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Design and Development on Intelligent Layout System of Stamping Blanks

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Abstract

The optimal layout of stamping blanks is a complicated problem under the control of multi-circumstances, and it cannot be best solved by any single algorithm. In order to solve this problem, the paper proposed a new kind of algorithm combining CHNN and genetic algorithm. It set up models for irregular parts, and these irregular parts were processed by using the surrounding rectangle methods and graphic composition. The paper used AutoCAD as a develop studio, and discussed CHNN and its mapping to layout and optimize the weight of CHNN by genetic algorithm. The kernel program adopted VB program language and developed the intelligent layout system. With the input of layout parts graphics and layout parameter, the system preprocessed graphics and gave layout results automatically. Sample analysis showed the results that the system had good man-machine interfaces, interactive features, high speed and quality retention of solution.

Keywords*: neural network, genetic algorithm, stamping blanks, layout, AutoCAD*

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1. Introduction

Layout is a key component in the stamping production. Different layout will greatly influence the utility of materials. In the stamping production, the cost of materials nearly accounts for 60% of the stamping cost. So improving materials utilization rate is to the essential way to reduce the cost of stamping parts, and the utility of materials depends mainly on stamping parts layout. Since the layout mode of parts in panel varies, and the shape of parts has become diverse, just relying on the experience of the designer, it is impossible to obtain the best material utilization in layout.

With the development of computer technology, some scholars at home and abroad have studied the problem of parts layout. And while doing researches on layout algorithm, they also developed corresponding layout soft wares. The main processing methods used in work include human-machine interactive technology,border encryption and the non-intersect of discrimination, etc. in which there are rarely any based on artificial intelligence. In algorithm, human-machine interactive technology is mainly used to conduct graph rotation and translation for the purpose of optimal layout. But generally speaking, only the intuitive feelings in human-machine interaction are not reliable in finding the optimal layout; and interactive process is excessive and too complicated, also difficult for users to accept[1-4].In addition, artificial intelligence, mathematics, theoretical simulated annealing(SA) and biological evolutionary theory(GA) are integrated in optimal layout of stamping blanks. Despite in many areas SA, GA have been successfully applied in sorts of optimization problems, and have solved lots of problems, but there is no mature optimal layout system that is established based on SA, GA, and machine-learning theories[5-7].

A new kind of algorithm combines CHNN artificial neural network and genetic algorithm is proposed in this paper. And on the basis of the algorithm, the author developed intelligent layout system.

2. Layout Algorithm Design

2.1. Layout Problems to CHNN Neural Network Mapping

Successive Hopfield artificial neural network (CHNN) constitute a monolayer fully connected neural network which is constituted by a number of basic neurons, Between any two

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neurons are connected by a symmetric link structure, Hopfield ,using the thoughts of energy function ,forms a new method of calculation.

As for the N nodes CHNN neural network model, the Momentum in the state changes of the neurons can be described using the following differential equations:

$$\begin{cases} C_i \dfrac{du_i}{dt} = \sum_{j=1}^{N} w_{ij} v_j + I_i - \dfrac{u_i}{R_i} \\ v_i = f(u_i) \quad \text{或} u_i = f^{-1}(v_i) \end{cases} \tag{1}$$

Its energy function defined as follows:

$$E = -\frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij} v_i v_j + \sum_{i=1}^{N} \frac{1}{R_i} \int_0^{u_i} f^{-1}(v_i) dv_i - \sum_{i=1}^{N} I_i v_i \tag{2}$$

Neurons in a row can change between the value [0,1].

Layout problem will be mapped to artificial neural networks: First of all, the problem of layout is mapped to a group of neural network in specific configuration, This layout configuration corresponds to the possible solution of layout problem. Then constructs an energy E function that is suitable to optimization problem and the function is proportional to the cost function of optimization. The evaluation of the selected function will have a direct impact on the efficiency and results of layout. The evaluation function adopted in this paper consists of two parts:

(1) Smallest parts height difference in each layout.

(2) Smallest parts width difference in each layout. The smaller the evaluation function is, the better corresponding program is.

To test its effectiveness, before layout the following rules are put forward:

(1) Calculate the surrounding rectangle of irregular parts.

(2) For similar parts of obvious size or saving space after composition, after paring, calculate the surrounding rectangle of irregular parts.

(3) For some of the irregular-shaped hole parts, inserting small parts and other methods can be used to combine components and then calculate the surrounding rectangle.

Aimed at this kind of surrounding rectangle of irregular parts, this paper builds models. Assuming that you have M components, then divided them into N group, Then there will be MXN neurons used in network. These neurons are arranged to row M line N. When the network to achieve steady state, asked to meet the following conditions:

(1) A layout only has one kind of a row, and belongs to a fixed group, only 1 per row, the other elements of "0."

