Digital Protection and Inheritance of Intangible Cultural Heritage of Clothing Using Image Segmentation Algorithm

Yanyan Qi[1] and Qiong Zhou[2]

[1]Textile Engineering And Academy Of Art, Anhui Agricultural University, HeFei, Anhui 230036, China, Qiyanyan@ahau.edu.cn
[2]School of information and computer, Anhui Agricultural University, HeFei, Anhui 230036, China, zhouqiong@ahau.edu.cn

Corresponding author: Yanyan Qi, Qiyanyan@ahau.edu.cn

Abstract. As an important part of traditional culture, the protection and inheritance of ICH costumes are facing many challenges. The clothing image segmentation algorithm plays an important role in the digital protection and inheritance of ICH clothing by using computer aided design (CAD) and virtual reality (VR). By segmenting the clothing image, the clothing region in the image can be extracted. This article will focus on developing a clothing image segmentation algorithm based on deep learning (DL), which can automatically identify and segment key parts of clothing images, including styles, colors and textures. Simulation test shows that the image segmentation algorithm based on convolutional neural network (CNN) has better performance in modeling accuracy and efficiency. Using the clothing image segmentation algorithm based on DL, detailed information such as the appearance, structure and texture of ICH clothing can be digitally captured and stored, and efficient and permanent protection can be achieved. Digital ICH clothing can be used for virtual display, dynamic demonstration, redesign and other applications, thus further promoting the inheritance and growth of ICH clothing.

Keywords: Computer Aided Design; Virtual Reality; Intangible Cultural Heritage; Digital Protection
DOI: https://doi.org/10.14733/cadaps.2024.S12.159-173

1 INTRODUCTION

With the rapid growth of modern science and technology, CAD and VR technology have been widely used in various fields, including clothing design, manufacturing and protection. However, the application research of these advanced technologies in the protection and inheritance of ICH clothing is still insufficient. As an important carrier of traditional culture and history, ICH clothing has extremely high cultural, artistic and historical values. With the continuous development of technology, Computer Aided Graphic Expression Learning (CAGLE) has become a highly focused research field. CAGLE improves learning efficiency and quality by using computer technology to assist in graphic design, production, and learning processes. However, to achieve the best results of CAGLE, learners need to receive timely and meaningful feedback. Alique and Linares [1] explored the importance of fast and meaningful feedback in computer-aided graphic expression learning. Research has identified the key role of fast and meaningful feedback in computer-aided graphic expression learning. To explore the impact of rapid and meaningful feedback on CAGLE, we adopted a combination of literature review and empirical research. Firstly, we conducted in-depth research on relevant literature to understand the current status and research progress of CAGLE. Secondly, we designed an empirical study to evaluate the impact of rapid and meaningful feedback on CAGLE by comparing the learning outcomes of the experimental group and the control group. However, due to the fragility and variability of their physical properties, how to effectively protect and inherit these costumes has become an important challenge. Digital protection and inheritance of ICH clothing is an effective way, which can solve the problems of fragile physical properties and easy damage of traditional clothing. By using CAD/VR technology, the detailed information such as appearance, structure and texture of traditional clothing can be digitally captured and stored, and the efficient and permanent protection of ICH clothing can be realized. In addition, digital clothing can also be used for virtual display, dynamic demonstration and redesign, thus further promoting the inheritance and growth of ICH clothing. This article aims to explore the digital protection and inheritance methods of ICH clothing based on CAD and VR, and focuses on the clothing image segmentation algorithm based on DL. In previous studies, the design and display of weft knitted seamless knee pads mainly relied on experience and practice, lacking systematic theoretical guidance and technical support. Although some studies involve the application of virtual display technology, no in-depth research has been conducted on the specific issues of weft knitted seamless knee pads. In addition, existing virtual display methods still need to be improved in terms of realism and interactivity. In response to the above shortcomings, Cong et al. [2] proposed a virtual display method for weft knitted seamless knee pads based on a free deformation model, aiming to solve the problems existing in existing technologies and improve the realism and interactivity of the display. By studying the implementation process of the free deformation model, specific steps and methods for the virtual display of weft knitted seamless knee pads are developed. Analyze the parameter settings of the free deformation model and find the optimal parameter combination to improve the virtual display effect. The free deformation model can simulate the actual deformation of the knee pads, making the virtual display more realistic. The free deformation model allows users to control the deformation process of knee pads through interactive means, enhancing the interactive experience with virtual scenes.

