Original Article: Theory and Computer Programming for the Optimization of Combinatorial Problems

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ABSTRACT

Combinatorial optimization problems go through several applications such as task scheduling and resources allocation, where an optimal element is to be determined from the analysis of computational complexity, which characterizes the optimality as best solution from feasible regions by objective functions. Some decision-making problems can be solved by surface scanning as it is in dynamic programming technique, where optimal solutions come by simple segmentation operations. Many algorithms on decision tree C4.5 and logical clustering to search solution space use dynamic programming. In this paper, optimization techniques and mathematical modeling for solving hard combinatorial problems were explored and juxtaposed with computer programming as computational aid. Technical computing and program module show the algorithm efficacy for implementation and correctness of combinatorial structure to obtain optimal solution.

Introduction

A combinatorial problem relates to a finite group of functional elements or some objects, with determination concern to determine one which satisfies the constraints set. Combinatorial concept came into being from convectional mathematics and statistical principle for arranging the collection of elements or an array of objects in sets [3]. Computer programming involves creation of code sequence for software application development or proposed system. Programming is more of an art than science because it requires creativity and rational thinking with frequent practice and time devotion [1]. Combinatorial optimization arises in quest to satisfy all possible conditional clauses; application

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areas include industrial practice and human undertaken with efficient algorithm design [10].

Linear Programming Problem (LPP) is the simplest kind of combinatorial optimization problem which takes to mathematical programming to produce optimal value or solution [9]. Meanwhile, the concept of 'programming' in this regard actually means planning; building a mathematical model for planning with optimality or optimal decision.

Discrete optimization techniques are not often used as their continuous counterpart but their usefulness is also very applicable to combinatorial optimization matters [4]. Discrete approach reached a large audience within the field of discourse and became famous by some works which adopted the normalized cuts approach. This technique has been used successfully in a wide variety of applications [2]. However, the discrete optimization technique which eventually became common choice is the branch and cut algorithm, that minimizes its certain objective for functionality. Its attraction is due to a thorough understanding of underlying theory as well as the attributes of the selection set; and implementation with exceptional computational complication is also available [5].

Combinatorial optimization problems

Some decision-making problems can be solved by surface scanning as it is in dynamic programming technique, where optimal solutions come by simple segmentation operations. Many algorithms on decision tree C4.5 and logical clustering to search solution space use dynamic programming [6]. The combinatorial optimization to data mining has been highlighted [7], which appears to be relatively close to modern computing, in machine learning and data mining for cluster analysis [8]. At times, a clustering case can be successfully transited to a kind of combinatorial optimization problems while approximation algorithms, finds their applications in design precise and efficient learning algorithms for the purpose of data mining [11]. Though, different cases call for different approaches but good algorithms can easily exploit the structure of the problem, because some techniques have generality feature and can be applied for variety of problems, which exempt hard combinatorial optimization problems [12].

Rationale for computer programming

Computer programming is an aspect of computing that deals with the process, techniques, tools and design standard of programs and system software [7]. Generally, computers are designed with physical components and made to be electronic and mechanical in structure. However, a computer will not be functional until a set of instructions that handle the internal control that is put into it. This set of instruction is a program [11].

In computing, programming is concerned with the design principles and development process of developing system programs and software that facilitate operational control and task execution. Programming requires effective tools and technical understanding of program development, computer is designed to receive users' input, execute and produce output [8]. Hence, a typical programming language may not be suitable for all purposes or problem domains, because every programming language has its syntactic structure and compiler [1]. Some languages and programming paradigm that express the logic of computation without describing its control flow as 'declarative' have been classified [8]. Thus, execution pattern tends to focus on the structure and elements of computer program without side effect because the attention is more on the operation than operands for computational process [5].

Materials and Methods

The use of mathematical model is quite germane to computational procedure for solving combinatorial problem. A model is an abstract representation of entity, theory or phenomenon that accounts for its known and inferred properties. Several types of models exist including mathematical and simulation models. The mathematical model in this context is a symbolic framework for optimization in combinatorial and decision-making problems.

The feasible region produces feasible (optimal) solution which is simply an assignment of values to variables in a way that satisfy all the constraints.

However, the objective function value should be less than or equal to all other feasible solution in MINIMIZATION case, while it is greater than or equal to all other feasible solution in MAXIMIZATION case. The need for mathematical model in computation of combinatorial optimization, by choosing problem solving framework from off-the-shelf product or applications, has always received attention.