(2) Each group may have the indeterminate number of layout. The outputs of the indeterminate number in each line are "1", and the other elements are "0".

(3) M parts in all, all MXN neurons' the output of "1" is the number of M.

The energy function of layout problem is established to solving problem above:

$$E = \frac{A}{2}\sum_{i=1}^{M}\left(\sum_{y=1}^{N} V_{iy} - 1\right)^2 + \frac{B}{2}\sum_{i=1}^{M}\sum_{j>i}^{M}\sum_{y=1}^{N}(l_i - l_j)^2 V_{iy} V_{jy} + \frac{C}{2}\sum_{x=1}^{M}\sum_{i=1}^{M}\sum_{j>i}^{M}(w_i - w_j)^2 V_{xi} V_{xj} \tag{3}$$

Where: A、B、C—positive coefficient;

l_i、w_i — length and width of layout parts;

V_{xi} —the output of neuron element in row X line I, that is, layout object is assigned into group x.

The weights between its neurons as follows:

$$w_{xi,yj} = -2A - 2B(l_i - l_j)^2 \delta_{xy}(1 - \delta_{ij}) + 2C(w_i - w_j)^2 \delta_{xy}(1 - \delta_{ij}) \tag{4}$$

Where:

$$\delta_{xy} = \begin{cases} 1 & x = y \\ 0 & x \neq y \end{cases}, \quad \delta_{ij} = \begin{cases} 1 & i = j \\ 0 & i \neq j \end{cases} \tag{5}$$

2.2. Genetic Algorithm Optimize CHNN Neural Network

Genetic algorithm is a random method based on the natural choice and the principles of genetics .It is the optimum and robust in large scale. Genetic algorithm combines Darwin's survival of the fittest strategy and randomly structured exchange of information, thus greatly accelerates the speed of optimization.

Genetic algorithm starts from group of candidates randomly generated, and each is denoted as the string of the form. Through the use of genetic operator, these strings are combined and the group of candidates develop towards a better direction. Simple genetic algorithm is composed of the three operators: reproduction, crossover, and mutation, which simulate natural selection and population genetics in the process of breeding, mating and mutation phenomenon. Following its solving process:

(1) Definition of an objective function.

(2) Initialization of groups of feasible solution under certain constraints. (each of feasible solution uses a vector encoding, then changes to a chromosome, the weight of vector stands for gene).

(3) Each chromosome of corresponding objective function value is calculated, and then the value calculated in this adaptation is examined, according to the size of the value feasible solution, good or bad.

(4)According to the mechanism of survival of the fittest, the chromosomes with poor fitness value are eliminated, and the survival chromosomes selected by probability of random form new groups according as their fitness value.

(5) By the operation of hybridization and mutation they have since.

(6) Repeat (3) to (5) until the chromosomes meet fitness value.

Neural networks will encode all connecting weights of neurons into binary code values or strings of digital strings that are the individual, which randomly generate code string of initial population that can be conventional genetic algorithm optimization. Every generation of computing, yard series will be decoded to a new weight which form new neural network, with training for all samples calculated output of neural network to determine the mean square error for each individual fitness value. After several generations, the neural network will evolve to the minimum error overall.

The main procedure of genetic algorithm optimizing CHNN neural network is shown in Figure1.

