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Multi Criteria Job Shop Schedule Using Fuzzy Logic Control for Multiple Machines Multiple Jobs

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***Abstract*—In the present scenario the modern engineering and industrial manufacturing units are facing lot of problems in many aspects such as machining time, raw material, man power, electricity, and customer's constraints. Such a complex problem of vagueness and uncertainty can be handled by the theory of fuzzy logic based in using a membership function to solve a fuzzy mix product selection. We use the amalgamation of fuzzy job shop scheduling approach to find profits and customer satisfaction using a fuzzy -JSP approach [1].**

***Index Terms*—Job shop scheduling, Fuzzy Logic, Production Planning, Multi criteria.**

I. Introduction

Fuzzy set theory has been utilized to develop hybrid scheduling approaches and it can be useful in modeling and solving job shop scheduling problems with uncertain processing **times**, constraints, and set-up times. These uncertainties can be represented by fuzzy numbers that are described by using the concept of an interval of confidence. These approaches usually are integrated with other methodologies [2] (e.g., search procedures, constraints and relaxation).

II. Introduction to Fuzzy Logic and Its Application

Fuzzy logic is a form of multi-valued logic derived from fuzzy set theory to deal with reasoning that is approximate rather than precise. In contrast with "crisp logic", where binary sets have binary logic, the fuzzy logic variables may have a membership value of not only 0 or 1that is, the degree of truth of a statement can range between 0 and 1 and is not constrained to the two truth values of classic propositional logic.

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Fuzzy logic is being incorporated worldwide in appliances to accomplish these goals, primarily in the control mechanisms designed to make them work. Appliances with fuzzy logic controllers provide the consumer with optimum settings that more closely approximate human perceptions and reactions than those associated with standard control systems. Products with fuzzy logic monitor user defined settings, and then automatically set the equipment to function at the user's preferred level for a given task [3],[4]-[5]-[6].

III. Fuzzy Rule Base

Fuzzy rule base is created using the three membership functions such as Due date, Customer Priority and Processing Time as given in table 3.1.

Rule: IF Customer Priority is very important
AND Due Date is Distant
THEN sequence is Medium.

TABLE 3.1 Fuzzy Rule Base

Customer Priority	Due Date	
	Close	**Distant**
Bad (B)	Reject	Reject
Low (L)	Sequence Quite High	Sequence Very Low
Medium (M)	Sequence High	Sequence Low
High (H)	Sequence Very High	Sequence Quite Low
Very Important (VI)	Sequence Extremely High	Sequence Medium

A rule matrix is created based on the fuzzy rules [6]. Depending upon the fuzzy rule that were derived based on the rule matrix. The sequence priority is calculated based on the Min Max factions given below

The Min Max Function as given below T=S °R

$$R_{ij} = \frac{\sum_{k=1}^{m} \min(X_{ik}\ ,\ X_{jk})}{\sum_{k=1}^{m} \max(X_{ik}\ ,\ X_{jk})} \text{ where i, j} = 1,2, \ldots, \text{n} \quad (1)$$

IV. Scheduling

Scheduling is concerned with the allocation of limited resources to activities with the objective of optimizing one or more performance measures. Depending on the situation, resources and activities can take on many different forms. Researchers in operation search, industrial engineering and management were faced with the problem of managing various activities occurring in workshop. Good scheduling algorithm can lower the production cost in a manufacturing process. The scheduling problems studied in the 1950's were relatively simple. A number of efficient algorithms have been developed to provide optimal solutions [7].

The objective is to create a schedule specifying when each task is to begin and what resources it will use that satisfies all the constraints while taking as little overall time as possible. This is the job-shop scheduling problem. In its general form, it is NP-complete [8], meaning that there is probably no efficient procedure for exactly finding shortest schedules for arbitrary instances of the problem. Job-shop scheduling is usually done using heuristic algorithms, dispatch rule that take advantage of special properties of each specific instance. Many jobs in industry and elsewhere require completing a collection of tasks while satisfying sequential and resource constraints. Sequential constraints say that some tasks have to be finished before others can be started. The resource constraints say that two tasks requiring the same resource cannot be done simultaneously (e.g., the same machine cannot do two tasks at once). The application of a fuzzy logic approach can be justified in the desire to optimize multiple objectives and so achieve a closer similarity to the real world.

