-speed processor to support complex image processing and CAD software running. In addition, a high-resolution display is needed to display and process images more accurately.

Parameter setting and data processing: In the experiment, some key parameters are set, including the threshold of the image segmentation algorithm and the line thickness of CAD creation. Furthermore, the data generated in the experiment process are processed and analyzed in order to assess the experimental results more accurately.

5.2 Display and Analysis of Results

Upon the conclusion of the experiment, the results were presented and examined. The findings revealed the print CAD outputs and image segmentation outcomes attained through the experimentation, visible in Figure 3.

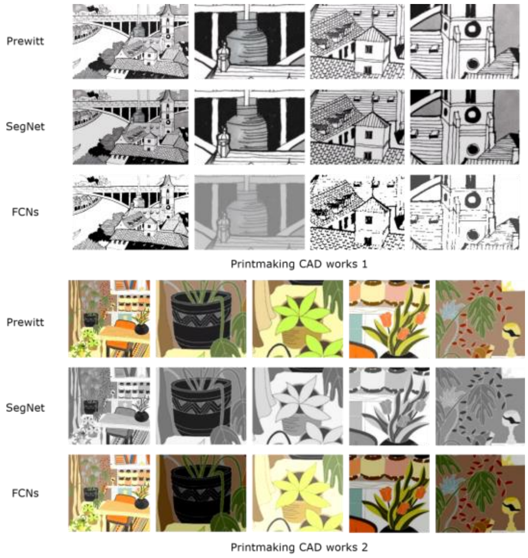

Figure 3: Image segmentation result display.

Print CAD works reflect the artist's creativity and style and have certain artistic value. Furthermore, the image segmentation results accurately and clearly extract the required image elements, which provides strong support for printmaking CAD creation.

Qualitative and quantitative analyses were conducted on the experimental results. The qualitative analysis primarily emphasized the artistic impression of the printmaking CAD works and the precision of the image segmentation outcomes. Meanwhile, the quantitative analysis evaluated the performance and efficacy of the experimental approach through meticulous counting and calculation of the experimental data. Figure 4 illustrates the precision of the image segmentation results. The MAE of the image segmentation result is shown in Figure 5.

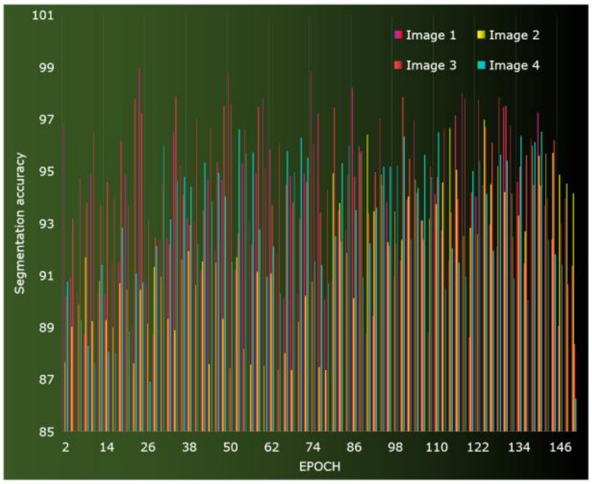

Figure 4: Accuracy of image segmentation results.

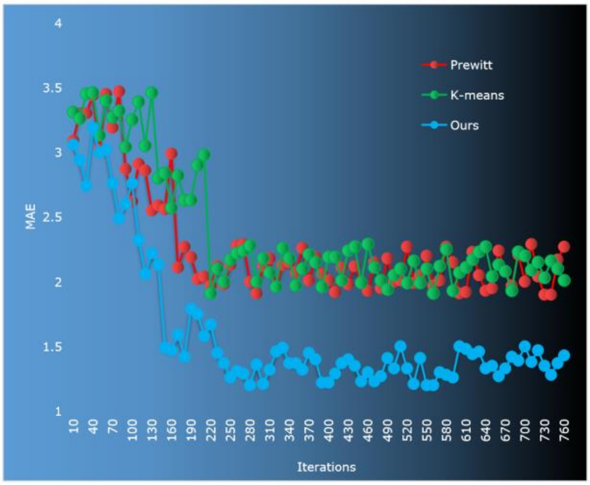

Figure 5: MAE of image segmentation results.

During image segmentation, MAE serves as a metric to measure the disparity between the forecasted and actual labels of individual pixels in the segmentation output. As demonstrated in Figure 5, a reduced MAE signifies enhanced pixel-level precision of the segmentation algorithm. The algorithm's efficacy is illustrated in Figure 6.

