Optimization of Production Scheduling and Actual Stock Using Fuzzy Genetic Algorithm

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Abstract. In this case, fuzzy is applied as a determination optimization of actual stock. Based on the research that has been done, solving the problem of scheduling and actual stock optimization with Fuzzy Genetic Algorithm method has better performance than non-fuzzy Genetic Algorithm method. Production scheduling with Fuzzy Genetic Algorithm shows faster process result. Seen from the iteration that occurs is 1 (one) for scheduling with Fuzzy while on non fuzzy production scheduling, the process is completed in the iteration to 34. Scheduling with Fuzzy also shows better optimum percentage that is with 100% average while in non fuzzy production scheduling is 97%.

1. Introduction
Genetic Algorithm (GA) is a heuristic algorithm based on natural selection mechanisms and natural genetics [3]. In previous studies GA has been used to solve scheduling problems, such as nurse scheduling at BeliMed Denpasar Hospital [2], and research on lecturer scheduling using Neighborhood Search method consisting of 3 algorithms namely Genetic Algorithm, Simulated Annealing, and Tabu Search algorithm [4]. GA is a popular algorithm and is often used to solve optimization problems [1]. Especially in the case of scheduling optimization. However, in production problem, there is uncertainty about the delay in the production process of goods (downtime) and the need for stock. In this case fuzzy applied as an optimization of the determination of actual stock on production scheduling with GA.

2. Theoretical Basis
2.1 Fuzzy Logic
Fuzzy logic is a concept that modeled the uncertainty in human reasoning. The first time the concept was introduced by Prof. Lotfi Astor Zadeh in a paper entitled 'Fuzzy Sets' in 1965, and since the mid-1970s this theory has also been successfully applied by Japanese researchers into practical problems. Zadeh in 1965 introduced the fuzzy concept as a means to describe complex systems. Fuzzy theory can help us in presenting and handling problems that contain elements of uncertainty [6].
2.1.1 Fuzzy Inference System
The inference stage is the transformation process of an input in the fuzzy domain to an output in the fuzzy domain. The transformation process in the inference section requires the fuzzy rules contained within the rule bases. Inference blocks use reasoning techniques to select rule and rule bases from knowledge base blocks. The reasoning technique used in this research is MAX-MIN reasoning technique that functions as the decision maker's logic. The technique is known as the Mamdani method [7].

2.1.2 Mamdani Method
The Mamdani method is one of the methods in Fuzzy Inference System (FIS) [7]. To produce the output, this method required 4 stages [8], namely: Fuzzy set up phase. In the fuzzification process the first step is to determine the fuzzy variable and fuzzy set. Application phase implication function that is use fungui min. Stage of the rule composition. The method used in the composition of rules, namely: max, additive and probabilistic OR. The last stage is affirmation (defuzzy). The defuzzy method used in this study is the method of centroid. In this method, the crisp solution is obtained by taking the center point of the fuzzy region. Mathematically the crisp solution can be determined by:

\[ z = \frac{\sum_{j=1}^{n} \mu(z_j)}{\sum_{j=1}^{n} \mu(z_j)} \]  

2.2 Genetic Algorithm (GA)
Genetic algorithms have been very popular used to solve complex optimization problems in the fields of physics, biology, economics, sociology and others. One application is the optimization of production scheduling in the field of manufacturing industry using genetic algorithm [9]. The main steps of the Genetic Algorithm process are as follows [10]:

- Generating a parent population of a number of chromosomes, determining the probability of crossover (Pc) and mutation Probability (Pm).
- Calculate Fitness of each generation. The fitness value of a chromosome describes the quality of the chromosome in that population. The fitness function can be seen in the following equation:

\[ \text{Fitness} = \frac{1}{1 + \text{fun}(\text{objet})} \]  

- Evaluate the solution. This process will evaluate each population by calculating the fitness value of each chromosome and evaluating it until it has met the stop criteria. If the stop criterion has not been met then it will continue with the marriage process.
- Crossover process. Determine the value of PC (Probability Crossover) and then determine the pairs of chromosomes that will be involved in the crossover process based on the value of the raised PC by using one of the crossover methods.
- Mutation Process. Determining the value of mutation rate, and then based on the value of the generated random number will be determined the genes involved in the mutation process.
- Making Child Chromosomes the result of the Crossover process and the mutation as a new population (offspring).
- Return to step 2 and repeat the process until the criteria are met

3. Research Methodology
This research process aims to get optimal production scheduling. In this study the authors compare two scheduling process, which one of them is scheduling with Genetic Algorithm and the other is scheduling with Fuzzy Genetic Algorithm.