V. The Job-shop Scheduling Problem

Job shop scheduling problems is used to finding sequential allocation of resources and jobs that optimizes a particular objective function. This problem consists of set of n jobs with a number of m machines [9],[11]. In each job lies a series of operations. At a particular time, one machine can only address at most one operation. Preceding operation must be scheduled to complete before the machine can proceed to its succeeding operations in the series. All operations are required to be completed in a continuous time without any interruption in a certain length on a specific machine [12]. The ultimate aim of job shop scheduling is to produce a schedule that minimizes the total time taken to complete all the activities [14].

VI. Existing Approach

Fuzzy logic allows the modeling of imprecise scheduling knowledge with linguistic variables defined by membership functions showing the degree of preciseness of the data and the reasoning about the imprecise data by using fuzzy rules[13]. This is a means of representation and processing that is transparent and comprehensible for the user. While the presented fuzzy-based approach is innovative within the field of multi-site scheduling, there already exist several approaches to solve general or local scheduling problems by techniques founded on fuzzy set theory and fuzzy logic [10].

VII. Proposed Approach

A search begins with an initial population to come out with better job sequence and job order to satisfy the customer needs. The population consists of membership function. Each membership function (μCp=0.0,0.25,0.50,0.75,1.0) is represented by the sequence of job orders, the sequence of operations and the set of machines to be used to accomplish the operation The representation does not directly represent a schedule; a transition from the membership function In this work the schedule is based modulated method and it is shown in Fig7.1 .

This algorithm generates feasible active schedules. Some studies have shown that the optimal schedules can be found from the set of active schedules Therefore there is a chances to get optimal schedules are higher from the set of active schedules [15].

The job shop scheduling process includes the functions mentioned below.

A.Due Date
B. Customer Priority
C. Processing Time

A. Due Date

Due Date is a factor to be controlled by the customer and the people who pick up the jobs (such as marketing personal).As per the usual method normally the due date is set at 28 days from the date of the order. The membership functions of "Close" and "Distant " were assigned depending on the due date allocated. The fuzzy sets C=Close and D=Distant membership functions, hence the universe U=[-∞,28 days]∈Z can be defined as below:

Membership of Close **Membership of Distant**

$\mu c(x)=1.0$ $x \le 0$ $\mu d(x) = 0$ $x \le 7$

$\mu c(x)=1.0-x/10$ $0< x<10$ $\mu d(x) = x/14 - 0.50$ $7 < x<21$

$\mu c(x)=0$ $x \ge 10$ $\mu d(x) = 1.0$ $21 \le x \le 28$

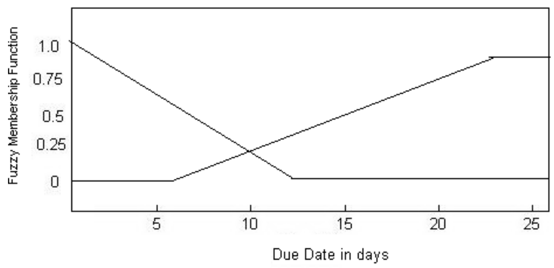

Fig.VII A. Due Date Membership Function.

