

Discrete Bacterial Memetic Evolutionary Algorithms for Solving High Complexity Problems

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Evolutionary algorithms attempt to copy the solutions nature offers for solving (in the quasi-optimal sense) intractable problems, whose exact mathematical solution is impossible. The prototype of such algorithms is the Genetic Algorithm, which is, however rather slow and often does not find a sufficient solution. Nawa and Furuhashi proposed a more efficient modified one, under the name of Bacterial Evolutionary Algorithm (BEA). Moscato proposed the combination of evolutionary global search with nested local search based on traditional optimization techniques, and called the new approach memetic algorithm (MA).

Our group started to combine BEA with Levenberg-Marquardt local search and we obtained very good results on a series of benchmarks. The next step was to apply the new type of MA for NP-hard discrete optimization, starting with the classic and well known Traveling Salesman Problem (TSP), applying discrete local search, and thus proposing the novel Discrete Bacterial Memetic Evolutionary Algorithm (DBMEA). Then, we continued with a series of related, but mathematically different graph search problems, applying the same approach. Although we could not improve the tailor made Helsgaun-Lin-Kernighan (HLK) heuristics for the basic TSP, we got comparably good results, and in some other problem cases, we obtained new, so far the best accuracy and running time combinations. The Traveling Repairman Problem is an eminent example, where DBMEA delivers the best solutions.

The advantages of the new approach are as follows:

- General applicability. With minimal adaptation to the concrete problem type the same method could be successfully applied, there was no need to construct new tailor made algorithms for every new problem
- Predictability. Knowing the problem size, it was easy to give a good estimation of the running time, assuming a certain accuracy. This is not true for any of the other approaches, including the HLK, and especially not true for other methods, finding approximate solutions (often with large error)

In the talk, several examples will be presented with standard benchmarks going up to large numbers of graph nodes, and the DBMEA results will be compared with the best practices from the literature. The predictability feature will also be illustrated by size-running time graphs.

Reference will be made to the importance of determining the initial population in achieving fast and accurate results. A new approach, the Bounded Radius Heuristics will be presented.

In the last part of the talk, a series of fuzzy extensions of the Time Dependent TSP (TD TSP) will be introduced, an extension of the TSP with real life aspects where the natural fluctuation of the traffic in certain areas causes non-deterministic features causing additional difficulties in the quasi-optimization. The novel extensions will be also tackled with the DBMEA approach successfully.

As a conclusion, one more example will be mentioned where the discrete NP-hard problem is of a rather different nature, and it will be shown that by changing the local search technique appropriately, DBMEA can still deliver superior results.