Analysis of Indigo Dyeing Pattern Design Structure based on Interactive Genetic Algorithm

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Abstract. With the development of economic globalization, all walks of life are carrying out positive changes and innovation. As one of the important parts of the modern industry, the garment industry has also been greatly affected. If enterprises want to maximize their own value and social benefits, they must attach importance to the optimization research of their production management links. Indigo dyeing is a very special dyeing and finishing process, which not only has high added value, but also can improve the quality of products and make products more competitive. Therefore, in order to effectively improve the application effect of this technology, it is necessary to strengthen the relevant research and development work, and through continuous improvement and perfection, to meet the needs of the market. Interactive genetic algorithm has a wide application prospect in the field of computer vision with its powerful global search ability and fast computing speed. It plays a crucial role in the selection of various parameters in the image processing of indigo dyeing design. Based on this principle, this paper introduces it into the clothing printing and dyeing industry, realizes the optimization of dye and other process factors, and finally improves the dyeing and finishing processing efficiency. In this paper, the traditional dyeing process is compared with the dyeing process based on interactive genetic algorithm. The results show that the dyeing process based on interactive genetic algorithm improves the efficiency of 10.42%, effectively reduces manual operation and saves labor cost, and can dynamically adjust the best parameters according to the actual needs to adapt to different fabric characteristics and production requirements.

Keywords: Interactive Genetic Algorithm, Fashion Design, Indigo Dyeing, Pattern Structure

1. Introduction

In modern clothing, color design is a very important content. It can not only make people feel comfortable and happy, but also play a beautifying and decorative role. Indigo dyeing achieves bright and charming effect by blending and dyeing different colors of dyes. Therefore, this paper takes indigo dyeing as the research object, analyzes its application status in fashion design, and makes some preliminary discussion on how to better apply it to practical work combined with genetic algorithm.

ICSETPSD 2023, November 17-18, Coimbatore, India

DOI 10.4108/eai.17-11-2023.2342786

Indigo dyeing has always been an important color matching method in clothing, which has been studied by many experts. Li Shan found a resurgence of interest in the use of natural indigo due to the fashion industry's growing awareness of the human and environmental health issues associated with synthetic dye production, and documented in detail the blue-dyeing processes used by the Landian Yao people, which were also used in garment making [1]. Yi Changhai developed a practical and environmentally friendly indirect electrochemical reduction method for indigo, and applied the method to cloth dyeing. The dyed fabric could reach the color fastness level of the industry standard, opening up a green route for the use of electrochemical reduction of indigo [2]. Hsu Tammy M uses a biochemical protective group to achieve sustainable indigo dyeing strategy, avoiding the use of toxic reagents for indigo chemical synthesis and eliminating the need for dye solubilizing reductants [3]. Athey Samantha N studied the dyeing phenomenon of modern blue jeans fabric at different temperatures by investigating the environmental distribution, path and source of indigo denim microfibers shed by denim clothing [4]. Technology has been widely used in the clothing industry, it can not only improve the appearance quality of clothing accessories products, improve the comfort of wearing, but also has a good effect on the removal of harmful components of human body, can effectively prevent contaminated substances into the body and cause diseases and other hazards.

As an advanced multi-objective decision-making method, genetic algorithm has been widely used in textile field, and many experts have carried out related research. Wang Kangkang found that during indigo reduction and dyeing, continuous injection of a lower amount of nitrogen prevented the dye from caking in the dye bath and produced a deeper tone and more even dyeing, and proposed an environmentally friendly dyeing strategy that significantly improved the sustainability of denim production in terms of economy, energy efficiency and environmental protection [5]. Putra Valentinus Galih Vidia built a theoretical model for sound absorption prediction of garment making based on acoustic wave equation correction and genetic algorithm. It used this model to conduct real-time simulation analysis of the sound in the process of dyeing, printing and sewing of garments, and accurately reflected the sound pressure loss caused by friction between fibers and fabrics. Provide basis for garment manufacturing enterprises to improve product quality [6]. Xu Jie used differential evolution algorithm to solve the production cost optimization problem of enzyme-washing indigo dyed cotton denim, and used improved genetic algorithm to optimize the fabric selection [7]. Sezgin Bozok Sabiha studied the influence of sol-gel technology on indigo dyed denim by using silica based coating to reduce the color change of denim due to external factors, and proved that the use of cross-linker during sol preparation can improve the rubbing fastness and washing fastness of commercial denim samples [8]. Genetic algorithm uses mutation operator to solve problems difficult to be solved by conventional algorithm, so as to make the designed scheme more reasonable and feasible, so as to achieve the purpose of high efficiency and economy.