B. Customer Priority

The customer priority is based on the importance of a customer and based on the fuzzy values. The fuzzy sets the customer priority CP which contains the five different fuzzy values. The customer priority fuzzy values are given below

TABLE VII.B Customer Priority (CP)

Scheduling by Job order (Machine wise)6×6

	MACHINE					
	1	2	3	4	5	6
JOBS	3	1	2	6	4	5
	5	3	1	2	6	4
	4	5	3	1	2	6
	6	4	5	3	1	2
	2	6	4	5	3	1
	1	2	6	4	5	3

µcp (Bad) = 0.0 to be rejected
µcp (Low) = 0.25 final preference
µcp (Medium) = 0.50 third preference
µcp (High) = 0.75 second preference
µcp (Very Important) = 1.0 first preference

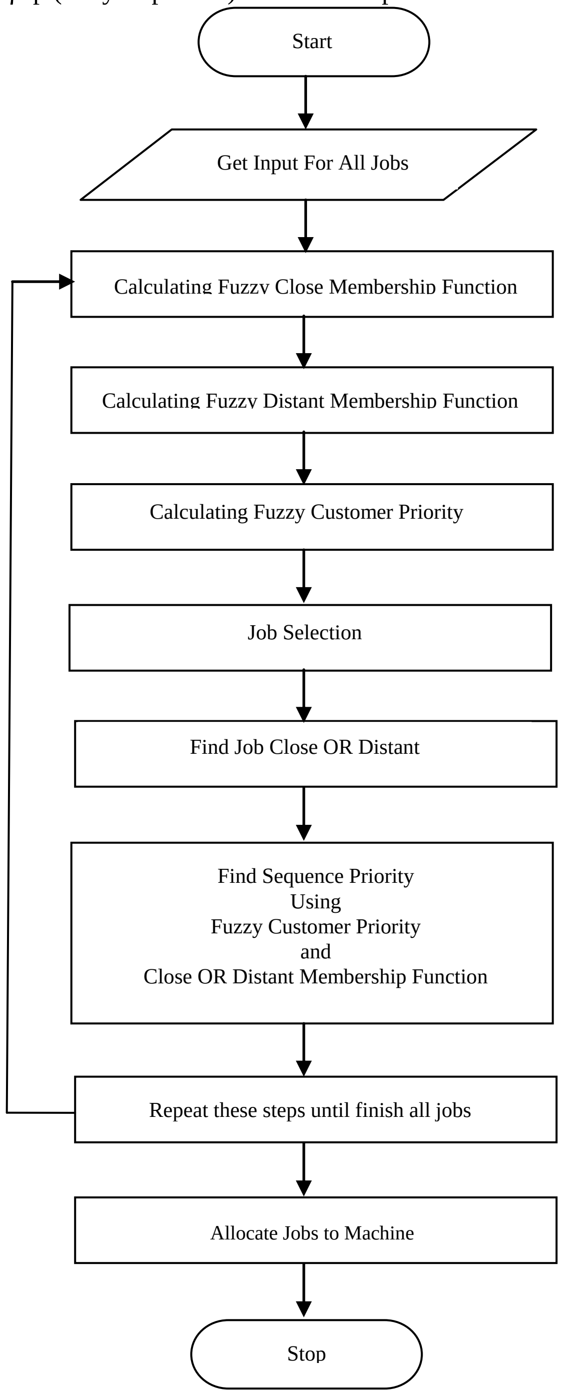

Figure VIII.1 Flow chart Proposed approach

C. *Processing Time*

Depending upon the processing time assigned to one particular job three fuzzy functions were assigned, for the fuzzy sets such as Short, Medium, and Long.

VIII. Algorithmic Approach

The scheduling process uses the Modulated algorithm and the scheduling process computation algorithm is given below. The mechanisms of modulated algorithms are similar as illustrated in the following steps and flow chart shown in figure VIII.1:

Step 1: Getting input using get data (number of jobs, Number of machines) due date, customer Priority, Processing Time.
Step 2: Calculating fuzzy close membership function using Fuzzy close (due date);
Step 3: Calculating fuzzy distant membership function Using fuzzy distant (due date);
Step 4: Calculating fuzzy customer priority using fuzzy Cuspriority (cust priority);
Step 5: Select the job per job vice
Step 6: Get Maximum of due order (fuzzy distant, fuzzy Close);
Step 7: Calculating sequence priority using due order and fuzzy customer priority.
Step 8: Select Max sequence priority
Step 9: Calculating new due date
Step 10: Do step 2 to step 8 for all jobs.
Step 11: Select job from job order
Step 12: Set job flag is true.
Step 13: Find the job is allocated or not
Step 14: If job is allocate skip to next job.
Step 15: Do step 12 to 14 until job flag all set true.
Step 16: Do step 12 to 15 for until machine flag are true.

