Scholar Publishing Group
International Journal of Multimedia Computing
https://doi.org/10.38007/IJMC.2022.030404
ISSN 2789-7168 Vol. 3, Issue 4: 41-52

# *Super Heuristic Genetic Algorithm for Fuzzy Flexible Job Shop Scheduling*

**Yu Han***

*Shenyang Jinbei Vehicle Manufacturing Co., LTD, Shenyang, Liaoning, China*

*84869006@qq.com*

**corresponding author*

***Keywords:*** Resource Scheduling, Super Heuristic Genetic Algorithm, Job Shop Scheduling, Flexible Job Shop, Multi-objective Scheduling

***Abstract:*** The purpose of this paper is to propose a hybrid super heuristic genetic algorithm for solving a class of fuzzy flexible job shop scheduling problems of work pieces processing time represented by using triangular fuzzy numbers, to minimize the optimization goal and reduce the fuzzy completion time. At the same time, under the conditions of product customization trend, diversified development of process routes, provide enterprises with a small-scale customized production that can be realized in time and a solution to improve the flexible operation of production systems .This paper first considers the practical problems in the production process of fuzzy flexible job shop and establishes a multi-objective optimization model. Then carried out a lot of research and analysis on traditional genetic algorithm, finding that the standard genetic algorithm is easy to fall into the problems of local optimum, low search efficiency and infeasible solution when solving the problem of shop scheduling. Came up with the hybrid heuristic algorithm for this problem, the algorithm incorporates methods such as hybrid heuristics, making the generated initial population as much as possible in the solution space of the whole problem, and to ensure the diversity of solution. Finally, through a series of improvements to the traditional genetic algorithm, improve the way of coding and genetic operators based on the super heuristic genetic algorithm, combine elite retention strategies and niche technologies to further optimize the convergence and diversity of algorithms. Calculates the fitness of the chromosome by weight coefficient change method. Therefore, the results of experimental analysis show that the proposed algorithm can verify the effectiveness of the proposed sorting criterion and super heuristic genetic algorithm, and can play a good role in the actual production process, it can also fully reflect the target requirements of fuzzy flexible job shop scheduling in production.

## 1. Introduction

The stable and advanced development of the manufacturing industry will be conducive to the rapid rise of the national economy. At present, while China's manufacturing industry is developing rapidly, its competitiveness is mainly in the scale of manufacturing and the cost of manufacturing [1]. Under the background of “Made in China” and “Internet +” and “Think Tank” transformation, it is imperative to lead the global manufacturing transformation and upgrading. It needs to cooperate with the Internet of Things and intelligent manufacturing. Enterprises must pay attention to the integration and adjustment of resources. Integrate development to enhance their core competitiveness [2]. Therefore, the industrial transfer and adjustment of the manufacturing industry has also become a major trend in industrial development. Production scheduling is the core of management decision-making and resource allocation in intelligent manufacturing. Efficient scheduling method is the key to realize the basis of intelligent manufacturing and improve the efficiency of enterprises [3]. Flexible Job Shop Scheduling Problem (FJSP) is a typical production scheduling problem. Since the traditional job shop scheduling problem has the property of non-deterministic polynomial NP-hard, and the problem is reduced to FJSP, FJSP is NP-hard problem. In the actual production process, the processing environment is complex and variable, and it is often difficult to obtain accurate processing time. Using the triangular fuzzy number in fuzzy theory to represent the uncertain processing time, and then establishing the fuzzy flexible job shop scheduling problem (FFJSP) model, it can be more objective Describe the actual production process. Therefore, the study of FFJSP has a high theoretical and practical value [4].

Workshop scheduling is not limited to the application of production management, but also can be extended to the transportation field of airports, ports, general multi-vehicle platform automobile assembly, engineering project management, software development, etc. [5]. The research on fuzzy flexible job shop scheduling problem can also provide reference for similar uncertainties in other fields. Shop scheduling is a hot research area of production planning and control [6]. It simulated the production process according to the production plan and the existing equipment, raw materials and production processes of the production department, and finds a reasonable scheduling plan. The scheduling model proposed in the relevant literature does not fully summarize the actual production environment. Fuzzy flexible scheduling can more accurately describe the values that cannot be accurately described in a certain range during the production process, including fuzzy processing time, fuzzy delivery time, prioritize changes in delivery time and customer demand changes. According to prior knowledge or on-site measurement, processing parameters set to fuzzy numbers close to actual production to obtain the optimal fuzzy scheduling plan, thereby reducing idle, waiting and processing time, improving equipment utilization, reducing costs, reducing machine load, and production scheduling. Probability greatly reduces obstacles and improves customer satisfaction [7]. The flexible job shop scheduling problem is the same as the classic job shop scheduling problem, which is a complex combinatorial optimization problem [8]. At the same time, the scheduling of most enterprises in China is still arranged by senior staff according to their own experience, unscientific and inefficient. Therefore, research and implementation of flexible job shop scheduling has important theoretical and practical significance.