3.1 Fuzzy Stock Processing Steps
The stages of the fuzzy stock process are the following:
- Input: the data that is input in this case is the ordering data.
• Fuzzification: this stage is to define fuzzy variables and fuzzy sets.
• Inference: at this stage is the fuzzy rule generation stage. This research uses one method of inference system at Mamdani that is Max, and the function of implication is min.
• Defuzzification: The method used in the defuzzification process is the centroid method, ie by the formula (1).

Fuzzy Stock process serves to make the stock of goods to be processed later on the process of genetic scheduling. Fuzzy Stock will produce the amount of stock for each product type. In the search for the amount of stock, this study uses the minimum data recaps and the maximum number of orders and the amount of downtime production (pd) obtained through research at PT. Medisafe Technologies.

3.2 Genetic Algorithm and Fuzzy Genetic Algorithm Processing Steps
The stages in the scheduling process with Fuzzy Genetic Algorithm is the same as Genetic Algorithm scheduling process, but before doing the scheduling phase with GA, firstly done the process of updating production data by reducing the amount of production data with actual stock that have been obtained from fuzzy process. Here is the different stages of the scheduling process with GA and Fuzzy Genetic Algorithm in pseudocode form:

| Production Scheduling Pseudocode with GA | Production Scheduling Pseudocode with Fuzzy Genetic Algorithm |
|-----------------------------------------|---------------------------------------------------------------|
| **Function**                           | **Function**                                                 |
| Scheduling Genetic Algorithm(population, Fitness) |
| → ProductionData {Input data order)   | Scheduling FuzzyGeneticAlgorithm(population, Fitness) |
| → Individu {individual formed by IDOrder, IDMesin, IDBahan, IDHari, IDWaktu, IDProduk} | → DataProduksi {Input data order) |
| → UpdateProductionData;                | → UpdateProductionData;                                      |
| Individu {individual formed by IDOrder, IDMesin, IDBahan, IDHari, IDWaktu, IDProduk} | |
| **Declaration**                        | **Declaration**                                             |
| i,x,y : Integer;                       | i,x,y : Integer;                                             |
| **algorithm**                          | **algorithm**                                               |
| Repeat                                 | Repeat                                                      |
| New_population ← 0;                    | New_population ← 0;                                          |
| Initialisation of penalties;          | Initialisation of penalties;                                |
| For i = 1 to size(population) do      | For i = 1 to size(population) do                             |
| x ← random selection (populasi, Fitness); | x ← random selection (populasi, Fitness);                   |
| y ← random selection (populasi, Fitness); | y ← random selection (populasi, Fitness);                   |
| child ← Reproduction by crossover (x,y) as big as Pc; | child ← Reproduction by crossover (x,y) as big as Pc; |
| if (SmallRandomProbability) then      | if (SmallRandomProbability) then                             |
| child ← Mutation (child);            | child ← Mutation (child);                                   |
| add child to new_population;          | add child to new_population;                                |
| until all individual makes fitness 1 or orders done; | until all individual makes fitness 1 or orders done; |
| return                                | return                                                      |
| Input best individual kedalam populasi based on Fitness value; | Input best individual kedalam populasi( based on Fitness value); |
| **Function** Reproduction by crossover (x,y : main individual) → individual | **Function** Reproduction by crossover (x,y : main individual) → individual |
| **Declaration**                        | **Declaration**                                             |
| **Algorithm**                         | **Algorithm**                                               |
| n ← Length (x);                       | n ← Length (x);                                             |
| c ← randomize numbers from 1 till n   | c ← randomize numbers from 1 till n                         |
| return Add (substring (x,1,c), substring (y, c + 1, n)) | return Add (substring (x,1,c), substring (y, c + 1, n)) |
4. Result and Discussion

4.1 View of Fuzzy Stock

Here is the view of amount of stock calculating process.

![Figure 4.1. Result stock calculation with fuzzy mamdani](image1)

The form above displays the results of stock calculations for each product type. The example data taken to calculate the stock is a recap of the number of orders and recap production data downtime (PD). The number of orders is the number of orders received in April 2016 to March 2017. While the DP (Downtime Production) is the number of unproduced or unfinished manufactured products caused by the downtime. PD is the result of data recapture in April 2016 until March 2017.

4.2 View of Production Scheduling Process

Production scheduling process with GA can be seen in Figure 4.2, while the production scheduling process with Fuzzy Genetic Algorithm can be seen in Figure 4.3.

