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Article

Genetic Algorithm and Neural Network with Fuzzy Times for Solving Job Shop Scheduling problems: A real life case study at Al-Qadir company for printing and publishing

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Abstract: In this research paper a methodology was adopted for solving Job Shop Scheduling and Planning (JSSP) problems which is one of the most important to the Decision makers in the field of production management.
A Model was built by using Genetic Algorithm and Neural Network, namely adaptive search algorithms, it was taken into account the uncertainties times of processing and due date by applying the fuzzy theory for this situation. The model was tested and then applied to optimize the highly complex target for Job Shop Scheduling and planning problem at Al-Qadir for printing and publishing company to obtain the optimal possible job sequences.
It was concluded that the use of the genetic algorithm and Neural Network is the most appropriate method for solving the fuzzy job shop scheduling at printing industry in developing countries such as in Iraq, also the model showed the optimal results with clear image to the decision makers at the printing and publishing for the company under study and will contribute to the satisfaction of their customers and to the knowledge of application the model for the Industry in Iraq.
Keywords: Job Shop Scheduling, Genetic Algorithms, Neural Network, Fuzzy Logic, JSSP, GANNT

1. Introduction

Schedule of job shop could be a complex issue and one of an important objective of the decision makers in order to control the production system, it is known that the manufacturing process begins after the schedule has been established, and it is very likely that operation managers will deviate from the specified start and completion times for each operation and thus any miss delivery dates from due dates will cause problems managers and supervisors because jobs are not completed on time exactly (Mohammed and Waris,2016), (Bushmaster, Palacic and Ojstersek ,2021), (Majid and Nezhad,2017).

Many approaches have been adopted by researchers in field of solving JOB shop problems such as (Azemi and et al ,2025) who adopted 5G optimizing production process for scheduling job shop problems , (Momenikorbekandi and Kalganova , 2025) showed review of papers which were used the expert systems methods for tackling Flexible Job Shop scheduling issues also (Frunt , 2024) applied mixed integer and linear programming technique for designing a method for solving Job shop problems , (Bragin and et al , 2023) applied Robust Manufacturing Scheduling for addressing Job Shop Scheduling problem, but there are little attentions for addressing Job Shop scheduling and planning problems in Developing Countries such as in Iraq .Owing to high competition in Iraqi Printing and Publishing Industry which results in a race against time to reduce production costs, optimal utilization of resources and time factor in order to achieve customer satisfaction and thus maximizing profits ,from this point of view this study adopted an approach to solve the problem of scheduling job shops at the Al-Qadir for printing and publishing company which is one the leading companies in this field in Iraq, first by using the fuzzy method for the uncertainty of the processing times and due dates to get the optimal potentiality of the sequences of job orders. and then applying Genetic Algorithms and Neural Network Theory (GANNT) for the problem under this study, this will have roles significantly to make an appropriate decision to reach the general goals of this company, client gratification by supplying the product in time, diminshing the total accomplishment period, this will lead to maximize the total profit of this company. Genetic Algorithms and Neural Network have been used in the problem of Job Shop Scheduling (Guohui et al ,2019),(Wathiq,2022),(Omid et al,2018),(Yeli and Yan,2012),(Hang and fansen,2016)(Guilherme and Heder,2017).The importance of this study is presented a realistic and effective model which will help the Decision Makers to take an appropriate decisions to the sequence of production operation times in a more practical method than their personal estimates times hence will contribute at the field of JSSP in Developing Countries .

2- The Methodology

2.1 Research Problem

Iraqi Industrial Sector Which adopted Production System due to Customer' order facing problems of how to schedule Jobs to their Processing Machines which caused problems of highly wasting of production time, due date of Jobs time which lead to customer's unsatisfactory.