Although indigo dyeing has a unique style and is the most widely used dye solution in the market at present, due to the limitations of traditional dye itself, in order to better promote the application and promotion of the new indigo dyeing technology in the clothing industry, it is necessary to further improve the dyeing quality and efficiency. Interactive genetic algorithm is an optimization design method based on

population evolution and cross mutation algorithm. It improves system performance by iteratively solving fitness function. In this paper, the strategy was introduced into indigo dyeing, and a complete set of indigo color simulation model was established, and the influence of process parameters on dyeing fastness, color difference and uniformity was studied by using the model.

2. Genetic Algorithm and Indigo Dyeing Structure Analysis of Clothing

2.1 Indigo Dyeing Pattern Design and Methods for Clothing

Indigo dyeing belongs to a special process of printing and dyeing industry. It is not only a dyeing technology but also a very fine and professional field. The processed fabric is a textile with high color purity and good dyeing performance. At the same time, through proper adjustment and control of indigo dye concentration and reducing agent concentration, high efficiency reduction dyes can be obtained to produce and design diversified combinations of psychological color sensitivity [9]. The general method for indigo dyeing is shown in Figure 1.

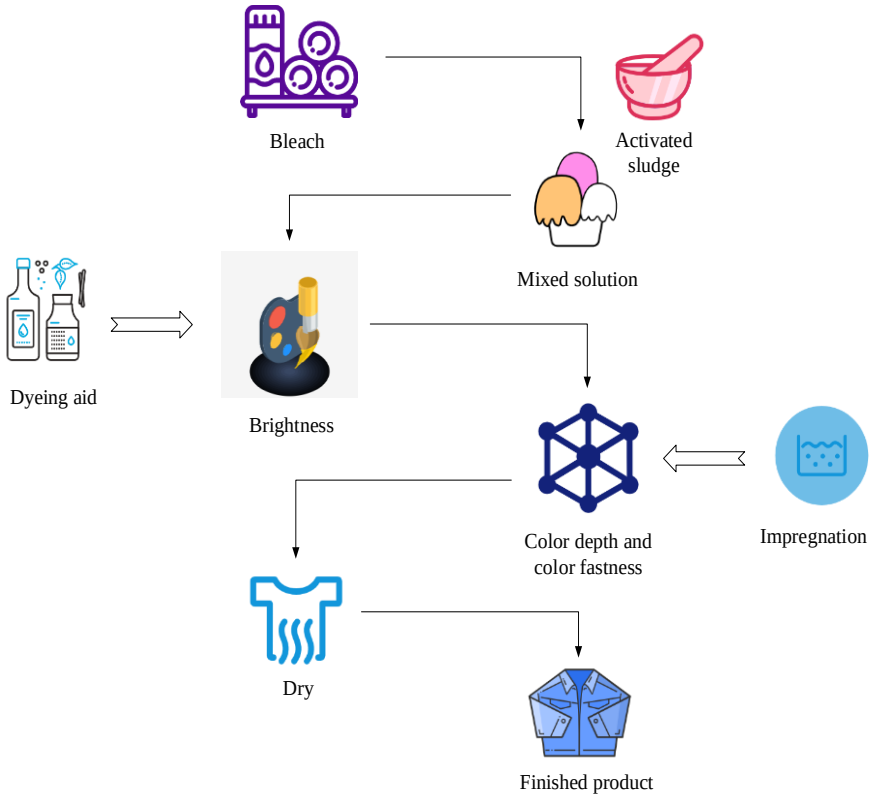


Fig.1 General method of indigo dyeing of garments

First of all, some basic research was done on the preparation work before indigo dyeing, such as chemical bleaching or physical bleaching of the fabric, and then different types and specifications of natural fibers were mixed into a dyeing solution in a certain proportion, adding different amounts of activated sludge, and then adding into the dye solution in an appropriate way to ensure the stability and uniformity of dye. And so that it can be fully dispersed in water, in the process of using the appropriate proportion of dyeing agents and additives can make it obtain a certain degree of brightness, at the same time, the way of immersion dyeing can also increase the color depth and improve the color fastness. Finally, put the dyed clothes in the oven to dry, so as to get a more ideal effect. The surface of the indigo dyed fabric is smooth, smooth and glossy, and the color layers are rich, showing a unique aesthetic feeling. This process is a very mature and representative technology in the traditional printing and dyeing industry. It can directly act on the surface of the fabric to form dyeing and color fixing effect, which makes the fabric more delicate and feel better. It greatly improves the overall appearance and color matching of the textile, and also effectively improves the product quality and added value of the product. To achieve the purpose of promoting the upgrading and transformation of textile manufacturing industry and improving economic benefits [10].

