SOLUTION OF TWO-DIMENSIONAL OBJECTS OF PACKAGING ARBITRARY GEOMETRICAL SHAPE OF PARTICLE SWARM

A.Dashkevich, E.Ohotskaya, K.Anisimov

Summary. **Solution the problem of two-dimensional packing of arbitrary objects, which have geometric shape, into rectangular container from the viewpoint of global optimization methods was examined. The technique of describing the contours of arbitrary shape on the complex plane is suggested. The main steps for solving the problem of two-dimensional package using particle swarm algorithm are shown.**

Keywords: **global optimization, complex plane, two-dimensional packing problem and particle swarm algorithm.**

Formulation of the problem. In industrial production, there is often the problem of cutting the material to the maximum possible number of work pieces with minimum quantity of waste . Also there is known problem of packing predetermined shape objects to the final number of containers certain form so that the number of used containers is minimized or number of objects, that are packed, is the greatest. This problem is known as the problem of packing in containers and arises in the transport sector and logistics. These problems are NP-hard and, with a large number of parameters, using the exhaustive search algorithm for the solution is not possible. In this connection there was a necessity of development of search algorithms of approximate solution of this problems' class, in particular of heuristic methods reducing the running over states.

Analysis of recent research. Existing approaches to the problems of cutting and packaging in containers can be divided into:

− methods based on the use of linear programming method ;

− heuristic optimization methods, which include simulated annealing algorithm, genetic algorithms, swarm intelligence methods, etc. [13].

These methods do not take into account the angle of rotation that doesn’t allow using them for solving problems of cutting complex parts.

The wording of the purposes of the article. Development and research of methods of cutting blanks in the plane of the material using the method of particle swarm.

Main part. The method of particle swarm - a method of numerical optimization, for using of which to know the exact gradient of optimized function is not required. It models multi-agent system, where the particles - agents move to the optimal solution and exchange information with the neighbors. The current state of the particles is characterized by coordinates in the solution space (ie, in fact, associated solutions) and a moving velocity vector. Both of these parameters are randomly selected during initialization. Furthermore, each particle stores the coordinates of the best found solutions, and the best one solution.

Let s - the number of agents in the swarm. Each i-th particle can be represented as an object with a number of parameters:

x_i - the position of the particle;

V_i - velocity of the particle;

y_i - the best position of the particle.

The best position of the particle - particle's position with the best value evaluation function which ever attended particle.

Let f - a function that must be minimized, then the expression for the best position depending on the time:

$$y_i(t+1) = \begin{cases} x_i(t+1) if\ f(x_i(t+1)) < y_i(t); \\ y_i(t+1) if\ f(x_i(t+1)) \geq y_i(t)). \end{cases} \quad (1)$$

There are two versions of the basic algorithm, called gbest and lbest. The difference is that, with which set of particles, each particle interacts. We denote this interaction $\hat{y}$.

Determining $\hat{y}$ in case gbest is represented in the following expression:

$$\hat{y} \epsilon \{y_0(t), y_1 \dots y_s(t)\}\ f(\hat{y}(t)) = \\ = min\{f(y_0(t)), f(y_1(t)), \dots, f(y_s(t))\}. \quad (2)$$

The stochastic component of the algorithm is represented by two random parameters $r_1 \sim U(0,1)$ and $r_2 \sim U(0,1)$, which are scaled by the constant coefficients c_1 and c_2 of acceleration, responsible for magnitude of the step, which can make the particle in one iteration time. Generally c_1, c_2 is (0 2]. The particle velocity at the *i-th* step is calculated separately for each measurement $j \in 1 \dots n$, thus $V_{i,j}$ denotes the *j-th* measurement of the velocity vector of *i-th* particle. Calculation of the *j-th* component of the velocity vector of the *i-th* particle at $t+1$ step by the formula:

$$V_{i,j}(t+1) = W_c V_{i,j}(t) + c_1 r_1(t)[y_{i,j}(t) - x_{i.j}(t)] + \\ + c_2 r_2(t)[\hat{y}(t) - x_{i,j}(t)]. \quad (3)$$