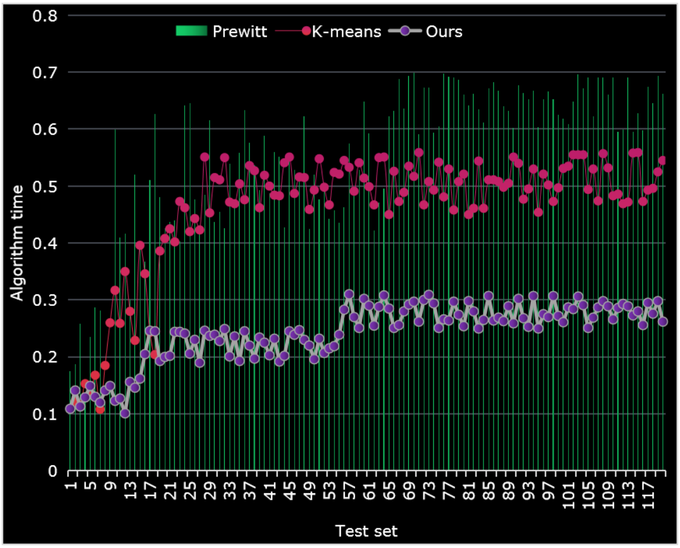

Figure 6: Efficiency of the algorithm.

The comparison of the algorithm's accuracy is exhibited in Figure 7.

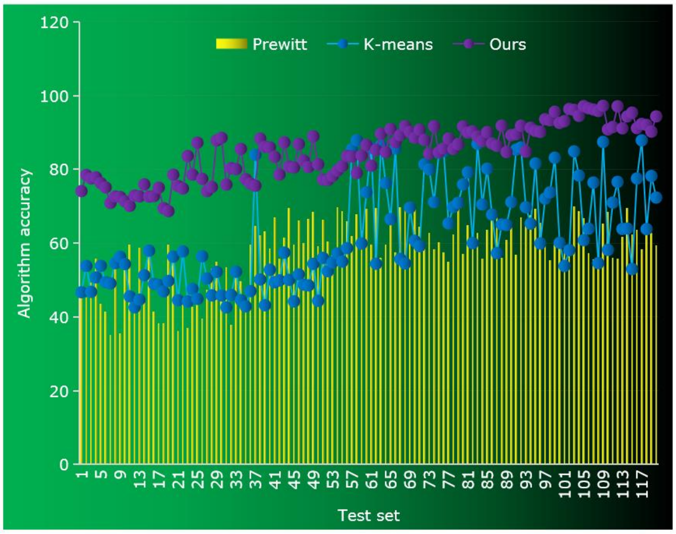

Figure 7: Accuracy comparison of the algorithm.

Drawing from the aforementioned results, it is evident that the proposed algorithm excels in image segmentation tasks, exhibiting not only remarkable accuracy and efficiency but also surpassing the Prewitt and K-means algorithms in terms of precision. This is due to the advanced technology used in the algorithm and the in-depth understanding of the characteristics of the data set.

In this section, experiments verified that the image segmentation neural network based on hole convolution and super-column features achieved a good segmentation effect on the data set and showed excellent performance in detail processing and boundary location. This provides strong technical support for the subsequent research and application of image segmentation.

6 CONCLUSIONS

This study has made significant breakthroughs in the field of printing CAD design, successfully integrating image segmentation technology and achieving the goal of accurately extracting key elements from complex images. It can accurately identify key elements in images and use CAD software to finely modify and improve them, ultimately creating highly personalized and artistic printmaking works. After a series of experimental verifications, we are confident that the application of image segmentation technology in printmaking CAD production can fully meet the fine requirements of artists for image element extraction and editing in the creative process. This innovative method not only greatly improves the efficiency of printmaking but also ensures the accuracy and artistic beauty of the final work. In addition, through simulation experiments, we further confirmed the effectiveness and superiority of this printmaking CAD method that combines image segmentation technology. Compared to traditional manual methods, this technology undoubtedly demonstrates higher efficiency and accuracy.

However, despite achieving significant results in this study, we are also acutely aware of the limitations and shortcomings that exist. Therefore, in future research work, we will be committed to studying the widespread application of various image processing technologies in printmaking CAD creation in order to expand creative methods further and improve the overall quality of artistic works. Looking ahead to the future, the printing CAD creation method based on image segmentation technology has extremely broad application prospects. We firmly believe that with the continuous progress and innovation of technology, future printmaking CAD creation will become more intelligent and personalized, bringing artists and audiences a richer and more colourful visual experience and artistic enjoyment.

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