Design Artificial Intelligence Fiber Testing System Aided by Computer

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Abstract. With the progress and development of society, in people's wardrobes, textile clothing belongs to a category of clothing that is used in people's daily life, and textiles for household goods also occupy most of the market. And with the increasing diversification of textile raw materials, it is more and more important to strengthen the detection of fiber content in textiles. There are many methods for determining fiber content in textiles. In fact, in the fiber inspection process, the high-speed camera can not recognize the image of the fiber surface. Computer-aided image processing and deep learning algorithms are used to realize computer-aided recognition through a series of inspection processes. Computer-aided technology has strong interaction and high accuracy, while artificial intelligence fiber testing technology has great responsibility for product manufacturing. Product model and simulation have an impact on product manufacturing quality and work efficiency. The artificial intelligence fiber testing system and computer-aided technology must be combined to improve the quality of the fiber purchased or sold, so as to obtain higher income for enterprises and provide better services for people. How to use computer-aided technology to serve the design of artificial intelligence fiber testing system to improve the user experience of the system is the purpose of this thesis. This article will discuss the general situation of artificial intelligence fiber testing system, the analysis of computer-aided technology in artificial intelligence fiber testing system, and the application analysis of computer-aided technology in artificial intelligence fiber testing system.

Keywords: Computer Aided, Artificial Intelligence, Fiber, Test System

1. Introduction
With the stable development of society and economy, the competition for the development of artificial intelligence fiber testing systems is becoming more and more fierce. Related companies should develop into efficient and stable development and ensure their own position in the process of industrial competition [1]. Reasonably integrate computer-aided technology into enterprise development and production, and rationally combine it with artificial intelligence fiber detection technology, which can effectively improve the accuracy of fiber testing and greatly reduce errors [2]. Computer-aided technology has considerable efficiency. Using computer-aided technology, the functions and
characteristics of various parts of machinery and equipment can be displayed three-dimensionally. In the actual process of the design of artificial intelligence fiber testing system, the calculation program of computer equipment is the most basic function of the design of artificial intelligence fiber testing system. Computer-aided programs can effectively improve the accuracy of calculation and analysis [3]. The application of computer-aided technology can not only improve the automation level of a single fiber test machine, but also expand the test content, and through the connection of multiple machines, automatically comprehensively analyze multiple indexes, comprehensively determine fiber performance, and provide important information for production engineering [4].

The testing system used to detect fiber composition and content is a necessary tool to judge whether textile products are qualified. The current computer-aided artificial intelligence fiber testing system can analyze and process fibers and images, and perform program design responses [5]. This technology integrates artificial intelligence technology into fiber testing. In order to explore mature and practical methods of artificial intelligence fiber testing, many universities have set up research related topics. Under the computer-aided technology, the artificial intelligence fiber testing system is adopted to improve the level of fiber testing, and the content of fiber testing indicators is expanded, and multiple indicators are automatically and comprehensively analyzed through multiple machines on the network, which completely improves the performance and performance controllability of fiber samples [6]. Provide valuable information about the production process of another trend in fiber inspection technology development and subsequent fiber quality prediction. The artificial intelligence fiber testing system is a professional testing fiber composition and content system based on computer-aided technology. With the development of the Internet, computers, and artificial intelligence, the system is also iteratively upgraded to closely follow the development and needs of society, universities and enterprises [7]. At present, the types of fibers are constantly changing with the market, and the fiber testing system is no longer doing simple tasks that rely solely on manual identification and discrimination, reducing the workload of related practitioners, and optimizing the fiber testing system is particularly urgent.

Regarding fiber testing, the specific methods are sampling of each package and HVI testing. After the fiber enters the factory, a certain number of fiber packages are randomly selected, and after balancing in the laboratory according to regulations, the test results are one by one [8]. Compared with the additional fiber index, the test result is tested according to the additional index within the scope of the internal management index. In addition, tests are performed according to packaging, and fiber quality is classified according to experimental results [9]. In the existing fiber testing process, the quality of the fiber will vary with the performance parameters of the fiber test, error control, and actual fiber test results. Computer-aided technology can connect fiber testing with computer equipment to accurately and reasonably sense fiber specifications. The use of computer-aided technology and the implementation of monitoring functions of the computer-aided design platform can better monitor and manage data [10]. Fiber testing As long as the computer-aided artificial intelligence fiber testing system is used, detailed parameters of the fiber can be easily tested. The detailed data of the tested fiber is convenient for testers to test fiber problems and defects, and scientifically complete information processing and recording work.

