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Performance comparison of genetic algorithms and particle swarm optimization for model integer programming bus timetabling problem

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Abstract. Genetic Algorithm (GA) is a common algorithm used to solve optimization problems with artificial intelligence approach. Similarly, the Particle Swarm Optimization (PSO) algorithm. Both algorithms have different advantages and disadvantages when applied to the case of optimization of the Model Integer Programming for Bus Timetabling Problem (MIPBTP), where in the case of MIPBTP will be found the optimal number of trips confronted with various constraints. The comparison results show that the PSO algorithm is superior in terms of complexity, accuracy, iteration and program simplicity in finding the optimal solution.

1. Introduction

The problem of optimal bus timetabling (or scheduling the trip of bus) is a matter of determining the number of bus departures by taking into account various bus operational constraints. Various bus scheduling models has been developed, one of them is through the integer programming model [1] which in the model has considered the constraints on the elements of manager and passengers. In the constraint managers elements include the number and capacity of the bus, the number and capacity of employees and the cost and travel time of the bus. In the passenger element of the model has paid attention to the number of passengers and minimum service standards that must be given to the passenger management.

The problem of integer programming has grown over the past 50 years. The problem can be categorized as NP-hard optimization problem. IP can be resolved precisely and also through an artificial intelligence based algorithm approximation. The exact problem of IP can be solved by the branch and bound method (B & B) which is the development algorithm of the simplex algorithm [2].

Artificial intelligence-based IP settlement can be solved with genetic algorithm and PSO. GA is a common algorithm used to solve cases of numerical optimization. This algorithm is based on artificial intelligence and uses the theory of life evolution as the basic idea of programming [3]. Particle Swarm Optimization is one of alternative algorithm to solve optimization problem. This algorithm puts forward the idea of colonizing from a bunch of feeding animals and can be used to solve integer programming problems [4]

The application of genetic algorithm has been done to solve the optimization problem of bus rapid transit. Among them can be found in [1], [5], [6], [7], [8] and [9]. The majority of these studies do not show the accuracy of GA with respect to the optimal solution. Research [1] reveals that the accuracy value reaches 99% with an opportunity to obtain a 100% accuracy value of 0.17. This raises new challenges to how to solve the problem of *Model Integer Programming for Bus Timetabling Problem*

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(***MIPBTP***) which will produce 100% accuracy with the chance of reaching an optimal solution approaching 1. So this study aims to find a better method to find MIPBTP solution. The PSO algorithm itself is a rarely optimized optimization algorithm for solving optimization in the case of Bus Timetabling Problem [10] & [11]. Both of the above approximation algorithms have different advantages and disadvantages in their application in the integer programming model in the case of bus time tables. This paper will discuss the performance of GA and PSO in MIPBTP. This paper provides a contribution to better algorithm recommendations of solving MIPBTP.

2. Research Method

The model used is linear programming integer model [1]. The data used in this experiment are real to existing BRT service in Bogor (Indonesia) and generated data to see various cases in progress using GA and PSO. The GA concept used is according to the study [1] with the flowchart as follows:

