NAT-DL: Self-study: NFL and bio-inspired computing Set 5 (week 7)

1. What are the implications of the NFL theorem for MHO? In order to discuss this question, assume that you are producing a comprehensive MHO software package that is meant to solve a large variety of problems for its users e.g. in logistics, IT, or finance.

2. There are a number of algorithms, search spaces and conditions that may seem to provide an escape from the No-Free-Lunch theorem. Discuss whether any of the following cases can lead to a free lunch (and also try to find other potential exceptions). Here, the question is not whether an optimisation problem will actually be solved, but whether there is a chance to get at least a small advantage over a random walk on average over all problems. Consider, however, that, if in some of the cases below the NFL theorem does not apply, then this does not automatically mean that there is a free lunch.
   a. Resampling algorithms, i.e. algorithms that do not check whether they have sampled a point already.
   b. Deterministic algorithms compared to stochastic algorithms.
   c. The *co-evolutionary* case where two algorithms are searching independently on the same problem and exchange the information about the next state and the fitness of the state after each iteration.
   d. An unknown algorithm produces samples and the tested algorithm is supposed to predict which sample the unknown algorithm will choose next. Can there be an algorithm that is better than others in emulating the unknown algorithm when averaged over all unknown algorithms?
   e. The case of a continuous search space, such as PSO.
   f. The case of an unbounded discrete search space (e.g. the set of natural numbers)
   g. The case of a small discrete problem where all fitness values can be evaluated.
   h. Memetic algorithms: Algorithm A chooses one algorithm from a set of algorithms, e.g. A can choose either A_1 or A_2 after sampling a certain number of fitness values.
   i. The case of an algorithm with critical parameter values (see e.g. DE or PSO) as compared to other parameter settings.
   j. A genetic algorithm with a diverse population compared to the case of a redundant population.
   k. An algorithm with a perfect balance of exploration and exploitation.
   l. The set of all real-world optimisation problems that have ever been studied.

3. Try to adapt the island model of GA to ACO algorithms. Given a set of ant colonies connected by a given topology, which strategies can be applied to exchange information between the colonies? Specify the integration procedure of the information received in the destination colony. [From E. Talbi, Metaheuristics]

4. A Lévy flight is a random walk with a diverging variance. Lévy flights were shown to provide suitable models for animal foraging behaviour. They have also been used in several MHO algorithms, e.g. Cuckoo search. Under what conditions is this type of exploration useful?

5. Choose one of the following papers (or, if you prefer, a similar one, e.g. from this list https://en.wikipedia.org/wiki/Table_of_metaheuristics). There is no need here to read your paper in depth, just make sure that you can briefly explain its main idea in class within 2 mins. You can choose to tell about (or to ignore) the respective biological inspiration or the algorithm. Likewise, you can discuss whether the algorithm is related to any of the main MHO algorithms that we have discussed so far.

    - Maziar Yazdani and Fariborz Jolai. “Lion optimization algorithm (LOA): A nature-inspired metaheuristic algorithm”. Journal Comput. Design and Engineering 3.1 (2016), 24–36.
    - Marko Mitić et al. “Chaotic fruit fly optimization algorithm”. Knowledge-Based Systems 89 (2015), 446–458.
    - Gai-Ge Wang et al. “A new metaheuristic optimisation algorithm motivated by elephant herding behaviour”. Int. Journal of Bio-Inspired Computation 8.6 (2016), 394–409.
    - Gai-Ge Wang, Suash Deb, and Leandro Dos Santos Coelho. “Earthworm optimisation algorithm: A bio-inspired metaheuristic algorithm for global optimisation problems”. International Journal of Bio-Inspired Computation 12.1 (2018), 1–22.
    - Xin-She Yang, Mehmet Karamanoglu, and Xingshi He. “Flower pollination algorithm: a novel approach for multiobjective optimization”. Engin. Optimiz. 46.9 (2014), 1222–1237.
    - Seyedali Mirjalili and Andrew Lewis. “The whale optimization algorithm”. Advances in Engineering Software 95 (2016), 51–67.
    - Ekrem Duman, Mitat Uysal, and Ali Fuat Alkaya. “Migrating Birds Optimization: A new metaheuristic approach and its performance on quadratic assignment problem”. Information Sciences 217 (2012), 65–77.
    - Gai-Ge Wang, Amir H Gandomi, and Amir H Alavi. “An effective krill herd algorithm with migration operator in biogeography-based optimization”. Applied Mathematical Modelling 38.9-10 (2014), 2454–2462.
    - Jose Orellana and Ricardo Contreras. “Bacterial resistance algorithm”. Int. Workconf. Interplay Between Natural and Artificial Computation, Springer (2019), 204-211.

See also: Nader Behdad (2022) Review: Metaheuristic Optimization Algorithms. Int. J. Computer Applications, **184** (30) 33-38.

As well as: Camacho-Villalón, C.L., Dorigo, M. and Stützle, T., 2023. Exposing the grey wolf, moth-flame, whale, firefly, bat, and antlion algorithms: Six misleading optimization techniques inspired by bestial metaphors. *Int. Transact. Operat. Res.* **30**(6), 2945-2971.