Al-Qadir company for printing and publishing is one of leading company in Iraqi printing sector , mainly their customers are Ministry of Oil , Iraqi Ports , Contractor Companies , Electricity Companies and others , This Company has 9 Processing Machines and its management recently has introduced Information Technology in order to control all their production process but problems of delay production and due date product time cause high production cost because the management depends on their experience for scheduling jobs and has given a little attention to the job shop scheduling techniques .

2.2 Research Objectives

Job Shop Scheduling tools plays a Vital role in different aspects, such as reducing delay production time, cost, delivery time in order to maximize customer satisfaction, thus our Objectives in this research can be summarized as follows: -

- Introduce the theoretical aspects of the (GANNT) for Job Shop Scheduling Planning problems
- Building a Model for Job Shop Scheduling by using GANNT with uncertain the handling and due times
- The Model will be programmed by Visual Mat lap, will be tested and implemented it for the production of the company under study and will be followed by the management

3. Theoretical review

3.1 Job Shop Scheduling Problems

Scheduling Job Shop Problem (JSSP) could be to some extent the most sophisticated issues in scheduling production operations, and it is as scheduling jobs on machines, and every single job passes via links of tools also every single machine has a predetermined processing time, it is tough to process further than one job on the same machine simultaneously, in problem of scheduling job shop the objective is to reduce completion jobs in the shortest possible time. The idea behind this objective is to provide resources (employees, machines) to carry out alternate jobs, or to deliver the product in the timed date (Nisha and Nathi ,2017),(Fahimi,2016),(Hassan,2005). It is a measure of the extent of completion business in the due date; This is for the delay could probably cause consequences or damage of the customer, and further standards.

3.2 fuzzy logic

The scientist Zadeh was the first propose a theory called the fuzzy group in 1965 (Bodenhofer,2004), (Mukesh and Biswas ,2020),(Sunday et al,2022)for the mathematical representation of uncertainty, and this theory reflects human logic in dealing with approximate and inaccurate information.

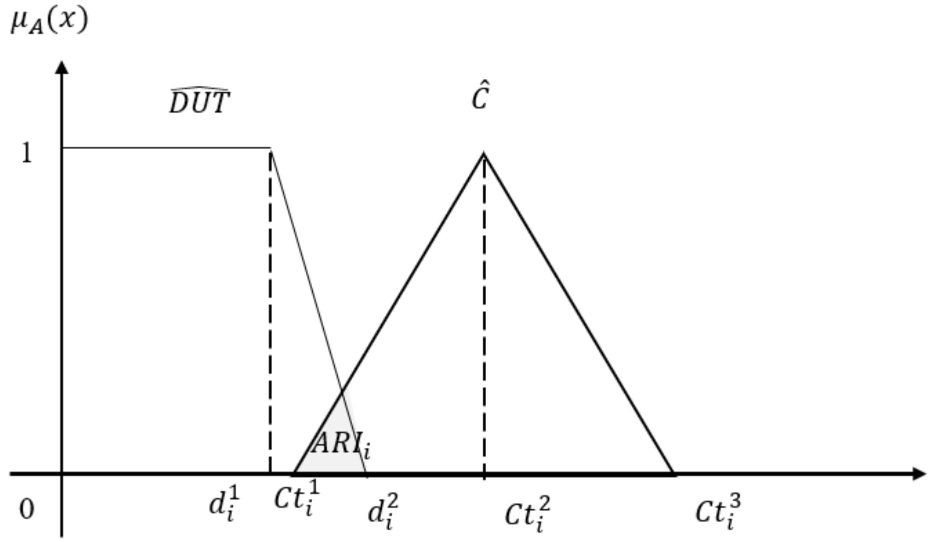

Figure 1: Fuzzy processing times and due date as shown by (Guohui *et al* ,2019)

The fuzzy logic is defined as one of the forms of logic that is used to infer uncertain of the time, also it is defined as theories and techniques that use the fuzzy set which is a set with no categorical bounds. Zadeh defines the fuzzy group as a group of elements defined within a continuous chain of degree of belonging that ranges between zero and one(Hamsa,2005), however it does not deal with the traditional two-value logic, in fig.1 we represent the fuzzing tringle method.