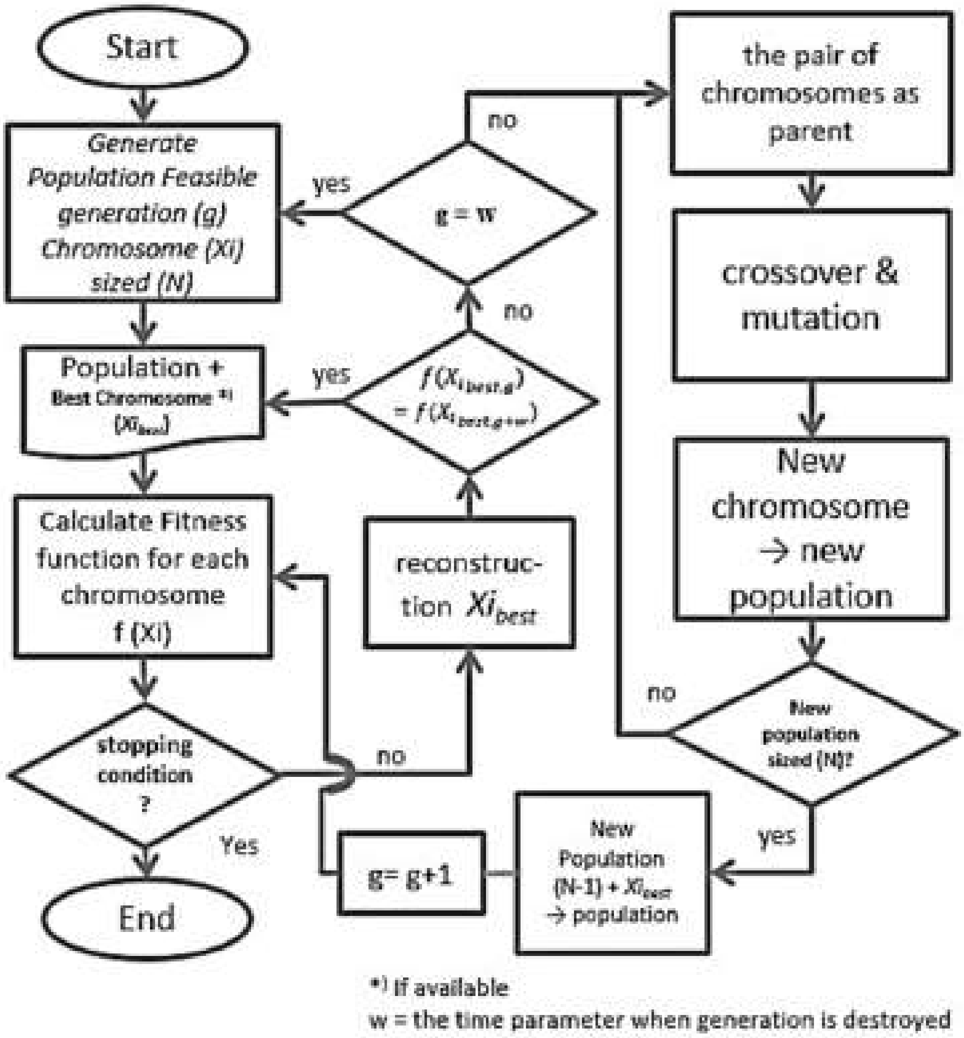

Figure 1. The GA Concept for MIPBTP

The concept of the PSO used is the development of the concept [4] modified according to the needs of model [1] with the result according to the flowchart in Figure 2:

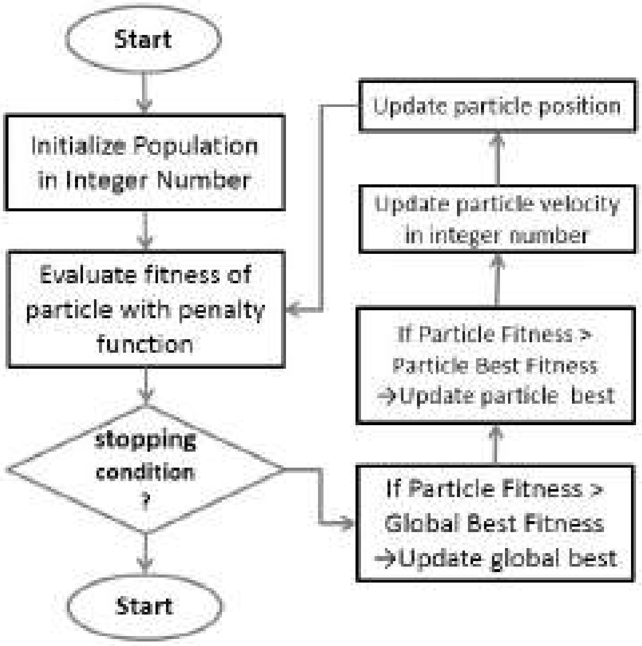

Figure 2. The PSO Concept for MIPBTP

In the initialization phase the vector is generated in the form of an integer. The process of particle movement is a rounded integer of the result rounding down so that it will produce a change of particle position which is also an integer. The evaluation process uses a penalty function where any constraints that are violated will reduce the value of the objective function. The parameter of the penalty function used is similar to the study [1]. Comparison is done by looking at the performance of each algorithm in reaching the optimal solution to the case of the number of variables and constraints on the category of small, medium (real data) and large. Trials in small and large categories use generated data for MIPBTP. In the small category use 2 variables and 6 constraints. While on a large scale used 100 variables and 202 constraints. In the medium category used real data onto 18 variables and 38 constraints.

3. Results and Analysis

The graph of the result of GA implementation in the case of the best solution according to the research [1] can be seen in Figure 3. The image shows the optimal solution improvement to reach the optimum point in each generation (iteration). The red line indicates the average optimal solution found for a set of generation (iterations) when the red line reaches the bottom point indicates that there is a process of population annihilation. The blue line shows the best fitness value of each generation.