With the continuous development of technology and the improvement of people's living standards, the concept of intelligence has penetrated into various fields. In the clothing industry, intelligent technology has also been widely applied. The intelligent clothing design CAD system, as an important embodiment of intelligent technology, aims to improve the efficiency and accuracy of clothing design, thereby enhancing the competitiveness of clothing enterprises. Hu [3] detailed the design and implementation of a component-based intelligent clothing modeling CAD system. The intelligent clothing modeling CAD system is a high-tech product that integrates computer-aided design, artificial intelligence, data analysis, and 3D printing technology. It can help designers quickly create clothing prototypes, perform virtual fitting and adjustment, reduce errors in traditional clothing production, reduce costs, and improve efficiency. At the same time, the intelligent clothing design CAD system can also quickly customize clothing according to the personalized needs of consumers, meeting the diverse needs of the market. Clothing image segmentation algorithm plays an important role in the stage of digital protection and inheritance of ICH clothing. By segmenting the clothing image, the clothing region in the image can be extracted, and then the subsequent processing such as feature extraction, style recognition, reconstruction and simulation can be carried out. The clothing industry, as one of the traditional manufacturing industries, has been constantly developing and innovating. Among them, knitted and woven fabrics, as two important clothing materials, play an important role in clothing design and production. With the continuous development of computer technology, computer-aided design and virtual clothing simulation have gradually become important tools in the clothing industry. Indrie et al. [4] explored computer-aided design and virtual clothing simulation for knitted and woven fabrics, with the aim of providing reference for research in related fields. In knitted fabric design, CAD software can simulate the texture and structure of different knitted fabrics, helping designers understand the characteristics and applicability of different knitted fabrics. In addition, CAD software can also carry out pattern design, color matching, and style planning according to the needs of designers, in order to improve the efficiency and accuracy of design. In the design of woven fabrics, the functionality of CAD software is equally powerful. This not only helps to improve the accuracy and efficiency of digital protection of ICH clothing, but also helps to realize the digital redesign and dynamic display of ICH clothing. Therefore, in digital game design, it is necessary to fully consider the needs of players and combine the characteristics of intangible cultural heritage to create a fun and educational gaming experience for players. In terms of functional requirements, digital games need to have rich functions and gameplay, including character design, scene design, game rule formulation, reward mechanisms, etc. In the design of digital games for intangible cultural heritage, it is necessary to combine the characteristics of intangible cultural heritage, concretize and innovate these functions, in order to enable players to experience the charm of intangible cultural heritage in the game, and achieve the goal of inheriting and protecting intangible cultural heritage. For example, a digital game with the theme of Chinese Paper Cuttings can be designed to let players understand and learn the history, characteristics and skills of Paper Cuttings art through simple and understandable level setting and vivid and interesting character design. At the same time, reward mechanisms can be set up in the game to encourage players to learn and explore intangible cultural heritage. As a powerful machine learning method, DL has been widely used in various image segmentation tasks, including clothing image segmentation. Kyosev [5] focuses on the material description of textile drape simulation, including data structure, open data exchange format, and experimental series automatic analysis system. The data structure of textile drape simulation mainly includes three parts: fabric structure data, fiber performance data, and simulation parameter data. Fabric organizational structure data includes fiber type, yarn density, fabric organization, etc., used to describe the microstructure and physical properties of textiles. These data can be obtained through methods such as image processing and chemical analysis. Fiber performance data includes mechanical properties such as elasticity, stiffness, and density of fibers, as well as physical properties such as moisture absorption and thermal properties of fibers. These data can be obtained through experimental measurements or literature. The simulation parameter data includes the magnitude and direction of external forces such as gravity, wind force, and friction force, as well as the calculation parameters such as time and spatial step size of the simulation. These data need to be set and adjusted according to experimental needs. By training the deep neural network, it can automatically learn and identify various features and patterns in clothing images, thus achieving efficient and accurate image segmentation. This article will study a clothing image segmentation algorithm based on DL, and learn and identify various features and patterns in clothing images by training deep neural networks, so as to achieve efficient and accurate image segmentation. By using the clothing image segmentation algorithm proposed in this article, the detailed information such as the appearance, structure and texture of ICH clothing is digitally captured and stored, and the efficient and permanent protection of ICH clothing is realized. Digital ICH clothing can be used for virtual display, dynamic demonstration, redesign and other applications, thus further promoting the inheritance and growth of ICH clothing.

This article will focus on developing a clothing image segmentation algorithm based on DL, which can automatically identify and segment key parts of clothing images, including styles, colors, textures and so on. This algorithm will greatly improve the efficiency and accuracy of image segmentation and provide key technical support for the digital protection and inheritance of ICH clothing. By using the above DL algorithm, I can extract the key features of ICH clothing and digitally protect it. Through the above-mentioned digital protection and inheritance methods, ICH clothing will be introduced into modern society, and new ways will be opened up for its inheritance and development. For example, through virtual display and dynamic demonstration, people can observe and understand these costumes at close range, thus enhancing the public's understanding and respect for ICH culture. In addition, digital clothing can also be used for modern fashion design and re-creation, and continue to inherit the cultural value of ICH clothing in new forms. Segmentation of clothing image by DL algorithm can extract the key features of clothing more accurately and efficiently, and provide technical support for digital protection. The innovation of the research is mainly reflected in the following aspects:

㊀ DL algorithm is applied to clothing image segmentation, which improves the accuracy and efficiency of image segmentation. Traditional image segmentation methods usually need to manually set the segmentation area or use a simple threshold segmentation method, while DL algorithm can automatically learn and identify the features and patterns in the image to achieve more accurate and efficient segmentation.

㊁ A method of digital protection and inheritance of ICH clothing is proposed. By using the clothing image segmentation algorithm based on DL proposed in this article, detailed information such as the appearance, structure and texture of ICH clothing can be digitally captured and stored to achieve efficient and permanent protection.

㊂ The clothing image segmentation algorithm based on DL proposed in this article is not only suitable for the protection and inheritance of ICH clothing, but also can be applied to other clothing fields, such as fashion prediction, clothing design and clothing production, which has a wide application prospect.

The structure of this article is as follows: The first section is the introduction, which introduces the background and purpose of the research. The second section is related work, summarizing the application of CAD and VR technology in the field of clothing and the application of DL in the field of image segmentation. The third section is the research of clothing image segmentation algorithm based on DL, and introduces the algorithm framework and implementation process proposed in this article in detail. The fourth section is experiment and analysis, which carries out experiments and analysis on the practical application of this algorithm, including experimental data, comparative experiments and result analysis. The fifth section is the conclusion and prospect, which summarizes the main contributions and conclusions of this article and puts forward the future research direction.

2 RELATED WORK

Traditional physical fitting has limitations in time and space, while virtual fitting technology can solve these problems, improve user experience and transaction rates. Among them, fabric modeling and simulation technology is the core of virtual fitting, and its accuracy and fidelity directly affect the effectiveness of user fitting. Therefore, studying fabric modeling and simulation in virtual fitting has important practical significance. The main task of fabric modeling is to describe and simulate the physical properties and motion patterns of fabrics in the real world. Among them, physical properties include the thickness, density, elasticity, etc. of the fabric, and motion laws include the stretching, bending, vibration, etc. of the fabric. In virtual fitting, fabric modeling is mainly achieved by establishing mathematical models, such as spring particle models, finite element models, etc. At the same time, in order to control modeling errors, it is usually necessary to optimize and adjust the model. Li et al. [6] provided an overview of fabric modeling and simulation techniques in virtual fitting. Users can experience the process and effect of trying on in a virtual environment, thereby better selecting products that are suitable for them. Warp knitted tubular bandages have a wide range of applications in medical and sports fields, such as wound dressing, limb fixation, etc. In order to optimize its design and usage, Liu et al. [7] introduced how to use a mesh model to simulate the geometry of warp knitted tubular bandages and explored its results. A mesh model is a geometric model based on mathematical methods that can accurately describe the shape, size, and material parameters of an object. When conducting geometric simulation of warp knitted tubular bandages, it is first necessary to establish a suitable mesh model, taking into account factors such as the warp knitted structure, tubular shape, and material properties of the bandage. During the process of establishing the model, it is necessary to carefully observe and measure the bandage to ensure that the model accurately reflects the actual shape and structure of the bandage. In the mesh model, it is necessary to mesh the bandage and select the appropriate mesh type and size. The selection of grid type and size has a significant impact on the accuracy and reliability of simulation results. To ensure the authenticity of the simulation results, it is necessary to select the appropriate mesh type and size based on the properties of the bandage material and the application scenario. As a new means of protection, digital protection provides new possibilities for the protection and inheritance of Qin Opera costumes. Digital protection can not only realize the true restoration and permanent preservation of Qin Opera costumes, but also endow Qin Opera costumes with new era characteristics and vitality through innovative design.