In this paper, the fuzzy number is added, subtracted, and increased according to the problem model when calculating the different job schedules of the fuzzy production scheduling problem or solving the corresponding objective function values [9]. At the same time, when evaluating the merits of different solutions, the objective function value of each solution should be compared [10]. In the traditional flexible job shop scheduling problem, considering the diversity and uncertainty of scheduling objectives, the problem model is extended, and the fuzzy decision processing method is proposed and applied to the adaptive computing of genetic algorithm. A two-layer hybrid hyper-heuristic genetic algorithm is proposed for fuzzy flexible job shop scheduling problem. [11] The work piece machining time is represented by a triangular fuzzy number, and the optimization target (the objective function) is to minimize the maximum fuzzy completion time. The properties of triangular fuzzy number sorting criteria used in existing fuzzy scheduling problems are analyzed. A more accurate triangular fuzzy number sorting criterion is designed, which can reasonably calculate the objective value of fuzzy flexible job shop scheduling problem and other scheduling problems.[ 12].

The first chapter of this paper introduces the background and significance of this research, summarizes the methods and ways to solve the flexible job shop scheduling problem, analyzes its inadequacies, and puts forward the research content and technical route of this paper. The second chapter introduces the concept, problem description, classification and characteristics of flexible job shop scheduling problem, determines the research object of this paper, and establishes the mathematical model of flexible job shop scheduling problem. The basic principle and operation flow of ant colony algorithm are introduced. The advantages and disadvantages of ant colony algorithm are analyzed and the improvement direction is proposed. The third chapter analyzes the experimental data analysis, experimental environment and algorithm implementation process of the super heuristic genetic algorithm for solving fuzzy flexible job shop scheduling problems. The fourth chapter introduces the experimental case of this article. Taking the fuzzy flexible job shop scheduling problem as an example, the designed algorithm is analyzed and verified, and compared with the basic genetic algorithm, the goodness of the solution is verified. The benchmark function is then used to test the convergence of the algorithm. A mathematical model of multi-objective flexible shop scheduling problem with dual resources is established and the algorithm is designed in detail. In the fifth chapter, the experimental cases of the algorithm are analyzed. The effectiveness of the proposed triangular fuzzy number sorting criterion and super heuristic genetic algorithm is verified by simulation experiments and algorithms. Finally, the paper summarizes and forecasts the full text.

## 2. Proposed Method

### 2.1. Related Work

(1) Research on fuzzy flexible job shop scheduling

The fuzzy processing and interval time are represented by triangular fuzzy numbers and trapezoidal fuzzy numbers, which are solved by particle swarm optimization. A multi-objective fuzzy flexible job shop scheduling problem model is established by using fuzzy priority rule coding. In addition, the Decomposed Integrated Genetic Algorithm (DIGA) and the Co-evolution Genetic Algorithm (co-evolutionary genetic algorithm) are proposed to solve the flexible job shop scheduling problem with fuzzy processing time. Khademi Zare integrated data mining into genetic algorithms, and utilizes the direct relationship between the optimal solution of data mining and existing solutions to solve the problem of flexible job shop scheduling with minimum delay time. Schlünz E B solved the multi-objective fuzzy flexible job shop completion time scheduling problem by using vertical and horizontal coordinated multi-group genetic algorithms [13]. Xia W proposed an adaptive genetic algorithm based on priority list coding, which solved the multi-objective fuzzy flexible job shop scheduling problem with semi-trapezoidal fuzzy delivery time, and established a time-number fuzzy processing time, time and machine load. Target fuzzy flexible job shop scheduling problem, and super-volume index to ensure the iterative refinement effect of NSGA-II algorithm combined with the relationship between gray digital sequences, transforming dynamic fuzzy flexible job shop scheduling problem into static scheduling problem, using fast distribution estimation Algorithm (FEDA) solves [14]. Wang J proposed TLBO to solve the flexible job shop scheduling problem with fuzzy processing time. In order to solve the fuzzy flexible job shop scheduling problem, Liu C proposed a hybrid genetic tabu search algorithm [15]. Gao Kaizhou used an improved artificial population algorithm to solve the flexible job shop scheduling problem with fuzzy processing time.