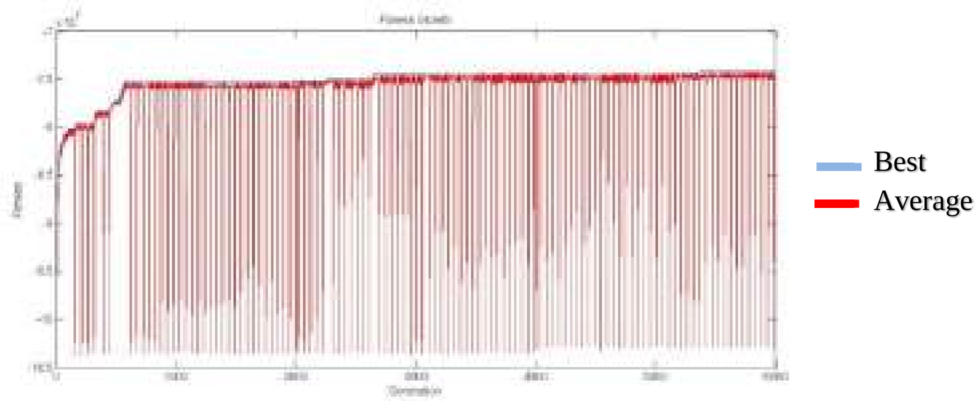

Figure 3. Best Results of Real Data MIPBTP with GA

The result of swarm movement towards 4000 iterations in finding the optimal solution can be seen in the Figure 4. This illustration uses the transformation function $f : x^{18} \rightarrow x^2$.

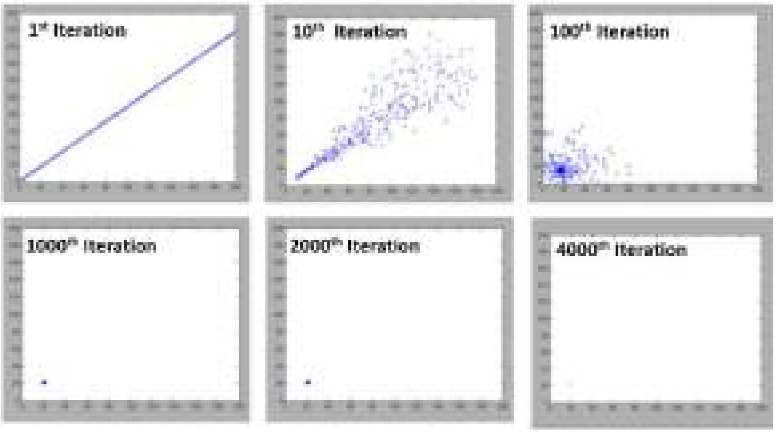

Figure 4. Particle Movement in Order To Find Optimum Solution of Real Data MIPBTP

The comparison performance of GA and PSO based on the number of iterations and the accuracy to get optimal solution in real data of MIPBTP can be see in the following graphics:

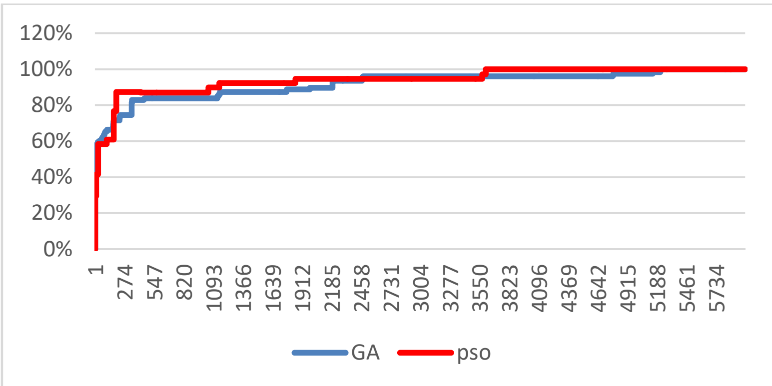

Figure 5. Comparison of GA and PSO Accuracy Charts

From the graph it is seen that the PSO algorithm is superior in terms of speed to reach the optimal solution. The difference between iteration in terms of achieving an optimal solution to 1567 iterations. Both algorithms have achieved the optimal solution. However, the GA probability of obtaining an optimal solution to 0.17% with an average accuracy of 99% [1] is different from the PSO which always got the solution to 100% accuracy. The trial results for MIPBTP case resolution from several categories can be seen to the following table.

