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Optimal Layout of Leather Rectangular Parts based on Firefly Simulated Annealing Algorithm

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Abstract:*In the mass customization of Leather products (such as sofa) , the intelligent layout is the key to improve material utilization.For optimal layout of leather rectangular parts problem,firefly simulated annealing algorithm is proposed .Applied to continuous space optimization of Firefly algorithm extended to rectangular pieces combinatorial optimization.For features of Optimal layout of leather rectangular parts , redefined Firefly algorithm of kinds relevant characteristics discrete it.Radius search field of Firefly algorithm was improved to eliminate the limitations ,which brought its value remains unchanged.Improving location update operation of Firefly algorithm was to accelerate the convergence rate.Meanwhile, in order to enhance local search ability and accelerate the convergence speed of the algorithm ,adding the simulated annealing algorithm, simulated annealing algorithm make appropriate improvements.Finally, the best nesting way and discharge order of rectangular leather samples was obtained by the algorithm, using the remaining rectangle algorithm for automatic nesting.Examples show that the algorithm of leather fabrics nesting is effective and a substantial increase in the utilization of leather fabric.*

Key words:*Optimal layout of rectangular parts;Firefly algorithm;Simulated annealing algorithm; Remaining rectangle algorithm*

I. Introduction

Leather fabric used in clothing, automobile, home, airplane seats, luggage, and other industries.Nesting optimization technology is essential in the leather industry, is an important means to save raw materials and make full use of the resources .the merits of nesting cutting directly impact on the leather production efficiency and economic benefits.In an increasingly competitive market environment,higher utilization of traditional optimization nesting cutting problem is heavily dependent on human experience, can not guarantee a higher utilization of leather material.Especially under conditions of mass production, to find an efficient algorithm to optimize nesting is imperative.Use of computer-aided nesting is an effective method.

Artificial leather nesting Generally is a two-dimensional rectangular sample-based rules.For irregular leather nesting, complementary sample make the fight against and filling, Cluster analysis,take the smallest envelope rectangle and Other pretreatments,irregular sample transformed into a rectangular sample,Finally, in the rules of artificial leather fabrics to optimize nesting.Use of computer-aided nesting rectangular sample is to make a series of rectangular leather samples emission on specifications artificial leather , find the optimal arrangement, so that get the maximum utilization of leather materials and improve production efficiency and economic benefits.Optimal layout of rectangular pieces are NP-hard problem, there are still more literature dedicated to finding efficient algorithms to solve a wide variety of two-dimensional rectangular pieces of packing problem.Research work in this area as early as linear programming and the knapsack problem [1-2] thinking applied to the problem of nesting,but it has a great computational complexity, suitable for small-scale problem solving, not very practical in engineering.With the development of intelligent algorithms and successfully applied to TSP and space allocation,literature [3-5] make the particle swarm optimization, ant colony algorithm, genetic algorithms, simulated annealing algorithm algorithm apply to the Rectangular Strip Packing Problem.However, due to the limitations of the algorithm itself, the nestingeffect is not too satisfied .

Firefly algorithm is recently proposed in the modern field of swarm intelligence optimization algorithm ,has been successfully applied in a multi-modal function optimization, multi-source track and locate, find harmful gas leaks and so on.Firefly algorithm to solve NP-hard problem also has great potential, has successfully solved the assembly sequence planning [6], path planning [7], TSP problem [8]and so on.Due to the limitations of Firefly algorithm itself, Its Local search ability is poor, easy to fall into local optimum, resulting in premature convergence.Advantages of simulated annealing algorithm is able to escape from local optima, with a strong local search ability, but the ability to grasp the search process is not strong.This paper propose an improved firefly simulated annealing algorithm, experimental results show that the algorithm can good solve the Leather Rectangular Strip Packing Problem.

II. Leather rectangle packing problem mathematical model

Leather rectangular nesting optimization problem is described as follows: In the wide W, height H of the rectangular artificial leather motherboard emissions without overlapping rectangular leather samples {P_1, P_2 .... P_i .... P_n}, any one leather rectangular samples P_i (i = 1,2, ..., n) can be expressed using a dimensional binary array:

$$P_i = (w_i , h_i)$$

w_i,h_i is the leather rectangular sample P_i's width and height.

Optimization constraints:Each rectangle leather sample does not exceed the edges of the rectangular artificial leather motherboard and its edges must be parallel to the edges of the rectangular artificial leather motherboard.After completion of the maximum height of nesting(That is the highest leather rectangular sample boundary of figure nesting, also known as the highest nesting contour)$H_{high} \leqq$ H(Referring to Figure 3 H_{high}).while meeting certain Cutting process requirements.