Liu et al. [8] discussed the feasibility and practicability of digital protection and innovative design of Qin Opera costumes. Through literature review, this paper summarizes the research status, methods, technologies and development trends of digital protection and creative design of Qin Opera costumes. At the same time, this study uses empirical research methods to analyze specific cases to verify the effectiveness of digital protection and innovative design on the protection and inheritance of Qin Opera costumes. The research results show that digital protection and innovative design are of positive significance in the protection and inheritance of Qin Opera costumes, and provide new ideas and directions for the innovative design of Qin Opera costumes. As an important part of Chinese traditional opera culture, Qin Opera costumes have rich cultural connotation and unique artistic value. Innovative design based on traditional craftsmanship can explore new production methods and materials through research and exploration of traditional craftsmanship, in order to optimize and upgrade costumes. Lu et al. [9] analyzed the rapid design and algorithm implementation of knitted sweater patterns. Design corresponding algorithms based on the theme and style of the pattern, such as genetic algorithm, particle swarm optimization algorithm, etc., to achieve automatic generation and optimization of the pattern. Implement algorithms through programming languages to generate patterns for knitted sweaters. Based on actual production requirements, evaluate the generated patterns, including color matching, graphic style, size ratio, and fine tune any unsatisfactory areas. By outputting specific parameters such as RGB values and area ratio of the generated pattern, the effectiveness of the algorithm in generating the pattern can be intuitively evaluated. At the same time, the generated patterns can be compared and analyzed with excellent works from existing knitted sweater pattern libraries to evaluate their innovation and practicality. In addition, through trial production and small-scale sales, customer feedback information can be collected to continuously improve and optimize the generated patterns. In short, using algorithmic ideas to design and implement patterns for knitted sweaters can not only improve design efficiency, but also provide designers with more creative inspiration and space to unleash. In the future, with the continuous development of artificial intelligence and computer technology, it is believed that the design and implementation of knitted sweater patterns will usher in broader development prospects. Meiklejohn et al. [10] introduced how to achieve the design and production of self forming woven textiles through simulation assisted design methods, and explored its application cases and future development directions. Self-forming woven textiles are intelligent materials manufactured using weaving technology, characterized by the ability to make corresponding morphological changes based on different environmental factors, thereby achieving adaptive capabilities. This material has broad application prospects in fields such as clothing, architecture, and transportation. To achieve simulation aided design of self-forming woven textiles, it is necessary to select different weaving techniques, fiber materials, and fabric structures based on actual application scenarios, in order to achieve the best adaptive ability. By mathematical modeling the structure of woven fabrics, using CAD software for simulation design, and optimizing the simulation results, the optimal design scheme is obtained. When producing self-forming woven textiles, 3D printing technology is needed to convert the design scheme into actual fabrics. Select appropriate 3D printing materials and printing processes based on the application scenario, such as photosensitive resins, plastic wires, etc. With the continuous development of technology, wearable devices have become a part of people's daily lives. Among them, the integration of wearable antenna technology has brought revolutionary changes to fashion clothing. As one of the current popular technologies, 3D virtual prototyping technology is increasingly widely used in integrating wearable antennas into fashionable clothing. With the continuous development of technology, augmented reality and virtual reality education spaces have become important components of modern education. Noah and Das [11] introduce the evolution of augmented reality and virtual reality educational spaces, the related technologies of computer animation and virtual worlds, and their applications in education. Virtual reality technology is only used to create static 3D models and scenes, and has evolved to create highly realistic dynamic environments and characters. Similarly, augmented reality technology has undergone a similar development process, allowing virtual elements to seamlessly integrate with the real world.

Papachristu and Anastassiu [12] introduced the application of 3D virtual prototyping technology in integrating wearable antennas into fashionable clothing. Designers can use this technology to create a wearable antenna and incorporate it into the design of clothing. This not only ensures the function of the antenna, but also makes the clothing look more fashionable and beautiful. In addition, 3D virtual prototyping technology can also optimize antenna performance during the production process, making it more suitable for human use. In the application of 3D virtual prototyping technology, some key technologies play a crucial role in integrating wearable antennas into fashionable clothing. Among them, digital virtual human technology and AI intelligence technology are the two most core technologies. Digital virtual human technology can help designers better understand the structure and motion of the human body, in order to design wearable antennas more comfortable and stable. The application of artificial intelligence in the field of wick process pattern design has provided designers with new ideas and methods, while also bringing new possibilities for sustainable development. Through artificial intelligence technology, we can obtain richer creative inspiration. Wang et al. [13] utilized machine learning and deep learning algorithms to learn a large amount of pattern data, in order to discover more innovative and practical design solutions. At the same time, artificial intelligence technology can continuously optimize and adjust design solutions based on user needs and feedback, in order to achieve more customized services. In terms of sustainable design, artificial intelligence technology also has significant advantages. By taking into account factors such as materials, processes, and the environment, artificial intelligence technology can help designers achieve more environmentally friendly and energy-efficient wick process pattern design. Digital humanities refer to the use of digital technology to record, analyze, and inherit various forms of human civilization. With the continuous development of artificial intelligence technology, the field of digital humanities has also begun to explore the application of artificial intelligence technology. Ye [14] takes Dunhuang culture as an example to explore the application of artificial intelligence technology in the inheritance, development, and innovation of Dunhuang culture. Digital humans refer to virtual character images created using artificial intelligence technology, which can be used for historical and cultural display, cultural inheritance, and cultural education. Virtual human refers to the use of artificial intelligence technology to simulate character images, which can be used in historical dramas, cultural activities, and artistic performances. Cultural digitization refers to the use of artificial intelligence technology to convert traditional cultural resources into digital formats for digital protection and inheritance. You [15] analyzed the digital empowerment of intangible cultural heritage CLO 3D virtual clothing design. Blue anti pinch dyeing customized clothing has a profound historical heritage and unique production techniques. It originated from ancient Chinese dyeing and weaving technology, and after generations of inheritance, it gradually formed a folk art with unique aesthetics and practicality. In order to protect and inherit blue anti pinch dyeing customized clothing, digital empowerment is adopted, and CLO 3D virtual clothing design technology is utilized to innovate its design. Firstly, conduct a demand analysis to comprehensively understand the cultural connotation, production process, and market demand of blue anti pinch dyeing customized clothing. Next, design ideas will be developed, combining modern aesthetics and traditional craftsmanship to provide creative inspiration for CLO 3D virtual clothing design. Finally, through the implementation of effects, the virtual design is transformed into actual products to meet consumer needs. Zheng and Jiang [16] used image processing and computer graphics methods to visually simulate and implement circular knitted transfer jacquard fabrics. Firstly, by taking high-resolution photos of circular knitted transfer jacquard fabrics in the real world, texture image data is obtained. Then, image processing techniques are used to preprocess the image data, including denoising, enhancement, and segmentation operations, in order to better extract pattern features. Next, using computer graphics technology, establish a three-dimensional model and convert the two-dimensional pattern into a three-dimensional fabric structure. In this process, factors such as yarn direction, coil arrangement, and jacquard need to be considered to truly reflect the structural characteristics of circular knitted transfer jacquard fabrics. Finally, simulation software is used to generate virtual fabrics with the same texture structure and performance.

