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THE APPLICATION OF IMAGE RECOGNITION TECHNOLOGY BASED ON DEEP LEARNING IN DATA ANALYSIS

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Abstract. To address the challenge of achieving high recognition accuracy across various image types, the author advocates for applying deep learning-based image recognition technology in data analysis research. The author first uses convolutional neural networks to train and process the raw laser image big data, extract image features, and set a threshold for pre segmentation to complete image preprocessing; then use the regularized least squares method to complete the laser image pattern recognition process and achieve image pattern differentiation; finally, construct an experimental section and analyze the application effect of this method. The experimental results show that the recognition rate of the preset target images for different types of images is stable at over 96%, the recognition error rate is stable at less than 2%, and the image recognition time is within 15 seconds, indicating that the method has good application effects. This method has a shorter recognition time and higher efficiency, providing impetus for the improvement of laser image analysis and processing technology.

Key words: Pattern recognition, Image preprocessing, Image analysis technology, Laser imaging, Spectral imaging technology, principal component analysis

1. Introduction. In the field of artificial intelligence research, intelligent image recognition technology is an emerging direction. This technology mainly focuses on analyzing various types of images as research objects. Due to the unique characteristics of different images, it is not possible to simply convert them into standardized image data [1]. Workers must process these images and then convert them into complex image data. On this basis, artificial intelligence technology is used to preprocess the data, select features based on the characteristics of the data, and select corresponding template matching models. Afterwards, massive data is classified using artificial intelligence and big data technology, and appropriate models are selected based on the analysis results. However, due to the many challenges involved in image generation, workers may encounter various problems during the image recognition process. The design work of an intelligent image recognition system is very complex, involving multiple different fields. Therefore, how to conduct information exchange is particularly important [2-3].

The quality and completeness of images play a crucial role in the accuracy of image recognition. Images with unclear or missing information pose challenges for accurate recognition. The integration of big data analysis and intelligent image recognition technologies offers a viable solution to enhance recognition accuracy. This fusion method involves optimizing database architecture and security design alongside advanced image recognition techniques. By adjusting pixel density based on image size and clarity, big data analysis ensures that data information integrates seamlessly into images. This approach alleviates the burden on data managers and simplifies the complexity of data management tasks. To address challenges in image recognition technology, it's crucial for stakeholders to prioritize technology integration and development [4-5]. By aligning with contemporary trends and leveraging advanced scientific concepts, innovations in image recognition can be guided and nurtured. The concept of big data involves processing vast amounts of data, and integrating this information into images facilitates user access. However, variations in image processing technology can lead to issues such as blurred images or poor pixel quality, limiting effective scanning or recognition capabilities [6]. To tackle challenges in scanning data images, personnel can harness the capabilities of domain adaptive

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technology within big data sets. This technology enables proactive adjustments to image properties, including pixel density and clarity. It intelligently selects optimal pixel points within specified ranges based on image size. Big data analysis technology is pivotal in enhancing intelligent image recognition by accelerating recognition times, improving recognition quality and efficiency, and easing the workload of personnel [7].

2. Literature Review. Human perception and information acquisition of external things mainly rely on vision, and images are the description and recording of objective things by humans, collecting a large amount of information that cannot be described in words through images [8]. With the continuous updating and optimization of image acquisition technology, laser images have become the main type of image acquisition currently. Currently, multiple scholars have conducted targeted research in this field. Advanced deep learning algorithms offer promising solutions by converting non-image machine learning (ML) challenges into problems that can be tackled through image recognition techniques. Kovalerchuk, B. et al. introduced the CPC-R algorithm, which transforms non-image data into visual representations akin to images. Subsequently, deep learning CNN algorithms are employed to address learning tasks based on these visualized representations. This method has targeted effects on facial and handwritten digit data, but it does not have corresponding advantages for other types of image recognition and does not have wide applicability [9]. Rani, P. et al. undertook a study focused on machine learning (ML) and deep learning techniques for image recognition of various microorganisms. This review explores several key research inquiries, including image preprocessing, feature extraction methods, classification techniques, evaluation metrics, limitations of existing methods, and the evolution of technology over time [10]. Hosseininia, M. et al. introduced a novel approach for annotating 3D images using deep learning and view-based image features. One of the primary hurdles in automating the annotation of 3D images is the extraction of suitable features to represent these images. Unlike traditional 3D representations like polygonal meshes, which are less compatible with deep learning methods, this method leverages view-based features to enhance annotation accuracy [11].

