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LOCATIION AND JOB SHOP SCHEDULING PROBLEM IN FUZZY ENVIRENMENT

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ABSTRACT

In this paper we consider job shop scheduling problem (JSSP) and quadratic assignment problem (QAP), simultaneously. We assume that each job has due date, tardiness and earliness penalty. Processing time, due date, transportation time and set-up time are fuzzy parameters. The aim of this paper is to determine machine location and job scheduling such that the summation of tardiness and earliness penalties as well as transportation cost is minimized. We call the new problem as Fuzzy Job shop scheduling and location problem (FJSSLP). To solve the proposed model, genetic algorithm will be proposed.

Keywords: job shop scheduling; quadratic assignment; fuzzy parameters, genetic algorithm

1. INTRODUCTION

Job shop scheduling problem (JSSP) is a very important problem in production planning because the assumption of JSSP and that of the real word are the same. In the JSSP, there are *m* machines and *n* jobs. The aim of JSSP is to determine the sequencing of jobs on machines such that criteria performance such as make span, penalty of tardiness is minimized. It is a long time that JSSP is appeared; JSSP is one of the most famous and hardest combinational problems [1]. Many researchers who deal with JSSP [2-4] assumed that parameters such as processing time, setup time and transportation time are deterministic. This assumption may be realistic if the operations are fully automated. However, whenever there is human interaction, this assumption may lead to difficulties in applying the schedule or even invalidates it. The uncertainty in these parameters has not received enough attention in. Recently, researchers concentrate on the uncertainty of the data (e.g. processing time, due date) and use fuzzy numbers to address this uncertainty [5-7].

Locating machines is also another problem in a job shop environment. In this problem, there are *m* locations for locating *m* machines; each machine can be assigned to only one location and vice versa. The objective is to minimize flow or transportation cost between machines. Many researchers tackle the location problem via quadratic assignment problem (QAP) [8].

Literature view represents that QAP and JSSP are considered by researchers independently, and up to now no paper has yet been organized regarding merging these two problems. In this paper, we present a new model called Fuzzy Scheduling and Location Problem in the Job-shop Environment merging QAP and JSSP.

This paper is organized as follows: In Section 2, we shortly describe the problem definition. Then, the mathematical formulation of FJSSLP is presented in Section 3. The proposed approach for solving fuzzy problem will be described in Section 4.

2. PROBLEM DEFINITION

Assume that there are *n* jobs that each job has a series of predetermined operations, i.e. the operation sequencing of each job is predetermined. Each job processes on each machine only once. We have *m* machines that perform the operations of jobs, and there are *m* locations for locating machines. Each machine operates only one operation at a time. The location of depot is predetermined and fix. At first, we assume that all of jobs are in depot. The objective is to determine scheduling of jobs and location of machines, simultaneously such that total cost including tardiness and earliness penalty and transportation cost is minimized. We call new problem as Job shop scheduling and location problem (FJSSLP).

2.1. Problem assumptions

The problem assumptions are as follows:

1- Each machine processes only one job at a time.
2- Transportation time between two machines depends on distance between them and transportation isn't automatically, so transportation time is a variable parameter and we consider it as a triangular fuzzy number.
3- Set up time for operation of each job is variable, and we consider it as a triangular fuzzy number.
4- Disruption of jobs is not allowed.
5- Processing time is variable, and we consider it as a triangular fuzzy number.
6- Each job has a specific due date, and we consider it as an trapezoidal fuzzy number.
7- Tardiness and earliness of each job has penalty.
8- Each machine can be located in each location.

2.2. Parameters

f_{kl}: Job flow between machine *k* and *l*.
D_{rs}: Distance between location *r* and *s*.
w: Transportation cost of unit job in unit distance.
C_{rskl}: Transportation cost between location *r* and *s* in which machine *k* and *l* are located. ($C_{rskl} = f_{kl} \times D_{rs} \times w$).
P_{1i}: Penalty of tardiness for job *i*.
P_{2i}: Penalty of earliness for job *i*.
$\tilde{d}_i$: Due date of job *i*.

$\tilde{P}_{Ki}$: Processing time of job *i* on machine *k*.
$\tilde{t}_{rs}$: Transportation time between location *r* and *s*.
$\tilde{s}_{ijk}$: Set up time of exchanging job *i* to *j* in machine *k*.
i_{last}: Last operation of job *i*.

As each machine operates only one operation, the number of operations is equal to the number of machines. Therefore, the index of operation demonstrates the index of machines and vice versa.

$\tilde{C}_i$: Completion time of job *i* defined as follows:
$\tilde{C}_i = \tilde{y}_{i\,last,i} + \tilde{P}_{i\,last,i} \quad ; \quad \forall\, i_{last}$
$\tilde{T}_i$: Tardiness of job defined as follows:
$\tilde{T}_i = \max\{\tilde{C}_i - \tilde{d}_i, 0\} \quad ; \quad i = 1, \dots, n$
$\tilde{E}_i$: Earliness of job defined as follows:
$\tilde{E}_i = \max\{\tilde{d}_i - \tilde{C}_i, 0\} \quad ; \quad i = 1, \dots, n$

As processing time is a fuzzy parameter, completion time, tardiness and earliness are fuzzy parameters as well.