Traditional methods mainly rely on manual setting and empirical judgment, and it is difficult to realize automation and intelligence. This article proposes a clothing image segmentation algorithm based on DL, and creates a digital database of ICH clothing and a VR system that can simulate and display these clothing. This method can effectively protect the integrity and authenticity of ICH clothing, Moreover, it can provide a more vivid and realistic display effect, and enhance the audience's immersion and experience.

3 METHODOLOGY

3.1 ICH Clothing Image Segmentation

With the progress of modern science and technology, DL technology has been widely used in the field of image segmentation. As an important part of traditional culture, ICH clothing is facing many challenges in its protection and inheritance. In ICH clothing image segmentation, CNN can be used to extract the features and patterns in the image, thus realizing rapid recognition. CNN consists of several convolution layers, pooling layers and fully connected layers. In the convolution layer, CNN extracts the features of the input image through convolution operation; In the pool layer, the amount of calculation and the quantity of parameters are reduced by down-sampling the feature map; In the fully connected layer, CNN classifies and recognizes the extracted features. In CNN model, the setting of super-parameter has great influence on the model performance. Common hyperparameters include learning rate, batch size and convolution kernel size. These parameters need to be adjusted according to specific tasks to obtain the best performance. The purpose of data cleaning is to remove noise and invalid information in data and improve data quality. Specifically, it is needed to remove the interference factors in the image, such as background and redundant information, and only keep the information related to clothing patterns. Data enhancement is to increase the diversity and complexity of data through random rotation, translation and scaling, so as to improve the generalization ability of the model. In the task of ICH clothing image segmentation, data enhancement can increase the diversity and complexity of the image by random cropping and flipping.

First of all, the image of ICH clothing needs to be taken as input for subsequent convolution operation. This image can be a color image or a gray image. In convolution operation, the convolution kernel is placed on a pixel of the image, and then the weight in the convolution kernel is multiplied by the pixel value at the corresponding position of the image, and then the products are added. For example, if the 3×3 convolution kernel is placed on a 3×3 image block, then each pixel point and its surrounding pixels will be weighted and summed to get a new intermediate result. This intermediate result is also a 3×3 matrix, which represents the result of convolution operation of the original image. When performing convolution operation, you need to specify the step size and padding. The step size determines the sliding distance of the convolution kernel on the image, and the filling determines whether additional pixels need to be added at the edge of the image when performing convolution operation. In the actual ICH clothing image segmentation algorithm, multi-layer convolution operation is usually used to extract different features in the image. For example, one layer of convolution operation can be used to extract the edge features in the image, and then another layer of convolution operation can be used to extract the texture features in the image. Finally, these features are combined to get a complete segmentation result of ICH clothing image. As shown in Figure 1, the convolution operation stage of ICH clothing pattern rapid recognition model.

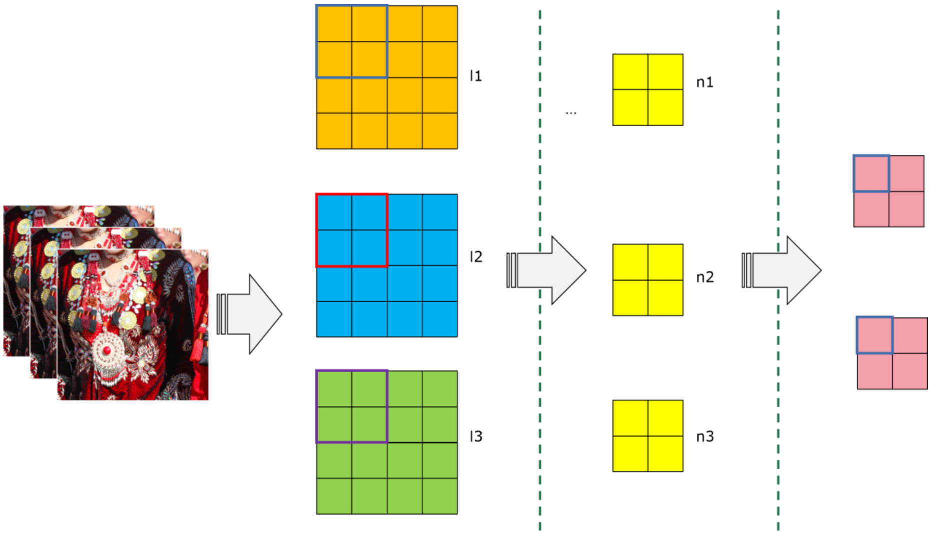

Figure 1: ICH clothing pattern rapid recognition model.

