Hybrid Parallel Genetic Simulated Annealing Algorithm (HGSA) for Solving Agricultural Mechanization Departments (AMD) Routing Problem

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Abstract

Combinatorial optimization is the process of finding an optimal solution for problems with a large discrete set of possible solutions. An optimization problem is a problem of finding the best solution from all feasible solutions. This real world application is a deceptive simple combinatorial problem. HGSA is to develop solutions based on the idea of meta-heuristics. The routing system is formulated as a traveling salesman problem (TSP). TSP involves finding an optimal route for visiting departments and returning to point of origin, where the distance between departments is known.

Two combinatorial optimization algorithms, Genetic Algorithm and Simulated Annealing, are presented to hybrid approach for AMD routing problem. In this thesis, a driving guide system "Hybrid Parallel Genetic Simulated Annealing Algorithm (HGSA) for Solving Agricultural Mechanization Departments (AMD) Routing Problem" has been implemented and visually demonstrated. This system provides optimal route based on distance. This system presents an attempt to solve Government's routing problem for optimization to route from Basic Workshop-2 (BWS-2) to various Agricultural Mechanization Departments for auditing and mobile preparing. This system serves to handle for 64 nodes (departments). Machines are needed to prepare in agriculture time. So, this system supports quickly to arrive from BWS-2 to AMD departments in a short time. This system will be implemented by using C# programming language.

1.Introduction

Meta-heuristic algorithms have proved to be good solvers for combinatorial optimization problems, in a way that they provide good optimal solutions in a bounded (usually short) time. Meta-heuristics algorithms are simulated annealing, tabu search, genetic algorithms, and many others. The meta-heuristic algorithms for TSP can be classified as construction algorithms, improvement algorithms and hybrid algorithms. Construction algorithms are those in which the tour is constructed by including points in the tours, usually one at a time, until a complete tour is developed. In improvement algorithms, a given initial solution is improved, if possible, by transposing two or more points in the initial tour. Hybrid algorithms use construction algorithms to obtain an initial solution and then improve it using an improvement algorithm.

Genetic algorithms are an optimization technique based on natural evolution and has been applied to a wide variety of problems including search problems, optimization problems, and in many problems in industry, economic, social science, manufacturing and other fields. HGSA is a hybrid method and it uses parallel SA with the operations that are used in genetic algorithms. The genetic operation is used as an enhancement of the origin parallel simulated annealing which allows recombining solutions produced by individual simulated annealing processes at fixed time intervals. HGSA has been used in a wide variety of applications. Some of these applications are drilling of print circuit boards (PCB), real-world routing of school buses, airlines, and delivery trucks. The HGSA method is used for finding the optimal route from BWS-2 to various departments. The routing system is formulated as a traveling salesman problem (TSP). TSP is to find the shortest possible tours that visit each city exactly once and returning to the starting point in a graph. A route in network can be used as a sequence of nodes. The objective function is the sum of the distances between all the departments of specific order. The objective function used Haversine Formula to find the distance between two departments. The fitness value is evaluated from distance of the solutions. Control parameters are selected by a roulette wheel selection based on the fitness value. After the SA steps, the control parameters are evolved by using GA operators and new control parameters are assigned to the multiple SAs. HGSA is a hybrid method and it uses SA with the operations that are used in genetic algorithms.