2. Fast R-CNN Algorithm

2.1. Dual Task Cost Function

The Fast R-CNN algorithm has two outputs, one is the output of the Softmax classifier, and the other is the output of the bounding box regression model.

Among them, the Softmax classifier has to output a probability p for each ROI:

\[ p = p_0, p_1, p_2, \ldots, p_k \]  (1)

Where k+1 is the number of categories learned by the classifier, including one category as the background.
The cost function of classifier classification is:

$$L_{cls}(p,k) = - \log (p_k)$$

(2)

The output of the bounding box regression model is:

$$t^k = (t^k_x, t^k_y, t^k_w, t^k_h)$$

(3)

In the formula (3), k represents the category, \( t^k_x, t^k_y \) is the scale unchanged translation of the positioning frame relative to the ROI after the correction, and \( t^k_w, t^k_h \) is the logarithmic space displacement of the positioning frame relative to the ROI after the correction.

The cost function of border regression is:

$$L_{loc}(t^k, v) = \sum_{i \in x, y, w, h} \text{smooth}_{L_1}(t^k_i - v)$$

(4)

In formula (4), k represents the category, represents the predicted frame offset, v represents the true offset between the predicted frame and the actual positioning frame, and the smooth function is as follows:

$$\text{smooth}_{L_1}(x) = \begin{cases} 
0.5x^2, & |x| < 1 \\
|x| - 0.5, & \text{other}
\end{cases}$$

(5)

Here x is the difference between the true value and the predicted value coordinates. The function is a quadratic function in the (-1,1) interval, and it is a linear function when x is other values. This function has better robustness to abnormal data.

Because there is only one cost function in the neural network, we represent the two cost functions together:

$$L(p, k, t^k, v) = L_{cls}(p, k) + \lambda [k \geq 1] L_{loc}(t^k, v)$$

(6)

It is agreed that k=0 represents the background and does not participate in the calculation of the cost function of the border regression.

### 2.2. Singular Value Decomposition

In the target test process, there are more regions of interest to be processed, so the Fast R-CNN algorithm will spend more time in the fully connected layer of the neural network. In Fast R-CNN, the fully connected layer after the region of interest is pooled requires about 2000 fully connected layer operations. In order to reduce the complexity of the algorithm and increase the speed of target testing, singular value decomposition (SVD) is used to improve the calculation speed of the Fast R-CNN fully connected layer.

If the input of the fully connected layer is X, the weight matrix is \( W_{u \times v} \), and the output is Y. Then, the output result of the fully connected layer can be expressed as:

$$Y = W \cdot X$$

(7)

At this time, the computational complexity is \( u \times v \). We can perform singular value decomposition on the weight matrix W, using the first t eigenvalues to replace the weight matrix W:

$$W \approx U \sum_t V^T$$

(8)

In this formula, \( U \) is the left singular matrix of \( u \times t \), \( ++ \) is the diagonal matrix of \( t \times t \), and \( V \) is the right singular value matrix of \( v \times t \).

After singular value decomposition, the original forward propagation is decomposed into two steps:

$$Y = W \cdot X = U \sum_t V^T X = UZ$$

(9)

The computational complexity is \( u \times t + v \times t \), when \( t < \min(u,v) \), the computational complexity
can be significantly reduced. Specifically, the fully connected layer after SVD decomposition can increase the speed by 30% in the experiment at the cost of an average accuracy drop of 0.3%. At the same time, when the SVD decomposition method is used to speed up the network, no additional fine-tuning operation is required.

2.3. Fast R-CNN Algorithm Principle
As an optimization of the R-CNN algorithm, the Fast R-CNN algorithm draws on SPPnet's hierarchical sampling method during the training phase, which realizes the sample sharing calculation and memory during training, improves the training speed of the algorithm and reduces the sample occupation during training. Memory space. In the target detection process, Fast R-CNN allows the entire image to enter the convolutional layer of the network first, calculates the feature map of the entire image, and then extracts the feature information of the area projected by the region of interest through the subsequent fully connected layer. Finally, a Softmax classifier and bounding box regression model are inserted at the end of the network. Because after the last convolutional layer, it still has to run nearly 2000 times on an image in the fully connected layer, Fast R-CNN proposed a singular value decomposition method; at the expense of a certain degree of accuracy, a good speed was obtained. Promote.