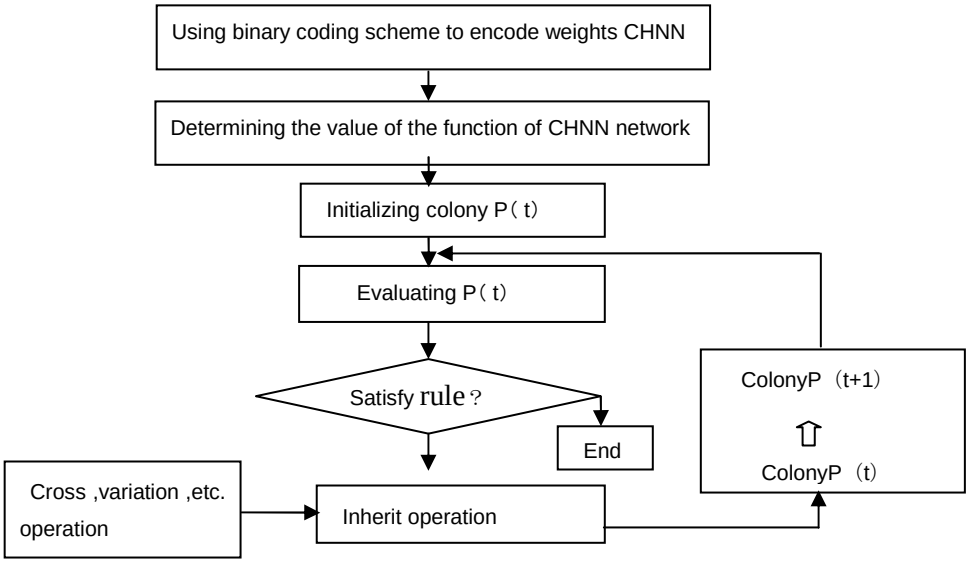

Figure1. The procedure of genetic algorithm optimizing CHNN neural network

3. Intelligent Layout System Design

3.1. Intelligent Layout System Module Structure

Development of layout system demands the graphics pretreatment. The paper uses AutoCAD as a development platform and the core program adopts programming language

Visual Basic preparation to develop the intelligent layout system. Systems utilizes expanding function of the Active X technology, with the development of object-oriented methods .Intelligent layout system modules include data input module, graphics preprocessing module, intelligent layout module, and the result display and text output. Intelligent layout system module structure is shown in Figure 2:

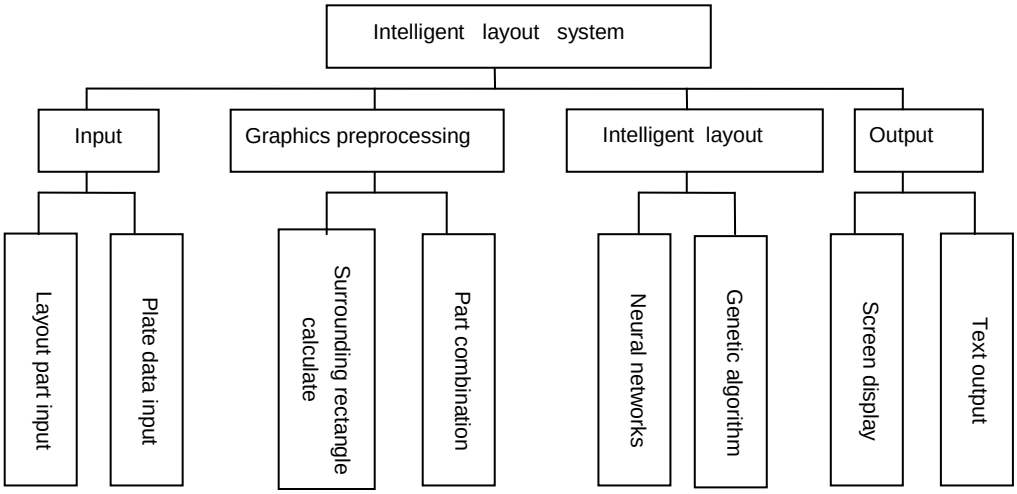

Figure2. Intelligent layout system module structure

3.2. The Procedures of Intelligent Layout System Program Developing

(1) Visual Basic 6.0 and AutoCAD connection: AutoCAD object class library used in VB "projects" on the menu choose "quote" choice "AutoCAD Object library." AutoCAD related to the specific object class can be checked in VB6.0 the "View" menu and selected in "Object Browser".

```
       Dim AcadApp As object
       Dim Preference As object
       Dim AcadDoc As object
       Dim MoSpace As object
       Dim PaSpace As object
‘Connecting procedures:
       Private Sub CmdLink CADClick()
       On Error Resume Next
Set AcadApp=GetObject(,“AutoCAD.Application”)
       If Err Then
       Err.Clear
Set AacdAPP=Create Object(“AutoCAD.Application”)
       If Err Then
       Msg Box  Err.Description
       Exit Sub
       End if
End if
AcadApp.visible=True
‘Setting global variables of Program:
     Set Preference =AcadApp.Preferences
     Set AcadDoc=AcadApp.Active Document
     Set MoSpace =AcadDoc.ModelSpace
     Set PaSpace =AcadDoc.PaperSpace
End Sub
```

(2) Rough graphics preprocessing: Utilizing AcadDoc.Open, AcadDoc.Export, AcadDoc. Import methods input or output of rough parts.

(3) Graphics Editing: According to CHNN neural network which is optimized by the genetic algorithm, the corresponding function is worked out, to produce layout graphics, and achieve layout project. Related operation:

- Selecting graphics entities: Using various methods to SelectionSet targeting select Options;
- The extract of layout parts area: Entities will be processed by AddRegion (Object) for the conversion of the region and then get A in the area by MoSpace(). Area, with Object.Rotate, Object.Move,etc. for editing graphs. Making use of UCSMatrix,TransformBy to achieve the coordinate transformation.