Fuzzy logic will be used to fuzzy the process times with a triangular uncertain number and the exact date with a uncertain binary number due to the uncertainty of the processing times due to the fabrication of the experiences of the decision makers and the performance of the machine.

So (Ct_i^1, Ct_i^2, Ct_i^3) , trigonometric fuzzy numbers represent completion time, and can be calculated from the following equation

$$ARI_i = \frac{area(\widehat{Ct}_i \cap \widehat{DUT}_i)}{area(\widehat{DUT}_i)} \quad \forall\, i \in \{1,2,\dots,n\} \qquad \dots (1)$$

where

ARI_i = Compatibility index for action i.

$\widehat{Ct}_i$ = the fuzzy completion time for demand job i.

$\widehat{DUT}_i$= fuzzy due date for demand job i.

The value of ARI ranges from zero to one.

3.3 The Genetic Algorithm (GA)

GA firstly was used to find an optimal strategy for playing games (Hassan,2005), its importance has emerged in solving complex issues as it has a huge number of alternative solutions.

The solution resulting from the genetic algorithm is an optimal solution or close to the optimality, the genetic algorithm relies on the ideas of genetic engineering in order to create individuals with good characteristics, and on this basis the genetic algorithm selects the best solutions from among a group of solutions and makes some interventions and alterations in order to form the better solution. This method will help in making optimal sequencing decisions for the production operations in a more objective manner, away from making decisions based on personal estimates and subjective experience.

3.3.1. Genetic algorithm parameters:

(1) Chromosome Representation

It is simulation of the chemical composition of living chromosomes, and it is defined as an expression of the decision variables for which optimal values avail, or it represents the accessible processed solutions. It is as a symbolic String consisting of a group of Genes. It can be represented in the form of a vector or a matrix, as shown in the table (1)

Table (1) shows the chromosome

GENE1	GENE2	GENE3	GENE4	GENE	GENE6	GENE7	GENE8	GENE9	GENE10
0	1	0	1	1	1	1	0	1	1

Each gene represents a value that can be calculated. The genetic algorithm requires a chromosome integer, real and binary coding process to facilitate dealing with genes to reach the solution

(2) Function of Fitness

A function measuring the suitability of the individual to the domestic setting or the proximity of the chromosome (solution) to optimum solutions, particularly, of high fitness value, that's for their higher chances of getting the reproductive operation (saleh,2013)

To clarify the fitness function, we assume that it has a function in terms of x, y, z, w, where the objective of the function is to find the greatest value.

$f(x, y,z,w) = (4x/122)+(y+2z)/w$, $x+y \le 5$, $z+3w \le 10$ ...(2)

here, the fitness value is found according to the above function, and as shown in the table 2

Table (2) is an illustrative example of the fitness function

Fitness	Chromosome				No
	W	Z	Y	X	
4.097	**2**	**3**	**2**	**3**	**1**
4.033	**2**	**2**	**4**	**1**	**2**
0.831	**3**	**1**	**0**	**5**	**3**
1.131	**3**	**1**	**1**	**4**	**4**

It is noted that the fitness value of the first chromosome is the highest

value, which has the greatest chance of mating.

(3) Parents' population:

It is a set of chromosomes (solutions) that are selected for the process of mating to generate new chromosomes.

d. Population of children:

They are new chromosomes (solutions) that were generated through the mating process that was performed on the parental population

3.3.2. Genetic Algorithm Operations:

(1) The initial population

It is a randomly generated set of chromosomes (primary solutions) of a certain size

according to the nature of the problem, which is used to perform the genetic algorithm process represented by (selection, selection, exchange, mutation (Guilherme et *al* ,2017), (hassan,2005)

(2) Election

This process consists in selecting a group of chromosomes with a high fitness value from the parents' population and transferring them directly to the children's population to preserve the most suitable or closest to optimal solutions. This means the proportion of chromosomes is elected or selected on the basis of the fitness value to ensure their survival in the subsequent population(Saleh,2013),(Hindi,2007)

