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Study on disruption management strategy of job-shop scheduling problem based on prospect theory

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ABSTRACT

In view of the disturbance in the process of uncertain job-shop scheduling problem, the measurement method of value function based on prospect theory and the disruption management strategy of user's psychological perception are proposed in this paper. A multi-objective optimization model for job-shop scheduling management is established through multi-objective programming. At the same time, the idea of gradual optimization for the target to obtain the job-shop scheduling adjustment scheme with minimum disturbance is introduced. Acting the user's psychological perception time as the reference point, the degree of the user's psychological perception of the expected time of goods is measured. In order to optimize the scheduling model and search the optimum solution of multi-objective optimization problem, an improved quantum bacterial foraging algorithm is proposed, and it is compared with the existing classical algorithms to verify its effectiveness.

1. Introduction

There are many uncertainties in Job-shop Scheduling Problem (JSP) process, and these uncertainties mainly come from disturbance factors that cannot be accurately described in the real world. Including the temporary departure of processing personnel or sudden failure of the processing machine and other unexpected events, as well as the floating data field of the workpiece with uncertain installation time, uncertain completion time and uncertain delivery date. The interference management is mainly based on the degree and nature of the disturbance of the problem, establishing a corresponding optimization model and designing an effective strategy to locally adjust the initial scheme to generate a minimized disturbance update scheme. The key to interference management is to control the adjustment of the initial scheme within the smallest possible range to achieve the least effect of the disturbance.

Domestic and foreign scholars mainly studied the problem of workshop scheduling disturbance under uncertain conditions from the aspects of fuzzy processing time and fuzzy delivery time. For example, D.Y.Sha (Bushuev and GuifBida, 2012) combined with tabu search algorithm to solve the JSP combination optimization. The Kun Fan design method improves the binary particle swarm optimization algorithm and obtains an optimal approximate solution. Domestic scholar Tang Jiafu have designed a two-phase heuristic algorithm to integrate delivery orders and undelivery delivery orders from the perspective of improving the use of distribution tools and enterprise distribution efficiency. Liu Aijun (Ehmke and Campbell, 2014) proposed a multi-objective flexible batch scheduling algorithm based on multi-population genetic algorithm. Zhang Jing (Gevaers et al., 2014) proposed a hybrid particle swarm optimization algorithm that combines Baldwinian learning strategy with simulated annealing. Chen Cheng (Yap et al., 2016) uses an improved adaptive particle swarm algorithm based on hormone regulation to solve JSP problems. Shi Jinfa (LI et al., 2010) uses continuous space ant colony algorithm to optimize the JSP for multi-constraint scheduling. Ding Qiulei, Hu Xiangpei, etc. (Xi-xi and Hong-cheng, 2016) based on the prospect theory, designed an interference management scheme that can balance the interests of all parties. Through the generalization and deformation can cover the characteristics of a variety of process styles, Jiang Yang (Ming and Lin-du, 2011) used a multi-branch form of the process tree method to solve the dynamic scheduling problem of FJSP complex process. Wang Shuangxi (Qiu-lei et al., 2016) described the multi-objective differential evolution algorithm based on Pareto concept to solve the FJSP problem under different re-dispatching

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cycles in the arrival environment of random parts, and achieved good results. But the literature did not further analyze the factors that caused rescheduling.

The above literature has made a very meaningful exploration and research on the problem of interference management in production shop scheduling, but the existing research does not consider the influence of the optimal solution based on the user's psychological factors enough. Therefore, this paper establishes a JSP interference management model based on user psychology perception method in behavior science and quantitative analysis methods in operations research, and proposes a disturbance measurement method based on prospect theory and an improved bacterial foraging algorithm. Using this model may provide a theoretical basis and technical support for JSP interference management decisions.

2. Disturbance measurement strategy based on prospect theory

2.1. Problem definition and assumption

The JSP scheduling with perturbation can be described as: There are p machining machines and q workpieces to be machined in one shop. Each workpiece includes a number of processes in which the sequence of the processes has been determined. Each process can select one machine among multiple machines that can be processed according to the machine conditions. The processing time will vary with the machine performance. The goal of scheduling is to select the right machine to determine the optimum machining time for the workpiece on different machines. In a JSP with perturbation, the processing time and processing cost for the same process on different machines are indeterminate random quantities. In the actual scheduling, it can be considered to classify the workpieces according to the difference in the delivery period interval and the importance degree priority, so that in the case of a conflict between the machine or manual resource, the initial distribution plan can be modified and then re-dispatched. In other words, it is local disturbance management (Kantola et al., 2017).