Table 1. Comparison of GA and PSO Performance

	Small	Medium	Big
Variable	2	18	100
Constrain	6	38	202
Data	Generate	Real	Generate
Iteration	600	6000	60000

	Small		Medium		Big	
Result	Average Accuracy	Best Iteration	Average Accuracy	Best Iteration	Average Accuracy	Best Iteration
GA	100%	49	99%	5221	93%	56743
PSO	100%	52	100%	3654	100%	44711

In Table 1 it is seen that there is no significant difference when using GA and PSO for cases with relatively small data. The decrease in accuracy of GA is seen when the number of variables increases. Some chromosome extermination techniques (or population destruction techniques) are required to keep accuracy high. This technique is done when the best fitness value of one generation does not change until the specified time. In this case the fitness value of one generation reaches the saturation point, so that chromosomal destruction of that generation is done, except the best chromosome. then the best chromosomes are added to the new N-1 chromosome population. This process continues in GA until it reaches the termination criteria. This technique is able to improve accuracy even though GA is not always able to find the optimal solution to each iteration on a medium and large scale. In contrast to GA, PSO has a stable condition in finding the optimal solution. No need to add population destruction techniques (as in genetic algorithms that have to destruct populations that have saturated at certain iterations to improve their accuracy), PSO is able to get optimal solutions in various conditions. In summary the results of the comparison of the two algorithms in terms of complexity, iteration and accuracy on MIPBTP can be seen in the following table.

Table 2. Summary of Comparative Results

Indicator	GA	PSO
Complexity	$O(n^2)$	$O(n)$
Accuracy	Solutions in large variables and constraints result in feasible solutions that are near optimal	Resolution produces the optimal solution
Iterate	The more variables and constraints, the more iterations required. In general, it takes much more than the PSO	The more variables and constraints, the more iterations required. Generally, it takes fewer iterations of the GA
Additional techniques used	It takes the addition of chromosome extermination techniques in certain generations in order to approach the optimum solution	No additional techniques

4. Conclusion

The results of GA and PSO implementation in the bus timetabling problem show that the PSO algorithm is superior in finding the optimal solution in terms of accuracy and iteration. In addition the PSO algorithm is also superior to the simplicity of the techniques used. For small scale there is no significant difference between the two methods. Differences are seen in medium and large scale where genetic algorithms can only produce feasible solutions that are near optimal. PSO algorithm has ease of implementation and also has high calculation accuracy.

References

[1] Wihartiko FD, Buono A and Silalahi BP, *Integer programming model for optimizing bus timetable using genetic algorithm*. IOP Conference Series: Materials Science and Engineering. 166(1) 1-9 (2017)
[2] Genova K and Guliashki V, *Linear Integer Programming Methods and Approaches – A Surve*y, Cybernetics and Information Technologies 11(1) 3-25 (2011)
[3] Huy PNA, San CTB and Triantaphyllou E. *Solving Integer Programming Problems Using Genetic Algorithms*. ICEIC. Ha-Noi. (2004).
[4] E.C. Laskari, K.E. Parsopoulos and M.N. Vrahatis, *Particle Swarm Optimization for Integer Programming*. IEEE. (2002).
[5] Chuanjiao S, Wei Z, Yuanqing W. Scheduling Combination and Headway Optimization of Bus

Rapid Transit. *Journal of Transportation Systems Engineering and Information Technology*. 2008; 8(5): 61–67
[6] Kidwai FA. *A Genetic Algorithm Based Bus Schedulling Model for Transit Network*. Eastern Asia Society for Transportation Studies. Bangkok. 2005; 05: 477–489
[7] Zhang M. *The Research on Multi-objective School Bus Vehicle Routing Problems Based On Bi-level Programming*. Chengdu, China: Southwest Jiaotong University; 2008.
[8] Ben Sghaier S, Ben Guedria N, Mraihi R, editors. *Solving School Bus Routing Problem with genetic algorithm*. Advanced Logistics and Transport (ICALT), 2013 International Conference on; 2013: IEEE. pp. 7–12.
[9] Minocha B, Tripathi S, editors. *Solving School Bus Routing Problem Using Hybrid Genetic Algorithm: A Case Study*. Proceedings of the Second International Conference on Soft Computing for Problem Solving (SocProS 2012), December 28–30, 2012; 2014: Springer. pp. 93–103.
[10] Zhang Y, Wang S, and Ji1 G, A *Comprehensive Survey on Particle Swarm Optimization Algorithm and Its Applications*. Hindawi Publishing Corporation Volume 2015, Article ID 931256, 38 page
[11] Ab Wahab MN, Nefti-Meziani S, Atyabi A (2015) A Comprehensive Review of Swarm Optimization Algorithms. PLoS ONE 10(5): e0122827. doi:10.1371/journal.pone.0122827