International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 1121-1126 www.ijaem.net ISSN: 2395-5252

Solving TSP by Genetic Algorithm

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Submitted: 10-08-2022 Revised: 20-08-2022 Accepted: 22-08-2022

ABSTRACT: The travelling Salesman Problem is one of the most NP-hard problems. Our research provides a yieldable method for solving the problem using genetic algorithm. To solve TSP we use genetic algorithm, a search algorithm which generates random tours and using crossover technique it gives almost optimized solution for for these kinds of problems. We are introducing a map reduction technique with Genetic Algorithm to create a new approach to solve TSP.

INTRODUCTION :

Day by day, our life Is getting complex. And to make our life easier we lean on to various electronic devices. But to make them work as we want, we need to address many mathematical problems. Travelling salesman problem is a very old mathematical problem. It is models a scenario where a salesman has many cities to visit in shortest possible time. Given the distance among the cities, he must calculate the shortest route.

Researchers have been working with Travelling Salesman problem for over centuries. Many models have been introduced to solve this legendary mathematical problem. In this paper I tried to introduce a new approach to solve the Travelling Salesman Problem.

I combined Genetic Algorithm Along with Map Reduction technique to get a new tactic and experimented to see whether the result is optimized.

THEORY :

1. The problem is very simple. Provided a list of cities and distance between them, it asks to find the shortest possible path so that, starting from any city, one can visit all the cities once and return to the starting city.

The origin of Travelling Salesman Problem (TSP) dates back to 1759 when the first instance of the travelling salesman problem was from Euler whose problem was to move a knight to every position on a chess board exactly once. Then in 1832 mathematician W.R Hamilton and Thomas Kirkman formulated it. The travelling salesman first gained fame in a book written by German salesman

BF Voigt in 1832 on how to be a successful travelling salesman.Though he did not mention TSP by name but suggested that to cover as many locations as possible not visiting any location twice is the key factor of scheduling of a tour. The standard or symmetric travelling salesman problem can be stated mathematically as follows:

Given a weighted graph G = (V, E); where the weight cij on the edge between nodes i and j is a non-negative value, find the tour of all nodes that has the minimum total cost.

OBJECTIVE and Field of Application :

The TSP has numerous applications, such as scheduling or planning, logistics, and the manufacture of microchips. A touch adjusted, it appears as a sub-problem in many fields,such as DNA sequencing. In these applications, the concept of city represents, for instance, customers, soldering points, or DNA fragments, and the concept distance represents travelling times or cost, or a similarity measure between DNA fragments. In many applications, additional constraints such as limited resources or time windows may be imposed.

The vehicle routing problem can be demonstrated as a traveling salesman problem. Here the problem is to find which customers should be attended by which vehicles and the minimum number of vehicles needed to serve each customer. There are different variations of this problem including finding the minimum time to serve all customers. We can address some ofthese problems as the TSP.

An application found by Plate, Lowe and Chandrasekaran is overhauling gas turbine engines in aircraft. Nozzle-guide fin assemblies, consisting of nozzle guide fins fixed to the circumference, are located at each turbine stage to ensure uniform gas flow. The placement of the fins in order to

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minimize fuel consumption can be modeled as a symmetric TSP. The scheduling of jobs on a single machine given the time it takes for each job and the time it takes to prepare the machine for each job is also TSP. We try to minimize the total time to process each job.

Complexity in Methods of Solving TSP:

At present the only known method guaranteed to optimally solve the Travelling Salesman Problem of any size, is by computing each possible tour and searching for the tour with least cost. Each possible tour is a combination of 123 . . . n, where n is the number of cities, so therefore the number of tours is n! . When n gets large, it becomes impossible to find the cost of every tour in polynomial time.