Optimization is concerned with the task of minimizing (or maximizing) a real-valued function and (the objective function) over a given set S. Organization of array storage is very important to the collection of combinatorial subroutines, to avoid frequently occurred combinatorial problems. Algorithm efficiency is determined if the optimal solution value to lower bound is greater than the current upper bound. Some algorithms for optimization techniques simplify hard combinatorial problem by dividing the main problem to smaller other problems; each sub problem is solved recursively after branching.

A combinatorial optimization CP = (E, F) has formation elements; E => Set, F => Feasible Region, C=> Cost function (optional). $F = F_1 \ldots F_n$, $\min c^T x = (\min c^T x)$, $\{1 \leq i \leq x\}$, $x \text{ € } ^T$. Computational approach for solving a problem usually comes as computing procedure to determine feasible solution with optimum value.

Results and Discussion

The quest for computer-based tool and computational technique in actualizing combinatorial optimization or solving mathematical problems relating to decision making is normally incited by convenience and accuracy factors like processing speed, timely execution, machine efficiency, accurate analysis, and large data. But, the functional logic of any computer program particularly specialized applications depends largely on its implementation algorithm.

Prototype Solver: A mathematical programming in MATLAB can implement ‘Branch and Cut’ algorithm or combinatorial optimization method for solving Traveling Salesman Problem.