IX. Experimental Results

Based on the inputs stated in the table 9.1 and customer priority, a fuzzy rule is formed as jobs are allocated based on the priority.

Schedule is done for all jobs and all machines. Job order is depending on job priority using modulated algorithm and job are schedule by SUDUKU algorithm. Schedule by 6*6 using modulated algorithm are shown in the fig 9.1 & 9.2.

TABLE IX.1 Customer Priority

JOB	**1**	**2**	**3**	**4**	**5**	**6**
Due Date	0	10	6	28	26	14
Process Time	5	1	8	6	2	4
Customer Priority	M	L	VI	VI	H	L
Fuzzy Customer Priority	0.50	0.25	1.0	1.0	0.75	0.25
Fuzzy Close	1.0	0.0	0.4	0.0	0.0	0.0
Fuzzy Distant	0.0	0.21	0.0	1.0	1.0	0.50
Max - Min	Clos e	dista nt	Clos e	dista nt	dista nt	dista nt
Sequence	H	VL	EH	M	QL	VL

µCp	0.0	0.25	0.50	0.75	1.0
Cp	Bad	Low	Medium	High	Very Important

Figure 9.1 6 Jobs 6 Machines using modulated algorithm Machines vice order scheduling

Scheduling by Job order (Job wise) 6×6

	MACHINE 1	2	3	4	5	6
JOBS	3	5	4	6	2	1
	1	3	5	4	6	2
	2	1	3	5	4	6
	6	2	1	3	5	4
	4	6	2	1	3	5
	5	4	6	2	1	3

Figure 9.2. 6 Jobs 6 Machines using modulated algorithm job Vice order scheduling

Based on the categories of job orders we can do lot of jobs on each machines depending on the priority given by the customer. The different categories of job scheduling are shown in Fig 9.3 & 9.4.

Scheduling by Job Order 4×6

	MACHINE 1	2	3	4	5	6
JOBS	3	1	2	6	4	5
	5	3	1	2	6	4
	4	5	3	1	2	6
	6	4	5	3	1	2

Figure 9.3 4 Jobs 6 Machines using modulated algorithm order scheduling

Scheduling by Job order 6×4

	MACHINE 1	2	3	4	5	6
JOBS	3	1	2	6		
	6	3	1	2		
	2	6	3	1		
	1	2	6	3		
	3	1	2	6		
	6	3	1	2		

Figure 9.4 6 Jobs 4 Machines using modulated algorithm order scheduling

The effective way of allotting jobs to the each machine for the betterment of job scheduling is shown in Table IX.2.

TABLE IX.2 OUTPUT

Job order	3	1	2	6	5	4
Customer priority	V	M	L	L	H	V
Due date	6	0	10	14	26	28
Process Time	8	5	1	4	2	6
Starting time	0	8	13	14	18	20
Completion Time	8	13	14	18	20	26
Lateness	2	13	4	4	-6	-2

X. CONCLUSION

The proposed approach is used to solve the job shop scheduling problems to meet customer demands and make profit and improve the ability of autonomous systems to optimize their operations by the deployment of intelligent systems, and with the optimizations of communications systems. For this reason, operations research analysts and engineers will continue this approach to pursuit well into the next century. Fuzzy set theory allows the complexity of real life issues to be included within the confines and rigors of the mathematical model. In this paper, a theoretical model has been presented which demonstrates how fuzzy decision making can support the dynamic scheduling process, enabling the conflicting priorities of multi-objectives to be managed effectively in polynomial time.

XI. FUTURE WORK

We presented here a multi-criteria methodology to dynamically insert new tasks into an existing schedule. An external memory of non dominated solutions is considered to save and update the non dominated solutions during the solution process. Numerical experiments show that the proposed algorithm is capable to obtain the solution near to the optimal solution.

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