Optimization objectives: the minimum gap of between Leather rectangular sample to make leather fabric maximum utilization (η).

Since guarantee the lowest H_{high} of the highest contour nesting figure, between leather rectangular sample gap is the minimum in nesting figure, so the optimization modeling in this paper can be simplified to only consider the impact of highest contour nesting map.Due to the width of Motherboard leather and the total area of all leather Rectangular samples is constant, the utilization of leather fabric η only relevant with total area of all rectangles and area of using motherboard sample, the optimization objective function is:

$$\eta = \mathrm{h}/H_{high} \qquad (1)$$

Where:

$$\mathrm{h} = \sum_{i=1}^{n} w_i \times h_i / \mathrm{W} \qquad (2)$$

Where, h is theoretical optimal height ,which is the resulting all the leather samples rectangular area divided by the width of leather motherboard .h is constant, H_{high} is variable.The objective function value η the closer 1 ,the closer optimal nesting.

III. Standard firefly algorithm principle

Firefly will be issued at a certain rate and rhythm of the flash, the flash signal can be perceived in a certain range of other fireflies, fireflies take to communicate, attract the opposite sex, attract prey, etc., and the brighter flash of fireflies,the bigger appeal , finally, most fireflies gather multiple positions of the brightest firefly.In 2009, the University of Cambridge Engineering YANG make fireflies flash feature and attraction characteristics idealistic,propose firefly algorithm[9] .To build the Firefly algorithm, for some fireflies flash characteristics idealized, idealized as follows guidelines:

(1)Firefly algorithm, regardless of male and female.

(2)Attractive force proportional to the intensity of flash.In any space of firefly within its effective range, found the brightest fireflies and close to its constantly moving, the brightest of fireflies make the random move.The size of attractive relevant with the distance of between firefly and air light absorption rate,the bigger distance and light absorption rate, the more small attractive small.

(3)Firefly brightness is determined by the value of the objective function optimization.

In space of any two fireflies i and j, its position was X_i (X_{i1}, X_{i2}, ... X_{id}) and X_j (X_{j1}, X_{j2}, ... X_{jd}), β was attraction between two fireflies.

$$\beta(\gamma) = \beta_0 \exp(-\gamma r_{ij}^{\ 2}) \qquad (3)$$

Where γ_{ij} is the distance between two of firefly i and j, β_0 is the attraction when the distance between firefly is 0, and generally 1, γ is the light absorption rate.

γ_{ij} of the distance between two of firefly i and j is defined as the Cartesian distance.

$$r_{ij} = \| X_i - X_j \| = \sqrt{\sum_{k=1}^{d} (x_{i,k} - x_{j,k})^2} \qquad (4)$$

Movement distance of firefly i since attracted by greater brightness firefly j

$$x_{i,k}^{t+1} = x_{i,k}^{t} + \beta_0 \exp(-\gamma r_{ij}^2)(x_{j,k}^{t} - x_{i,k}^{t}) + \alpha(rand - 0.5) \qquad (5)$$

Where α is the unknown parameter ,*rand*∈（0,1）.

IV. Solving leather rectangular nesting problem of discrete firefly algorithm

Standard Firefly algorithm only applies to optimization problems on the continuous field, but the leather rectangle packing problem is discrete combinatorial optimization problem, it is necessary to carry out the traditional standard discrete Firefly algorithm improvements to meet the requirements of the rectangle packing problem.The following discrete Firefly algorithm [6] related operations will be described:

4.1Encoding method of Leather Rectangular Strip Packing Problem

Each firefly's position initialized for an n-dimensional vector whose elements is an 1-n integer of different sizes, there are positive and negative points, each number represents a rectangular sample. Each firefly's position corresponds to a group of rectangular samples into sort column, fireflies i position is Xi,

$$X_i = (x_{i,1}, x_{i,2}, ... x_{i,k}, ..., x_{i,n}) \; x_{i,k} \in \{1,2,\ldots,n\}$$

Where n is the dimension of the firefly or the number of the rectangular sample to be ranked, $x_{i,k}$ is the k-th element of i firefly.Suppose there is a firefly location i {1, -7,5,2, -6,3,4} indicates the number of rectangles 1 to 7 into the drainage order 1 → 7 → 5 → 2 → 6 → 3 → 4,which -7,- 6 show coding rectangular pieces 7 and 6 rotated 90 degrees, the length and width areinterchangeable.

