CHAPTER 5
CONCLUSION

5.1. Conclusion

This research evaluated two optimization algorithms, Genetic Algorithm (GA) and Firefly Algorithm (FA), both enhanced with K-Means clustering, to solve the Traveling Salesman Problem (TSP). Both algorithms demonstrated good performance in finding optimal solutions, with distinct characteristics based on the problem's complexity. GA exhibited slower computational time with fewer clusters (1-5), this is due to it's broader search space, but as the number of clusters increased (10-15), it became more efficient, achieving a travel distance of 407.871.

FA, on the other hand, showed its strength with larger clusters (15-25). Although it took longer than GA in smaller clusters, it's swarm-based nature allowed it to explore the solution space more thoroughly, leading to highly optimized solutions. The optimal route for FA achieved a travel distance of 418.665. FA is better suited for more complex problems, where extensive exploration is needed, despite its higher computational cost.

While both algorithms benefit from clustering to enhance optimization, excessive clustering can lead to inefficient solutions. This occurs due to fragmented routes and excessive inter-cluster travel. Therefore, while clustering can improve optimization, it's important to avoid over-clustering to maintain a balance between exploration and exploitation and prevent inefficiencies

For further research, the researcher suggests using advanced parameter tuning methods, such as grid search or Bayesian optimization to optimize the hyperparameters of both GA and FA, and exploring a hybrid approach that combines the strengths of GA and FA. Since this study is limited to a cluster size of 25 due to computational constraints, future research could explore larger cluster sizes to determine if the optimal route lies in higher cluster counts. This would also help avoid local minima and ensure the discovery of the global minimum.

REFERENCES

[1] W. A. Khan, N. N. Hamadneh, S. L. Tilahun, and J. M. T. Ngnotchouye, "A Review and Comparative Study of Firefly Algorithm and its Modified Versions," in *Optimization Algorithms - Methods and Applications*, O. Baskan, Ed., InTech, 2016. doi: 10.5772/62472.

[2] M. F. N. Ni'am and N. Hamid, "Penerapan K-means dan Algoritma Genetika untuk Menyelesaikan Multiple Traveling Salesman Problem," vol. 13, 2023.

[3] A. Jaradat, B. Matalkeh, and W. Diabat, "Solving Traveling Salesman Problem using Firefly algorithm and K-means Clustering," in *2019 IEEE Jordan International Joint Conference on Electrical Engineering and Information Technology (JEEIT)*, Amman, Jordan: IEEE, Apr. 2019, pp. 586–589. doi: 10.1109/JEEIT.2019.8717463.

[4] S. E. Fradina and F. Y. Saptaningtyas, "PENERAPAN ALGORITMA SWEEP DAN ALGORITMA GENETIKA PADA PENYELESAIAN CAPACITATED VEHICLE ROUTING PROBLEM (CVRP) UNTUK OPTIMASI PENDISTRIBUSIAN GULA".

[5] A. Alexander and H. Sriwindono, "The Comparison of Genetic Algorithm and Ant Colony Optimization in Completing Travelling Salesman Problem," in *Proceedings of the 2nd International Conference of Science and Technology for the Internet of Things, ICSTI 2019, September 3rd 2019, Yogyakarta, Indonesia*, Yogyakarta, Indonesia: EAI, 2020. doi: 10.4108/eai.20-9-2019.2292121.

[6] Y. Sibaroni, S. S. Prasetiyowati, M. P. Fairuz, M. Damar, and R. Salis, "Performance Analysis of ACO and FA Algorithms on Parameter Variation Scenarios in Determining Alternative Routes for Cars as a Solution to Traffic Jams," *J. Online Inform.*, vol. 7, no. 1, p. 97, Jun. 2022, doi: 10.15575/join.v7i1.797.

[7] E. Osaba, X.-S. Yang, F. Diaz, E. Onieva, A. D. Masegosa, and A. Perallos, "A discrete firefly algorithm to solve a rich vehicle routing problem modelling a newspaper distribution system with recycling policy," *Soft Comput.*, vol. 21, no. 18, pp. 5295–5308, Sep. 2017, doi: 10.1007/s00500-016-2114-1.

[8] Y. Pulhani, A. S. Kang, and V. Sharma, "Performance analysis on self organization based clustering scheme for FANETs using K-means algorithm and firefly optimization," *Int. J. Inform. Commun. Technol. IJ-ICT*, vol. 11, no. 2, p. 148, Aug. 2022, doi: 10.11591/ijict.v11i2.pp148-159.

[9] N. Bacanin, K. Venkatachalam, T. Bezdan, M. Zivkovic, and M. Abouhawwash, "A novel firefly algorithm approach for efficient feature selection with COVID-19 dataset,"

Microprocess. Microsyst., vol. 98, p. 104778, Apr. 2023, doi: 10.1016/j.micpro.2023.104778.

[10] T. B. Chandrawati, A. A. P. Ratna, and R. F. Sari, "The development of Firefly algorithm with fuzzy logic integration for priority search simulation of flood evacuation routes," *East.-Eur. J. Enterp. Technol.*, vol. 1, no. 4 (115), pp. 66–76, Feb. 2022, doi: 10.15587/1729-4061.2022.252917.

[11] A. Y. Nugroho, A. Suyitno, and R. Arifudin, "PERBANDINGAN ALGORITMA BRANCH AND BOUND DAN ALGORITMA GENETIKA UNTUK MENGATASI TRAVELLING SALESMAN PROBLEM," 2016.

[12] N. I. Manik, Y. Nursalim, and D. Suhartono, "DESIGN OF OPTIMAL DISTRIBUTION APPLICATION USING FIREFLY ALGORITHM," vol. 8, no. 3, 2017.

[13] C. Sharma, "Travelling Salesman Problem Optimisation Using Genetic Algorithm and Parameter Tuning".

[14] O. I. R. Farisi, B. Setiyono, and R. I. Danandjojo, "A hybrid approach to multi-depot multiple traveling salesman problem based on firefly algorithm and ant colony optimization," *IAES Int. J. Artif. Intell. IJ-AI*, vol. 10, no. 4, p. 910, Dec. 2021, doi: 10.11591/ijai.v10.i4.pp910-918.