

# HYBRID METAHEURISTICS AND MACHINE LEARNING METHODS

DIRECTEUR DE THESE : LHASSANE IDOUMGHAR

CO-ENCADRANTS : MAHMOUD GOLABI, ABDENNOUR AZERINE, LAURENT MOALIC

INSTITUT IRIMAS, 12 RUE DES FRERES LUMIERE 68200 MULHOUSE

TÉL : 06 99 90 70 33 / E-MAIL : [LHASSANE.IDOUMGHAR@UHA.FR](mailto:LHASSANE.IDOUMGHAR@UHA.FR)

Solving large-scale optimization problems requires approximate methods, particularly metaheuristics, which provide high-quality solutions within reasonable computational times. These methods have demonstrated their efficacy in a wide range of academic and industrial fields, including healthcare, automotive engineering, telecommunications, finance, and energy systems.

Despite their versatility, metaheuristics require manual parameter tuning and problem-specific adaptations, which demand significant expertise. Hybridization with other optimization techniques [1], including exact methods [2], has been explored to improve their performance. However, these approaches remain largely static, relying on predefined rules and empirical configurations, limiting their adaptability across different problem landscapes.

A promising direction is the integration of Artificial Intelligence (AI) and Machine Learning (ML) to make metaheuristics more adaptive, autonomous, and efficient. AI and ML can enhance metaheuristics by automating algorithm selection [3], guiding initialization strategies [4], estimating fitness functions [5], dynamically adjusting parameters [6], and designing adaptive search strategies [7] to improve efficiency and solution quality.

Nevertheless, several fundamental questions remain: How can different approaches be combined dynamically? When should a particular strategy be applied? How can hyperparameters be optimized in real time? How can learning mechanisms improve search efficiency and scalability?

This Ph.D. thesis aims to address these questions by designing next-generation AI-enhanced metaheuristics, capable of self-adaptation, intelligent decision-making, and improved computational performance. The expected outcome is a new class of efficient, scalable, and self-improving optimization methods tailored to tackle complex real-world problems.

## REFERENCES

1. Zaimen, K., Moalic, L., Abouaissa, A., & Idoumghar, L. (2024, April). A Hybrid Binary Grey Wolf Optimiser for WSN Deployment in Indoor Environments Based on BIM Database. In *2024 IEEE Wireless Communications and Networking Conference (WCNC)* (pp. 1-6). IEEE. [10.1109/WCNC57260.2024.10570720](https://doi.org/10.1109/WCNC57260.2024.10570720)
2. Azerine, A., Oulamara, A., Basset, M., & Idoumghar, L. (2024, June). Improved Methods for Solving the Electric Vehicle Charging Scheduling Problem to Maximize the Delive. In *2024 IEEE Congress on Evolutionary Computation (CEC)* (pp. 1-8). IEEE. [10.1109/CEC60901.2024.10611957](https://doi.org/10.1109/CEC60901.2024.10611957)
3. Kerschke, P., Hoos, H. H., Neumann, F., & Trautmann, H. (2019). Automated algorithm selection: Survey and perspectives. *Evolutionary computation*, 27(1), 3-45. [10.1162/evco\\_a\\_00242](https://doi.org/10.1162/evco_a_00242)
4. Rakhshani, H., Keedwell, E., Brevilliers, M., Lepagnot, J., & Idoumghar, L. (2018, October). A novel population initialization method based on support vector machine. In *2018 IEEE International Conference on Systems, Man, and Cybernetics (SMC)* (pp. 751-756). IEEE. [10.1109/SMC.2018.00136](https://doi.org/10.1109/SMC.2018.00136)
5. Sulaman, M., Golabi, M., Essaid, M., Lepagnot, J., Brévilliers, M., & Idoumghar, L. (2024). Surrogate-assisted metaheuristics for the facility location problem with distributed demands on network edges. *Computers & Industrial Engineering*, 188, 109931. <https://doi.org/10.1016/j.cie.2024.109931>
6. Quevedo, J., Abdelatti, M., Imani, F., & Sodhi, M. (2021, July). Using reinforcement learning for tuning genetic algorithms. In *Proceedings of the Genetic and Evolutionary Computation Conference Companion* (pp. 1503-1507) <https://doi.org/10.1145/3449726.3463203>
7. Durgut, R., Aydin, M. E., & Atli, I. (2021). Adaptive operator selection with reinforcement learning. *Information Sciences*, 581, 773-790. <https://doi.org/10.1016/j.ins.2021.10.025>