4.2 Rectangular pieces of leather coding transcoding operations

In order to facilitate the rectangular sample coding updates, namely Firefly location update, this paper use a transcoding operation.For a full permutation of possible coding constituting (x_1, x_2, ... x_n), the so-called transcoding is to encode the elements arranged in ascending order of the method, corresponding to the arrangement of the obtained numerical subscript constituted (y_1, y_2 , ..., y_n) is the transcoding.As a practical coding (4,2,7,6,1,3,5), after the transcoding operation, coding into (1,2,3,4,5,6,7), while the corresponding to the arrangement of the obtained numerical subscript constituted (5,2,6,1,7,4,3) is the transcoding.After Firefly location update, also become encoded form, namely, reverse code operation.Inversion code operation similar to transcoding operation, for transcoding (y_1, y_2, ..., y_n) of elements in ascending order corresponding to the arrangement of the obtained numerical subscript configuration (x_1, x_2, ..., x_n)is the corresponding coding.Example above transcoding (5,2,6,1,7,4,3), which becomes (1,2,3,4,5,6,7)after the inverted code operation, corresponding to the numerical subscript constitute arrangement was (4,2,7,6,1,3,5).Theoretical proof encoding and transcoding is one relationship [10].

4.3Distance formula between Firefly

In order to updated position of the firefly , distance between firefly must be known.According to the coding element is represented by a rectangular sample sequence into the row, so this definition of the distance between the fireflies is the degree of difference coding elements multiply by a constant .For encoding firefly $X_i = (x_{i,1}, x_{i,2}, ..., x_{i,n})$, $X_j = (x_{j,1}, x_{j,2}, ... x_{j,n})$, between them similarity is:

$$\tau_{ij} = \frac{\sum_{k=1}^{n} | d_{ij}(k) |}{M} \qquad (6)$$

Where, $d_{ij} = X_j - X_i$, | * | represents the absolute value operation, M is the maximum of $\sum_{k=1}^{n} | d_{ij}(k) |$,When the rectangular sample to be ranked number n is odd, $M = \frac{(n-1)(n+1)}{2}$;When the number of samples to be ranked rectangle n is even, $M = \frac{(n-1)n}{2}$.

Calculated by the difference in the degree of coding, the distance formula to define firefly i and j is:

$$D_{ij} = c\tau_{ij} \qquad (7)$$

Where c is a constant, the size was decided by according to the number of to be ranked rectangle pieces.

4.4 Leather rectangular sample coding updates

Coding update phase of leather rectangular sampleisfireflyposition movement stage.In orderto meet thediscreterectanglesissue,locationupdate formulaofstandardFirefly algorithmwasmodified as follows:

(1)Subtraction operations between locations($X_j \Theta X_i$): Subtraction operations between locationsexpressed bythe main direction S_i of the firefly i toward thefirefly j， S_i expressedas follows

$$S_i = X_j \Theta X_i \qquad (8)$$

Performinga locationssubtractionoperation , compares successiveXi, Xjof eachcorrespondingvalue of the element, if thek-th element$X_{i,k}=X_{j,k}$,then$S_k=0$;otherwise$S_k=X_{j,k}$。

(2) The number multiply operation of the direction: In the standard firefly algorithm, $\beta_0 \exp(-\gamma r_{ij}^2)$ is moving firefly steps, which ranges from (0,1) ,to control the distance traveled of firefly i toward firefly j. This paper redefined product of S_i and $\beta_0 \exp(-\gamma r_{ij}^2)$, as follows:

$$-S_i = \beta_0 \exp(-\gamma r_{ij}^2) \otimes S_i \qquad (9)$$

In this paper, the number multiply operation of the direction indicates that Si whether inherited elements -Si in each position or not, the number of elements in succession by a joint control of the size of $\alpha \mid rand - 0.5 \mid$ and $\beta_0 \exp(-\gamma r_{ij}^2)$ .The number multiply operation of the direction ofthe formulais as follows：

$$-S_{i,k} = \begin{cases} S_{i,k} & \alpha|rand - 0.5| < \beta_0 \exp\left(-\gamma r_{ij}^2\right) \\ 0 & others \end{cases} \qquad (10)$$

As can be seen from the above equation, the value of r_{ij} smaller, -Si inherit more number of the elements Si, which is consistent with the smaller distance between the fireflies, the greater the attraction and the greater the distance traveled of fireflies firefly i toward j.

(3) Addition operation of the position and direction: Location Update of discreteFirefly algorithm is mainly firefly position and direction vector sum on time . As follows:

$$X_i(t+1) = X_i(t) \oplus -S_i \qquad (11)$$

In the fireflylocation updateoperation, iftheelement ofdirection vector—S_i:—$S_{i,k}$=0,then$X_{i,k}(t+1)=X_{i,k}(t)$;otherwise,$X_{i,k}(t+1)$=—$S_{i,k}$.