2.Background Theory

Combinatorial optimization is a problem of finding the best solution from all feasible solutions. The subject of combinatorial optimization consists of a set of problems that are central to the disciplines of computer science and engineering. This area aims at developing efficient techniques for finding minimum or maximum values of a function of very many independent variables. This function usually called the cost function or objective function represents a quantitative measure of the "goodness" of some complex system. The cost function depends on the detailed configuration of many parts of that system. The importance of the TSP is representative of a larger class of problems known as combinatorial optimization problems. The TSP problem belongs in the class of combinatorial optimization problems known as NP-complete (Non- deterministic Polynomial time). The TSP is one which has commanded much attention of mathematicians and computer scientists specifically because it is so easy to describe and so difficult to solve. The problem can simply be stated as: if a traveling salesman wishes to visit exactly once each of a list of N cities (where the cost of traveling from city i to city j is c_{ij}) and then return to the home city [4]. TSP is to find the shortest Hamiltonian cycle in a graph. TSP is to find a shortest possible tour that visits each city exactly once and returning to the starting point in a graph. Given a list of N cities and a means of calculating the cost of traveling between any two cities, one must plan the salesman's route, which will pass through each city once and return finally to the starting point, minimizing the total cost. Two subsidiary problems are of general interest: predicting the expected cost of the salesman's optimal route, averaged over some class of typical arrangements of cities, and estimating or obtaining bounds for the computing effort necessary to determine that route. TSP is applied in many different places such as warehousing, material handling and facility planning. There are many algorithms used to find optimal tours, but none are feasible for large instances since they all grow exponentially. The TSP has been an early proving ground for many approaches to combinatorial optimization, including classical local optimization techniques as well as many of the more recent variants on local optimization, such as simulated annealing, tabu search, and genetic algorithms. The TSPs are given a set $\{c_1, c_2, \ldots, c_N\}$ of cities and for each pair $\{c_i, c_j\}$ of distinct cities a distance $d(c_i, c_j)$. The tour distance is expressed as follows:

$$\sum_{i=1}^{N-1} d(c_i, c_{i+1}) + d(c_N, c_1) \tag{2.1}$$

where c_i is the i-th point (city) in a tour, $d(c_i, c_j)$ is the distance between two points, and $d(c_i, c_j) = d(c_j, c_i)$. Tour distance is the length of the tour a salesman would make when visiting the cities in the order specified by the permutation, returning at the end to the initial city.

3. Hybrid Parallel Simulated Annealing Using Genetic Operatiions

GA and SA have complementary strengths and weaknesses. While GA exhibits parallelism and suffers from poor convergence properties and a serial bottleneck due to global selection. SA has good convergence properties, but it cannot easily exploit parallelism. However, SA does employ a completely local selection strategy where the current candidate and the new modification are evaluated and compared. A hybrid method combines the recombinative power of GA operation and annealing schedule of SA is presented. The new method, referred to as Hybrid Genetic Simulated Annealing Algorithm (HGSA), has been performing better than either GA or SA. The hybrid method consists of several processes, and in each process SA is operated and the information of the solutions is transferred after some steps. HGSA is a hybrid method and it uses SA with the operations that are used in genetic algorithms. The hybrid algorithm can reduce the processing time even in continuous problems. The genetic operation is used as an enhancement of the origin Parallel Simulated Annealing (PSA) which allows recombining solutions produced by individual simulated annealing processes. Generally, it can be said that GA is good at searching globally and SA is good at searching locally. Therefore, the hybrid method of SA with GA operator is good at searching not only locally but also globally. HGSA have only two main concepts. The first one is based on the algorithm SA which is enhanced with particular genetic operation. The second one is based on the concept of GA which uses SA algorithm at the selection process [7]. In this thesis, HGSA is used the first concept.

Simulated Annealing (SA) is one of the frequently used algorithms known as an effective technique for solving combinatorial optimization problems. It is inspired by annealing in metallurgy which is a technique of controlled cooling of material to reduce defects. Because many real-world design problems can be cast in the form of such optimization problems, there is instance interest in general techniques for their solution. SA has been successfully adapted to give approximate solutions for the TSP. SA was given this name in analogy to the “Annealing Process” in thermodynamics, specifically with the way metal is heated and then is gradually cooled so that its particles will attain the minimum energy state (annealing). At high temperatures, the molecules of a liquid move freely with respect to one another. If the liquid is cooled slowly, thermal mobility is lost. The atoms are often able to line themselves up and form a pure crystal that is completely ordered over a distance up to billions of times the size of an individual atom in all directions. SA searches randomly around the neighborhood of a present searching point. SA algorithms repeat these steps, and the optimization state is finally expected from given initial state. Then, the aim for a SA algorithm is to randomly search for an objective function [9].

Evaluation is to associate each individual or chromosome with a fitness value that reflects how good it is based upon its achievement of the objectives. The fitness function is the essence of the problem: it provides the means by which the quality of a solution may be assessed, and the probability that a solution will reproduce. The function needs to be a direct measure of the quality of the solution. A fitness-based selection method is used to choose those solutions which will produce the next generation.