3. Modeling Method

3.1. Establishment of Fiber Test Model
Testing the fibers requires precise rejection of the fibers, and dynamic spatial positioning of the fibers. First, after segmentation, median filtering, and morphological analysis of the obtained fiber samples, the fiber sample data is binarized. For the fiber sample data after binarization, each fiber forms a connected domain. That is, as shown in formulas (10) and (11):

\[
x_m = \frac{1}{N} \sum_{i=1}^{N} x_i
\]

\[
y_m = \frac{1}{N} \sum_{i=1}^{N} y_i
\]

The decisive factor of threshold segmentation is how to obtain the best threshold, which means that the segmentation method is actually a process of finding a threshold that meets the experimental requirements through a certain algorithm and then segmenting the target.

\[
T = T[x,y,p(x,y),f(x,y)]
\]

In formula (12): \(f(x,y)\) represents the gray value of the point \((x,y)\), \(p(x,y)\) represents the local property of the point \((x,y)\), such as the neighborhood of the point \((x,y)\) Average gray value. After thresholding, the parameter \(g(x,y)\) can be obtained as:

\[
g(x,y) = \begin{cases} 
1 & f(x,y) > T \\
0 & f(x,y) \leq T
\end{cases}
\]

The purpose of Equation 13 is to mark the background pixel in the fiber sample as 0 and the target pixel as 1.

The first moment can be expressed as:

\[
\begin{align*}
m_{10} &= \sum_{x} \sum_{y \in x} x \\
m_{01} &= \sum_{x} \sum_{y \in y} y
\end{align*}
\]

Then the regional centroid \((x, y)\) can be expressed as:
\[ \begin{align*} 
x_0 &= \frac{m_{10}}{m_{00}} \\
y_0 &= \frac{m_{01}}{m_{00}} 
\end{align*} \] (15)

Common methods of threshold segmentation include: local statistical threshold segmentation, global threshold segmentation, threshold segmentation based on seed growth, adaptive threshold segmentation and optimal threshold segmentation.

4. Evaluation Results and Research
First, select a few typical foreign fibers to measure, weigh, and then mix them, and randomly feed them into a laboratory carding machine for carding, spinning, and weaving into a fabric. The artificial intelligence fiber testing system under computer-aided technology is used to make a fabric. The fiber is tested and analyzed to accurately reflect the quality of the fiber. The experimental data statistics chart is shown in Table 1. The influence of various foreign fibers on the quality of the fabric, that is, the statistics of the number of defects.

Table 1. Statistics on the influence of several types of typical heterogeneous fibers on fabric quality

| Heterosexual fiber | Cloth block | Hair | Feather | Plastic bag | Plastic film | Polypropylene yarn |
|--------------------|-------------|------|---------|-------------|--------------|-------------------|
| Quantity           | 1           | 1    | 1       | 1           | 1            | 1                 |
| Area(mm²)          | 600         | 4    | 2.8     | 864         | 1856         | 750               |
| Weight mg          | 118.4       | 0.35 | 0.2     | 22.1        | 4.9          | 11.6              |
| Number of foreign fibers | 90 | 1    | 1       | 90          | 193          | 18                |
| Number of defects (pcs/mg) | 0.76 | 2.86 | 5       | 4.07        | 39.39        | 1.55              |
| Number of defects (pieces/mm²) | 0.15 | 0.25 | 0.36   | 0.10        | 0.10         | 0.024             |

From the data in Table 1, because of the different types of foreign fibers and different densities, the area per unit weight is also different. The artificial intelligence fiber testing system perceives a large number of foreign fiber defects remaining on the fiber fabric.

Therefore, considering this situation, it is necessary to maximize the cost savings and improve production efficiency. It is necessary to classify the foreign fibers in the raw cotton and do the corresponding treatment. The key consideration is here. By classifying and testing the fibers, according to the production needs of the production unit, foreign fibers can be selectively removed to improve production efficiency and save other costs (such as recycling raw cotton in foreign fibers, processing and removing Foreign fiber and other costs).