(2) Research on genetic algorithm in shop scheduling problem

Evolutionary computation has the advantages of optimal solution and robustness, and it has received more and more attention in dealing with large-scale complex scheduling problems. Davis first used genetic algorithms to solve job shop problems. Since then, evolutionary calculations have been widely used in the field of research on the job shop and have achieved satisfactory results. In recent years, Han Y used genetic algorithms to evolve the priority rules for part scheduling [16]. In the new century, Vallejos-Cifuentes P designed a controlled evolutionary computation using heuristic rules to generate initial populations using parallel machine coding mechanisms. Fuzzy logic and confidence strategies were used to predict geneti collaborative operations through multiple crossover operations. In the same year, Li Y developed a generator that could change the complexity configurability problem. The device can better test the role of genetic algorithm in job shop scheduling problem research, so as to better understand the advantages and disadvantages of genetic algorithm [18]. At the same time, Yang X designed a rule set scheduler to simulate the performance of the genetic algorithm. The data mining algorithm is used to extract the information in the result set of the genetic algorithm scheduling [19]. In recent years, hybrid genetic algorithms have received extensive attention at home and abroad. Its research has received more and more attention. At the end of the 20th century, Davis developed a method of genetic algorithm to carry out northern blotting where possible. In 2000, Dimopoulos and others agreed that hybrid genetic algorithms will undoubtedly become a new research hotspot. At the same time, Wu W proposed some hybrid genetic algorithms specifically for solving the problem of shop scheduling, and combined the local search method with the genetic algorithm to solve the problem of shop scheduling [20]. The job shop has only been researched in China in recent years. Due to technical limitations, dispatchers mainly rely on their own experience to complete the resource allocation of the workshop. Due to the effectiveness and superiority of genetic algorithms in solving job shop problems, the research of evolutionary computing has received more and more attention in China. However, most of the current research is still based on experimental research, and there is still a long way to go to develop a mature shop scheduling software system.

## 2.2. Fuzzy Flexible Job Shop Scheduling Problem

(1) Proposed fuzzy problem

Because the production process is often accompanied by many uncertain factors, the processing time of each work piece can only be used as a rough range to determine the fuzzy flexible job shop scheduling problem. The triangular fuzzy number is usually used to represent the processing time of each process, the triangular fuzzy number. Usually (TFN= (t1, t2, t3)). The membership function image is shown in Figure 1.

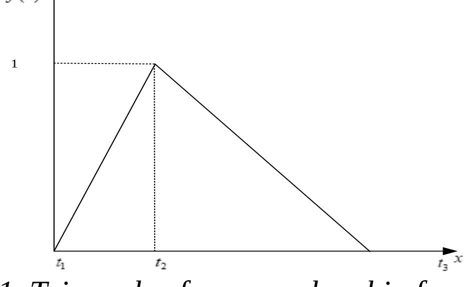


*Figure 1. Triangular fuzzy membership function*

Among them, is the most optimistic processing time, is the most likely processing time, and the membership degree is 1, which is the kernel of this fuzzy number and is the most conservative processing time. The membership function of the triangle fuzzy number is expressed as:

$$\mu_{TFN}(x)=\begin{cases}0, x\le t_1\\ \frac{x-t_1}{t_2-t_1}, t_1<x\le t_2\\ \frac{t_3-x}{t_3-t_2}, t_2<x\le t_3\\ 0, x\ge t_3\end{cases} \quad (1)$$

There will be several situations as follows:

When $t_2=t_3$:

$$\mu_{TFN}(x)=\begin{cases}0, x\le t_1\\ \frac{x-t_1}{t_2-t_1}, t_1<x\le t_2=t_3\\ 0, x\ge t_3\end{cases} \quad (2)$$

When $t_1=t_2$:

$$\mu_{TFN}(x)=\begin{cases}0, x\le t_1\\ \frac{t_3-x}{t_3-t_2}, t_1=t_2<x\le t_3\\ 0, x\ge t_3\end{cases} \quad (3)$$

When $t_1=t_2=t_3$:

$$\mu_{TFN}(x)=\begin{cases}1, x=t_1=t_2=t_3\\ 0, other\end{cases} \quad (4)$$

Since the processing time is represented by a triangular fuzzy number, the mode completion time is also a triangular fuzzy number, which is expressed as the fastest completion consensus of $C_i=(c_1,c_2,c_3), c_1,c_2,c_3$ is i work piece, and is most likely to complete the consensus and the most conservative completion time.

The sorting model of the fuzzy flexible job shop scheduling problem is described as follows: $n$ independent work pieces are processed on the $m$ machine. The $i$ work pieces have $u_i$ process, and each process can be processed by at least one machine. $j_i$ is $i$. The work piece $O_i$, $j$ is the $j_i$ process of the work piece $j$, and must meet the following constraints: the same work piece can be processed on only one machine at any one time. The same machine can only process at most one operation at any one time. Any operation cannot be interrupted during processing. The process of the same work piece must be processed in the previous process before the next process can be processed. It is required to assign a suitable machine for each process and determine the machining path of the work piece on each machine. The objective function of the problem is equation (5), which is to minimize the maximum fuzzy completion time, where $C_i$ represents the fuzzy completion time of the $i$ work piece. , $n$ represents the number of artifacts:

$$C_{\max}=\min(\max_{i=1,2,\dots,n} C_i) \quad (5)$$

This paper uses the problem sorting model. The decision variables of this model are coded based on the arrangement of operations or components. For any particular arrangement (ie a solution to the problem), a certain decoding method can be used to determine and calculate the completion time of each work piece on each machine, and then calculate the objective function of the problem.