The selection method is biased towards individuals of higher fitness, in order that better genetic material can persist in the population, and be improved upon through reproduction. The selection operator decides which individuals should continue in the population or should be discarded in the next generation, based on the objective function evaluation of all the individuals of the current generation and using a stochastic procedure. In roulette wheel selection, individuals are given a probability of being selected that is directly proportionate to their fitness. Two individuals are then chosen randomly based on these probabilities and produce offspring. A roulette wheel selection algorithm is shown below.

```
for all members of population
    sum += fitness of this individual
end for
for all members of population
    probability = sum of probabilities + (fitness / sum)
    sum of probabilities += probability
end for
loop until new population is full
    do this twice
        number = Random between 0 and 1
        for all members of population
            if number > probability but greater than next probability
            then they have been selected
        end for
    end create offspring
end loop
```

4.Design and Implementation

A driving guide system "Hybrid Parallel Genetic Simulated Annealing Algorithm (HGSA) for Solving Agricultural Mechanization Department (AMD) Routing Problem” is implemented by using HGSA method as an underlying technique Microsoft Access Database as well as C# Programming Language.

The user can choose AMD department for auditing. Starting department is always BWS-2 department in Kyaukse township. After choosing the locations, the system gets the information from the database. And then, the system also calculates the optimal path based on distance by using HGSA method. This system also provides user-friendly information such as AMD positions and BWS-2 position.

The map for each township of AMD department is presented by the undirected graph with about 64 departments as vertices. Physical distance is used to represent the straight-line distance as well as the optimal path which is the shortest traveling distance.

There are eight classes in this system. They are department class, haversine class, city class, route class, entity class, traveling salesman solution class, traveling salesman problem class and genetic algorithm class. The relationship of these classes is shown in Figure 4.2.

In department class, AddDepartment ( ) method serves user to add latitude and longitude of departments and DeleteDepartment ( ) method serves user to delete latitude and longitude of departments.

In haversine class, Calc (+1 overload) method calculates the distance between two departments.

In city class, City ( ) method serves to point of departments.

In entity class, Entity ( ) method performs to arrange the departments sequence.

In route class, Route ( ) method is to show the road graph of departments.

In traveling salesman solution class, CreateRoute ( ) method serves to create route for department sequence and FindBest ( ) method is to find the shortest distance by comparing other distance.

In traveling salesman problem class, GetNextArrange ( ) method is to get the next arrangement of departments sequence and GetTotalDistance ( ) method is to get the total distance of departments.

In genetic algorithm class, FitnessFunction ( ) method is to calculate the control parameter of anneal.

5.Conclusions

Knowledge and use of basic mathematics is widespread, as it has been throughout history. Among the finding methods used TSP that is simple and easy to use. TSP is to find at least total distance in weighted graph. In this thesis, HGSA approach for solving real world problem in the form of AMD routing has been presented. This system presents an attempt to solve Government's routing problem, routing from Basic Workshop-2 (BWS-2) to various Agricultural Mechanization Departments for auditing and mobile preparing. This system provide only for finding the optimal path within each township of AMD departments and support the user's decision making for the efficient selection of the traveling route. Physical distance is used to represent the straight-line distance as well as the optimal path which is the path that has the shortest traveling distance.

HGSA could handle various TSP within its scope and is reasonably efficient as evidenced by the computational results. GA and SA have complementary strengths and weaknesses. The hybrid algorithm can reduce the processing time in continuous problems.

This system supports only for finding the optimal path within each township of AMD departments in upper Myanmar. This system is based on only distance information, to find the optimal path from BWS-2 to other AMD departments for traveling.

This system will be extended to solve larger number of departments. This system can be solved to route AMD departments in lower Myanmar. Other scheduling and routing types of real problems such as time table scheduling could be solved using HGSA achievable approach. HSGA could be applied to many different types of vehicle routing problems with various side constraints. Other approaches can used for finding AMD routing problem, Such as Ant Colony Optimization, Particle Swarm Optimization and Tabu Search.

6. References

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