In order to reduce the negative impact of current laser image pattern recognition methods on image applications, a laser image pattern recognition method based on big data analysis is proposed. Firstly, briefly explain the principles of big data analysis applied in the research process; Implement image analysis and training processing on the original laser image big data; Extract the features of laser images and perform pre segmentation on them to achieve pre-processing of the original laser images; Finally, the pattern recognition of laser images is completed using the regularized least squares method. Set up a simulation experiment to verify the application effect of this method. Using 10 types of laser images and a total of 1000 images as samples, set the preset target image recognition rate, recognition error rate, and image recognition consumption time as evaluation indicators for the simulation experiment. Apply this method for image pattern recognition analysis.

3. Method.

3.1. Overall Process of Design Methods. The process of laser image pattern recognition based on big data analysis technology is shown in Figure 3.1.

According to the content in Figure 1, set the laser image pattern recognition process into three stages. In the first step, apply the foundation of big data analysis to train and process images, and use it as the basis for image pattern recognition [12,13]. Referring to computer vision technology and digital image processing technology, set up the laser image pattern recognition process to achieve the design goal. After the design of the identification method is completed, an experimental section is constructed to analyze the application effect of this method and clarify its advantages and disadvantages.

3.2. Principles of Big Data Analysis. Compared with various big data analysis techniques, convolutional neural network technology was used to train and process the original laser images in this study [14]. Considering the unique attributes of laser images, formulas 3.1 and 3.2 have been derived to define the calculation framework of the convolutional neural network.

$$a(x,y) = h \times g = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} h(w,z)g(x-w,y-z)dwdz \tag{3.1}$$

$$A(i,j) = \sum_{m}\sum_{n} H(m,n)G(i-m,j-n) \tag{3.2}$$

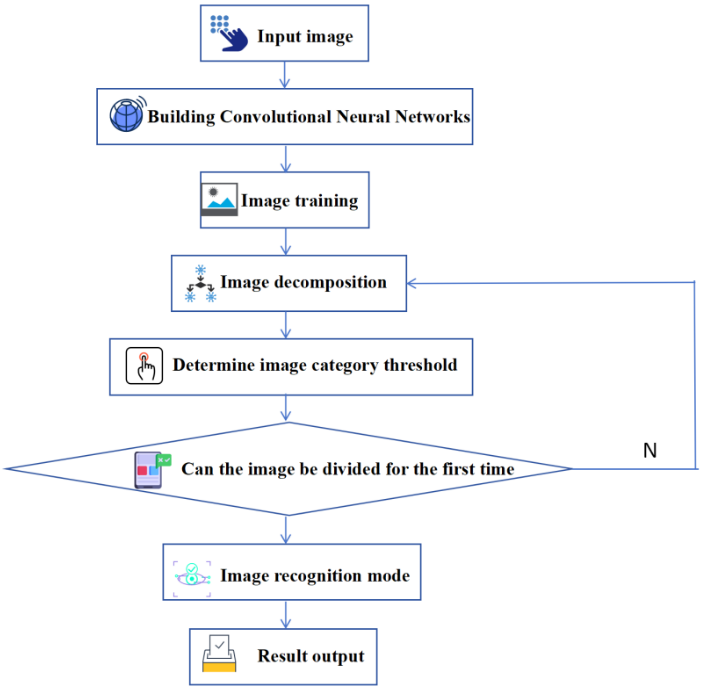

Fig. 3.1: Laser Image Pattern Recognition Process for Big Data Analysis

In equations 3.1 and 3.2, a(x,y) denotes the node position within the convolutional neural network. H signifies the convolutional calculation function employed. g represents the total number of layers in the convolutional neural network. h(w,z) corresponds to the original features of the image. d denotes the distance between nodes in the network. h(m,n) refers to the coordinate indices of the convolutional neural network nodes.

Using the above formula, perform convolution on the image to obtain the size of the processed convolution kernel. Then, based on this calculation result, obtain the length and width of the processed image. The specific value results are shown in equation 3.3:

$$\begin{cases} out_l = \frac{in_i}{stride_i} \\ out_w = \frac{in_w}{stride_w} \end{cases} \tag{3.3}$$

After determining the length and width of the image matrix, it is necessary to use this convolutional neural network again for secondary processing to remove noise from the image. In this process, the activation function of the neural network needs to be set, which can be expressed as equation 3.4:

$$f(a) = \frac{1}{1+\alpha^{-a}} \tag{3.4}$$

Control and optimize the calculation process of the neural network through this activation function for further processing.