(3) Selection

It is the selection of a double chromosomes as parents to conduct the marrying process and create a new population that has common attributes from the parents. The crossover process has an important part in developing the genetic algorithm. There are several ways to choose (Hindi,2007)

- Roulette wheel selection
- Rank select:
- Tournament select:

In this paper tournament choosing method is employed because it combines randomness and preference in selecting pairs according to the fitness function, this is to ensure that chromosomes with a high fitness function do not overwhelm the rest of the chromosomes, and thus determine the genetic algorithm with the new chromosomes that will be generated due to the replication of the same parents.

(4) Crossover

It is also known as (the procedure of getting over or exchange) is the exchanging traits among parents to create dual new embryos (new chromosomes) that have corporate traits from the parents. There are several ways to perform the crossing process, as shown in the following: (Saleh,2013)

- Single Point Crossover: A point from the chromosome of both parents is randomly selected, then the genes located before the point that was selected are replaced to generate new children
- Crossover with Two Points: Two points are randomly selected from each chromosome that has been selected to perform the mating process, and to exchange genes located between the two points to generate new offspring
- Arithmetic crossover: This type of overlap uses the following equation to perform the gene exchange

$$.Child1 = a \times parent1 + (1-a) \times parent2 \; Child2 = a \times parent2 + (1-a) \times parent1 \;) \quad \ldots (3)$$

- Uniform Crossover: The exchange takes place at the level of one gene, that is, genes are transmitted from the first father to one of the sons (presumably the first son) with a certain percentage of the number of genes. Also genes are inherited in the same proportion to the second son, and so on until all the genes of the first father are inherited, then Genes of the second father will be treated in the same way

In this study, we will use this computational overlap for two reason first reason is to ensure that most of the good traits for parents who hold the value of a better competency function remains within the traits of one of the children and to make some changes that may lead to improving the value of the fitness function, second is that the process of conducting the exchange randomly or using the regular exchange may lead to solutions that are not possible due to the difference in the sequence between the jobs.

(5) Criterion of Stop: A measurement or standard employed to hinder the genetic algorithm out of creating novel solutions or people. Numerous methods that specify once the implementation of the genetic algorithm stops, and among these methods reach the specified maximum number of repetitions.

A. Community members are the same for more than one cycle (replication).

B. The genetic algorithm could undoubtedly have the optimal individual for most iterations.

C. If the function of fitness is got in a range specified by the user.

All above Genetic Operations and Stop Criterion will use in model building in this research study for solving the problem under study

3.4 Neural Network

Neural network is an expert system which has been designed and applied for job shop scheduling problems. it consists group of neurons which simulate

the human brain neural cells and each neuron has numerical information transfer to another neurons as shown in the figure 2

4. Model formulation

4.1Notations:

no= no. of demand jobs

nm= number of production machines

nor = number of operations

pt_{ijk} = processing time for demand job i on process j on production machine k

fpt_{ijk} = fuzzy processing time

$\widehat{DUT_i}$ = fuzzy due date for demand job i

$FDUT_i$ = fuzzy due date for demand job i

ST_{ijk} = start time for job I on process j on production machine k

$\widehat{FC_i}$ = fuzzy completion time for demand job i

4.2 Decision Variables

$F\hat{C}_i$ = fuzzy completion time for demand job $_i$

jobseqm = job sequencing on each production machine

4.3 Constraints

(1) Sequence constraints

It known as precedence restrictions, these constraints indicate that process j can't do so demand job i till the process preceding it has been processed, i.e. starting of process j is larger than or equal to the end time of the process j-1 (Hisha and Nathi,2015),(Fahini,2016),(hassan,2005) as explained by the following inequality:-

$$ST_{ijl} - ST_{i(j-1)k} - Pt_{i(j-1)k} \geq 0 \quad \forall\ i \neq k \qquad (4)$$