Obviously we need to find an algorithm that will give us a solution in a shorter amount of time. The travelling salesman problem is NP-hard so there is no known algorithm that will solve it in polynomial time. We will probably have to sacrifice optimality in order to get a good answer in a shorter time.Many different methods of optimization have been used to try to solve the TSP. Among themGreedy algorithm, Nearestneighbour algorithm, minimum spanning tree is mentionable. The Genetic Algorithm (GA) however is preferable to many researchers for its reputation to solve these kinds of problem close to optimally.

Genetic Algorithm:

Genetic Algorithms were invented to imitate some of the courses observed in natural evolution. Many people, biologists included, are astonished that life at the level of complexity that we observe could have evolved in the relatively short time suggested by the fossil record. The idea with GA is to use this power of evolution to solve optimization problems. The father of the original Genetic Algorithm was John Holland who invented it inthe early 1970's.[3]

Genetic Algorithms (GAs) are adaptive heuristic search algorithm based on the evolutionary ideas of natural selection and genetics. As such they represent an intelligent exploitation of a random search used to solve optimization problems. Although randomized, GAs are by no means random, instead they exploit historical information to direct the search into the region of better performance within the search space. The basic techniques of the GAs are designed to simulate processes in natural systems necessary for evolution, specially those follow the principles first laid down by Charles Darwin of "survival of the fittest.". Since in nature, competition among individuals for scanty resources results in the fittest individualsdominating over the weaker ones.

Overview of GA:

GA simulates the survival of the fittest among individuals over consecutive generation for solving a problem. Each generation consists of a population of character strings that are analogous to the chromosome that we see in our DNA. Each individual represents a point in a search space and a possible solution. The individuals in the population are then made to go through a process of evolution. GAs are based on an analogy with the genetic structure and behaviour of chromosomes within a population of individuals using the following foundations:

- Individuals in a population compete for resources and mates.
- Those individuals most successful in each 'competition' will produce more offspring than those individuals that perform poorly.
- Genes from `good' individuals propagate throughout the population so that two good parents will sometimes produce offspring that are better than either parent.
- Thus each successive generation will become more suited to their environment.

There are three 5 main aspects of GA. They are namely

- Population
- Fitness calculation
- Selection
- Crossover
- Mutation

1. Population:

A population of individuals is maintained within search space for a GA, each representing a possible solution to a given problem. Each individual is coded as a finite length vector of components, or variables, in terms of some alphabet, usually the binary alphabet {0,1}. To continue the genetic analogy these individuals are likened to chromosomes and the variables are analogous to genes. Thus a chromosome (solution) is composed of several genes (variables). A fitness score is assigned to each solution representing the abilities of an individual to `compete'. The individual with the optimal (or generally near optimal) fitness score is sought. The GA aims to use selective `breeding' of the solutions to produce `offspring' better than the parents by combining

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information from the chromosomes. In the figure below the parent1 and parent 2 are the population