2.2 Principle of Interactive Genetic Algorithm

Interactive genetic algorithm is a new method of population evolution designed on the basis of existing genetic operators, using mutation operation and crossover mechanism. It has strong robustness in solving complex problems, and can better meet the global optimal solution and local search ability required in multi-objective decision making. Therefore, it has become one of the hot spots in modern artificial intelligence research and engineering application.

Its basic definition is:

$$N(m,t+1)=N(m,t)\frac{g(m)}{\overline{m}}\left[1-\frac{Q_a \bullet \partial(m)}{n-1}-L(m)\bullet Q_b\right] \quad (1)$$

Where m represents a specific pattern, t represents the algebra of heredity, and A and b represent two definite positions respectively, $\partial(m)$ represents the distance between ab, $L(m)$ represents the order of a specific pattern.

Crossover operator and mutation operator based on real coding have good convergence speed and low computational complexity. Suppose that the parent string participating in crossover is:

$$A_1^t=(A_1^1,A_2^1,...,A_N^1) \quad (2)$$

$$A_1^t=(A_1^2,A_2^2,...,A_N^2) \quad (3)$$

Taking point crossover as an example, the result can be expressed as:

$$A_1^{t+1} = (A_1^1,..., A_i^1, A_{i+1}^1,..., A_j^1, A_{j+1}^1,..., A_m^1, A_{m+1}^2,..., A_N^2) \quad (4)$$

In the formula, i, j and m respectively represent the three crossing points.

The single uniform mutation operator is:

$$A_i = \begin{cases} \lambda & i = j \\ A_i & i \neq j \end{cases} \quad (5)$$

Where λ is a random number from 0 to 1, $j = \{1,2...N\}$.

Crossover and mutation are important characteristics of interactive genetic algorithm. Crossover and mutation operators are two basic units that must be dealt with in solving complex problems.

2.3 The role of Genetic Algorithm in Fashion Design

Genetic algorithm (GA) is a new mathematical tool developed in recent years, and also a new branch of the subject emerged after the combination of computer graphics and image processing technology. It introduces the traditional genetic operator into the design process to solve complex problems, so as to improve the solving efficiency. At the same time, it can also avoid the disadvantages of increasing the amount of computation caused by cross operation. It has been widely used in the garment industry and has become one of the important means of realizing automatic control and information management in the garment industry. The specific function of this algorithm in fashion design is shown in Table 1.

Table 1. The role of genetic algorithm in fashion design

Function	Description
Improve the appearance of clothing	Quickly and accurately determine the design scheme and get the optimal solution
Improve efficiency	Reduce the workload and labor intensity of designers
Personalized customization	Develop new technologies and processes
Maximize the value of your clothes	Optimize clothing structure

First of all, it provides a method for designers to quickly and accurately determine the design scheme and obtain the optimal solution, improve the appearance of clothing, make it have a good shape, avoid the blindness and randomness caused by manual drawing patterns, ensure the coordination of the shape of all parts of the human body, in line with the principle of ergonomics. Secondly, it can save a lot of time for structural design, effectively reduce the workload and labor intensity of designers, thus greatly shortening the design cycle, improving production efficiency, saving labor costs, and reducing waste of material resources. Thirdly, through the research and analysis of various process parameters, the best production process is obtained, and the new technology and new process matching the product can be developed to realize personalized customized service, and on this basis, the product quality can be further improved. Finally, to optimize the clothing structure, improve the formula of clothing accessories, rational use of raw materials and digital technology, design not only to meet the needs of consumers and reflect the personality

of the fabric and style, in order to maximize the value of clothing.

2.4 Indigo Dyeing Pattern Design Method for Clothing based on Interactive Genetic Algorithm

Aiming at the problems of large color difference and poor dyeing effect of dyed fabric in traditional printing and dyeing process, a new printing technology was proposed to adjust the color difference between cloth and dye by using crossover operator and mutation operation to improve the color fastness. According to the requirements of thermal comfort of fabric at different temperatures, the amount of dye and the ratio of dyeing agent were adjusted. Intelligent control method is adopted to complete multi-step continuous regulation and control, and customized programs are generated according to user requirements. The specific implementation process is shown in Figure 2.