Where:

ST_{ijl} = Starting period of action i of process j on production machine l

$ST_{i(j-1)k}$= Starting period for action i of process (j-1) on production machine k

$Pt_{i(j-1)k}$ = Processing period for demand job i of process (j-1) on production machine

(2) Resource constraints:

The spans of starting jobs or operations are the decision variables for the problem of scheduling job shops that have an essential part in figuring out the optimum sequence that attains the objectives of the establishment. This because numerous jobs complete at the simultaneous for resources. (Machine)(Hang and Fansen,2016)and the various resource limitations can be illustrated below:

$$\{ST_{ijk} - ST_{lpk} - Pt_{lpk} \geq 0 \ OR \ S_{Tlpk} - ST_{ijk} - Pt_{ijk} \geq 0 \quad \forall\ i \neq l \qquad \dots (5)$$

where

ST_{ijk}= start time to do i of process j on the production machine k.

ST_{lpk} = Start time to do l of operation p on the production machine k.

Pt_{ijk} =Processing time to do i of process j on the production machine k.

Pt_{lpk} =Processing time to do l of operation p on the production machine k

The Model was built according to Genetic Algorithmic and Neural Network in order to be easy used by the management of Al-Qadir company where we have (n ×m) Fuzzy Job Shop Scheduling problem, the proposed method is as follows

(1) after we input data as shown above, we generate initial starting time for each job on each machine according to the operation process by using the following equation

$$ST_{ijk} = ST_{i(j-1)k} + PT_{i(j-1)k} \quad \text{... (6)}$$

$$i = 1, \dots, n \quad j = 2, \dots, m \quad k = 1, \dots, m$$

(2) calculate the variable pointer layer (YLI) according to starting time

$$YL_{ipk} = 1 \; if \; ST_{ijk} \le ST_{plk} \quad \forall p > i \quad YL_{ipk} = 0 \; if \; ST_{ijk} > ST_{plk} \quad \forall p > i \quad \text{... (7)}$$

Where:

YL_{ipk} = compatible pointer between demand job i and job p on production machine k

ST_{pik} = starting time for demand job i, operation p on production machine k

ST_{ijk} = starting time for demand job i, operation j on production machine k

Layer (YLI) contains b of neurons where b

$$b = \frac{n \times m(n-1)}{2}$$

(3) calculating the function of fitness for every single solution

4.4 input data

(1) FTM: A matrix of degree (3m×n), where m stands for the total of machines and n the total of jobs, and the elements of the matrix stand for the fuzzy process times of the process (i,j).

$$FTM = J_i \quad O_1 \quad O_2 \quad \dots \quad O_m \quad 1 \; 2 \; \vdots \; n \; \left[\widetilde{ft_{1,1,k}} \; \widetilde{ft_{2,1,k}} \; \widetilde{ft_{1,2,k}} \; \widetilde{ft_{2,2,k}} \; \dots \dots \; \widetilde{ft_{1,m,k}} \; \widetilde{ft_{2,m,k}} \; \vdots \; \vdots \; \ddots \vdots \; \widetilde{ft_{n,1,k}} \; \widetilde{ft_{n,2,k}} \; \cdots \; \widetilde{ft_{n,m,k}} \right]; \quad k = 1,2,\dots,m \quad \text{... (8)}$$

here:

$\widehat{ft_{i,j,k}}$ = A vector of degree (1×3) standing for the fuzzy processing time for every single process.

