SC42050 Literature Assignment

No Free Lunch Theorems for Optimization

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Optimization is considered to be the underlying principle of learning. In the area of control, one might want a robot to learn a specific task, and the learning task is usually formulated as an optimization problem. Optimization involves two ingredients: 1) the cost function to optimize; 2) and the optimizer itself. Given the problem we would like to choose the "best" optimization algorithm. Of course, some algorithms may be preferred because of their sample efficiency, others because of the type of data they use (discrete, continuous), some have shorter wall clock time, etc. But can we say something more general about our choice? Something that does not really depend on the algorithm itself? No Free Lunch theorems provide answers to these questions. After reading (Wolpert and Macready, 1997) answer the following questions:

1. Perform a short literature survey on the following topics.

   1a) Deterministic and stochastic optimization. Explain in details any two optimization algorithms, e.g. hill-climbing algorithm, simulated annealing, tabu search, genetic algorithm, etc.

   1b) Static and time-dependent optimization problems (and 2-3 examples)

   1c) Travelling salesman problem

   1d) Prior probability or simply prior (and 2-3 examples). Can you find some examples in the nature?

2. Given the two algorithms you have explained in 1a), give examples of possibly "good" and "bad" cost functions, i.e. functions on which you expect the performance to be "good" and "bad", respectively. Why do they perform differently? Can you hypothesise about the way to improve the performance on these "bad" problems? Why do you think the performance will improve? Will it affect the performance on the "good" problems? Does this improvement contradict with Theorem 1?

3. Imagine that you are trying to optimize some cost function. At first, you know nothing about it, but you can investigate some properties of it. What would be your steps to find the solution to the problem? Support your steps with what you have learnt from the referenced paper and those which you included in the short literature survey in 1.

References

Wolpert, D. H. and Macready, W. G. (1997). No free lunch theorems for optimization. *IEEE Transactions on Evolutionary Computation*, 1(1):67–82.