(2) Flexible job shop scheduling problem

The specialty of the flexible job shop scheduling problem is mainly in the following aspects:

Complexity On job shop scheduling issues, flexible operations are more complex in terms of machine technology selection and machine scheduling adjustments for shop floor scheduling problems.

Uncertainty, there will be people or equipment caused by actual production accidents, such as employee departure, intermediary maintenance, mechanical equipment failure, etc. On the other hand, if the processing time and delivery time are uncertain, some processes are related to the proficiency of the workers, and small batches. Even personalized product products, because they cannot accurately measure and then arrange the scheduling, only within a certain scope based on prior knowledge should be set more reasonable, and the change in order demand of the open-loop production system can easily lead to the advance of the order or Delayed delivery date.

## 2.3. Fuzzy Theoretical Basis

(1) Representation of fuzzy sets

The most common method is the Zade method. When the domain is a finite set, the fuzzy set is expressed as:

$$\tilde{A} = \frac{u_{\bar{A}}(u_1)}{u_1} + \frac{u_{\bar{A}}(u_2)}{u_2} + \ldots + \frac{u_{\bar{A}}(u_n)}{u_n} \quad (6)$$

The fractional line in the formula is not a division, but refers to the correspondence between the element $u_i$ and the membership degree $u_{\bar{A}}(u_i)$ in U. The operation is not addition and summation, but means that all correspondences are included.

When the domain U is connected to an infinite set, the expression is:

$$\tilde{A} = \frac{u_{\bar{A}}(u\ )}{u} \quad (7)$$

fuzzy numbers and operations

The application of fuzzy information needs to be quantized with fuzzy numbers different from fuzzy real numbers. This paper briefly introduces the summation and summation operations in fuzzy scheduling. The other four operations are similar. Let the addition of $\forall_{x,y,z} \in R, \tilde{A}, \tilde{B}$ be:

$$u_{\bar{A}+\bar{B}}(z) = \vee_{z=x+y} (u_{\bar{A}}(x) \wedge u_{\bar{B}}(y)) \quad (8)$$

Similarly, subtraction is available:

$$u_{\bar{A}-\bar{B}}(z) = \wedge_{z=x-y} (u_{\bar{A}}(x) \vee u_{\bar{B}}(y)) \quad (9)$$

The formula for taking the maximum value of the fuzzy number is defined as:

$$u_{\bar{A}\vee\bar{B}}(z) = \vee_{z=x\vee y} (u_{\bar{A}}(x) \wedge u_{\bar{B}}(y)) \quad (10)$$

Where z takes a relatively large value in x and y, and the value of point z is derived from the largest membership value in the set of points under the membership value of the x and y combination. The form of the curve is a complex fuzzy number operation, the triangular fuzzy number can solve the problem sorting, and the weight distribution factor is suitable for multiple decision problems, usually in the shop scheduling problem of triangular fuzzy numbers, processing time, trapezoidal fuzzy number It is a good idea to say that customer satisfaction exceeds the expected delivery time interval and shows a gradual downward trend, which is used to represent a simplified fuzzy delivery time information.

### 2.4. Hybrid Hypertext Genetic Algorithm

In the high-level policy area, each of the six low-level heuristics in the strategy of genetic algorithm in the population, the individual of each chromosome is a simple heuristic, the length of the chromosome is equal to the number of strategically focused low-level heuristics, and each chromosome is allowed to operate in the same low-level heuristic. Decoding the chromosomes into a lower problem domain solution, ordering left-to-right sequences according to different genes on the chromosomes to reduce heuristics, each performing low-level heuristics, they will get new and old solutions If the new fitness value (ie, the objective function value) is less than the adaptation value of the old solution, then replace the old one with the new solution, no longer perform the remaining low-level heuristics, or continue. This allows a local search for low-level solutions. The fitness value of each individual in the advanced policy domain is equal to the fitness value of the solution to the problem with which it is updated.

To reduce the problem domain, each individual is a process with a sequence of original problems. The solution to the original problem corresponds to a new advanced policy domain algorithm that updates a solution, thereby reducing the overall size of the problem domain to be the same as the top-level policy domain. . Flexible job shop scheduling problem and job shop scheduling problem, the main difference is that each process can be processed on multiple machines, the general order, where $u_i$ is the number of processes of the $i$ work piece. The process alignment code length of this problem is U, which can be expressed as $(p_1, p_2, ..., p_n)$, $p_u \in \{1,2,...,n\}$, where n is the number of work pieces. If $p_u$=3, then 3 total $u3$ times occur in the sequence. If 3 is the third occurrence, it represents the third process of the $p_u$ corresponding workpiece, and the data can be obtained as an example of a coded individual (3, 1, 3, 2, 1, 2, 3). Since flexible manufacturing also requires the selection of a suitable machine, the greedy strategy is to use decoding, adjust the sequence of each process in the process to open all the machines can be workflow activities to solve the code, and then choose the machine that minimizes the current maximum fuzzy completion time. Processed to form a specific schedule. Compared with the two-phase coding and decoding of the text, the method has a shorter coding sequence, and can better select the idle time interval of each machine while the machine idle time interval, thereby reducing the waste of processing time, thereby improving the Quality of solution.

