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Research Article

GENETIC ALGORITHM AND ITS APPLICATION IN INDUSTRIAL MACHINERY SCHEDULING WITH FUZZY DUE DATE

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ABSTRACT
Appropriate programming in a gorge of plant or the key and strategic machine has much effect to increasing efficiency. Due to increasing global market competitiveness the regarded targets have become complex. Thus one criterion is not enough and scheduling with multiple criteria is more realistic. The main difficulty of these scheduling problems is extensive solving time needed to it. This paper proposed a new fuzzy scheduling model for single machine scheduling problem and aims to improve it to a real-world application through fuzzy set theory. For this purpose, due dates of jobs are defined as fuzzy numbers.

Key Words: *Genetic Algorithms, Single Machine Scheduling, Fuzzy Sets, Due Dates*

INTRODUCTION
In just-in-time (JIT) environment, each job should be completed as close as possible to its due date. It is involved producing goods only when necessary. Owning to the wide adoption of this philosophy in recent decades, scheduling problems for meeting the due date requirement have been investigated extensively, including those with general earliness-tardiness penalties about a common due date. Missing a Job's due date may result in loss of customer or the need to compensate for the delay along the production or assembly line. On the other hand, producing a job much earlier than its due date may cause unwanted inventory and/or deterioration of the product. in the modern competitive environment the cost of tardy deliveries, such as a company's goodwill, future sale and rush shipping cost, and the cost of early include holding cost for finished goods, deterioration of perishable goods and opportunity cost will significantly decrease a company profits. Therefore minimizing total weighted completion time, tardiness and earliness is not only a measure of academic interest but also useful and important in practice. Indeed flow shop, flexible flow shop, job shop and open shop scheduling problem are often addressed decomposing the original planning process into many sub problem that can be solved by using single machine techniques.
Genetic algorithm (GA) is a powerful search technique based on natural biological assessment which is applied for finding an optimal or near-optimal solution. The idea of GA was first suggested by Holland Holland (1975) in the early 1970s and since then has been widely used in solving optimization problem. In contrast to other optimization methods, GA functions by generating a large set of possible solutions to a given problem instead of working on a single solution. The technique such as the process of selection, crossover, mutation and evaluation has been implemented successfully in many scheduling problems, in particular job shop scheduling. Job shop scheduling problem (JSSP) is a difficult NP-hard combinatorial optimization problem. Earlier work on solving JSSP centered on exact algorithms such as branch-and-bound approach Applegate and Cook (1991). However, the work focused on small sized instances which can be solved in a reasonable computation time. As the problems become more complex, the research focused various other techniques such as simulated annealing and genetic algorithms Akhshabi *et al.*, (2011).
Some other papers considered the corresponding identical parallel machine scheduling problem in which the machines have the same speed. The literature in recent years mainly focused on the problem with unequal release dates, i.e. Pm|rj|Lmax problem. Carlier *et al.*, (1998) and Néron *et al.*, (2008) developed

some exact branch-and-bound algorithms for the problem. Vakhania (2004) and Gharbi and Haouari (20-07) considered the development of heuristics. Mastrolilli (2003) and Carlier and Pinson (1998) proposed some approximation algorithms. Eren (2009) considered the m-identical parallel machine scheduling problem with a learning effect to minimize the maximum lateness. He proposed a model, which can optimally solve the problems with 18 jobs and 4 machines within 7000 s on a personal computer with Pentium IV/2 512 Ram. For the single machine with minimizing the maximum lateness, recent literature mainly considered some extensive problems. For example, Wu *et al*., (2007) considered the single-machine maximum lateness minimization problem with a learning effect. The simulated annealing algorithm they proposed outperforms the traditional heuristic algorithm in terms of quality and execution time for a large number of jobs. It can solve the problems with 200 jobs within 21.24 s on a Pentium IV personal computer. Uzsoy and Velasquez (2008) addressed the problem of scheduling a single machine subject to family dependent set-up times in order to minimize maximum lateness (Akhshabi, 2011).

Fuzzy Membership

Triangular Fuzzy Numbers:

A triangular fuzzy number A or simply triangular number with membership function _A(x) is defined on R by

$$\mu_{A(x)} = \begin{cases} \dfrac{x-a_1}{a_M-a_1} & a_1 \le x \le a_M \\ \dfrac{x-a_2}{a_M-a_2} & a_M \le x \le a_2 \\ 0 & otherwise \end{cases}$$

Where *(*a1; a2*)* is the supporting interval and the point (aM; 1) is the peak (see Figure 1). The third line can be dropped.

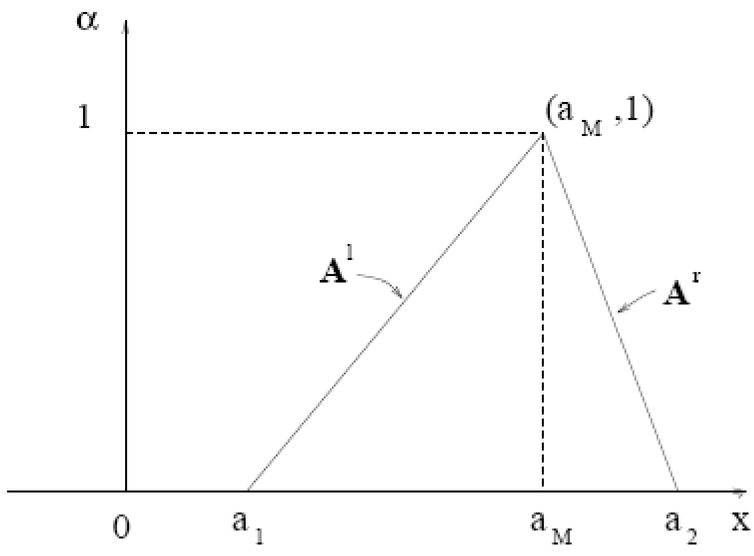

Figure 1: Triangular fuzzy number

Triangular Trapezoidal Fuzzy Numbers:

A trapezoidal fuzzy number A or shortly trapezoidal number (see Figure 2) is defined on R by A

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$$\mu_{A(x)} = \begin{cases} \dfrac{x-a_1}{b_1-a_1} & a_1 \le x \le b_1 \\ 1 & b_1 \le x \le b_2 \\ \dfrac{x-a_2}{b_2-a_2} & b_2 \le x \le a_2 \\ 0 & otherwise \end{cases}$$

It is a particular case of a fuzzy number with a flat. The supporting interval is A = *(*a1; a2*)* and the flat segment on level α = 1 has projection *(*b1; b2*)* on the x-axis. With the four values a1; a2; b1, and b2, we can construct the trapezoidal number. It can be denoted by A = (a1; b1; b2; a2): If b1 = b2 = aM, the trapezoidal number reduces to a triangular fuzzy number and is denoted by (a1; aM; aM; a2). Hence a triangular number (a1; aM; a2) can be written in the form of a trapezoidal number, i.e. (a1; aM; a2) = (a1; aM; aM; a2).

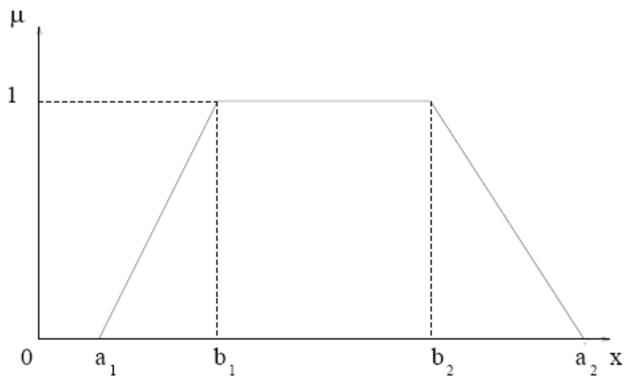

Figure 2 Trapezoidal fuzzy number

Similarly to right and left triangular numbers we can introduce right and left trapezoidal numbers as parts of a trapezoidal number.

The right trapezoidal number denoted Ar = (b1; b1; b2; a2) has supporting interval *(*b1; a2*)* and the left denoted Al = (a1; b1; b2; b2) has supporting interval *(*a1; b2*)*. Especially they are suitable to represent small Ar = (0; 0; b2; a2) (Figure 1.3(a)) and large Al = (a1; b1; b2; b2) where b1 is a large number (Figure 3(b)).

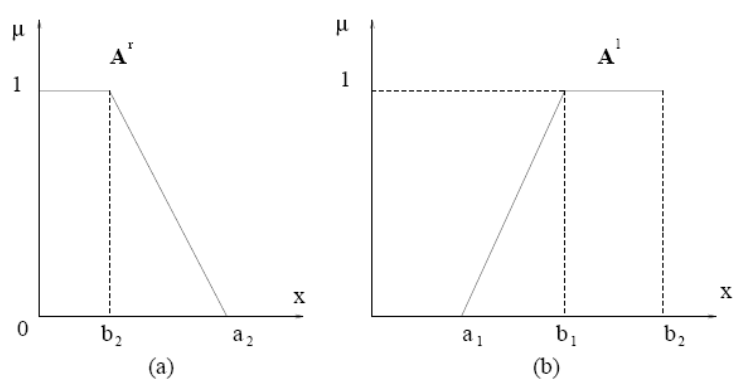

Figure 3: (a) Right trapezoidal number A^r representing small; (b) Left trapezoidal number Al representing large.

RESULTS

To study the function of Genetic Algorithm, some example questions are randomly created and then the results obtained from the calculation of presented mathematical model by Lingo 8 software are compared with the calculation of the question by GA are analyzed. To calculate the above model, a PC with the specification of CPU 2.4 GHZ, 512 MB of RAM is used and GA algorithm has been expanded by MATLAB 7.0. To create there supposed questions of which the whole functions are at present zero time and the processing time of the works have been created randomly from the event distribution of U *(*10, 20*)* and tardiness penalty is created randomly between 3 till 8 and then multiplied by tardiness rate. Since the tardiness penalty is more than the earliness penalty for each order a random number is produced from the event distribution of *(*1.5, 3*)* and multiplied by the earliness rate and as a result the amount of delay for the order is obtained.

Table 1: Comparing Lingo8 and GA

Objective Value		Solution Time (Second)		Job Number	Number
Ga	**Lingo**	**Ga**	**Lingo**		
0.2335	0.5172	0.17	1	4	1
0.2476	0.6219	0.128	10	5	2
0.2948	0.6428	0.64	156	6	3
0.3283	0.7289	0.92	9724	7	4
0.3371	0.7552	1.17	17138	8	5
0.3392	−	1.25	>36000	10	6
0.3425	−	1.73	−	15	7
0.3568	−	2.38	−	20	8
0.3719	−	3.05	−	25	9
0.3898	−	3.86	−	50	10
0.4085	−	4.58	−	75	11
0.4257	−	5.97	−	100	12

In Table 1 the results obtained from the Lingo8 software calculation and GA calculation for 5 to 100 dimension jobs have been compared.
As shown in the Table 1, by the increase of the dimensions of the problem the difference between delivery time and the quality of the obtained result by the Lingo8 and GA will be increased. As specified, by the increase of the number of jobs, mathematical model is not able to provide result whereas in GA algorithm, the time of calculation is highly low. The quality of the result from GA is much better than Lingo8 software.

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