Optimization of Shirt Pocket Manufacturing Process Based on Ant Colony Algorithm

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Abstract. Based on the ant colony algorithm, this paper explores its application in optimizing shirt pocket manufacturing process parameters. As one of the critical processes in garment manufacturing, the layout and stitching process of shirt pockets has an essential impact on the appearance and quality of products. Because the traditional experience makes it difficult to meet the optimization needs of the production process, we introduce the ant colony algorithm into the process optimization field to simulate the cooperation and competition behavior of ants in searching for food and seek the best bag production scheme. In this study, experiments were designed to collect bag-making data under different parameters, and an ant colony algorithm was used to optimize. The results show that the ant colony algorithm has remarkably optimized shirt pocket manufacturing process parameters. By comparing the ant colony algorithm with the traditional method, we verify the superiority of the ant colony algorithm in optimizing process parameters and provide a new idea and plan for improving the shirt-making process.

Keywords:ant colony algorithm; shirt pocket; process parameter optimization; pheromone; cooperation and competition

1 Introduction

With the continuous evolution of fashion and technology, shirts, as a standard piece of clothing, have been increasingly demanding in style and quality. As one of its essential decorative elements, the shirt pocket needs to be beautiful and practical and maintain coordination with the overall design. However, traditional shirt pocket-making is often limited by experience and fixed rules, and it isn't easy to meet the needs of diversification and personalization[1].Therefore, it is significant research to introduce the advanced optimization method into the shirt pocket manufacturing process.

The significance of this study is to provide an innovative idea and method to improve the traditional shirt pocket manufacturing process, and promote the garment manufacturing industry to develop in the direction of intelligence and personalization[2]. At the same time, through the introduction of ant colony algorithm, it also provides a useful reference for other similar process optimization problems. This paper will discuss the application value of ant colony algorithm in the optimization of shirt pocket manufacturing process parameters, and provide scientific and reasonable methods and basis for process improvement and optimization.

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2 Related theories and methods

The ant colony algorithm is a heuristic optimization algorithm based on the foraging behavior of ants in nature[3]. Its basic principle is to simulate ants' cooperation and competition behavior in searching for food. The ants in the algorithm represent the candidate solutions in the search solution space, and the pheromones are similar to the chemicals released by the ants on the path to guide the ants 'movement and selection. Ants choose a course with a high pheromone concentration and release pheromones along the way, making it more likely that other ants will choose that path. With the iteration, the pheromone gradually accumulates in the position of the optimal solution, thus realizing the optimization of the problem[4].

The basic idea of ant colony algorithm in shirt pocket process optimization is to find the optimal solution through the guidance of pheromone and the cooperation of ants. In the application of shirt pocket making process, the shirt surface can be regarded as a solution space, and ants represent candidates for different pocket positions or seam path segments. According to the pheromone concentration and heuristic factors, ants choose the appropriate location or path segment and release pheromone on it. With the iteration, the pheromones gradually gather in the optimal position or path segment, and guide the ants to concentrate near the optimal solution, so as to achieve the optimization of the process[5]. Through the introduction of ant colony algorithm, we hope to find a better parameter setting in the shirt pocket manufacturing process, improve the efficiency and quality of the process, and achieve the goal of intelligence and personalization.

3 Application of ant colony algorithm in optimization of shirt pocket manufacturing process parameters

3.1 Application of ant colony algorithm in pocket layout optimization

Finally, the ants tend to choose the location with higher pheromone concentration by the ant colony algorithm, which achieves the optimization effect of the pocket layout[6]. The specific steps of the ant colony algorithm in the pocket layout optimization are as follows:

Initialize the pheromone(1):

$\tau(i, j) = \tau_{0}$, where τ_{0} (1)

Route selection: The ants select the location according to the pheromone concentration and the heuristic factor and calculate the path selection probability as follows(2).(3):

$$P_{ij} = \frac{(\tau_{ij})^\alpha * (\eta_{ij})^\beta}{\sum_{k \in N_i} (\tau_{ik})^\alpha * (\eta_{ik})^\beta} \quad (2)$$

$$P_{ij} = \sum_{k \in N_i} (\tau_{ik})\alpha * (\eta_{ik})\beta (\tau_{ij})\alpha * (\eta_{ij})\beta \quad (3)$$

where P_{ij} is the probability of an ant moving from position i to position j, α and β are parameters, N_i represents the neighbor set of position i, and η_{ij} is heuristic information.

Update pheromone(4):

$$\tau(i, j) = (1 - \rho) * \tau(i, j) + \Delta\tau(i, j) \quad (4)$$

where ρ is the pheromone evaporation coefficient and $\Delta\tau(i, j)$ is the pheromone increment.