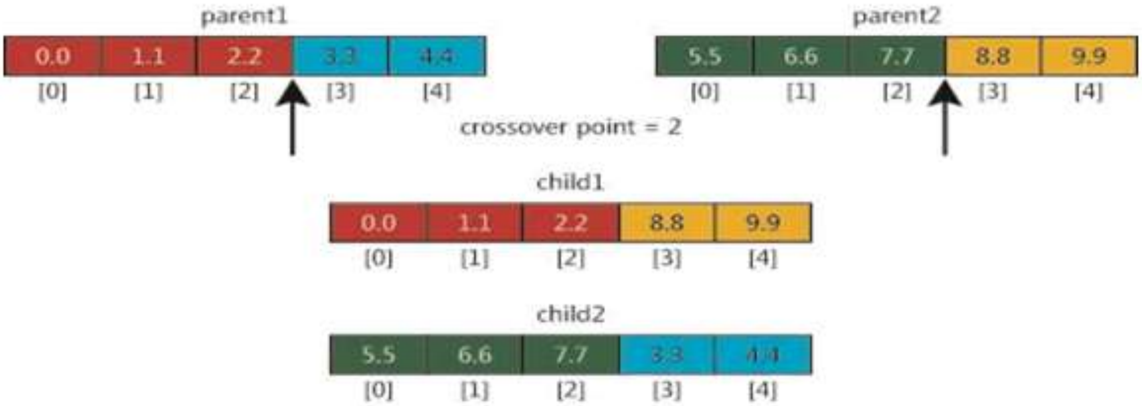

Fig 1 : Population Crossover

2. Fitness Calculation

Fitness calculation is a way to determine which candidates of the population serves the purpose best. For instance. Incase of TSP, the way to calculate fitness is to determine which route in the population cost least. For different problems fitness calculation method changes accordingly.

3. Selection:

There can be more the two individuals in population. Then certain number of candidate must be chosen for the crossover. This is called the selection. The selection process is based on the fitness calculation. It gives preference to better individuals, allowing them to pass on their genes to the next generation. The goodness of each individual depends on its fitness.Fitness may be determined by an objective function or by a subjective judgment.

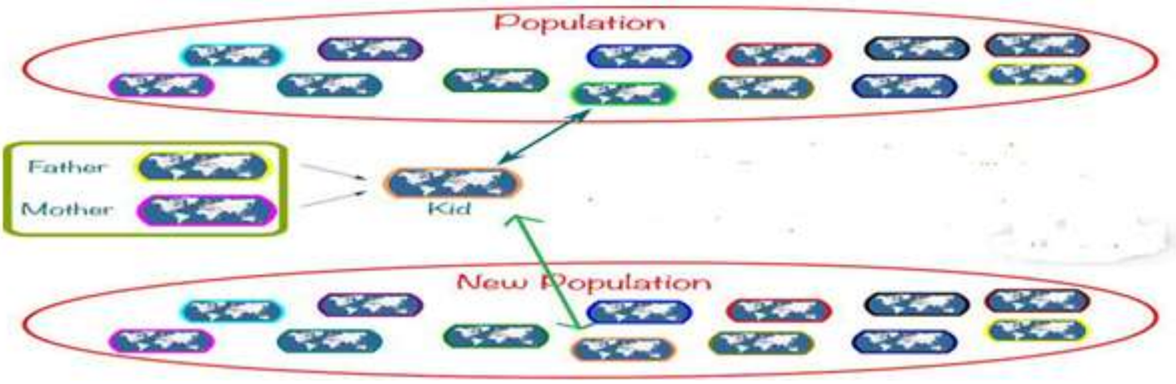

Fig 2 : Selection from population

4. Crossover:

Crossover refers to merging of two or more parent individuals to make new offspring. In crossover a portion of uniform size is selected from both the parents. Then the portion from first parent is added to the portion of second, thus a offspring is born. Similarly second child is produced. Prime distinguished factor of GA from other optimization techniques. Two individuals are chosen from the population using the selection operator.A crossover site along the bit strings is randomly chosen. The values of the two strings are exchanged up to this point. If S1=000000 and s2=111111 and the crossover point is 2 then S1'=110000 and s2'=001111, the two new offspring created from this mating are put into the next generation of the population. By recombining portions of good individuals, this process is likely to create even better individuals.

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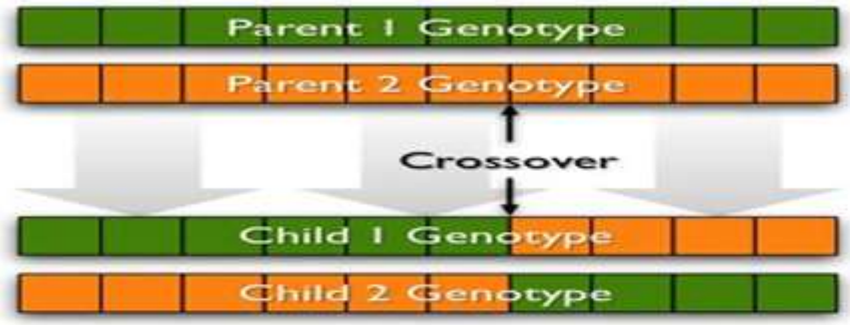