(4) Layout effect output: Load the menu of "layout results output" and its submenu in AutoCAD.

```
Sub Disable MenuItem()
     Dim currMenuGroup As AcadMenuGroup
     Set currMenuGroup = ThisDrawing.Application.MenuGroups.Item(0)
     'Creat a new menu
     Dim newMenu As AcadPopupMenu
     Set newMenu = currMenuGroup.Menus.Add("layout results output")
     'Creat submenu in the new menu
     Dim Menu layout drawing output As AcadPopupMenuItem
     Dim Menu layout text output As AcadPopupMenuItem
     Dim Menu save layout result As AcadPopupMenuItem
     Dim Menu result print As AcadPopupMenuItem
     Dim Menu Separator As AcadPopupMenuItem
     Dim Menu exit As AcadPopupMenuItem
     Dim OpenMacro As String
        .
        .
        .
        .
        .
.
     'Display the menu on the menu bar
     newMenu.InsertInMenuBar (ThisDrawing.Application.MenuBar.Count + 1)
End Sub
```

3.3. The Basic Function of the System

Intelligent layout system functions as follows:

(1) The system can automatically optimize layout of various different types and numbers of parts to achieve the aim of higher material utilization.
(2) The system can automatically calculate the utilization of materials, and automatically give the layout drawing.
(3) The system can withstand a certain degree of error interference, having a certain degree of robustness. It also can expand the further functions based on some certain conditions.
(4) The system interface is friendly, and the operation is relatively simple, which is easy to use.

3.4. Layout System Operator Process

In AutoCAD, according to the ratio 1:1, the graphics of parts is drawn, (or transferring from the disk .dwg format graphics files), picking the contour graphics and making it a storage option set. As a follow-up handling, it will be input through dialog layout material indicators, direction azimuth angle incremental and layout parameters and calculates layout results.The final result of ultimately layout parameters and the pictures of results are shown in AutoCAD window. Operating processes are shown in Figure 3.

4. System Example Application

4.1. Rectangle part layout

The paper analyzed the development of intelligent layout system using sample analysis, and taking the production car of a product box material as an example, each car box contains 16 parts plate, and the following Table 1.is the size of each one.

The material used is ordinary steel 6mm with the size L = 2000mm and B = 1500mm. If the parameters were put into the system, the entire calculation process is very rapid. Click the drawing button to start the AutoCAD drawing, and then get the following layout drawing is shown in Figure 4. The output of material utilization is 91.58%, which can prove that effect of the system is efficient.

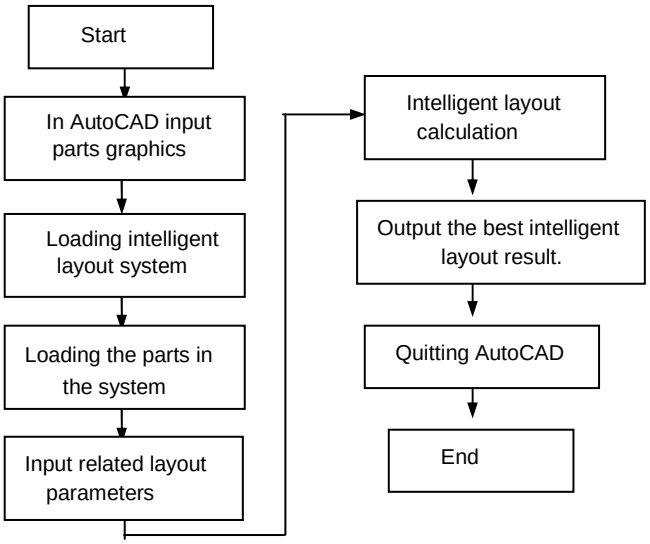

Figure 3. Effects of selecting different switching under dynamic condition

Table1. Layout parts parameters table

Part name	Length/mm	Width/mm	number
J1	840	350	3
J2	654	350	3
J3	355	255	4
J4	440	420	4
J5	480	250	2