(2) VOP: a vector of degree (n×m). The matrix elements represent the production machine number of the operation j (Operation) according to the demand job i .

$$VOP \;=\; J_i \quad O_1 \;\; O_2 \;\; \dots \;\; O_m \quad 1\;2 \;\vdots\; n \;\begin{bmatrix} M_{1,1} & M_{2,1} & M_{1,2} & M_{2,2} & \dots\dots & M_{1,m} & M_{2,m} \\ \vdots & \vdots & \ddots \\ \vdots & M_{n,1} & M_{n,2} & \cdots & M_{n,m} \end{bmatrix} \qquad \dots (9)$$

(3) MFDUE: A matrix of (2×n) score representing the fuzzy due date for each demand job.

$$\mathrm{M}\,FDUE = J_1\, J_2 \;\vdots\; J_n \;\;\left[\widetilde{DUT}_1 \;\widetilde{DUT}_2 \;\vdots\; \widetilde{DUT}_n\right] \qquad \dots (10)$$

where $\widetilde{DUT}_i$= A vector of degree (1×2) representing the fuzzy due date for the demand job i

(4) VW_j = a vector which represent the weighted important for each Demand Job i

(5) IP = The size of the initial community to be created.

(6) NP = the number of the number of frequencies.

(7) ACI= The acceptable compatibility index value for every single demand job, and its value ranges between (1- 0.5)

4.5 output data

(1) MSFuzzy= A matrix of degree (3m×n) standing for the fuzzy start time for every single process.

(2) MCFuzzy= A matrix of degree (3×n) is the fuzzy complete time for every single demand job.

(3) MJob-Seq = A matrix of degree (m×n) is the sequence of demand jobs for every single production machine.

(4) MARI = A matrix of degree (1×n) is the value of the agreement index for each job according to the following equation

$$ARI_i = (\text{area } (\breve{C} \cap (\breve{DUT}))/(\text{area}((\breve{DUT})) \qquad \dots (11)$$

(5) MinARI= is the lowest value of the agreement index

(6) MARAI= It is the average of the agreement index, as indicated by the equation

$$MARAI = \frac{\sum_{i=1}^{n} \; ARI}{n} \qquad \dots (12)$$

(7) WARI = Compatibility Index according to the weighting important for each Job as indicated by the following equation

$$\text{WARI} = \sum_{i=1}^{n} (WJi \times ARIi) \quad 0 \le \text{WJi} \le 1 \quad \cdots(13)$$

Where WJi = late delivery demand Job penalty

(8) NTARI = The degree of satisfaction with the number of delayed jobs, as in the following: -

$$NTARI = \{0 \quad if \quad ARI_i \le \lambda \; 1 \quad if \quad ARI_i > \lambda \quad ; \quad 0 \le \lambda \le 1 \quad \ldots(14)$$

Where λ *is determined by the user*

(9) $SINTJ = \sum_{i=1}^{n} \frac{NT_i}{n}$ …(15)

(10) opt fun

$$= \frac{ARAI + minARI_i + WARI + NTARI}{4} \quad \ldots (16)$$

(11) $E(c_i)$ = fuzzy expected completion time

4.6 Criterion function

$$(1) z1 = ARI_i$$

$$(2) z2 = ARAI$$

(3) max z3 = SIWIJ

$$(4) z4 = SINTJ$$

$$(5) z4 = optfun$$

5. Model Programming, Solving and Testing

The flow charts for the model were written and then programmed by visual Mat lap, the flow chart of this program is shown in fig. (3), then the model was tested by using a theoretical data for a problem of degree (6×6) as shown in the table (3)

Table (3) The first problem of the degree (6 × 6)

Job	Fuzzy processing time in(hours) per process						Fuzzy completion time
	O1	O2	O3	O4	O5	O6	
j1	(5,7,10) M6	(10,14,17) M5	(1,3,5) M4	(1,3,5) M3	(4,6,8) M2	(9,10,11) M1	(81,88)
j2	(6,7,8) M5	(9,13,17) M1	(8,12,13) M3	(2,3,4) M6	(10,13,16) M4	(2,3,4) M2	(66,80)
j3	(4,5,6) M3	(10,11,12) M1	(9,12,16) M5	(8,12,13) M2	(6,9,12) M6	(4,7,9) M4	(89,92)
j4	(1,2,4) M4	(2,4,5) M5	(5,7,8) M6	(5,8,10) M3	(3,5,7) M1	(6,8,10) M2	(52,60)
j5	(9,11,15) M4	(4,6,9) M1	(1,2,3) M5	(10,11,15) M6	(4,7,8) M2	(10,11,12) M3	(91,96)

j6	(6,7,9) M5	(1,2,4) M3	(6,9,11) M2	(10,14,18) M6	(1,2,3) M4	(9,13,14) M1	(54,59)