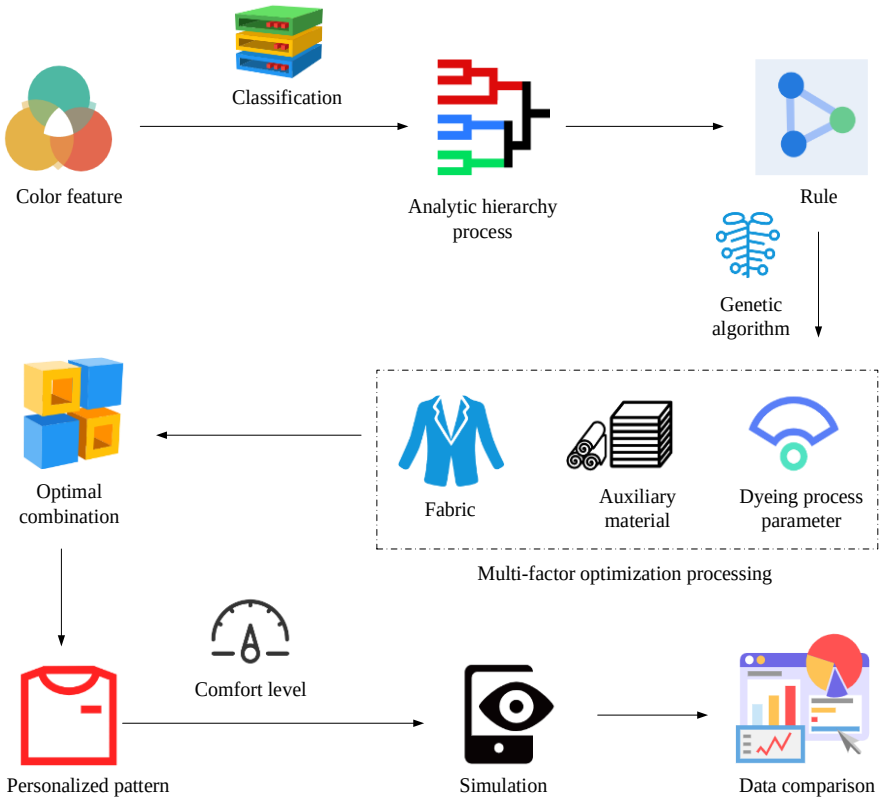


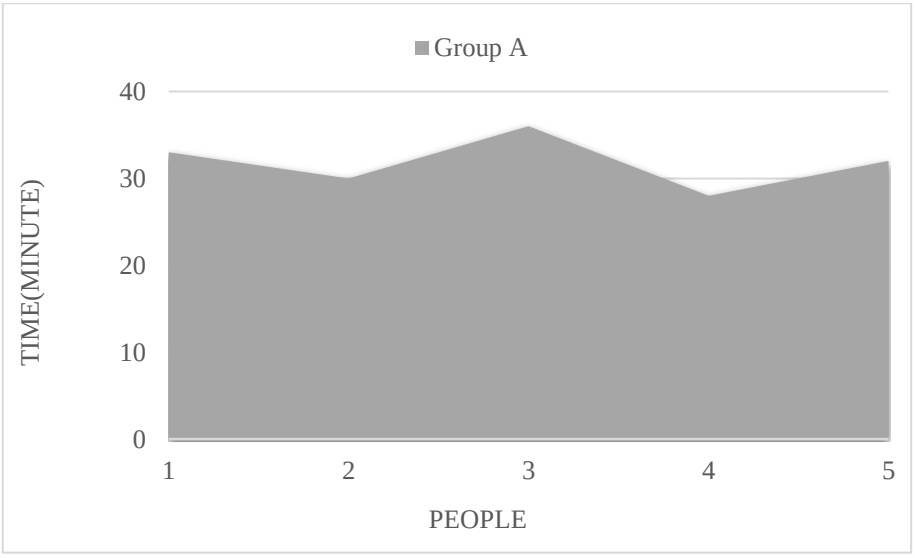
Fig.2 Indigo dyeing pattern design method of clothing based on interactive genetic algorithm

Firstly, the color classification standard was determined according to the color characteristics of textiles, and the degree of influence of various factors on the color distribution law was determined by the analytic hierarchy process (AHP). The