![Figure 4.2. Production Scheduling Process with Genetic Algorithm](image2)
Figure 4.3. Production Scheduling Process with Fuzzy Genetic Algorithm

The picture above shows the results of the scheduling process using GA and Fuzzy Genetic Algorithm, where there is a number of chromosomes of 199 obtained from production data that is converted into coding form into chromosome-forming genes. The coding is IDOrder, IDHari, IDWaktu, IDBahan, IDProduk. The crossover Probability used in the crossover process is 70% or $P_c = 0.70$, and the mutation probability is 10% or $P_m = 0.01$.

Comparison of results obtained based on data testing using Genetic Algorithm and Fuzzy Genetic Algorithm, can be seen in Table 4.1. following:

|               | Production Scheduling with Genetic Algorithm | Production Scheduling with Fuzzy Genetic Algorithm |
|---------------|---------------------------------------------|--------------------------------------------------|
| Chromosomes   | 179 Chromosomes                             | 20 Chromosomes                                  |
| Optimum Percentage | 97%                      | 100%                             |
| Fitness Average     | 0.994                           | 1                                         |
| Iteration        | 34                                 | 1                                          |

From several experiments that run on production scheduling process with GA, and production scheduling process with Fuzzy Genetic Algorithm. The system shows different results between the two processes, including the number of chromosomes, the optimum percentage and the average fitness.

Difference The number of chromosomes is 179 chromosomes. The chromosome is formed from the number of incoming orders as much as 199 chromosomes sehingga on the process of production scheduling process with Genetic Algorithm / Non-Fuzzy, chromosome fixed numbered 199 chromosomes while the production scheduling process with Fuzzy Genetic Algorithm, the number of chromosomes to 20 chromosomes. This is because the number of incoming orders has been reduced by the amount of stock available. The stock is the result of fuzzy stock processing seen in Figure 4.1. The difference is also seen in the optimum percentage and average fitness. There is a 3% difference between the two methods. In the non-fuzzy scheduling process, the average optimum percentage generated is 97%, while in the production scheduling process with Fuzzy Genetic Algorithm the optimum percentage reaches 100%. The average fitness produced in the non-fuzzy scheduling process is 0.994, while in the production scheduling process with Fuzzy Genetic Algorithm is 1. Iteration on non-fuzzy scheduling process is 34 while in production scheduling process with Fuzzy Genetic Algorithm is 1.
5. Conclusions

From the results of research and discussion can be drawn some conclusions as follows:

1. Production scheduling with Fuzzy Genetic Algorithm shows faster process results. Seen from the iteration that occurs is 1 for scheduling with Fuzzy while on non fuzzy production scheduling, the process is completed in the 34th iteration.
2. Scheduling with Fuzzy also shows better optimum percentage result that is with 100% average while in non fuzzy 97% production scheduling.
3. The use of Fuzzy Stock on production scheduling is able to produce the optimal amount of stock so as to reduce the number of orders and the amount of production downtime available.

References

[1] A. Ansori and A.A. Bakar 2014 “A Comparative Study of Three Artificial Intelligence Techniques: Genetic Algorithm, Neural Network, and Fuzzy Logic, on Scheduling Problem”. Proceedings of 4th International Conference on Artificial Intelligence with Applications in Engineering and Technology, pp. 31-36.

[2] D.M.D.U. Putra and Subanar 2012 “Penerapan Algoritma Genetika untuk Menyelesaikan Permzasalahan Penjadwalan Perawat dengan Fuzzy Fitness Function”. IJCS 6(2): 11 – 22.

[3] N.K. Mawaddah and W.F. Mahmudy 2006 Optimasi Penjadwalan Ujian Menggunakan Algoritma Genetika. Kursor 2(2): 1-8.

[4] O.K. Sulaiman. “Optimasi Jadwal Perkuliahan Dosen Dengan Neighborhood Search Methods”, Thesis. Universitas Sumatera Utara. (diakses tanggal 15 Juli 2016)

[5] B. Hosseinzadeh, H. Zareiforoush, M.E. Adabi and A. Motevali. 2011 Development of a Fuzzy Model to Determine the Optimum Shear Strength of Wheat Stem. International Journal of Computer Science and Telecommunications 2(4): 56-60.

[6] E.H. Mamdani and S. Assilian 2011 “An Experiment in Linguistic Synthesis with a Fuzzy Logic Controller”, International Journal of Man Machine Studies 7(1): 1-13.

[7] S. Kusumadewi 2013 Artificial Intelligence (Teknik dan Aplikasinya). Graha Ilmu: (Yogyakarta).

[8] W.F. Mahmudy, R.M. Marian and L.H.S. Luong 2014 Hybrid genetic algorithms for part type selection and machine loading problems with alternative production plans in flexible manufacturing system. ECTI Transactions on Computer and Information Technology (ECTI-CIT) 8(1): 80-93.