3.3. Image Analysis Training Processing. After using convolutional neural networks for big data analysis of the original laser image, the analysis and training processing of the laser image begins [15]. In order to ensure the stability of the application effect of image convolutional neural networks, the constant during image training is set to $\eta = 10^{-8}$, the initial training parameter is set to λ, the first-order variable is initialized to e=0, the second-order variable is initialized to r=0, the initialization step is set to t=0, and the number of samples in the image training set is set to m'. At this time, the calculated gradient of the image training process can be expressed as equation 3.5:

$$s \leftarrow \frac{\nabla\sigma \sum_t K(f(x^i;\sigma), y^i)}{m} \tag{3.5}$$

After determining the gradient calculation, set the step size update formula as equation (6):

$$t \leftarrow t+1 \tag{3.6}$$

After determining the above calculation process, use the above content to train the image, in order to improve image quality and provide a foundation for subsequent image processing and recognition.

3.4. Laser image preprocessing. Based on the results of image training and processing, extract image features and set a threshold for pre segmentation. After comparing multiple methods, the OTSU threshold segmentation method was used to complete this part of the processing [16]. Set the pixel grayscale value range in laser image o (x, y) to , the probability of each grayscale value appearing to be set to , and the threshold to be set to T. This threshold is set to two categories according to the grayscale value range of pixel points, as shown in equation 3.7:

$$\begin{cases} L_0 = \{0, T\} \\ L_1 = \{T+1, Z-1\} \end{cases} \tag{3.7}$$

The probability of these two types of thresholds appearing can be expressed as equation 3.8:

$$\begin{cases} u_0 = \sum_{i=0}^{i} p' \\ u_1 = 1 - u_0 \end{cases} \tag{3.8}$$

According to formulas 3.7 and 3.8, the average grayscale of two types of laser images is obtained, expressed as equation 3.9:

$$\begin{cases} \zeta_0 = \sum_{i=1}^{i} \frac{ip'}{u_0} = \frac{\zeta_i}{u_0} \\ \zeta_1 = \sum_{i=1}^{z-1} \frac{ip'}{u_0} = \frac{\zeta-\zeta_i}{1-u_0} \end{cases} \tag{3.9}$$

In equation 3.9,$\zeta = \sum_{i=1}^{z-1} ip'$,$\zeta_i = \sum_{i=1}^{t} ip'$.

After determining the threshold, mathematical morphology is used to determine the center of regions for different image types [17]. According to this threshold, the original image set is set to G, where H represents the structural elements of the image. Consider the process of image pre partitioning as setting a sliding window in the image and performing morphological calculations on each element in the graph. In this study, expansion and corrosion operations were mainly used for laser image features [18]. Expansion and corrosion operations are shown in equations 3.10 and 3.11 respectively:

$$G' \oplus H' = \{x | [\overline{H'}_x \cap G] = \varnothing\} \tag{3.10}$$

$$G' \oplus H' = \{x | \overline{H'}_x \subseteq G\} \tag{3.11}$$

Using the above operation, divide the image into two parts according to the preset threshold. After the image segmentation is completed, remove the images that cannot be partitioned, and store these two parts of the images in different databases [19].

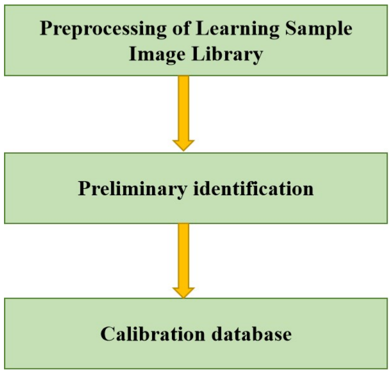

Fig. 3.2: Raw image data acquisition process

3.5. Laser Image Pattern Recognition. Use regular least squares method to analyze image elements in different databases and complete the laser image pattern recognition process [20]. In this study, the processed laser image pattern recognition process is considered as an image optimization problem, and the processing process can be set as equation 3.12:

$$\widetilde{z'} = argmin \frac{1}{u'} \sum_{i=1}^{u'} W'(y_i' - f(x_i'))^2 + J||z'||_i^2 \tag{3.12}$$

In equation 3.12, x_i' represents the feature vector of the image after initial segmentation; i represents the independent variable factor of the image sample; y_i represents the dependent variable data of the image sample.