## 3. Experiments

### 3.1. Data Acquisition

Y Bus Co., Ltd. is one of the earliest listed companies in the Chinese bus industry. It has been producing large and medium-sized buses for nearly four years. The Z workshop mainly produces parts of the assembled chassis for assembling the chassis. The main production of four parts, a total of 7 work pieces process, the work piece two four processes, there are 8 process work piece LAN, work piece four 8 procedures, a total of eight kinds of mechanical equipment for processing: ordinary, CNC machine tools 1, 2, hollow sharp bed CNC machine tools, desktop sharp beds, radial drilling machines, vertical drilling machines, and paint machines. These four components are assembled to the chassis of the bus, but the production of these four components is independent of each other.

At least in each process of processing on a machine, and processing time is different, it can be seen that the shop scheduling problem belongs to the flexible job shop scheduling problem. The input of the research object in this paper is to assign the appropriate machine for processing in 27 processes, or the process and order are determined for each machine, and the total W run time is the shortest. According to the current scheduling scheme, it takes 5291 seconds to complete one process for 4 work pieces, which is about 1.47 hours. When there are more orders, the production cycle can no longer meet the needs of chassis assembly, and the workshop urgently needs a new scheduling scheme to shorten the production cycle. The data shown in Table 1 was obtained by the above method.

*Table 1. Numbering table for each process and machine*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| O11 | O12 | O13 | 014 | 015 | 018 | 021 | 022 | 023 | 024 | 031 |
| 1 | 2 | 3 | 4 | 5 | 8 | 9 | 19 | 21 | 22 | 24 |
| O32 | O33 | O34 | O35 | O36 | 041 | OMT | OMT1 | CNC | CNC1 | PMM |
| 25 | 26 | 27 | 31 | 33 | 35 | 1 | 2 | 3 | 4 | 5 |

## 3.2. Experimental Environment

This experimental environment is programmed with Matlab2017b under the WIN10 operating system of Intel(R) Gore(TM) 2.3GHz and 16G memory.

## 3.3. Experimental Steps

Step 1: Initialize the advanced policy domain and low-level problem domain population. In the first iteration, the length of the individual 6 in the high-level strategic area is randomly generated, and the total length ordinal U of the process scheduling work (that is, the solution to the low-level problem or the individual) is randomly generated, and the corresponding advanced and low-level pop-up population size.

Step 2: Set the initial simulated annealing temperature TS=200.

Step 3: Evaluate the two groups of people. The solution of the problem is updated with each set of low-level heuristics, and the adaptive value of the solution is calculated according to the objective function. The individual of the advanced policy domain has the same fitness value as the corresponding solution, that is, the quality of the solution also indirectly represents the quality of the search method.

Step 4: Use roulette to select the elite solution in the strategy population for cross-variation.

Step 5: In the newly generated policy individual, use six low-level heuristics to update the solution of the problem in turn. If the fitness value of the new solution is better than the old solution at each update, the old solution will be replaced, the subsequent low-level heuristic operation will no longer be used for searching, or the difference decomposition will be accepted with a certain probability according to the current temperature.

Step 6: If accepting the poor solution obtained by the current low-level heuristic operation, determine whether the inner loop number of the operation is equal to 5; if not, continue to use this heuristic operation to update the solution of the problem; otherwise, continue to the next step.

Step 7: Optimize the new and old people in the two fields separately, and liberate the elites in each field to the corresponding groups. Step 8: According to the cooling coefficient of cooling, determine whether the number of iterations reaches the maximum algebraic maximum. If not, go to step 4, or terminate the loop.

## 4. Discussion

### 4.1. Experimental Results and Comparison of Fuzzy Flexible Shop Scheduling Problems

(1) Taking the 6×4 fuzzy flexible job shop scheduling problem as an example, the fuzzy processing progress, the three numbers of fuzzy processing time represent the minimum processing time, the most likely processing time and the maximum processing time respectively. The blank indicates that the process cannot be correct.The scheduling goal is the minimum scheduling scheme that gets the maximum completion time. In order to verify the effectiveness of the algorithm, the algorithm proposed in this paper performs 10 operations on the data shown in Table 1. The experimental results are shown in Table 2 and Figure 2. Parameter setting: population size pop size=100, memory size 50, maximum iteration Max Iteration=100, initial crossover probability 0.8 mutation probability 0.1, optimistic coefficient 0.7.