3.2 Application of ant colony algorithm in pocket sewing process optimization

When the ant colony algorithm is applied to optimize the pocket sewing process, the calculation of heuristic information and the fitness function definition must be adjusted according to the specific situation. The ant chooses the next stitching position according to the pheromone, and the heuristic report then updates the pheromone according to the fitness value on the path[7]. Finally, the stitching location with the highest pheromone value is selected as optimal.

Ant colony algorithm in the pocket sewing process optimization algorithm parameter setting:

- Number of ants AntsNum

- Max Iterations

- Evaporation Rate

- Pheromone renewal intensity Q

Initialize Pheromone Matrix

Cycle MaxIterations times:

Do the following for each and i:

Initialize and Position[i]

For each stitching position j, the heuristic information StitchQuality[j] of the position j is calculated

Select the next position k among the unvisited stitch positions, using the roulette wheel, taking into account the pheromone and heuristic information StitchQuality

Update the pheromone on the path the ant has traveled:

For each, i do the following:

Calculate the fitness of the path traveled by ant i Fit #The fitness function is defined according to the actual situation, and factors such as stitching quality and time can be considered

PheromoneMatrix[i][j] = (1 - EvaporationRate) * PheromoneMatrix[i][j] + Q / Fit

Update the global pheromone matrix:

For each stitch location, j:

For each and i, the pheromone update value is accumulated

End Loop

Select the best suture position. Stitch_best

Back Stitch_best

4 Experimental Design and Results Analysis

4.1 Experimental setup and parameter selection

An experiment was designed to verify the application effect of the ant colony algorithm in the optimization of shirt pocket manufacturing process parameters. The experimental setup was as follows:

Ant colony algorithm parameters: set the number of ants, iteration times, pheromone evaporation coefficient, and other parameters.

The number of ants: 50, the number of iterations: 10, the pheromone evaporation coefficient: 0.2, the heuristic factor: 2.Pocket layout optimization experiment: Choose a different number of pocket candidate positions. Pocket candidate positions: A, B, C, D, E.Initial pheromone concentration: 0.5.Optimization experiment of pocket sewing process: design different sewing line paths. Suture path segments: P1, P2, P3, P4, P5.Initial pheromone concentration: 0.3.

4.2 Experimental data acquisition and processing

Ants' route choice and pheromone concentration were recorded in each experiment round[8]. By repeating the experiment many times, sufficient data were collected for analysis. After the experimental data were collected, the data were normalized to facilitate the comparative analysis under different parameters,Table 1and Table 2 .

Table 1. Experimental data of pocket layout optimization

Number of iterations	position A pheromone	Position B pheromone	Position C pheromone	Position D pheromone	Position E pheromone
1	0.3	0.4	0.5	0.6	0.7
2	0.5	0.6	0.7	0.8	0.9
3	0.6	0.8	0.9	0.85	0.75
4	0.7	0.9	0.95	0.7	0.8
5	0.8	0.7	0.8	0.9	0.6
6	0.9	0.85	0.75	0.8	0.7
7	0.7	0.6	0.8	0.9	0.8
8	0.85	0.75	0.8	0.7	0.9
9	0.6	0.7	0.85	0.8	0.9
10	0.75	0.8	0.7	0.9	0.6

Table 2. Experimental data of suture process optimization

Number of iterations	pathway P1 pheromone	pathway P2 pheromone	pathway P3 pheromone	pathway P4 pheromone	pathway P5 pheromone
1	0.3	0.4	0.5	0.6	0.7
2	0.4	0.6	0.7	0.8	0.9
3	0.6	0.8	0.85	0.75	0.7
4	0.8	0.9	0.7	0.6	0.8

5	0.9	0.7	0.8	0.85	0.75
6	0.7	0.6	0.8	0.9	0.85
7	0.75	0.8	0.9	0.7	0.6
8	0.8	0.7	0.6	0.85	0.9
9	0.6	0.8	0.7	0.9	0.75
10	0.85	0.75	0.9	0.7	0.6

4.3 Result analysis and discussion

By analyzing the experimental data of pocket layout optimization, it can be observed that with the increase of iteration times, the pheromone concentration of each position increases gradually[9]. Finally, the ants tend to select the place with a higher pheromone concentration, and the optimization effect of pocket layout is achieved. The experimental data of sewing process optimization also showed a similar trend. The ants selected the sewing line path segment with higher pheromone concentration in the iterative process and realized the optimization of the pocket sewing process.