4.5 Infeasible encoding process

When updating of coding,in fact ,transcoding performing the update.In the rectangular sample Nesting , whether transcoding sequences or coding sequences, requiring all numbers(ranging from 1 to n) are present and can appear only once.After transcoding updated ,some code number will be repeated or some may be lost.In the reverse code operation ,code mayappear several code number can not determine the order. If two fireflies i and j, respectively location X_i = (2,8,6,4,1,5,7,3) and X_j = (7,2,6,8,4,5,1,3), assuming that the fireflies firefly j move closer to the firefly i within the effectively search radius.First, after transcoding operations, Y_i = (5,1,8,4,6,3,7,2), Y_j = (7,2,8,5,6,3,1,4).After subtraction position S_i = (7,2,0,5,0,0,1,4), when the number carry onmultiply operation of the direction, becauseno definiteparameters, assumptions are as follows:

k=1, $a \mid rand - 0.5 \mid < \beta_0 \exp(-\gamma r_{ij}^2)$,then -S_1=7; k=2, $a \mid rand - 0.5 \mid > \beta_0 \exp(\gamma r_{ij}^2)$,then -S_2=0;

k=3, $a \mid rand - 0.5 \mid < \beta_0 \exp(\gamma r_{ij}^2)$,then -S_3=0;k=4, $a \mid rand - 0.5 \mid < \beta_0 \exp(-\gamma r_{ij}^2)$,then -S_4=5;

k=5, $a \mid rand - 0.5 \mid > \beta_0 \exp(-\gamma r_{ij}^2)$,then -S_5=0;k=6, $a \mid rand - 0.5 \mid < \beta_0 \exp(-\gamma r_{ij}^2)$,then -S_6=0;

k=7, $a \mid rand - 0.5 \mid > \beta_0 \exp(-\gamma r_{ij}^2)$,then -S_7=0;k=8, $a \mid rand - 0.5 \mid < \beta_0 \exp(-\gamma r_{ij}^2)$,then -S_8=4.

To sum up $S_{i,k}$=(7,0,0,5,0,0,0,4),and finally through the addition operation of the position and orientation , Y_i(t+1)=(7,1,8,5,6,3,7,4),amongthe number7repeated , number2lost.AfterinversioncodeoperatingY$_i$(t+1)=(1,3,4,5,6,7,7,8),andX$_i$(t+1)=(2,6,8,4,5,1,7,3)or(2,6,8,4,5,7,1,3) in both cases, in order todeterminethe order ofparagraphs 6 and7elements,This paperprovides: d_{ij}=(5,-6,0,-4,-3,0,6,0), becaused$_{ij}$(6)<d$_{ij}$(7),according to default arrangement method in ascending order of Matlab obtained Xi (t + 1) = (2,6,8,4,5,1,7,3), otherwise the sixth elements and the seventh elements exchanged, Xi (t + 1) = (2,6,8,4,5,7,1,3).

V. Improved Discrete Firefly algorithm

Firefly algorithm are essentially random search algorithm category, each fireflies are within its search field radiusto find the brightest fireflies, due to the radius of the search area is restricted, so that fireflies are divided into several groups gathering area, it is difficult in the firefly population to find the optimal solution, in the course of evolution iteration prematurely fall to a standstill phase. This phenomenon occurs mainly due to the search field radius of each firefly is fixed, so that the large brightness of fireflies only attracted with other fireflies within search field radiusand the radius of the search area beyond fireflies unable to communicate, most individuals excellent information can not be shared with group, limiting the convergence rate. How to set the radius of the search area for convergence of the algorithm is extremely critical.If the radius of the search area is too small, algorithmcan well maintain the diversity of the firefly populationin the early iterations, but the population soon stalled on an iterative evolution, fireflies gather in several groups within a relatively bright fireflies area; if the radius of the search area is too large, the group quickly gathered the brightestfireflies areas into local optimum. So we put the firefly search field radius set as follows: In the initial , radius of the firefly search field appropriate small , in the later stages,radius of the firefly search field appropriate large , a specific set of circumstances to be decided by the size of population.

In the standard firefly algorithm iteration, each firefly close to maximum fitness fireflies in its search field radius, update their fitness until each firefly move once, to complete one iteration. In each iteration process,before every fireflies location update,we must calculate the distance between the other fireflies, add fireflies search field radius to search the list, calculate each firefly fitness ,Select one of the largest fitness firefly to close it, for a rectangular piece nesting requires a lot of time in the calculation of fitness, so the algorithm complexity very large, algorithm optimization ability and convergence speed are poor.For the above, standard discrete Firefly algorithm has been improvedin this paper. Before each iteration, the fireflies by fitness sorted from small to large, from the smallest start updating its location fireflies. In the search process ,the largest fitness fireflies begin to calculate the distance to see if the search field meet in radius, if met, then update its position, otherwise the second highest fitness to judge fireflies, and so on, up to the maximum Firefly fitness random location update, complete iteration. This greatly reduces the calculation fireflies fitness, distancebetween them ,improving the algorithm optimization ability and convergence speed.