$\tilde{y}_{ki}$: Starting time of job *i* on machine *k*. As processing time, set up time and transportation time are fuzzy parameters, so starting time is fuzzy parameter as well.
z_{kr}: If machine *k* is assigned to location *r*, z_{kr} is equal to 1 else 0.
X_{kij}: If job *i* is operated earlier than job *j* on machine *k*, X_{kij} is equal to 1 else 0.

3. FJSSLP MODELING

Suppose *n* jobs are to be operated on *m* machines and there are *m* locations for locating machines. The location of depot is fixed and predetermined. We assume that at first all of jobs are in depot. Each job is represented by Index *i* (i=1, 2… *n*) and each job has predetermined operation (O_{ki}) where *k* is the index of machine (*k*=1, 2… *m*). For example, O_{23} means the operation of job 3 that will be operated on machine 2. In addition, each job has a predetermined path for operating. This path is denoted by A_i.

Processing time of job *i* on machine *k* is denoted by $\tilde{P}_{Ki}$. Note that $\tilde{P}_{0i} = 0$, *i* =1… *n*. Transportation time consists of transportation between depot and machine and between two machine, and this time depends on the location of machines. For example, if job *i* are to be carried between machine *k* and *l* and these machines are located in location *r* and *s*, the transportation time between two locations is denoted by $\tilde{t}_{rs}$. The objective is to minimize total cost including transportation cost and tardiness and earliness penalties. The following model is the mathematical modeling of FJSSLP.

$$\min\left\{\sum_{i=1}^{n} P_{1i}\tilde{T}_i + P_{2i}\tilde{E}_i + \sum_{k=0}^{m}\sum_{\substack{l=0\\k\neq l}}^{m}\sum_{s=0}^{m}\sum_{\substack{r=0\\s\neq r\\r<s}}^{m} C_{rskl}Z_{kr}Z_{ls}\right\}$$

Subject to:

$$\sum_{k=0}^{m} Z_{kr} = 1 \quad ; \quad r = 0,1,\dots,m \tag{1}$$

$$\sum_{r=0}^{m} Z_{kr} = 1 \quad ; \quad k = 0,1,\dots,m \tag{2}$$

$\forall (k,i) \to (l,i) \in A_i;\ i = 1,\dots,m;\ k,l,r,s = 0,\dots,m;\ r \neq s, r < s, l \neq k$:

$$\tilde{y}_{li} \geq \tilde{y}_{ki} + \tilde{P}_{ki} + \tilde{t}_{rs} - M\big((1 - Z_{kr}) + (1 - Z_{ls})\big) \tag{3}$$

$\forall (K,i),(K,j) \quad ; \quad k = 1,\dots,m \quad ; \quad i,j = 0,1,\dots,n$:

$$\tilde{y}_{kj} \geq \tilde{y}_{ki} + \tilde{P}_{ki} + \tilde{S}_{ijk} - M\big(1 - X_{kij}\big) \tag{4}$$

$\forall (K,i),(K,j) \quad ; \quad k = 1,\dots,m \quad ; \quad i,j = 0,1,\dots,n$:

$$\tilde{y}_{ki} \geq \tilde{y}_{kj} + \tilde{P}_{kj} + \tilde{S}_{jik} - M\, X_{kij} \tag{5}$$

$$Z_{00} = 1 \tag{6}$$

$$\tilde{y}_{0i} = 0 \quad ; \quad i = 1,\dots,n \tag{7}$$

$$\tilde{y}_{ij} \in R^{+} \quad ; \quad i,j = 1,\dots,n \tag{8}$$

$$Z_{kr} \in \{0,1\} \quad ; \quad k,r = 0,1,\dots,m \tag{9}$$

$$X_{kij} \in \{0,1\} \quad ; \quad \forall (K,i),(K,j) \quad ; \quad k = 1,\dots,m \ ; \ i,j = 0,1,\dots,n \tag{10}$$

In (3), (4), (5), *M* is a great positive number. Equation (1) expresses that each location assigns to only one machine. Equation (2) expresses that each machine assigns to only one location. Equation (3) expresses that if job *i* must be processed on machine *k* before machine *l*, start time of job *i* on machine *l* must be more than start time of this job on machine *k* plus its process time on machine *k* and transportation time between machine *k* and *l*. Equation (4) and (5) expresses that two jobs cannot be processed on one machine, simultaneously; that is, each machine processes one job at a time. Equation (6) guarantees that the location of depot is fixed. Equation (7) demonstrates that at beginning all jobs are fixed in depot. Finally, (9) and (10) expresses that Z_{kr} and X_{kij} are binary parameters, respectively.

4. SOLUTION APPROACH

As processing time and due-date are fuzzy parameters, the objective function including earliness and tardiness penalty will be fuzzy numbers. To solve the proposed model, we first elicit the membership function of earliness and tardiness penalty. Then, summing tardiness and earliness penalty as well as transportation cost, we calculate the objective function as a fuzzy number. Finally, to solve the proposed model, genetic algorithm will be used. Since the chromosomes of genetic algorithm need to be ranked, Lee and Wang method, a helpful method for ranking the fuzzy numbers, will be used.

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