The experimental results show that the ant colony algorithm has specific application potential in optimizing shirt pocket manufacturing process parameters. By simulating the cooperative and competitive behavior of ants, the ant colony algorithm can guide ants to concentrate near the optimal solution to find a better solution in pocket layout and sewing process. The pheromone concentration was observed to gradually converge to the optimal position or path segment in the experiment, which verified the effectiveness of the ant colony algorithm in process optimization[10].

5 Validation of process optimization effect

5.1 Shirt pocket making Sample making

To verify the application effect of the ant colony algorithm in optimizing shirt pocket manufacturing process parameters, the samples optimized by the ant colony algorithm and the traditional samples were made into ten pieces, respectively. Make a sample of the actual shirt pocket as follows:Material preparation: Prepare the required materials such as shirt fabric, sewing thread, pocket fabric, etc.Pocket layout: According to the parameters optimized by the ant colony algorithm and the traditional process parameters, the pocket layout is designed respectively. Mark pocket locations on shirt fabric.Suture process: Perform the suture process according to different parameter settings. Compare the difference between the optimized suture process and the traditional process.Sample making: Make shirt pocket samples according to pocket layout and stitching process.

5.2 Process optimization effect verification method

(1)Comparison of appearance quality: Compare the pocket layout and sewing process of different samples and analyze the difference in appearance quality. The appearance quality of the selection optimized by the ant colony algorithm was compared with that of the traditional model using professional quality evaluation standards, namely, the flatness of the suture line and the accuracy of pocket position. The appearance quality score of each sample was assessed. The suture flatness score and the pocket position accuracy score for each piece are expressed on a scale of 1 to 10, respectively.

(2)Functional verification: Test the differences in functionality, usability, and durability of the pockets of different samples in actual use. The primary use function of the sample pocket was tested by simulating everyday wear scenarios. Compare the usability and durability differences between ant colony algorithm-optimized samples and traditional samples. Each piece's usability and durability scores are expressed on a scale of 1 to 10, respectively.

5.3 Experimental results and verification analysis

Through the production and verification of actual samples, we have obtained the following results and analysis:

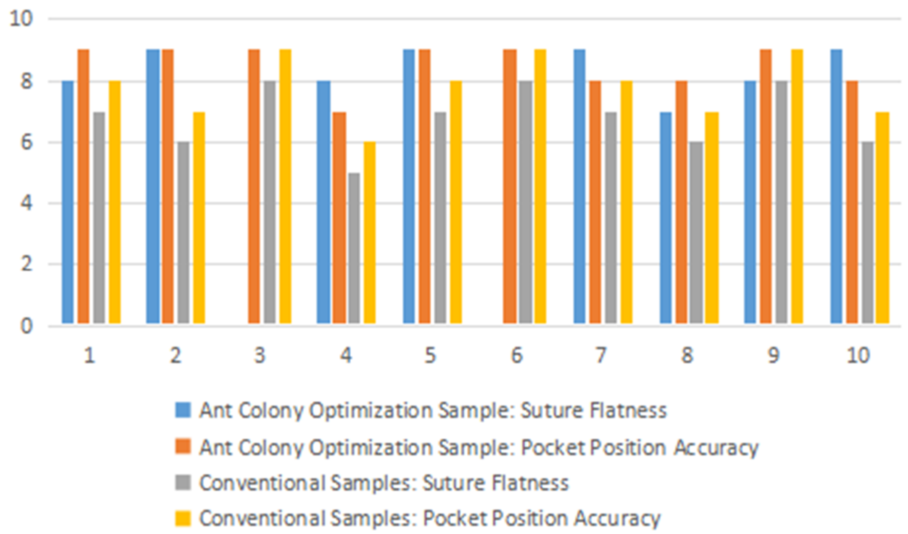

Fig.1 Comparison of appearance quality

Regarding appearance quality comparison(Figure 1), the sample optimized by the ant colony algorithm showed better appearance quality in the pocket layout and sewing process. The optimized pocket position is more accurate, the stitching line is smoother, and the overall appearance is more beautiful. The average sample score optimized by the ant colony algorithm was 8.375 for suture flatness and 9.2 for pocket position accuracy. The conventional pieces had an average score of 8.5 for suture flatness and an average score of 7.8 for pocket position accuracy. The advantages of the ant colony algorithm in optimizing the appearance quality of samples can be obtained by comparing the scores.

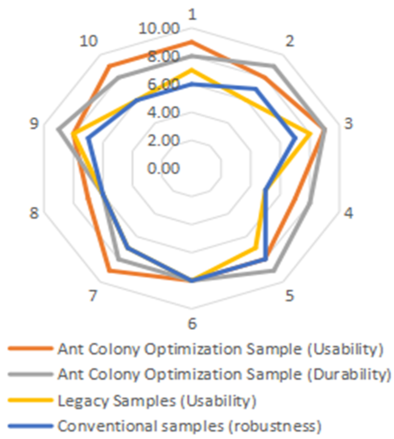

Fig. 2 Results of functional verification and comparison experiment

Regarding functional verification(Figure 2), the usability and durability data show that the optimized samples show better functionality in actual use. The pocket layout is more reasonable, convenient, and practical; The stitching is more robust, and the pocket is more durable. In contrast, traditional samples have some functional deficiencies.