Input and required output are provided to the network, and the input is represented as each node connected to another node in the hidden layer. Each connection is a random weighted value. The output of all layers can be calculated according to the following formula:

$$a_j^l = f\left(\sum_k w_{jk}^l a_k^{l-1} + b_j^l\right) \tag{1}$$

Where a_j^l represents the output of the j neuron in the l layer; w_{jk}^l represents the weight parameter of connecting the k neuron in $l-1$ layer to the j neuron in l layer; f stands for activation function.

If the RGB of each pixel is exactly the same, that is, $R=G=B=Y$. Where $R=G=B=Y$ is called the gray value, which is within a certain range:

$$Y_{\min} \le Y \le Y_{\max} \tag{2}$$

Change the color bitmap from the following formula to a grayscale image:

$$Y = 0.299B + 0.587G + 0.114B \tag{3}$$

Let $f(i,j)$ be the gray value of the pixel, and $g(i,j)$ represent the gradient value corresponding to the pixel. Then the gradient of any pixel in the image is defined as follows:

$$g(i,j) = \sqrt{[f(i,j) - f(i+1,j+1)]^2 + [f(i+1,j) - f(i,j+1)]^2} \tag{4}$$

In this article, fractal difference is introduced into parameters as a special local operator, which has no memory and is updated by momentum information. In addition, in order to improve the effect of network optimization, the concept of average momentum is introduced into the parameter training of convolutional neural networks. The formula is as follows:

$$v_{ij}^{(l)}(k)=\mu v_{ij}^{(l)}(k-1)-\eta\frac{\partial E}{\partial w_{ij}^{(l)}(k-1)} \tag{5}$$

$$w_{ij}^{(l)}(k)=w_{ij}^{(l)}(k-1)+v_{ij}^{(l)}(k) \tag{6}$$

Suppose $f_{ij}^{(l)}(k)$ is the negative gradient of the k iteration:

$$f_{ij}^{(l)}(k)=-\eta\frac{\partial E}{\partial w_{ij}^{(l)}(k-1)} \tag{7}$$

The negative gradient $f_{ij}^{(l)}(k)$ indicates the change rate of $v_{ij}^{(l)}(k)$. In order to prevent the gradient from falling too fast, the negative gradient of the current iteration and the previous iteration is synthesized. Therefore, in the k iteration of the previous moment, $v_{ij}^{(l)}(k)$ is:

$$v_{ij}^{(l)}(k)=\mu v_{ij}^{(l)}(k-1)-\eta\frac{\partial E}{\partial w_{ij}^{(l)}(k-2)} \tag{8}$$

After completing the 3D modeling, it is needed to map the different parts of the segmented image onto the corresponding 3D model. This involves texture mapping technology, that is, mapping the texture information of two-dimensional images to the surface of three-dimensional models to obtain realistic clothing models. Through VR technology, the digital model of ICH clothing can be displayed in the virtual environment, allowing users to observe and interact from multiple angles. This requires the creation of virtual scenes, light sources and cameras to simulate the real-world display effect. In addition to virtual display, it is also needed to visually analyze the digital model of ICH clothing. For the digital protection and inheritance of ICH clothing, data storage and sharing are very important. Digital data needs to be stored in a reliable data center or cloud platform, and appropriate data access rights should be set to ensure data security and privacy. Moreover, it is also needed to provide data sharing function so that relevant personnel can access and use these data conveniently.

3.2 Digital Application of ICH Clothing

Through VR technology, the digital model of ICH costumes can be displayed in the virtual environment, so that people can observe and appreciate these precious costumes at close range. Through dynamic demonstration, we can simulate the dynamic effects of wearing, taking off, fluttering and so on, and enhance the audience's immersion and experience. This exhibition mode can attract more audiences to pay attention to and understand ICH culture, and promote the inheritance and growth of ICH culture. By digitizing ICH clothing, we can protect its integrity and authenticity, and avoid the possible damage or loss caused by traditional preservation methods. Moreover, digital preservation can facilitate data backup and sharing, so that more people can access and use these precious resources. This way of preservation can provide important support and guarantee for the inheritance and growth of ICH culture. By introducing the digital model of ICH clothing into modern fashion design, it can provide designers with new inspiration and creativity. Designers can copy, modify and recreate ICH costumes through digital models to show the charm of ICH culture in new forms. The digital application mode of ICH clothing is shown in Figure 2.

Through the image segmentation algorithm, different parts of ICH clothing images can be segmented and classified, and different features can be extracted. These features may include color, texture, shape, etc. The extracted features can be used to construct the three-dimensional model and texture mapping of ICH clothing digital model, so as to obtain a more realistic and accurate digital model.