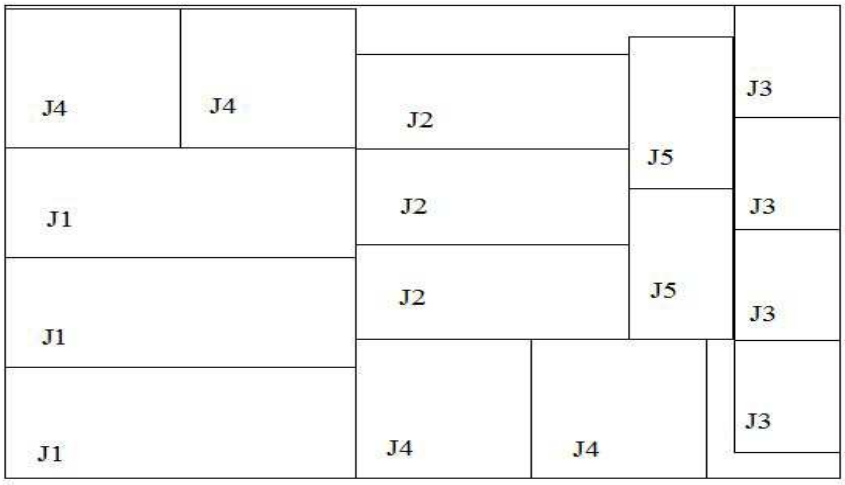

Figure 4. Layout effect drawing

4.2. Irregular part layout

In order to test the combination layout effect of irregular parts,The paper tests the system functions by inputting 60 irregular parts. First, input layout parts by selecting layout parts menu; then choose the sheet metal used for layout from the management menu of the sheet metal; at last, layout results is shown in Figure 5.

The output of material utilization is 83.72%. The system is also able to correctly deal with the layout of many plates, when the layout of one board is finished, the system can automatically generate a layout of new board.

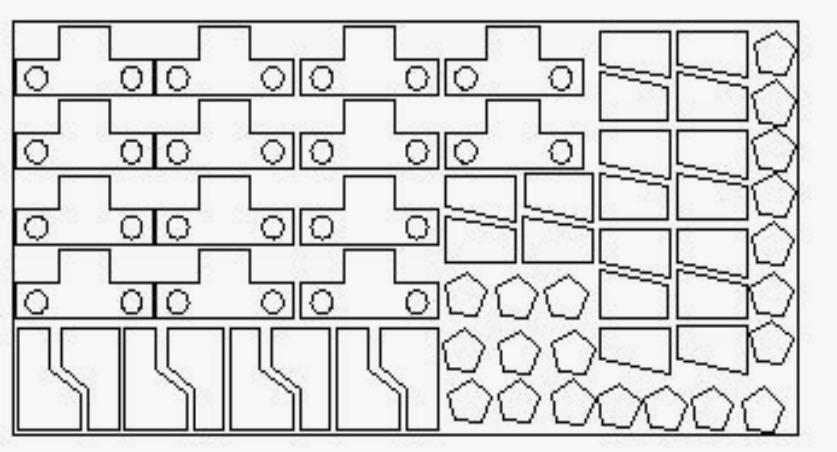

Figure 5. Layout effect drawing of irregular parts

5. Conclusion

(1) With this application intelligent of Active X program to develop AutoCAD for the second time. By the usage of Visual Basic 6.0 program, to prepare the final link to the AutoCAD system, it is convenient for the client.
(2) This paper uses the combination of neural networks and genetic algorithms for the regular parts layout. The quality is stable and the effectiveness of materials' utilization increase dramatically.
(3) The system which is used in the production of scene is not only of a good interface and interactive functions, but also of a high degree of automation layout, and maintain convenient as well as is suitable for small or medium enterprises to deal with the layout materials occasions.

References

[1] Bo Li, Zhi-Yan Zhao,Ju-Dong Li. A hybrid algorithm for nesting problems. Proceeding of the Second International Conference on Machine and Cybernetics. Xi'an, 2003: 1424-1429.
[2] HaoHongyan. Optimized Layout CAD System of Blanking Based on Object ARX.Die Manufacturing. 10(2005): 1-3.
[3] Hopper E, Turton B. An empirical investigation of meta- heuristic and heuristic algorithm for a 2D packing problem. *European Journal of Operational Research*. 2001; 128: 34~57
[4] Liu Xinxiong, Xu Cangyong, Wang Hong. Sample irregular graphics automatic nesting design. *Huazhong University of Science and Technology Journal (Natural Science).* 2002, 30(2).
[5] Mhand H, Vangelis T.P, Vassilis Z.A simulated annealing approach for the circular cutting problem. European Journal of Operational Research.159(2004): 430-448.
[6] CaoJun, Yue-Qi. The application of genetic neural network in optimization blanking plate of Furniture stuff. Forest Project. 19(2003): 36-37.
[7] Wang Zhenjin, Zhao Zhongjin. Based on genetic algorithm optimal Layout. *Innovative Design*. 2(2004): 54-57.
[8] Han Liqun.Artifical neural network tutorial. Beijing University of Posts and Telecommunications Publishing, 2007.