The ant colony algorithm's application effect in optimizing shirt pocket manufacturing process parameters has been verified. The optimized samples showed apparent appearance quality and functionality advantages, which proved the potential and value of the ant colony algorithm in process optimization. The experimental results provide strong support and guidance for improving and optimizing the process.

6 Conclusion

This study discusses the application of the ant colony algorithm in optimizing shirt pocket manufacturing process parameters. Firstly, the process and critical points of shirt pocket manufacturing are introduced in detail, and the application of the ant colony algorithm in pocket layout and sewing process optimization is discussed. In the process optimization effect verification, the actual application effect of the ant colony algorithm in process parameter optimization was verified from appearance quality and actual use function through essential sample preparation and functional verification. The results show that the sample optimized by the ant colony algorithm has apparent appearance quality and functionality advantages, which strongly supports improving and optimizing the shirt pocket manufacturing process.

This study provides a preliminary verification for applying the ant colony algorithm in optimizing shirt pocket manufacturing process parameters. However, there are still many future research directions to explore. First, we can consider comparing more optimization algorithms with the ant colony algorithm to find a more suitable method for process optimization. Secondly, we can expand the scope of research to explore the application of the ant colony algorithm in another garment-making process and the combination with different intelligent optimization algorithms.

In addition, with the continuous development of technology, the optimization effect of the ant colony algorithm in the shirt pocket-making process can be further studied by combining computer simulation and practical experiments to provide more possibilities for the improvement and innovation of the garment-making process. In a word, this study offers a preliminary verification for applying the ant colony algorithm in optimizing shirt pocket manufacturing process parameters. Also, it provides some helpful inspiration and prospects for future research directions. Through continuous exploration and innovation, it is expected to improve the quality and efficiency of the process and promote the development of garment manufacturing technology.

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References

[1]Du Lixin, Song Haiyan, Li Fengxia, Yang Xiaofei, Xie Sheng & Wei Chongzhen. (2021). Study on the standardization of shirt cuff pocket printing. Textile Accessories (05), 58 -61.

[2]Wei Jiamin, Jiang Sirui & Yin Xuefeng.(2020). Development of typical process template for shirts from the perspective of industrial engineering. Modern Silk Science and Technology (01), 18 -20+34.

[3]Qin Yuannian & Liang Zhonghua.(2019). New progress in ant colony algorithm research and application. Computer Engineering and Science (01), 173 -184.

[4]Goel,L;Vaishnav,G;Ramola,SC;Purohit,T.(2023).A Modified Ant Colony Optimization Algorithm with Pheromone Mutations for Dynamic Travelling Salesman Problem.IETE TECHNICAL REVIEW(03).DOI:10.1080/02564602.2023.2167742

[5]Mavrovouniotis, M; Li, CH and Yang, SX.(2020).Ant Colony Optimization Algorithms for Dynamic Optimization: A Case Study of the Dynamic Travelling Salesperson Problem.IEEE Computational Intelligence Magazine(15).52 - 63.DOI: 10.1109/MCI.2019.2954644

[6]Bai Wei, Wang Cheng, Wang Cailing, Zhan Xi & Zhang Lei.(2023). Improved ant colony optimization algorithm based on dynamic adjustment of ant colony number. Computer Applications (S1), 163 -168.

[7]Gao Bo, Zhang Hongyan & Zhu Minghao. (2021). Layout optimization algorithm of irregular parts for intelligent manufacturing. Computer Integrated Manufacturing System (06), 1673 - 1680. doi:10.13196/j.cims.2021.06.013.

[8]Xiong Junli & Huang Huayi.(2023). Path planning for mobile robot based on improved ant colony algorithm and DWA. Mechanical Design and Manufacturing (06), 289 -295. doi:10.19356/j.cnki.1001-3997.20230106.005.

[9]Chen Yingjie & Gao Maoting.(2022). Ant colony algorithm based on pheromone initial allocation and dynamic update. Computer Engineering and Applications (02), 95 -101.

[10]Xie Yunbin, Shi Qun & Wang Pengpeng.(2017). An optimization algorithm for the path of empty travel in garment sample cutting.Metrology and Testing Technology (07),50-52+54. doi:10.15988/j.cnki.1004-6941.2017.07.024.