An initial GENE was generated with a frequency of 30 and the number of iterations (new GENE) was 500 populations, the acceptable compatibility index was (0.9). The output of the model was shown in tables (4 to 8).

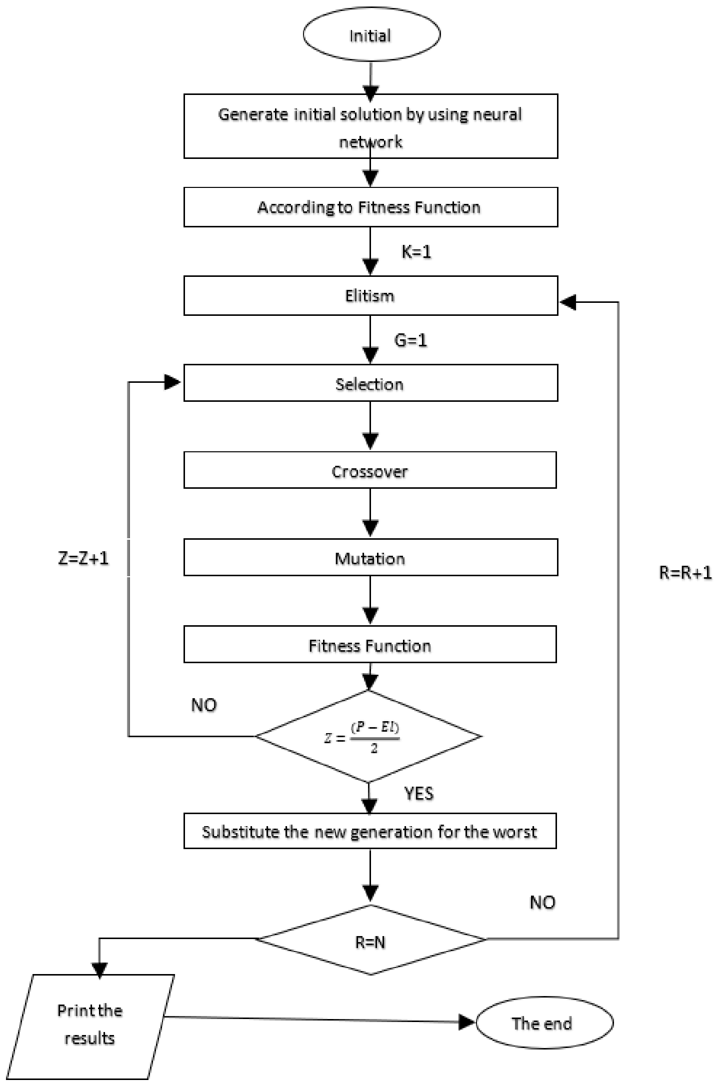

Figure (3) The proposed genetic algorithm and neural network flow chart

Table (4) Fuzzy start time in (hours)

job1			job2			job3			job4			job5			job6		
S^1	S^2	S^3	S^1	S^2	S^3	S^1	S^2	S^3	S^1	S^2	S^3	S^1	S^2	S^3	S^1	S^2	S^3
0	0	0	14	18	22	24	32	39	31	41	49	41	56	68	45	62	76
0	0	0	14	16	18	23	29	36	31	43	55	33	46	59	45	62	76
0	0	0	4	5	6	24	32	39	33	44	55	44	57	74	50	66	86
0	0	0	6	7	8	8	11	13	15	20	26	23	29	36	26	34	43
1	2	4	26	34	43	33	44	55	34	46	59	47	65	80	51	72	88
8	11	13	14	18	22	15	20	26	21	29	37	31	43	55	32	45	58