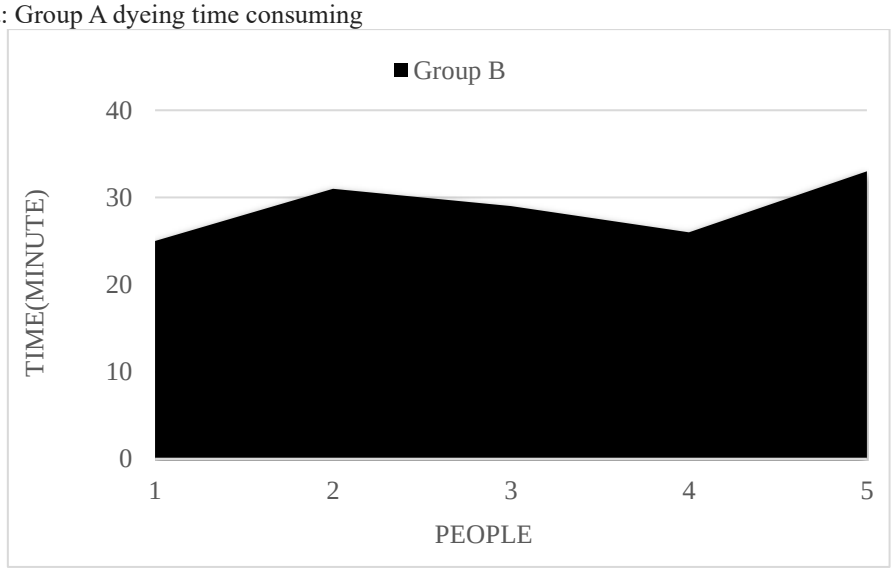
functional relationship between the color of clothing fabrics and the color matching parameters of dyes was established, that is, the content of dyes required by clothing and the dyeing effect were quantitatively described. Then, the interactive genetic algorithm was used to calculate the weight of the principal components in the color scheme, and the fabric, auxiliary materials and dyeing process parameters were used to optimize the fabric. The objective function was converted into a simple linear equation set and solved. The optimal combination was selected as the optimization objective. Thirdly, the appropriate dyeing and finishing process scheme is selected according to the color and style characteristics of the clothing, so as to obtain the personalized pattern meeting the comfort requirements of the human body. The amount of dye and dyeing agent ratio are adjusted according to the thermal comfort requirements of the fabric at different temperatures, so as to ensure that the amount of dyeing liquid required by the fabric meets the comfort requirements of the human body. Finally, the Matlab software is used to simulate the garment processing process, establish a three-dimensional model and compare the actual processing data, analyze the color difference changes in each stage of the process, so as to determine the best production process plan. In practice, this method can be used to realize intelligent, automatic and information management of indigo dyeing products, and effectively enhance the competitiveness of enterprises.

3. Comparative Experiment of Indigo Dyeing in Clothing based on Interactive Genetic Algorithm

10 people were randomly selected from the indigo dyeing process of A garment factory to design and make clothing dyeing patterns, and the 10 people were evenly divided into two groups, which were named as groups A and B, with 5 people in each group. Group A was made using the traditional indigo dyeing process, and group B was optimized by interactive genetic algorithm on the basis of the traditional indigo dyeing process. Given that the two groups of garments have the same type, the dyed and finished fabrics are compared based on the dyeing time, and the results are shown in Figure 3.



a: Group A dyeing time consuming



b: Group B dyeing time consuming

Fig.3 Comparison of indigo dyeing efficiency between two groups

As shown in Figure 3, Figure a shows the dyeing time of group A, while Figure b shows the dyeing time of group B. It can be clearly seen that the image area of group B is smaller but unstable. The difference between the longest time and the shortest time of group B is about 8 minutes, while the longest time difference of Group A is also about 8 minutes, indicating that some employees in group B still have not mastered the dyeing technology based on genetic algorithm. After calculation, the average time of group A is about 31.8 minutes, and that of group B is about 28.8

minutes. The working efficiency of group B is about 10.42% higher than that of group A. Therefore, the indigo dyeing pattern design scheme of clothing based on interactive genetic algorithm proposed in this paper can greatly shorten the production cycle, and the clothing can also obtain better color difference and color light performance. Achieve higher color fastness and gamut range, effectively improve the amount of dye, reduce the cost of dyeing and finishing.

4. Conclusion

Indigo dyeing of clothing is a promising dyeing method, which uses various types of indigo to make fabrics more beautiful without affecting the wearing effect. It is especially suitable for some rich and varied colors of fabrics. The interactive genetic algorithm has good global optimization ability and adaptive ability, which has a wide application prospect in solving the relationship between indigo dyeing pattern design and production. It can effectively shorten product design time, reduce product manufacturing costs, and ensure product quality and improve enterprise economic benefits. The algorithm proposed in this paper can effectively solve the problems existing in the traditional artificial coloring method, introduce it into the clothing printing and dyeing industry, realize the optimization of dye and other process factors, improve the dyeing and finishing processing efficiency, and can adapt to a variety of colors or material color changes, to better meet the needs of consumers and market requirements.

Acknowledgements

Wuhan Business School's scientific research project "Application Innovation of Indigo Dyeing in Fashion Design", project number: 2020KY014

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