VI. Simulated Annealing Algorithm

Although the standard discrete Firefly algorithm has been improved, but experiments show that firefly populations in later iterations, each firefly gathered at a location point, population diversity destruction falling into local optimum.In order to avoid appear premature convergence and into local optimal solution of firefly algorithm.Drawing on thinking Memetic algorithm, after performing Firefly algorithm, then the simulated annealing local search. However, experiments show that when using only standard simulated annealing,for the leather rectangular nesting, a substantial increase in computational algorithms, and there will be fluctuations in the phenomenon. In this paper, the simulated annealing algorithm for the following improvements: In the firefly population, only the fitness value of the largest individual fireflies do simulated annealing operation, only to accept a higher degree of adaptation of new individuals to replace the old individual, the other fireflies are mutating, maintain the population diversity, significantly reducing the amount of calculation algorithms and enhanced global search ability of the algorithm The following simulated annealing algorithm to do the following instructions：

6.1 The initial temperature

In order to ensure 1 probability of convergence to the global optimal solution, simulated annealing algorithm initial temperature should be high enough. However,the initial temperatureof infinitycan not be achieved. In this paper,the initial temperatureis set as follows:

$$T_0 = a_1 n\left(\frac{1}{F_{\min}} - \frac{1}{F_{\max}}\right) \qquad (12)$$

$\alpha_1$isadjustable parameters; n isthe length ofthe individual; F_{min}andF_{max}arerespectivelythe minimumand maximumfitness valueofthe initial population.

6.2 Cooling function

In thesimulated annealingalgorithm, therapid coolingstrategy israpid coolinginthe high temperature region, slow coolingin thelow temperature range, the ratio of the coolingfunction satisfiesthis condition.Therefore, this paperuses theratio ofthe coolingfunction:

$$T_{k+1} = \lambda T_k \qquad (13)$$

λ is acoolfactor, $\lambda \in (0,1)$.

6.3 Produce new individuals

In the field of individuals X produced a new individual X ', in order to X out of local optimum condition when Xfall into local optimum , according to a rectangular Nesting encoded form, randomly generated two integers r_1 and r_2 ($1 \leqq r_1, r_2 \leqq n$), In X individual coding, the first element r_1 and $r_2$exchange elements to form a new individual X '.For example,X=（3,7,1,4,2,6,5）r_1=2,r_2=5,to generatea newindividualX'=（3,2,1,4,7,6,5）.

6.4 New individual acceptance criteria

To avoid the brightest firefly individual population unnecessary appear degradation and fluctuations in the iterative process, In this paper,only when the fitness of new individual larger than fitness of the original individual, the new individual can replace the old individual, otherwise retaining the original individual.

VII. The remaining rectangular nesting algorithm[10]

In order toevaluate thefitness ofthe individual, the individual must be the decoding operation. Decoding operationisthecodingsequenceof individuals inthe populationconverted intonestingmap.Nestingalgorithm determinesthe rules oftherowof rectangularsample, and the quality ofnestingalgorithmdetermines the level ofutilizationofthe leather. In this paper, the remaining rectangular nesting algorithm as a decoding method.The remaining rectangular nesting algorithm [11] with a rectangle Data set to represent currently remaining of leather fabric, any unused space emissions (including isolation gap) are included in the remaining rectangle collection; Before rectangular pieces of leather into the row, The most reasonable position emission based on the remaining rectangle centralized data to overcome the lowest level algorithm can not enter the hollow area of the defect row.The main flow of the algorithm:

(1) Coordinates high left corner and the coordinates of the lower right cornerof plate Respectively is （0,0）and （W,H）, the initialdata setonlywhenthe remainingrectangleisa rectangleR_1=[（0,0）,（W,H）].

(2) From the piece to be ranked order according to the order of coding X_i (i = 1,2, ..., n) to select the Rectangular i (wide w_i , high h_i), the assumption of rectangular pieces are horizontal (rectangular pieces not rotated 90 degrees), after the lower left corner of the rectangular piece coordinates (x_{1i}, y_{1i}), the remaining rectangle lose focus rectangle piece part i intersect to form a new set of residual matrix:

$[（0,0）,（W.H）]-[(x_{1i},y_i),(x_{1i}+w_i,y_{1i}+h_i)]$

$=\{[(0,0),(W,y_{1i})],[(0,0),(x_{1i},H)],[(0,y_{1i}+h_i),(W,H)],[(x_{1i}+w_i,0),(W,H)]\}$,(Fig 1)

Each rectangle piece into row, the remaining rectangle and the row of rectangular pieces matching calculations, both in the length and width greater than the remaining parts of the rectangle to be ranked, minimal residual value of Rectangles with the remaining rectangle width as the best match of the priority emissions, if there is more than one best match remaining rectangle, select the lowest priority to the leftmost position emissions, lower left corner of the rectangular piece coincides with the remaining rectangle .