Table (5) The fuzzy expiry date

C^1	C^2	C^3
54	72	87
47	65	80
54	73	95
32	42	53
61	83	100
41	58	72

Table (6) Sequence of jobs according to each mechanism

M1	M2	M3	M4	M5	M6
3	6	3	4	2	1
2	4	6	5	4	4
4	3	4	1	6	6
5	1	2	6	1	2
6	2	1	2	3	5
1	5	5	3	5	3

Table (7) completion time in (hours)

Job	completion time	compatibility Index
Job1	71.25	1
Job2	64.25	1
Job3	73.75	.9884
Job4	42.25	1
Job5	81.75	.9658
Job6	57.25	1

Table (8) The fuzzy completion date

agreement index AAI	accruement Index AI	compatibility Index WIJ	Satisfaction index NTJ	Optimum Function opt-fun
0.9924	**0.958**	**0.9926**	**1**	**0.9877**

It can be shown from Table (7) that the lowest compatibility index for Job5 is 0.9658 which means that the probability of not delivering the product is 0.0342, this probability is very low, also the probability of not delivering

Job3 is equal to 0.0116 , moreover all other jobs would be delivered on their due dates and no delay for any completion Jobs .comparing with the compatibility of the fuzzy completion date as shown in table(8) is 0.9926 was between (0.9658 and 1), also the satisfaction index was 1 which satisfy the decision makers for job shop scheduling.

6. Model Implementation for Al-Qadier Problem

Al- Qadier company for printing and publishing has many specialized and fully computerized machines for different types of jobs according to the customer's demand.

The model was applied for Al- Qadir problem, the management of this company was involved for all model steps we use the actual data but fuzzy starting time as was determined by the management for 4 Jobs, 11 machines and 8 operations, but Jobs 1 ,3 and 4 didn't required all operations and didn't required to be processed on all machines, the model was run with initial Gen = 30 and 500 iterations output data was shown in tables (9), (10) and (11)

Table (9) anticipated completion span for each job

Job	expected completion time
job1	116.625
job2	10.375
job3	45.875
job4	9.135
average expected time for all jobs	45.5

Table (10) compatibility index

compatibility value	**Job**
0.98721	**1**
1	**2**
1	**3**
1	**4**

Table (11) criterion values

Criterion	**value according to model**
AAI	**0.9955**
Min AI	**0,9821**
AIW	**0.9928**
AINT	**1**
Opt fun	**0,9926**

As shown in tables above that the model output is more accuracy than the output of the management of Al-Qadir company, thus it will help them in minimize the cost

and completion time which will lead to satisfy their customers,

7. Conclusions and further study

7.1 Conclusions:

(1) The usage of the genetic algorithm to address the problem of scheduling fuzzy job shops gives good results and a clear picture that greatly helps the decision-maker to make decisions that contribute greatly to reaching customer satisfaction by attaining the ideal sequence to reduce the completion time and deliver the product on time.

(2) Using the fuzzy due date and fuzzy processing time in the problem of scheduling job shops contributes to addressing the uncertainty of product delivery dates to the customer due to the different experiences of decision makers and the performance of the machine, by adopting scheduling based on indecision that assists in making more precise decisions.

(3) The procedures and output of the model was satisfied the management and can implementing the model.

7.2 further study

This study recommends for further study:

(1) Building a model a smart system by using the genetic algorithm with an artificial intelligence system to solve the problem of dynamic rescheduling or in case of partially rescheduling or generating new scheduling in response to a change or event that occurs in the production environment like machine failure or new business or cancel job orders.

(2) Conducting trial experiments to make comparisons to the performance of the genetic algorithm with other methods and algorithms adopted to handle the problem of fuzzy job shop scheduling such as the bee algorithm, block search, pseudo-fusion, or other developed applications

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