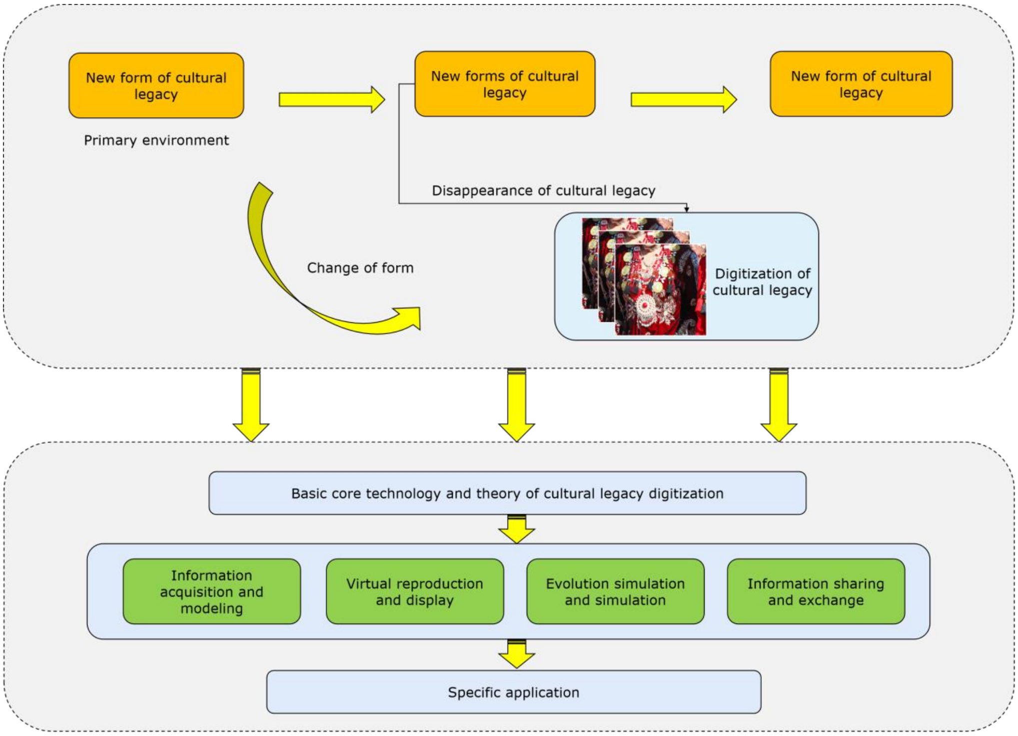

Figure 2: ICH clothing digital application mode.

Through image segmentation algorithm, different parts of ICH clothing digital model can be segmented and classified and stored in different data structures. In this way, the digital model can be stored and shared more flexibly, and it is also convenient for users to retrieve and access it. Through the image segmentation algorithm, the dynamic display and interaction of ICH clothing digital model can be realized. For example, the digital model can be divided into different parts according to the characteristics of clothing, and each part can be dynamically displayed. Moreover, users can interact with the digital model in an interactive way, such as changing the shape, color and other characteristics of the digital model, so as to experience the characteristics and beauty of ICH clothing more truly. Through the application of feature extraction, digital preservation and sharing, dynamic display and interaction, the inheritance and growth of ICH culture can be promoted, and the public's cognition and interest in ICH culture can be improved. Moreover, these applications can also provide valuable resources and support for researchers, designers and the public in related fields.

4 RESULT ANALYSIS AND DISCUSSION

As can be seen from Figure 3, the traditional method and CNN-based method have obvious differences in time consumption when dealing with VR image segmentation of ICH. When traditional methods deal with images with a large quantity of feature information pixels, their time consumption increases significantly. This is because the traditional method usually needs to process each pixel separately, so when the quantity of pixels increases, its processing time will also increase. In addition, traditional methods usually require complicated calculations and operations, which will also lead to an increase in processing time.

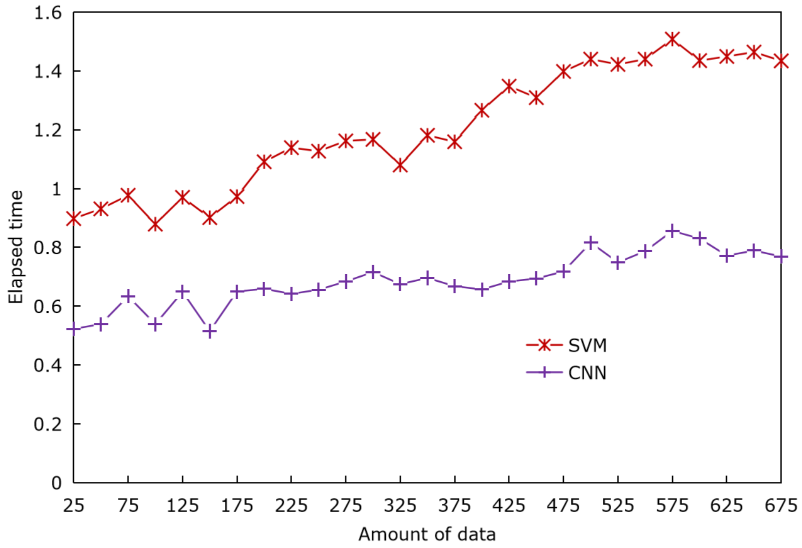

Figure 3: Time-consuming comparison results of image segmentation effects of different methods.

The method based on CNN takes relatively short time when processing the same quantity of feature information pixels. This is because CNN can use its hierarchical structure to segment the image, instead of processing each pixel separately. This kind of CNN can also learn the features of images through training, so as to make better use of these features for classification in the segmentation process. This learning ability enables CNN to converge to the optimal solution more quickly when dealing with the complicated VR image segmentation task of ICH, which further shortens the processing time. As can be seen from Figure 4, the accuracy of the ICH modeling method proposed in this article is significantly improved compared with the SVM algorithm. Specifically, this method improves the modeling accuracy by 26.66%.

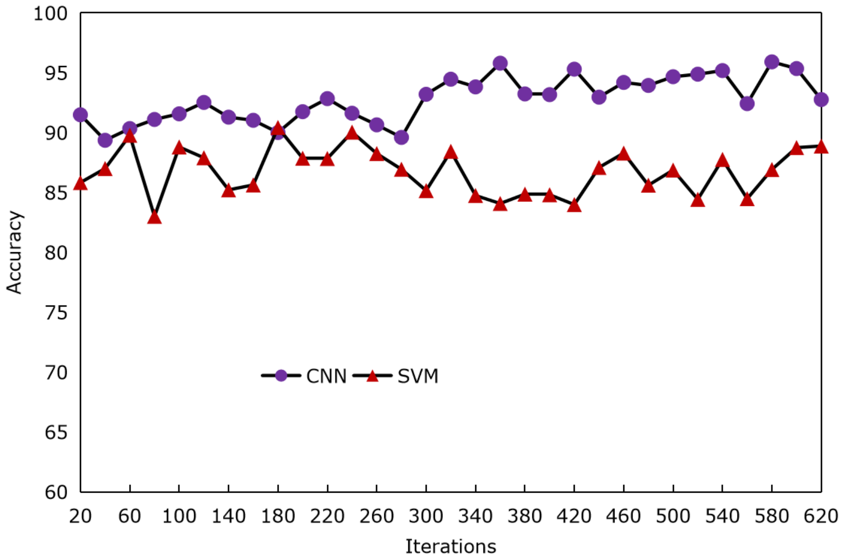

Figure 4: Accuracy results of different algorithms.