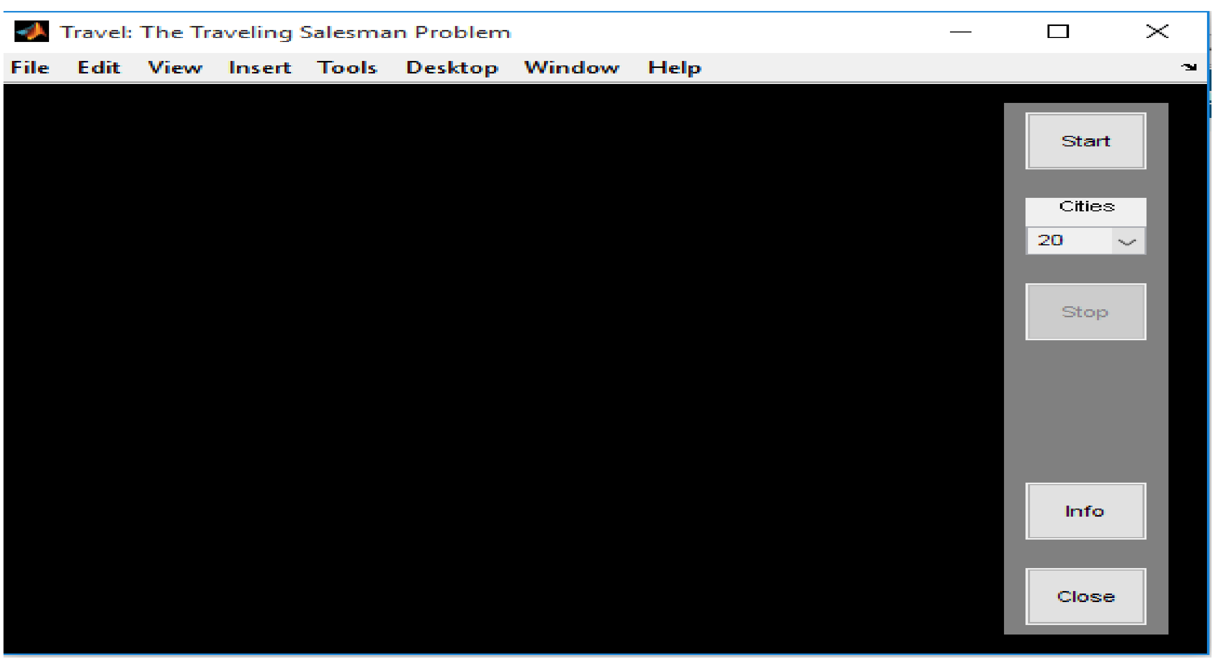

Figure 1. External Interface initialization for TSP (solver) program in MATLAB

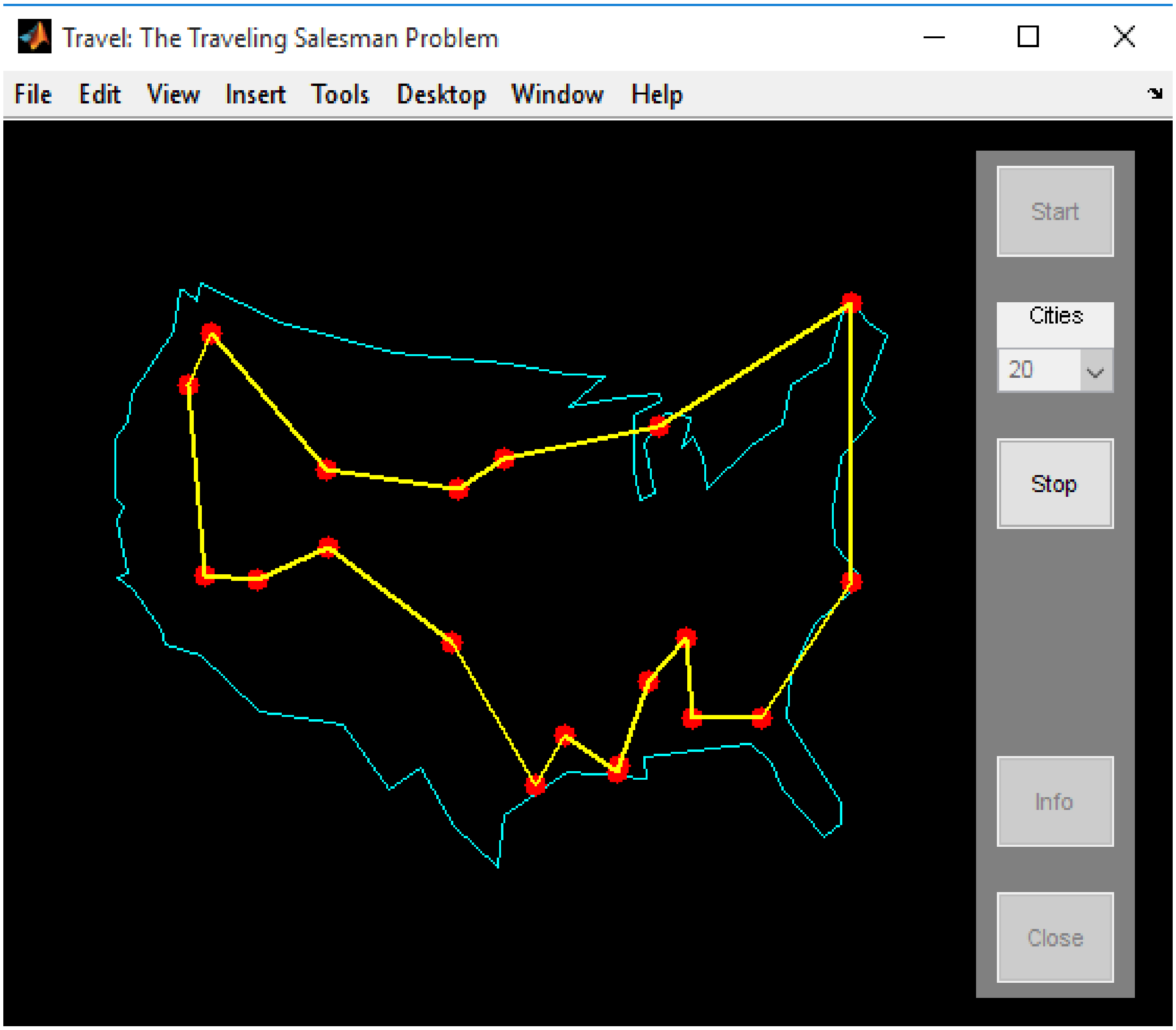

Figure 2. Location/Cities Spanning for TSP solver during execution in MATLAB

Conclusion

Correctness and efficiency are considerable factors in choosing optimization framework to solve combinatorial problems, as well as analyzing combinatorial structures for optimality derivation. Computational complexity and approximating function are applied through formal method for correctness proof. However, it is capital intensive to implement efficient solver for a new application in proprietary domain of hard optimization problem; therefore, generic solvers capable of automatically analyzing problem structure shall be considered for further study.

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