Section 3. Information Technology

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HYBRID ALGORITHM BASED ON FISH SCHOOL SEARCH AND GREY WOLF OPTIMIZER ALGORITHMS FOR FOOD ENTERPRISE MANAGEMENT

Abstract. The article proposes a hybrid method on the basis of optimization algorithms inspired by nature for solving problems of food enterprise production process management in conditions of uncertainty and risk. This hybrid algorithm is based on FSS (Fish School Search) and GWO (Grey Wolf Optimizer) algorithms. The advantages of algorithm hybridization are the formation of alternative solutions to the production management task of finding the desired global optimum within a reasonable time with avoiding local optimums.

Keywords: enterprise management, hybrid algorithm.

Introduction

Food industry enterprises are of strategic importance to many countries. Their functioning depends on the demand of the end user, seasonal fluctuations of prices for energy resources, raw materials and auxiliary supplies. Constant food market competition is based on the flow of goods from internal and external producers. All of the above requires the operational management of all parts of the enterprise in conditions of uncertainty and risk, which cannot be achieved using standard management methods that lead to the waste of time and cannot ensure real-time management.

The main task of management is to ensure the manufacture of products in full and range to meet the needs of customers for a given time. Such task belongs to the class of multiobjective NP-hard combinatorial tasks [1; 2].

In the article [2], the authors proposed a mathematical model of the task of planning contract execution and a modified method of an ant colony for its implementation. But the disadvantage of the proposed approach is the orientation on the execution of service contracts.

The authors of the articles [3] proposed a hybrid planning algorithm based on particle swarm

optimization and ant colony optimization algorithm. The proposed algorithm does not take into account economic and social impacts in finding the optimal plan.

In [4], a critical analysis of common factors that hinder the planning of various production processes based on optimization methods has been performed and approaches to their elimination have been proposed. But the article does not take into account the specific characteristics of food industry enterprises.

The task of production management using hybrid algorithms of the inspired by nature remains relevant despite the fact that solutions using classical, heuristic and evolutionary methods have been considered by various scientists.

Objects and research methods

The authors offer a new modified method based on a hybrid of FSS and GWO algorithms. As a mathematical model, the authors have taken the models given in [1; 2]. Depending on the general situation and trends of the whole enterprise, a task can include a certain set or all partial criteria [1].

The authors have conducted a number of practical research on the effectiveness of the proposed method on the statistical data presented by enterprises of the food industry of Ukraine, namely, pasta, meat processing and dairy production.

Results and its discussion

Let us examine the general application of the proposed algorithm in detail.

Upon receipt of an order, the conditions of its execution, workload of production facilities, equipment condition, schedule of planned repair and maintenance works, availability and schedule of resources delivery, possibility of their postponement or transfer, priority of each order execution, determine the possibility of full or partial reconfiguration of the plan are analyzed [1].

Then the orders are classified into groups using decision tree algorithm. The choice of this algorithm is justified by its ability to represent objects in the form of a hierarchy based on classification parameters, where each element corresponds to a single decision tree node [5; 6]. By the example of sausage products manufacturing all orders are divided into boiled and smoked products, then by the equipment involved and the type of packaging.

The main operators of FSS algorithm are: the feeding and the movement operators (movement of agents). The feeding operator determines how the agent weight gain is accomplished at each iteration. FSS algorithm distinguishes three types of movement: *individual, collective-instinct* and *collective volition*.

In case of individual movement, an agent moves randomly with the same probability in any direction at a given speed or at a given distance. To be applied to the task in question, the transition distance acts as an execution order. Individual movement includes more than one iteration and is aimed at finding the optimal solution.

Collective-instinct movement is carried out after all possible individual movements of all agents. At each step, each agent takes into account the movement of the entire group, that is, choose the sequence of tasks in which we get the most benefit.

Collective volition movement is carried out after instinctive movement. This type of movement consists in shifting all agents in the direction of the current center of gravity of the population, if the total weight of the school as a result of individual and collective-instinct movement increased, and in the opposite direction – if this weight has decreased. Otherwise, the population expands from the same center of gravity, increasing its diversification properties.

The authors apply GWO algorithm for collective volition movement, which copies their hunting process in nature. According to our task, the pack is hunting for the victim, which corresponds to the optimal operational plan of execution of orders. Each wolf pack corresponds to an alternative operational plan at each iteration. After each iteration for each wolf is calculated value of its alternative operating plan using the target function. According to the value of evaluation of each wolf in the pack they are divided into four types:

alpha – the wolf leader, the evaluation of which is the optimal solution by specific criteria or evaluation function; Beta and delta – the wolves driving the victim, whose evaluation is ranked second and third place among the best; Omega – all others [9–11]. The first three types of wolves are fixed in the next iterations until new alternatives are found that will be better than the current one or a given number of iterations will be exhausted. The alpha, beta and delta wolves influence the formation of omega wolves [11]. The first iteration use the best options obtained by collective volition movement as alpha, beta and delta. Using GWO algorithm, we get variants of order execution plans.

The work stops when the specified number of iterations is exhausted or when the optimal solution is repeated during the specified number of iterations.

The authors have compared the proposed hybrid algorithm with various algorithms inspired by nature, using statistical data from the Ukrainian food industry, namely pasta, dairy processing plants and enterprises producing sausage and meat products.

According to the results of comparisons, the proposed hybrid algorithm is significantly better in time expenditure, because all the algorithms are limited by the number of iterations, and the resulting plan of order execution will be more optimal with an increase in the number of input data. If we use each algorithm and its modifications separately, the search time increases as the task size increases.

For example, in comparison with GWO algorithm, the algorithm in question finds a better solution with the selected input data of 200 or more orders 40% faster.

Conclusion

The article proposes a hybrid algorithm based on the FSS and GWO algorithms to solve the multiobjective problem of food enterprise management, specifically, the formation of a plan of manufacturing products on order. Application of the proposed algorithm allows you to form new plans and to reconfigure existing ones in a short time.

The proposed hybrid algorithm will be included in the decision support system for food industry enterprises, which will increase profits by reducing the cost of manufacturing products, the optimal use of production facilities, warehouses for storage of finished products and raw materials, as well as other parameters.

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