Before the Fast R-CNN algorithm, it is necessary to select a suitable color model, and use the artificial intelligence fiber testing system to distinguish the original surface of each pixel of the RGB color image, compare the surface with a certain number of samples, and produce the image data obtained by processing. At the same time, the R, G, and B charts of a variety of fibers analyze the RGB charts and cluster statistics to obtain the fiber color model and the average square deviation of the R, G, and B components. The color of heterogeneous fiber is generally different from that of cotton. The collected fiber photos are used for RGB statistics. The average value and average square error of the three primary colors of fiber colors form special fibers within the error range. Figure 1 shows the data of non-foreign fibers, and Figure 2 shows the RGB component data values of the foreign fibers.
Figure 1. RGB components of the image of non-contrasting fibers

From the statistical data, the mean square errors of the three primary colors can be taken as R=161.2886, G=159.9581667, B=150.4672667.

Generally, the color of this fiber is different from that of the original fiber, so the RGB amount can be calculated. The chromaticity of photos without foreign fibers is uniform, and the chromaticity of photos containing foreign fibers is very different from the average amount. With this function, a simple fiber test method can be established to check the quality of the fiber.

5. Conclusion
Computer-aided technology is an indispensable subject for product systems. A good user experience is a sign of product maturity, especially in a modern society where the Internet and computers are so developed. The design team of product systems needs to be user-centric and pay close attention to labor. The application trend of smart fiber inspection in products and systems. Combined with the current development status of artificial intelligence fiber testing in China and the development needs of artificial intelligence fiber testing software systems, conduct in-depth analysis and research on the design of artificial intelligence fiber testing software systems and users of operating systems, and design a good user experience. The update plan, the future direction of improvement is to train the generative model through more targeted testing methods, in order to achieve better fiber testing results. The artificial intelligence fiber testing system makes the software system have a good use experience.

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Application of augmented reality technology in project management (18JK0964).

References
[1] Dai Y, Qiu D, Wang Y, et al. Research on Computer-Aided Diagnosis of Alzheimer's Disease Based on Heterogeneous Medical Data Fusion. International Journal of Pattern Recognition and Artificial Intelligence, 2019, 33(5):1957001.1-1957001.17.
[2] Junior J A R, Thainá Maria da Costa Oliveira, Albuquerque P R N E S, et al. Computer Aided Design Versus Building Information Modeling: aplicaco em projetos de sistemas prediais. Brazilian Journal of Development, 2020, 6(5):30824-30833.
[3] Randive S N, Senapati R K, Rahulkar A D. A review on computer-aided recent developments for automatic detection of diabetic retinopathy. Journal of Medical Engineering & Technology, 2019, 43(2):1-13.
[4] Thrall J H, Li X, Li Q, et al. Artificial Intelligence and Machine Learning in Radiology: Opportunities, Challenges, Pitfalls, and Criteria for Success. Journal of the American College of Radiology, 2018, 15(3):504-508.
[5] Gruenigen S V. Artificial intelligence in spinning mills. Melliand international, 2019, 25(1):28-28.
[6] Lee J N, Cho H C. Development of Artificial Intelligence System for Dangerous Object Recognition in X-ray Baggage Images. Transactions of the Korean Institute of Electrical Engineers, 2020, 69(7):1067-1072.
[7] Motil A, Danon O, Peled Y, et al. Pump-Power-Independent Double Slope-Assisted Distributed and Fast Brillouin Fiber-Optic Sensor. IEEE Photonics Technology Letters, 2018, 26(8):797-800.
[8] Zhang Y J, Xu J J, Wang P, et al. Programmable Codelivery of Doxorubicin and Apatinib Using an Implantable Hierarchical-Structured Fiber Device for Overcoming Cancer Multidrug Resistance. Angewandte Chemie International Edition, 2019, 54(4):10837-10851.
[9] Tímea Kollár, Eszter Kása, Árpád Ferince, et al. Development of an in vitro toxicological test system based on zebrafish (Danio rerio) sperm analysis. Environmental ence & Pollution Research International, 2018, 25(1):1-11.
[10] Yeap Y M, Geddada N, Satpathi K, et al. Time- and Frequency-Domain Fault Detection in a VSC-Interfaced Experimental DC Test System. IEEE Transactions on Industrial Informatics, 2018, 14(10):4353-4364.