In ICH modeling, SVM algorithm may not be able to deal with the complex features and shapes of images well. This is mainly because SVM algorithm is based on linear classifier to learn and predict, and it may not be able to accurately model complex and nonlinear image features. The ICH modeling method proposed in this article can better deal with the problems of unclear and stereoscopic images. This is because in the stage of modeling, not only the pixel value of the image, but also the spatial information and other characteristics of the image are considered.

The VR image segmentation method of ICH based on CNN has better performance and efficiency compared with the traditional method when dealing with different numbers of pictures and different nodes (see Figure 5). Moreover, with the increase of the quantity of pictures and nodes, the time-consuming of the method based on CNN also increases accordingly.

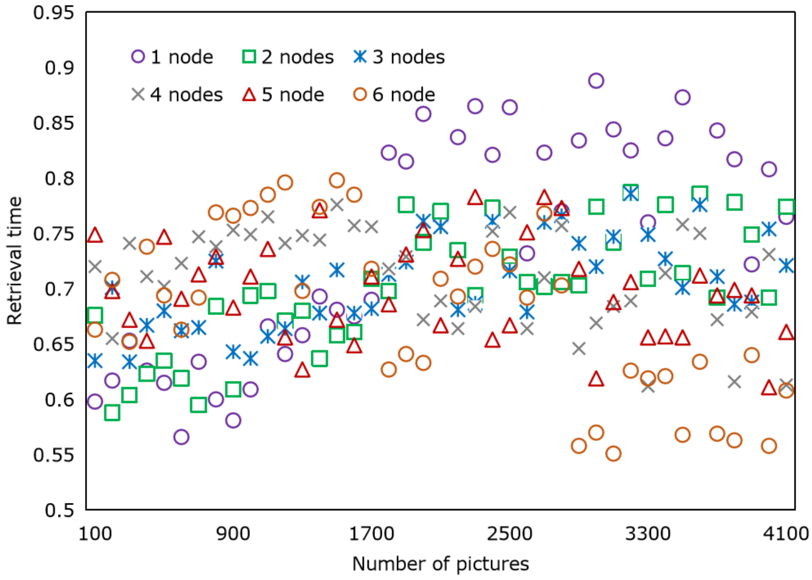

Figure 5: Image recognition consumes time.

As the quantity of images increases, the time consumption of CNN based ICH VR image segmentation methods is also increasing. This is because CNN requires a large amount of forward and backward propagation to train the network and recognize ICH images. As the quantity of images increases, the required quantity of training sessions also increases, resulting in an overall increase in training time. As the quantity of nodes increases, the time consumption of CNN based ICH VR image segmentation methods is also increasing. This is because increasing the quantity of nodes means increasing the depth of the network, making it more complex and requiring more time for training and reasoning. When the quantity of images and nodes is different, CNN based methods have advantages over traditional methods in terms of time consumption. Especially when dealing with a large quantity of images and nodes, the time-consuming advantage of CNN based methods is more obvious. This further proves the effectiveness and superiority of CNN in handling complex image segmentation tasks.

From Figures 6 and 7, it can be seen that the scatter plots of predicted and actual values on the test samples using the SVM model and the CNN based ICH digital protection model.

For the SVM model (Figure 6), we can see that scattered points are distributed on both sides of the straight line, but they are not very close to the straight line. This shows that there is a certain error between the prediction results of SVM model and the actual values on the test samples. SVM algorithm is based on linear classifier to learn and predict, and there may be some restrictions on the VR image segmentation task of complex nonlinear ICH.

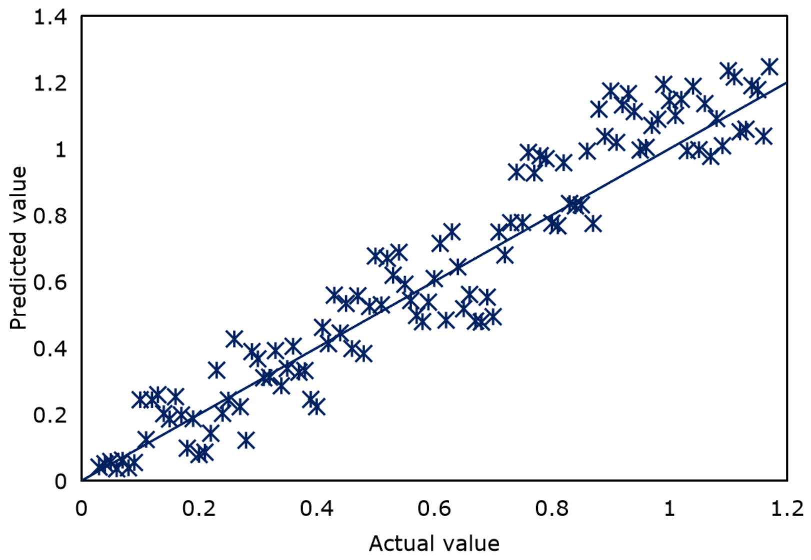

Figure 6: Scatter plot of actual value and predicted value of SVM.

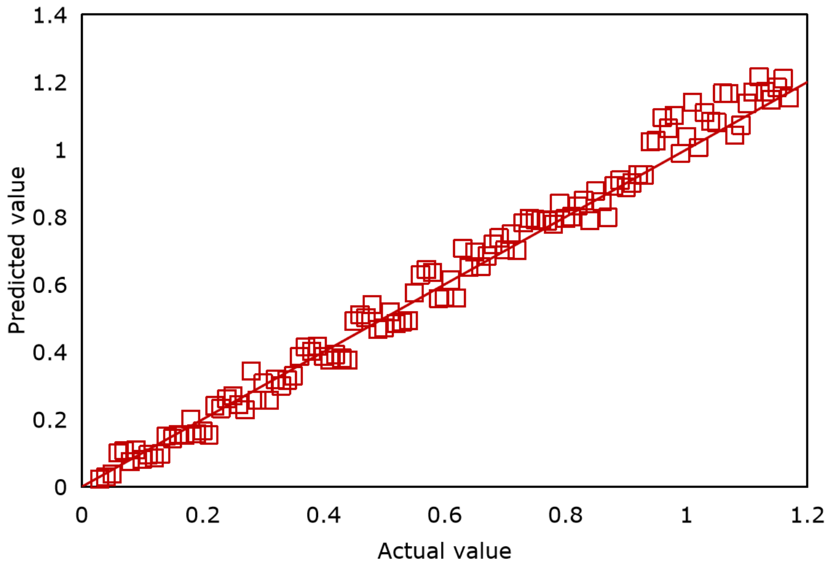

Figure 7: Scatter plot of actual value and predicted value of CNN.