*Table 2. Experimental results*

| Number of Runs | Optimal Solution | Evaluation Result | Worst Solution |
|---|---|---|---|
| 20 | 19.8 | 22.3 | 24.5 |

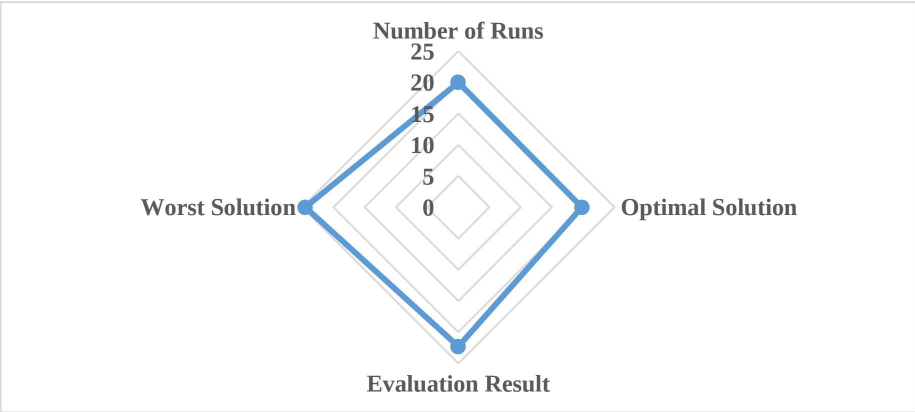


*Figure 2. Comparison of experimental results*

(2) By solving the fuzzy flexible job shop scheduling problem, the performance of the improved immune genetic algorithm in fuzzy flexible job shop scheduling problem is tested. To minimize the completion time and maximize the average and minimum satisfaction. 4×6, 6×10, 8×8, and 10×10 examples were tested. The population size population is pop size=200, the maximum number of iterations is Max Iteration=100, the selection probability is 0.9, the crossover probability is 0.8, and the mutation probability is 0.02. The test results are shown in Figure 3.

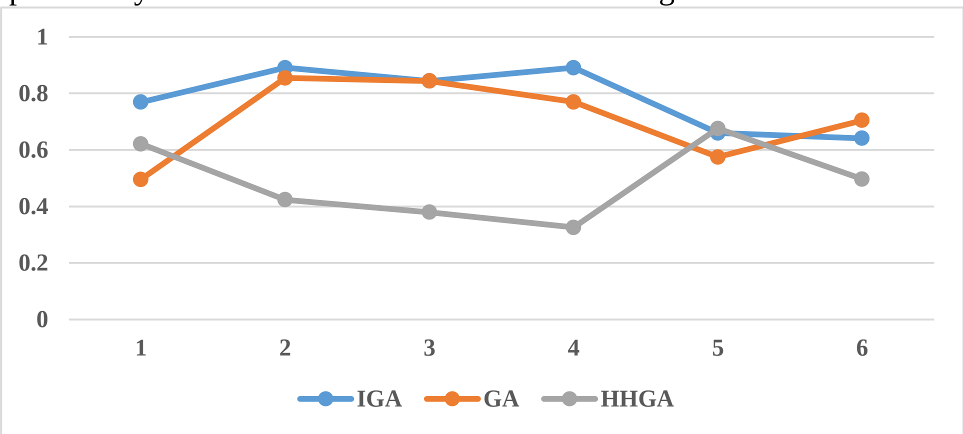


*Figure 3. Fuzzy flexible job shop scheduling problem map*

### 4.2. Experimental Results and Comparison of Embedded Simulated Annealing Mechanism

(1) To verify the effectiveness of the algorithm is embedded in the simulated annealing mechanism, using the HHGA simulated annealing mechanism and completing the HHGA simulation experiment, each algorithm is consistent with other parameters, and each time the size is run independently 20 times, each algorithm The optimal value is 20 times, the average value and the worst, as shown in Figure 4.

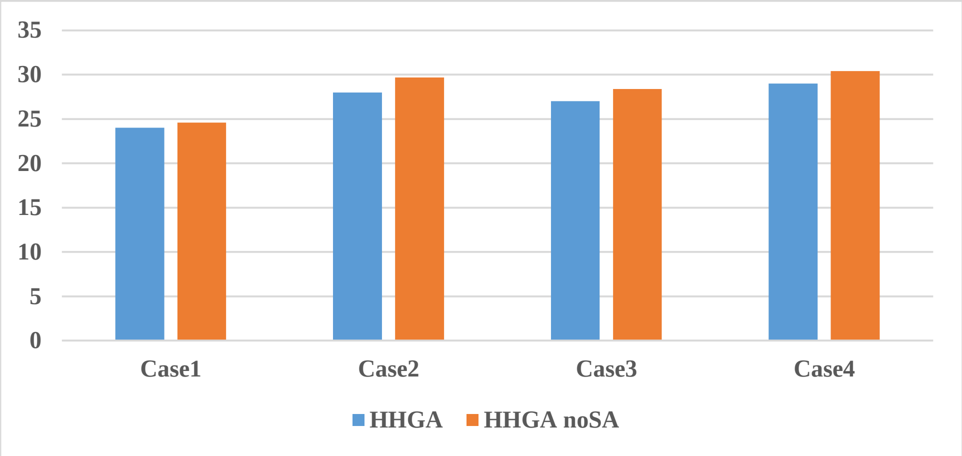


*Figure 4. Simulated annealing experiment*

(2) In order to test the performance of HHGA, 5 experiments were performed. The experimental results were then compared with the existing five strong algorithms CGA, TLBO, HBBO, EDA and HABC. The comparison results are shown in Figure 5.