Updatethe remainingrectangleset: deletethe remainingrectangle which areais approximately zero, or unable todischargeany remainingrectanglepiecesto be ranked; fully retainedthe remainingrectangles which hasintersectedrelationship,Removing inclusion relation with the smaller residual matrix, the equally remaining matrix retain only one.

Repeat(2), One by one according to the coding sequence of rectangular pieces of emissions, only to finish the rectangular pieces emissions.

Individualswithacodingexample, itsthesortlisted(1，2，3．4，5). Using differentalgorithms fornesting, The resultsshown in Figure2, 3

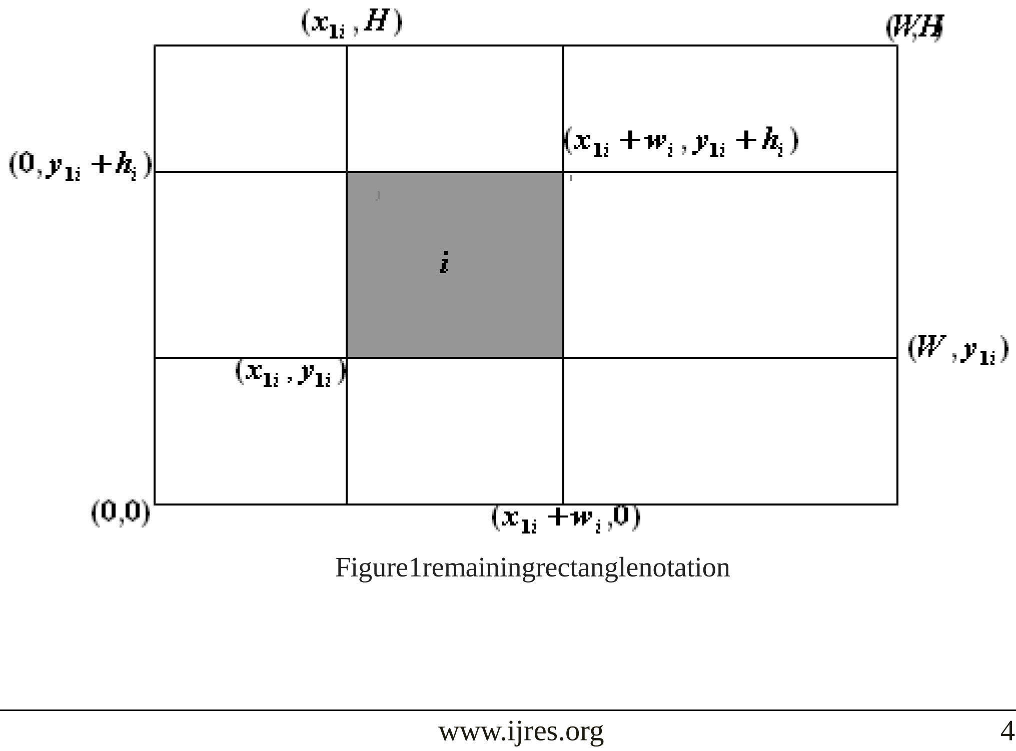
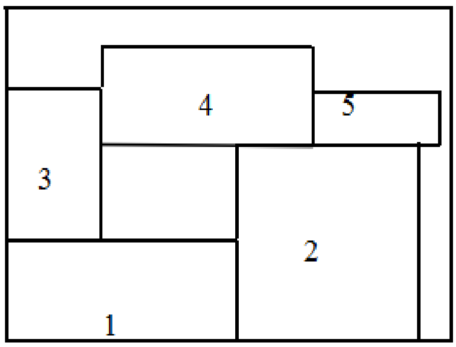