The study of the problem based on completely rational assumptions is difficult to apply directly to the actual production of the interference management problem, so this paper proposes a disturbance metrics strategy based on the prospect theory.

2.2. Functional representation based on prospect theory

Prospect theory is a decision model that describes the sensitivity of users to results under uncertain conditions. Based on the prospect theory, the overall evaluation value V^i of the objective i of the problem can be expressed as a function of τ^i and υ^i, as shown in equation (1):

$$V^i(x,m;y,n) = \tau^i(m) \bullet \upsilon^i(x) + \tau^i(n) \bullet \upsilon^i(y) \tag{1}$$

Among them, m、n represent the objective probability value that brings negative influence (loss) and objective probability value that bring positive effect (profit). $\tau^i(m)$ represents the probabilistic decision weight function of probability m. $\tau^i(n)$ denotes the probabilistic decision weight function of probability n, namely $\tau^i(0) = 0$, $\tau^i(1) = 1$. υ^i represents a cost function. $\upsilon^i(x)$ and $\upsilon^i(y)$ represent user subjective values relative to the reference point (Here choose the expected processing completion time as a reference point). The value function model $V^i(x)$ of target i is shown in formula (2):

$$V^i(x) = \begin{cases} x^{\alpha^i} & ,x \geq 0 \\ -\lambda^i\left(-x\right)^{\beta^i}, x<0, & \mathrm{i}=1,2,\ldots,\mathrm{n} \end{cases} \tag{2}$$

Equations (2) A and B respectively correspond to the degree of convexity and concavity of the power function , which represents the value of the profit and loss intervals. The convex type indicates the loss range, and the concave type indicates the profit range. If the value of α and β is less than 1, it means that this is a decreasing sensitivity. Parameter λ corresponds to a steeper feature of the loss interval than the profit interval, and a value greater than 1 indicates loss aversion. The value function curve of target i is shown in Fig. 1.

The user's psychological perception of production delivery time is affected by various aspects of the dispatching system, such as scheduling efficiency, delivery time, and subjective decisions of managers. If the delivery time is different from the user's psychological expectation time, it will increase the user's psychological aversion, which will affect the psychological perception of the scheduling service. From the point of time when the user's order is issued, the user will obtain the time information (T_h) of the product to be delivered through different channels, thereby generating the psychological expected time (T_0). The larger the value of (T_h-T_0), the higher the user's perception of psychological aversion to production scheduling.

2.3. Fuzzy job shop scheduling problem model

The objective function model for establishing this fuzzy problem is shown in equation (3):

$$f = \delta \min\left[\max\left(\sum_{m=1}^{M} F_m\right)\right] + \eta \min\left[\sum_{i=1}^{N}\left(M_i + \sum_{j=1}^{n_i} \times \sum_{m=1}^{M} C_{ijm}S_{ijm}\right)\right] + \gamma \min\left\{\sum_{i=1}^{N}[pe_i \max((d_i - t_i),0) + pl_i \max(((t_i - d_i),0)]\right\}(\mathrm{K}) \tag{3}$$

$\min[\max(\sum_{m=1}^{M} F_m)]$ in formula (3) represents the minimized maximum completion time. F_m represents the total completion time of machine m, $F_m = \sum_{i=1}^{N}\sum_{j=1}^{n_i}(S_{ijm}b_{ijm} + S_{ijm}t_{ijm})$. b_{ijm} indicates the start processing time of the process R_{ij} on the machine m. t_{ijm} indicates the processing time of the process R_{ij} on the

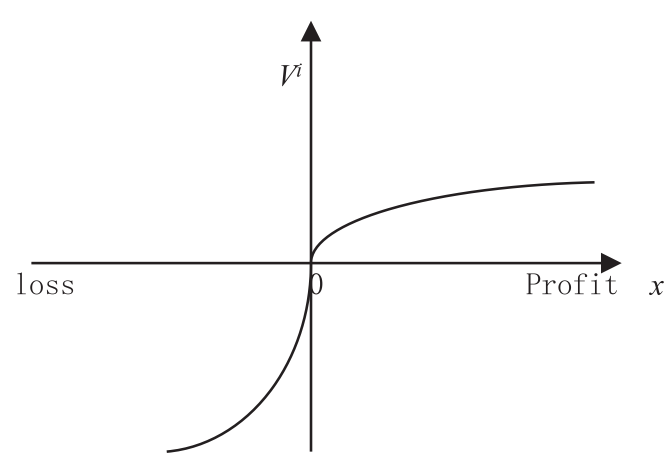

Fig. 1. The value function of prospect theory.