The above calculations are all completed under the premise that the image sample set contains u' samples, where $||z'||_i^2$ represents the norm of the function z' induced by the calculation process. According to this calculation principle, on the premise of determining the image target pattern, the pattern recognition process is integrated into the form shown in equation 3.13:

$$max = v_0(\gamma_0 - \gamma_i)^2 + v_1(\gamma_1 - \gamma_i)^2 \tag{3.13}$$

In equation 3.13, the expansion forms of $v_0, v_i, \gamma_0, \gamma_1$, and γ_i are shown in equation 3.14:

$$\begin{cases} v_0 = \sum_{i=0}^{t-1} b'(i), v_o = \sum_{i=0}^{t-1} b'(i) \\ \gamma_0 = \frac{\sum_{i=0}^{t-1} ib'(i)}{v_0}, \gamma_1 = \frac{\sum_{i=0}^{t-1} ib'(i)}{v_1}, \gamma_i = \sum_{i=0}^{t-1} ib'(i) \end{cases} \tag{3.14}$$

In equation 3.14, represents the target mode image features; v_1 represents non target mode image features; γ_0 represents the information value of the target image library after the initial segmentation; γ_1 represents the information value of the non target image library after the initial segmentation; γ_i represents the information value of the calculation result obtained from formula 3.12; b' represents the image pattern segmentation coefficient.

After the calculation of formula 3.13 is completed, the final division is performed using the binary method, and the target mode can be expressed as equation 3.15:

$$E' = E_0 \times b' \tag{3.15}$$

The process of collecting raw data is shown in Figure 3.2.

Organize the above calculation steps to obtain the final laser image pattern recognition result.

By integrating the content set in the previous text, the laser image pattern recognition method based on big data analysis has been set up.

Table 3.1: Sample Division Results of Laser Image Experiment

Experimental Image Set Number	Number of images	Main image type
CY-01	100	X-10
CY-02	100	X-3
CY-03	100	X-4
CY-04	100	X-6
CY-05	100	X-7
CY-06	100	X-8
CY-07	100	X-9
CY-08	100	X-5
CY-09	100	X-1
CY-10	100	X-2

3.6. Experimental Analysis. In this study, 10 types of laser images were used as sample images, which can be divided into 4 categories, with a total of 1000 images. The laser image type serial numbers are set to X-1 to X-10, corresponding to 10 different image types. Due to the different sources of experimental images, there are certain differences in the accuracy of the images. To avoid this difference affecting the image recognition results, the images are converted into high-dimensional image information and input into the computer to complete the recognition process.

In order to improve the contrast of the experiment, the original images were summarized and divided into 10 experimental image groups. Each experimental group also had 50 corresponding laser images of its own group and 5 different types of laser images, with 10 laser images in each group. The specific experimental group division results are shown in Table 3.1.

Organize the above settings and import them into the experimental platform to provide a foundation for the subsequent experimental process.

The design of this method is mainly aimed at strengthening the training process of the original image in laser image pattern recognition, improving the ability of image pattern recognition, and thereby improving the recognition accuracy for different types of laser images. Therefore, based on previous experimental research results, the evaluation indicators of image pattern recognition methods are set as preset target image recognition rate, recognition error rate, and recognition accuracy in the experimental section. They can be specifically expanded as follows:

(1). Default target image recognition rate:

$$T' = \frac{R_1}{R_{all}} \times 100\% \tag{3.16}$$

In equation 3.16, R_1 represents the number of recognized target images; R_{all} represents the number of target type images set.

(2). Recognition error rate

$$D = \frac{(N - N_{all})}{N_{all}} \times 100\% \tag{3.17}$$

In equation 3.17, N represents the number of correctly recognized pattern images; Nall represents the total number of various pattern images present in the experimental image set.

By converting the selected laser image into high-dimensional image information and inputting it into the computer, the recognition process can be completed. The start and end recognition times can be obtained, and the difference between the two can be calculated to obtain the recognition consumption time for each experimental image. Further select image recognition methods such as enhanced canonical correlation analysis, dynamic near-infrared spectroscopy, and feature vector extraction to compare with this method, and analyze their advantages and disadvantages.