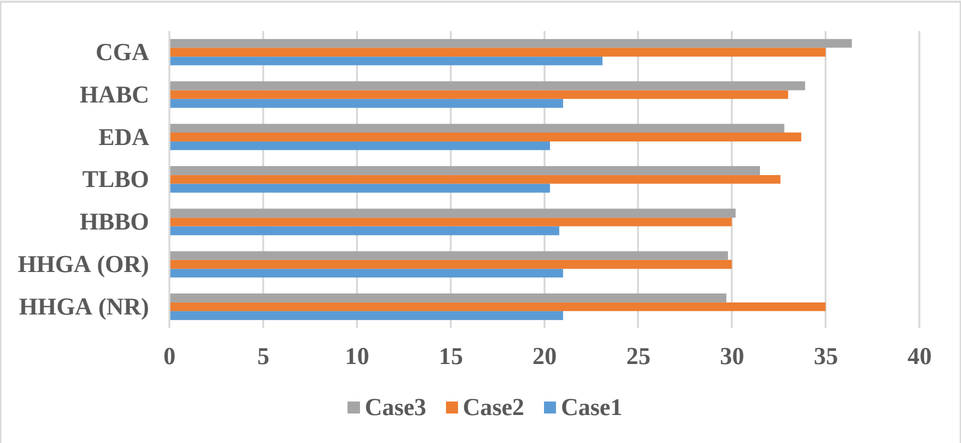


*Figure 5. Comparison of five algorithms*

## 5. Conclusion

As can be seen in Figure 5, for five different size examples, HHGA is very close to HBBO. In this paper, Sakawa collation's sorting algorithm is superior to other algorithms. In particular, Cases 1 and 2 HBBO HHGA, found the same solution, Numerical Example 2 due to differences in evaluation criteria, resulting in a final fuzzy completion time is different, in this article, under the ranking criteria (35, 42 years old, 59) greater than 30, 45 years old,so that (35, 42 years old, 59) should be the final fuzzy completion time, the calculation can be verified (30, when comparing (35, 42 years old, 59) and (45, 58) The latter is more accurately used as the final fuzzy completion time. Example 3, Example 4 and Example 5HHGA are superior to the other five algorithms and are in a leading position. When the problem scales up, this advantage is more obvious. It can be seen that HHGA With strong competitiveness and effectiveness in FFJSP, HHGA uses the ranking criteria of this article to get more reasonable results.

In this paper, solving FFJSP with two-layer hybrid hyper-inspired genetic algorithm. The triangle fuzzy number is used to represent the work piece processing time. The optimization goal is to minimize the maximum value between the fuzzy completion time and the completion time. Firstly, by using the detailed analysis of the existing fuzzy scheduling problem, the classification criterion of the triangular fuzzy number is used, and it is pointed out that the classification standard will not be accurate enough in some cases, and the large degree of approximation error and fuzzy operation are fully considered, and a more design is designed. Accurate triangular fuzzy number ordering criteria can reasonably calculate the objective function values of FFJSP and other types of scheduling solutions. Secondly, the existing methods combine genetic algorithm and super heuristic algorithm, that is, the underlying search lacks effective local search algorithm and the whole is easy to fall into the local minimum. The early problem solving algorithm can be divided into two layers, in the first six low-level inspirations. The operation is the optimization of the layout of the six effective neighborhood operations, so that the neighborhood local search of the compact variable can be performed, and the adaptive mutation operator and the simulated annealing mechanism are designed respectively in the upper and lower parts to avoid the algorithm falling into the local minimum value. Finally, the key parameters of the algorithm are determined by experimental design method. The effectiveness of the proposed algorithm and HHGA algorithm is verified by simulation experiments and algorithms.

The results show that the model is reasonable, can deal with single-target requirements, multi-target requirements, and can deal with uncertain target requirements in reality. In addition, it can meet the different requirements of different parts and the same part. This paper believes that the analysis and research of various indicators in the scheduling target, combined with the processing of uncertain factors in the production process, will help to develop a general and practical scheduling optimization system.