Figure1remainingrectanglenotation



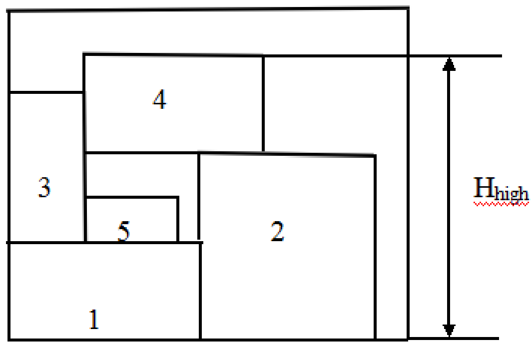
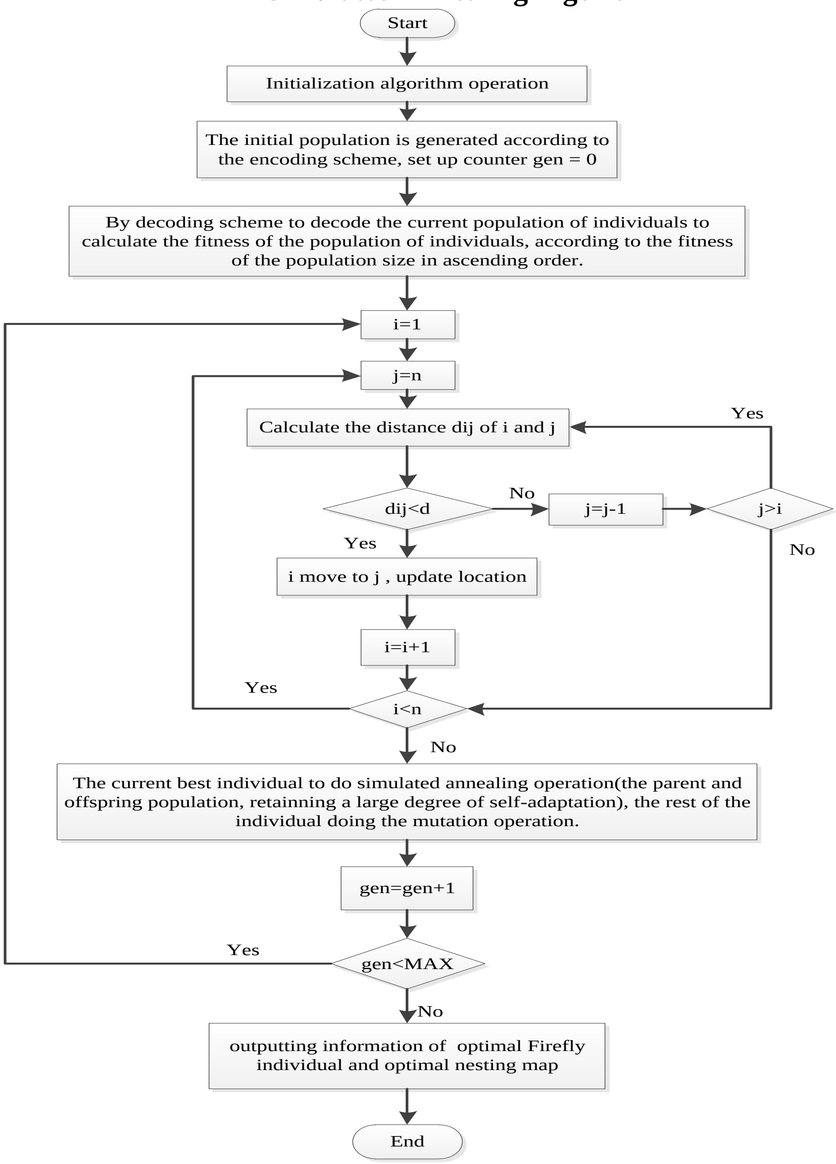


Figure2"minimumlevel" algorithm nestingmapFigure3remainingrectangularnestingalgorithmmap

VIII. Convergence criteria

In this paper, the convergence criteria set: if utilization of optimal nesting solution greater than the set value ηk, stop evolution; otherwisehereditary algebragreaterthan the setmaximum number ofevolutionaryMAXGENstopped. Finally,exporting the optimal solutionand the correspondingoutputnestingmap.