For the ICH digital protection model based on CNN (Figure 7), we can see that the scattered points are more concentrated near the straight line, indicating that the error between the predicted value and the actual value is smaller. CNN has the ability to learn and capture image features, and can better handle the complex features and shapes of images, thus achieving better prediction results in the VR image segmentation task of ICH.

To sum up, by comparing and analyzing the modeling performance of SVM model and ICH digital protection model based on CNN, we can see that the model based on CNN has better performance in modeling accuracy and efficiency. This provides strong support for the digital application of ICH clothing, and also provides valuable reference for the research and application in related fields.

5 CONCLUSION

As an important carrier of traditional culture and history, ICH clothing has extremely high cultural, artistic and historical values. Aiming at the problem of digital protection of ICH, this study proposes an image segmentation algorithm based on DL, which realizes efficient segmentation of the VR image of ICH through feature extraction and classification of the image. The comparative experimental results show that this method has obvious advantages in dealing with complex image segmentation tasks and can better adapt to the protection needs of various ICH. In terms of research advantages, the proposed method has high accuracy and efficiency, and can quickly process a large quantity of image data and realize high-precision image segmentation. In practical application, the method of this study can provide strong support for the digital protection of ICH. For example, in museums, art galleries and other places, we can use the method of this study to carry out high-precision digital protection and virtual display of cultural relics, so as to enhance the audience's visit experience and the level of cultural relics protection. Moreover, this method can also provide effective technical support and reference for academic research in related fields.

In this study, an effective digital protection method of ICH is proposed. Through experimental comparison and analysis, the advantages of this method in accuracy, efficiency and applicability are proved. In the future, this method will be further optimized and its wider application prospect in the field of ICH digital protection will be explored.

Yanyan Qi, https://orcid.org/0000-0002-3077-4045
Qiong Zhou, https://orcid.org/0009-0008-1756-5602

REFERENCES

[1] Alique, D.; Linares, M.: The importance of rapid and meaningful feedback on computer-aided graphic expression learning, Education for Chemical Engineers, 27(1), 2019, 54-60. https://doi.org/10.1016/j.ece.2019.03.001

[2] Cong, H.; Shen, Y.; Zhang, J.: Research on the virtual display of a weft-knitted seamless kneepad based on the free-form deformation model, Textile Research Journal, 92(19-20), 2022, 3545-3553. https://doi.org/10.1177/00405175221081444

[3] Hu, L.; Design and implementation of a component-based intelligent clothing style cad system, Computer-Aided Design and Applications, 18(S1), 2020, 22-32. https://doi.org/10.14733/cadaps.2021.S1.22-32

[4] Indrie, L.; Mutlu, M.-M.; Ork, N.: Computer aided design of knitted and woven fabrics and virtual garment simulation, Industria Textila, 70(6), 2019, 557-563. https://doi.org/10.35530/IT.070.06.1659

[5] Kyosev, Y.: Material description for textile draping simulation: data structure, open data exchange formats and system for automatic analysis of experimental series, Textile Research Journal, 92(9-10), 2022, 1519-1536. https://doi.org/10.1177/00405175211061192

[6] Li, X.; Li, X.-R.; Li, Y.; Feng, W.: Review of cloth modeling and simulation for virtual fitting, Textile Research Journal, 93(7-8), 2023, 1699-1711. https://doi.org/10.1177/00405175221135625

[7] Liu, H.; Jiang, G.; Dong, Z.: Geometric simulation for warp-knitted tubular bandages with the mesh model, Textile Research Journal, 91(21-22), 2021, 2612-2623. https://doi.org/10.1177/00405175211013836

[8] Liu, K.; Gao, Y.; Zhang, J.; Zhu, C.: Study on digital protection and innovative design of Qin opera costumes, Heritage Science, 10(1), 2022, 127. https://doi.org/10.1186/s40494-022-00762-x
[9] Lu, L.; Jiang, G.; Cong, H.; Xia, F.; Peng, J.: Rapid design and algorithm implementation for knitted sweater pattern, The Journal of The Textile Institute, 112(4), 2021, 636-645. https://doi.org/10.1080/00405000.2020.1788198
[10] Meiklejohn, E.; Devlin, F.; Dunnigan, J.; Johnson, P.; Zhang, J.-X.; Marschner, S.; Ko, J.: Woven Behavior and Ornamentation: Simulation-Assisted Design and Application of Self-Shaping Woven Textiles, Proceedings of the ACM on Computer Graphics and Interactive Techniques, 5(4), 2022, 1-12. https://doi.org/10.1145/3533682
[11] Noah, N.; Das, S.: Exploring evolution of augmented and virtual reality education space in 2020 through systematic literature review, Computer Animation and Virtual Worlds, 32(3-4), 2021, e2020. https://doi.org/10.1002/cav.2020
[12] Papachristou, E.; Anastassiu, H.-T.: Application of 3D virtual prototyping technology to the integration of wearable antennas into fashion garments, Technologies, 10(3), 2022, 62. https://doi.org/10.3390/technologies10030062
[13] Wang, T.; Ma, Z.; Yang, L.: Creativity and sustainable design of wickerwork handicraft patterns based on artificial intelligence, Sustainability, 15(2), 2023, 1574. https://doi.org/10.3390/su15021574
[14] Ye, J.: The application of artificial intelligence technologies in digital humanities: applying to Dunhuang culture inheritance, development, and innovation, Journal of Computer Science and Technology Studies, 4(2), 2022, 31-38. https://doi.org/10.32996/jcsts.2022.4.2.5
[15] You, L.: Digital empowerment intangible heritage-CLO 3D virtual fashion design for custom clothing of blue clamp-resist dyeing, Learning & Education, 10(7), 2022, 62-65. http://dx.doi.org/10.18282/l-e.v10i7.2951
[16] Zheng, P.; Jiang, G.: Modeling and realization for visual simulation of circular knitting transfer-jacquard fabric, Textile Research Journal, 91(19-20), 2021, 2225-2239. https://doi.org/10.1177/0040517521994497