## References

*[1] Bae E Y, Mah J S. The role of industrial policy in the economic development of Uzbekistan. Post Communist Economies, 2018, 31:1-18.https://doi.org/10.1080/14631377.2018.1443252*

*[2] Steen M, Njøs R. Green restructuring, innovation, and transitions in Norwegian industry: The role of economic geography. Norsk Geografisk Tidsskrift / Norwegian Journal of Geography, 2019, 73(1):1-3.https://doi.org/10.1080/00291951.2018.1558281*

*[3] Yu H, Fang L, Sun B. The role of global economic policy uncertainty in long-run volatilities and correlations of U.S. industry-level stock returns and crude oil.. Plos One, 2018, 13(2):192305.https://doi.org/10.1371/journal.pone.0192305*

*[4] Gao K, Yang F, Zhou M C, et al. Flexible Job-Shop Rescheduling for New Job Insertion by Using Discrete Jaya Algorithm. IEEE Transactions on Cybernetics, 2018, PP(99):1-12.*

*[5] Xie N, Chen N. Flexible job shop scheduling problem with interval grey processing time. Applied Soft Computing, 2018, 70:513-524.https://doi.org/10.1016/j.asoc.2018.06.004*

*[6] Syahputra M F, Apriani R, Sawaluddin, et al. Genetic algorithm to solve the problems of lectures and practicums scheduling. IOP Conference Series: Materials Science and Engineering, 2018, 30(8):12046.https://doi.org/10.1088/1757-899X/308/1/012046*

*[7] Sun L, Lin L, Gen M, et al. A Hybrid Cooperative Coevolution Algorithm for Fuzzy Flexible Job Shop Scheduling. IEEE Transactions on Fuzzy Systems, 2019, PP(99):1-1.*

*[8] Wang C, Na T, Ji Z, et al. Multi-objective fuzzy flexible job shop scheduling using memetic*

*algorithm. Journal of Statistical Computation & Simulation, 2017, 87(14):1-19.https://doi.org/10.1080/00949655.2017.1344846*
*[9] Zhang X, Hipel K W, Tan Y. Project portfolio selection and scheduling under a fuzzy environment. Memetic Computing, 2019,67(3):1-16.https://doi.org/10.1007/s12293-019-00282-5*
*[10] Donahoe E, Metzger M D. Artificial Intelligence and Human Rights. Journal of Democracy, 2019, 30(2):115-126.https://doi.org/10.1353/jod.2019.0029*
*[11] Zhang X, Wang Y, Liu C, et al. A novel approach of battery pack state of health estimation using artificial intelligence optimization algorithm. Journal of Power Sources, 2018, 376:191-199.https://doi.org/10.1016/j.jpowsour.2017.11.068*
*[12] Li W, Özcan E, John R. A Learning Automata-Based Multiobjective Hyper-Heuristic. IEEE Transactions on Evolutionary Computation, 2017, PP(99):1-1.*
*[13] Schlünz E B, Bokov P M, Vuuren J H V. Multiobjective in-core nuclear fuel management optimisation by means of a hyperheuristic. Swarm & Evolutionary Computation, 2018, 42:58-76.https://doi.org/10.1016/j.swevo.2018.02.019*
*[14] Xia W, Quek T Q S, Zhang J, et al. Programmable Hierarchical C-RAN: From Task Scheduling to Resource Allocation. IEEE Transactions on Wireless Communications, 2019, 18(3):1-1.https://doi.org/10.1109/TWC.2019.2901684*
*[15] Wang J, Liu C, Li K. A hybrid simulated annealing for scheduling in dual-resource cellular manufacturing system considering worker movement. Automatika – Journal for Control Measurement Electronics Computing and Communications, 2019, 60(2):172-180.https://doi.org/10.1080/00051144.2019.1603264*
*[16] Han Y, Li J Q, Gong D, et al. Multi-Objective Migrating Birds Optimization Algorithm for Stochastic Lot-Streaming Flow Shop Scheduling With Blocking. IEEE Access, 2019, 7(9):5946-5962.https://doi.org/10.1109/ACCESS.2018.2889373*
*[17] Vallejos-Cifuentes P, Ramirez-Gomez C, Escudero-Atehortua A, et al. Energy-Aware Production Scheduling in Flow Shop and Job Shop Environments Using a Multi-Objective Genetic Algorithm. Engineering Management Journal, 2019,43(1):1-16.https://doi.org/10.1080/10429247.2018.1544798*
*[18] Li Y, Yang Z, Zhao D, et al. Incorporating energy storage and user experience in isolated microgrid dispatch using a multi-objective model. IET Renewable Power Generation, 2019, 13(6):973-981.https://doi.org/10.1049/iet-rpg.2018.5862*
*[19] Li B, Yang X, Xuan H. A Hybrid Simulated Annealing Heuristic for Multistage Heterogeneous Fleet Scheduling with Fleet Sizing Decisions. Journal of Advanced Transportation, 2019, 2019(10):1-19.https://doi.org/10.1155/2019/1524178*
*[20] Wu W. HG-means: A scalable hybrid genetic algorithm for minimum sum-of-squares clustering. Pattern Recognition, 2018, 88:569-583.https://doi.org/10.1016/j.patcog.2018.12.022*