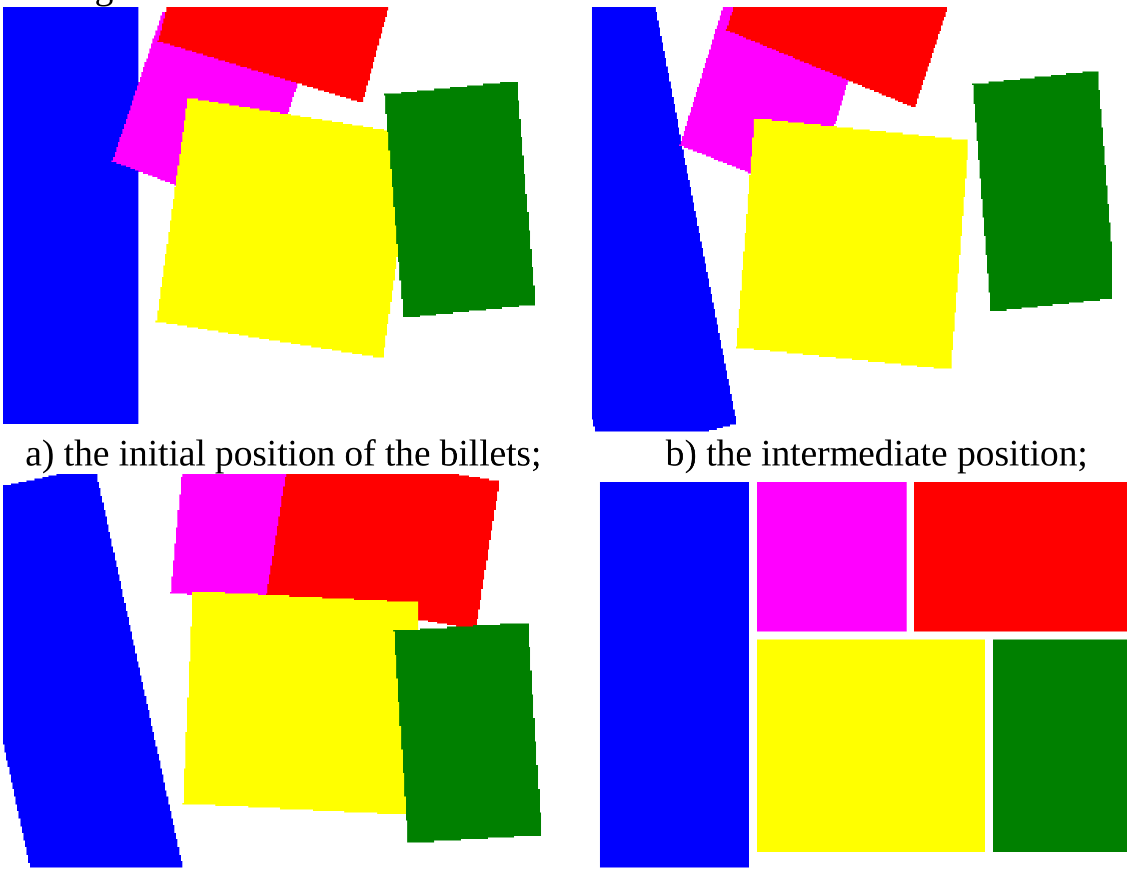
Thus, c_2 manages by impact of global the best position, and c_1 controls work of the best position of all used on the speed of each particle. To improve the convergence of the algorithm is introduced inertia ratio W_c. The position of each particle in the *i-th* dimension is calculated as follows:

$$x_i(t+1) = x_i(t) + V_i(t+1). \quad (4)$$

For the problem under consideration one of the important steps is choice of ways to describe the geometric shape contours of work pieces and defining a set of coordinates xi, which describes the location of each billet. Also it has a great influence the choice of the objective function. To solve this problem was chosen method of defining the contours as a set of coordinates of the corner points of each contour, allows to set any geometrical shape of the work piece with the necessary accuracy.

Ratio of the area occupied by the work pieces to the total area of the material (the fill factor) has been selected as the objective function. The vector x_i is defined as a pair of coordinates *(x, y)* center of mass of the work piece and the angle of rotation about the axis of abscissas circuit *(φ)*.

Figure 1 shows an work example of the obtained algorithm for rectangular billets.



a) the initial position of the billets; b) the intermediate position;

c) the intermediate position; d) the target position of the billets;

Fig. 1. Stages of the particle swarm method.

Conclusions. The resultant method of specifying the contours billets and the use of the particle swarm method to optimization of their location allows you to:

1) automate the cutting of the material to products of complex geometric shapes;

2) significantly reduce the time of the optimal position calculation of parts and material consumption.

Literature

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