IX. Flow chart of Optimal Layout of Leather Rectangular Parts Based on Firefly Simulated Annealing Algorithm



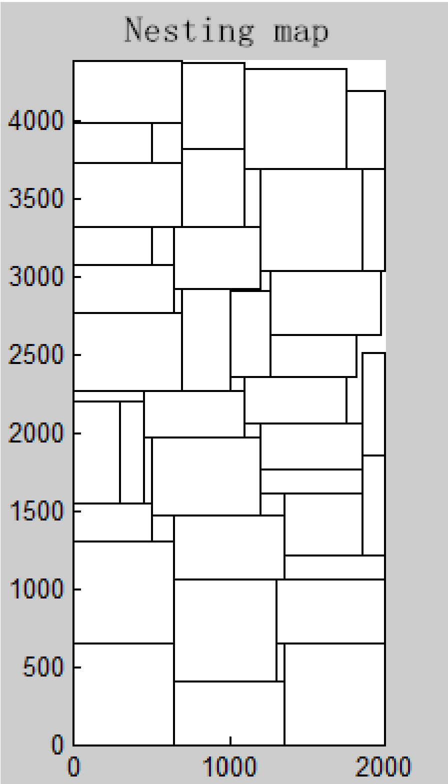
X. Experimental Analysis

In order to verify the validity of firefly simulated annealing algorithm , a set of selected samples of rectangular leather sofa from a furniture plant for nesting computing.Set the parametersas follows: After repeatedcomparison test, get: β_0=1,γ=0.0048，α=1.5，D_1=32，D_2=43,α_1=2，λ=0.9, population sizem = 100.Convergence criteriaG_{max}=100，η_k=0.98.Artificial leather fabric width is 2m,assuming infinite length. The sizeandnumber ofrectangularleathersofafabricasshown in Table 1:

Table 1 The sizeandnumber ofrectangularleatherfabric

Kind of rectangular pieces	The length of the rectangular pieces long(mm）	The width of the rectangle pieces wide(mm)	Quantity
1	700	410	6
2	650	300	6
3	650	150	6
4	650	650	6
5	500	400	2
6	500	250	4
7	700	500	2
8	550	265	2
9	550	400	2

Using matlab software for simulation， nesting results shown in Figure 5 , nesting height of the evolutionary process diagram in Figure 6.the results can be seen from Figure ,nesting height Hhigh = 4375mm, leather fabric utilization of 95.35%, obtaining the number of iterations of the final layout diagram for the first 62 times, the entire nesting process run time of 172.56s.



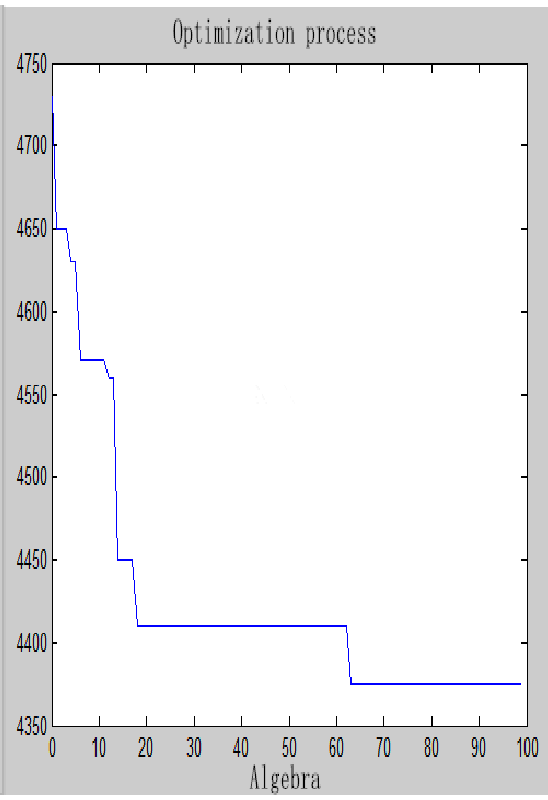


Figure4nestingresults .Figure5Nestingheightevolutionchart

In order to verifythe efficiency ofthe algorithm,above a set of leather sofas rectangular sample respectively use GA (genetic algorithm) and SA (simulated annealing algorithm) algorithm nesting , the results were compared ,remaining rectangle algorithm as the decoding algorithm; The results obtained for the above-described algorithm are compared, as shown in Table 2

Table2comparesthe four algorithmsresults

	GA	SA	This Paper Algorithm
H_{max}	4575	4560	4470
H_{min}	4400	4360	4300
H_{avg}	4461	4443.5	4410
η_{avg}(%)	93.53	93.18	94.59

Can be drawnfrom Table2, for leather rectangular sample layout, the results obtained using this algorithm regardless of maximum height H_{max}, the minimum height H_{min}, average height H_{avg}, average η_{avg} are better than other algorithms.

XI. Conclusion

Optimal Layout of Leather Rectangular Partsonpractical applications andtheoretical researchhas importantsignificanceofresearch, Firefly simulated annealing algorithm was proposed,the optimal order and arrangement for Leather rectangular samples obtained by this algorithm ,and then using the remaining rectangle algorithm make true leather rectangular sample automatic nesting.Bycomparison of the datawith theGAandSAexperimentsprovethe algorithm isbetterand superiorperformance.Inthe production oflarge quantities ofleathersofas, the proposed algorithmcan significantlyimprove the utilization ofleathermaterial, can bring significanteconomic benefits, it has important practicalsignificance.

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