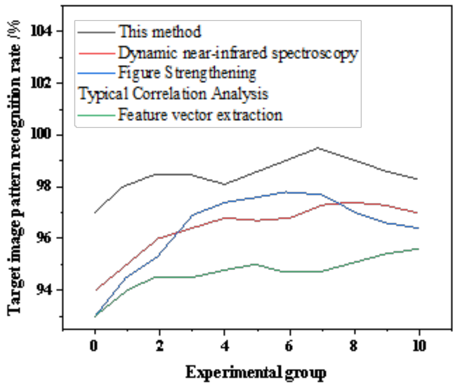

Fig. 4.1: Experimental results of preset target image recognition rate

4. Results and Discussion. The experimental results of the preset target image recognition rate are shown in Figure 4.1. Upon examining the findings presented in Figure 3, it is evident that this method achieves a notably high recognition rate for the predefined target images. Implementing this approach can effectively ensure satisfactory image recognition outcomes. Compared with this method, the image recognition performance of feature vector extraction is relatively poor, with a recognition rate of less than 95.00%. This method cannot obtain high-quality image recognition results. The target image recognition rates of the other two methods are higher than those of neural networks, but the overall volatility is high and the usage effect is unstable. Based on the above experimental results, it can be preliminarily determined that the application effect of this method should be superior to the other three methods.

The experimental results of recognition error rate are shown in Figure 4.2. In this study, this indicator was used to verify the recognition accuracy of image pattern recognition methods for different pattern images. After the experiment is completed, plot the experimental data as shown in Figure 4. From the analysis of the above images, it can be seen that this method has a relatively low recognition error rate for different pattern images, indicating that this method can be used to finely divide images and avoid unclear classification of image categories. Compared with this method, the error rates of different pattern image recognition for the other three methods are significantly higher than this method. This experimental result confirms that big data analysis technology has a certain recognition accuracy in this method, and the application of this technology can improve the discrimination effect of different types of information to a certain extent.

Figure 4.3 shows the experimental results of image recognition time consumption. Analysis of the image content in Figure 5 shows that there are significant differences in the recognition time of the sample images among the four methods. The recognition time of this method is significantly shorter than the other three methods, and the overall time is smaller and tends to be stable. The other three methods have higher recognition time for some groups, but the recognition time for some groups is not ideal. By organizing the above content and combining the experimental results of preset target image recognition rate and recognition error rate, it can be determined that this method is the best image recognition method among the experimental methods.

This method can ensure a preset target image recognition rate of over 96% for different types of laser images, which is significantly better than the three comparison methods; The overall stability of the recognition error rate is below 2%. Indicating that the application effect of this method is good and the accuracy of image recognition is high. Finally, the time consumption for pattern recognition of different types of laser images under various methods was counted, and it was found that the average time consumption of this method was 9.4 seconds, which belongs to a lower level, confirming that this method has a shorter recognition time and higher efficiency. With the continuous expansion of the application scope of laser images, this method provides impetus for the improvement of laser image analysis and processing technology.

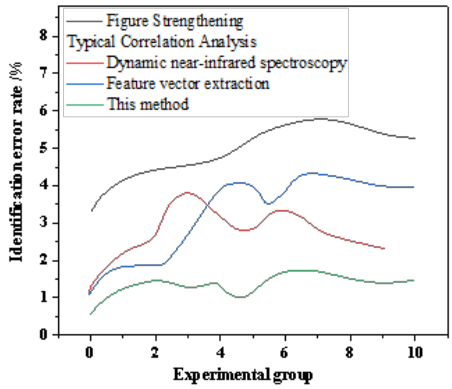

Fig. 4.2: Experimental results of recognition error rate

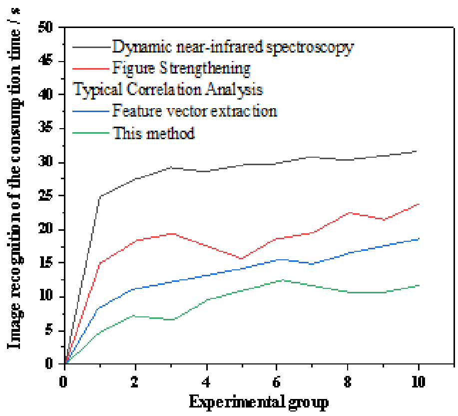

Fig. 4.3: Experimental results of image recognition time consumption

5. Conclusion. The author proposes the application research of deep learning based image recognition technology in data analysis. To minimize recognition errors in laser image recognition methods and enhance accuracy in this domain, the research proposes a method leveraging big data analysis technology. Utilizing convolutional neural networks ensures stability in learning from ample data, thereby improving recognition accuracy. Training and processing the raw laser image big data can effectively enhance its performance in the image training stage, and the above steps have laid a solid foundation for improving the accuracy of laser image pattern recognition.

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