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Principled Modelling Of The Google Hash Code Problems For Meta-Heuristics

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Abstract

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Chapter 1

Introduction

"I've got a bad feeling about this..."
— Han Solo*, Star Wars*

1.1 Motivation

Optimization (O) problems are ubiquitous in real-world scenarios. Consider, for example, the task planning a road trip, which involves various optimization challenges. These range from selecting the best route considering factors like fuel efficiency, travel time, and budget limitations, to efficiently packing luggage. Solving these problems entails finding good feasible solutions, ideally in most time-efficient manner possible.

Tackling an optimization problem typically begins by understanding the problem and its details. Then, a strategy is employed to solve the problem. This highlights the two main steps: first, describing the problem's details to construct a representation (model), and second, using the gathered information to employ a strategy (solver) aimed at discovering feasible solutions.

In fact, this approach serves as the foundation for one of the most widely employed methods used to address optimization problems, wherein a standard mathematical formulation (model) describing the problem is developed. Subsequently, one of the numerous available generic solvers, such as the "simplex" algorithm, is utilized to find solutions. Notably, "simplex", being an exact solver, ensures the optimality of the obtained solutions.

Although this method for solving optimization problems is clearly established in the community there is recently growing interest in how to employ heuristic and meta-heuristic strategies to solve these problems, specifically, in the Combinatorial Optimization (CO) field.

Heuristic (H) methods are a set of, often problem-specific, procedures that attempt to quickly solve a problem and provide a helpful "rule of thumb" for achieving reasonably good results, usually in a greedy fashion. Meta-Heuristic (MH) methods combine several subordinate heuristics thus being more generic and can be applied to broad a range of problems. Natural processes and phenomena, such as collective behavior, natural selection, and some physical properties of materials, inspire several meta-heuristic search processes making them flexible and adaptable, although more computationally intensive than more conventional heuristics. Remarkably, both strategies are generally more time-efficient than exact approaches, though without an associated guarantee of optimality.

Given the nature of Heuristic and Meta-Heuristic methods, and the inherent diversity of problems, crafting universal meta-heuristic solvers is challenging. Unlike mathematical optimization, there's no established modelling framework for meta-heuristics that follows the same principled approach, possibly due to skepticism about its feasibility and effectiveness.

The establishment of this framework would standardize problem-solving approaches, facilitate the reuse of meta-heuristic methods, and distinctly separate the tasks of problem modeling and solver development. Moreover, it would provide researchers and practitioners with a useful tool to experimentally assess the performance of Meta-Heuristic methods across a range of diverse problems.

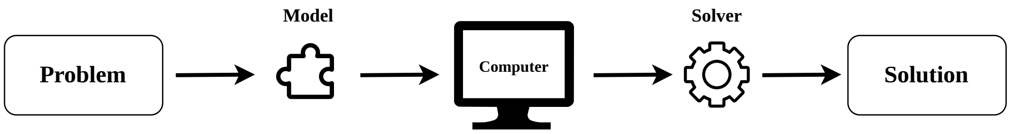

Figure 1.1: Modelling and Problem Solving

In summary, the concept of a modeling framework for problem tackling can be visually depicted as shown in Figure 1.1. For a given problem, a computational model that describes the problem is generated and provided to a machine, which then employs a meta-heuristic solver to acquire solutions. This approach is built upon prior work [1, 2] that has initiated the formalization of this objective.

Simultaneously, alongside the development and application of meta-heuristic strategies to address combinatorial optimization problems, there exists a community interest in constructing a collection of benchmark optimization problems that hold both theoretical and practical significance. The Google Hash Code Competition problems, arguably, present themselves as suitable candidates.

The Hash Code programming competition, formerly hosted annually by Google, challenged teams of up to four members to solve intricate problems within a four-hour time frame. Participants were allowed to use any tools, resources, and programming languages of their choice. These problems often drew inspiration from real-world issues and engineering challenges, such as vehicle routing, task scheduling, and Wi-Fi router placement. Essentially, can be classified as "open" research problems. Importantly, if not entirely, the majority of these problems can be classified as Combinatorial Optimization problems.

Given the pertinence of these problems, they serve as apt benchmarks for the evaluation of meta-heuristics. Moreover, they offer a suitable approach to assess the feasibility of the aforementioned principled modeling approach. Not only do these problems present challenges from theoretical and practical standpoints, but they are also have well written and detailed statements. The competition context in which they were presented also provides a wealth of empirical data regarding the best solutions attained thus far.

1.2 Goals & Scope

1.3 Contribution

1.4 Software

1.5 Outline

Acronyms

AC Adaptive Computation. ii

ALGO Algorithms and Optimization Laboratory. ii

CISUC Centre for Informatics and Systems of the University of Coimbra. ii

CO Combinatorial Optimization. 1, 2

FCT Foundation for Science and Technology. ii

H Heuristic. 1, 2

MH Meta-Heuristic. 1, 2

O Optimization. 1

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