

Complexity Science mini-project: Multiobjective Simulation Analysis

Background: Simulation is an important tool for understanding complex systems, because it allows revealing and measuring emergent properties that are otherwise difficult to capture. Therefore, simulation is often used to compare different possible configurations of a complex system, with the aim to identify the best alternative. Examples include staffing levels at call centres, dispatching rules in manufacturing, or different mechanical designs in engineering.

If the simulation is stochastic, multiple runs need to be performed to be able to decide, with sufficient confidence, that one system configuration is better than another. However, simulations are time consuming. The research field concerned with identifying the best system configuration using the least number of simulation runs is known as “Ranking and Selection”.

Many real-world problems have multiple conflicting objectives. For example in finance, one would like to invest in a portfolio of assets with high expected return but also low risk. Since it is generally difficult for a decision maker to weigh the different criteria before alternatives are known, one popular approach is to search for all efficient, Pareto-optimal solutions (solutions where there is no solution better in all criteria) and let the decision maker choose among those.

Mini-project: The aim of this project is to develop a ranking & selection algorithm for the case where one objective is deterministic (e.g., the amount of money invested), while the other is stochastic (e.g., the achieved throughput of the factory). For example, given a set of alternatives with different (known) investment, identify the solutions that are Pareto-optimal according to investment and throughput. [1] proposes an algorithm that makes first steps in this direction, but falls short of identifying all Pareto-optimal solutions.

PhD prospect: Ranking & Selection is currently a very hot research topic, as it has many practical applications in understanding complex systems and decision making. There are many avenues to extend this work. One particularly interesting area is multi-objective simulation-optimization, where there are far more alternatives than can be tested. A key question to look at would then be whether computational effort should rather be spent on comparing more solutions, or on evaluating solutions more accurately.

Deliverables:

Algorithm to efficiently identify the Pareto-optimal solutions from a larger set of solutions for a problem with one deterministic and one stochastic criterion.

References:

[1] Yan/Zhou/Chen: “Efficient simulation budget allocation for selecting the best set of simplest good enough designs.”, Winter Simulation Conference, 2010

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