Fig3 : Crossover in Genetic Algorithm

5. Mutation:

After Crossover has run several times and yet expected result is not found, then mutation comes into action. Mutation refers to changing each candidate parent at certain point or points.With some low probability, a portion of the new individuals will have some of their bits flipped. Its purpose is to maintain diversity within the population and inhibit premature convergence. Mutation alone induces a random walk through the search space. Mutation and selection (without crossover) create a parallel, noise-tolerant, hill-climbing algorithms .

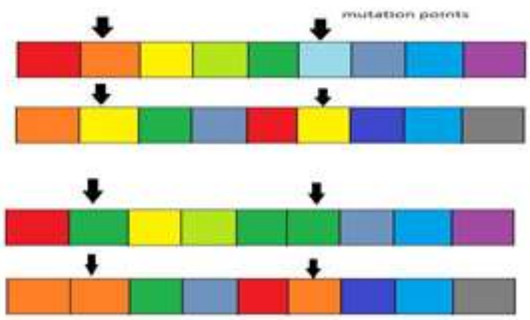

Fig 4 : Mutation in Genetic Algorithm

Map Reduction:

Map Reduce is programming model which has proven to be very effective to run a query on big data.

Generally speaking, it works like this:

- The data is **partitioned** across multiple computer nodes.
- A **map** function runs on every partition and returns a result.
- A **reduce** function reduces 2 results into one result. Its continuously run until only a single result remains.

The figure bellow shows map reduction on TSP. Given the cities, we can scenario into four possible co-ordinates and solve them separately.

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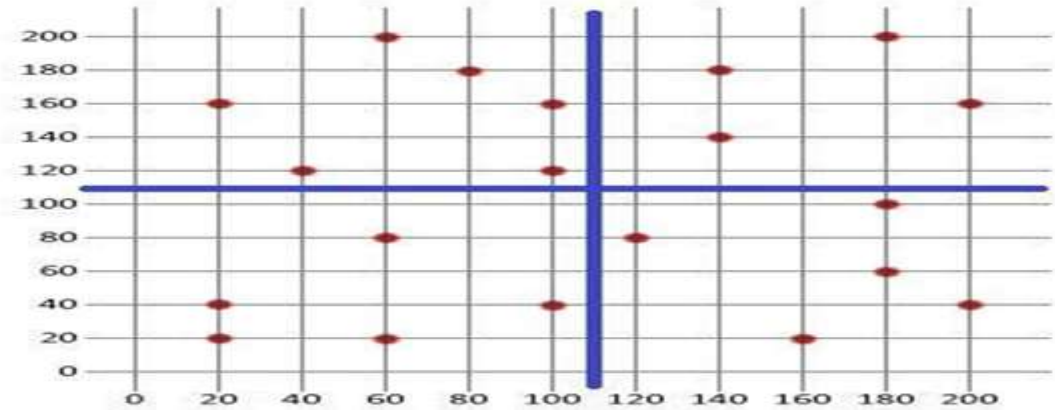

Fig 5: Map reduction

Solving TSP with GA and Map Reduce:

Travelling Salesman problem being a complex and famous one, researchers have tried to achieve optimality using numerous methods and algorithms. We have come across many works that has solved TSP with GA. Also new crossover technique has been introduced over time to make result optimal and efficient .

As, TSP is a NP- hard problem, researchers often tried to reduce in complexity by dividing it into pieces of several problems, however, optimality was beyond reach. It is established that Map Reduce cannot solve any planning problem optimally.

Previously researchers at Optaplanner organization have showed that Map Reduce can not be a reasonable approach to TSP. What their approach was-

- Divide the Map of cities into four co-ordinates
- Solve each co-ordinate separately to get the shortest path at each
- Merge the shortest path

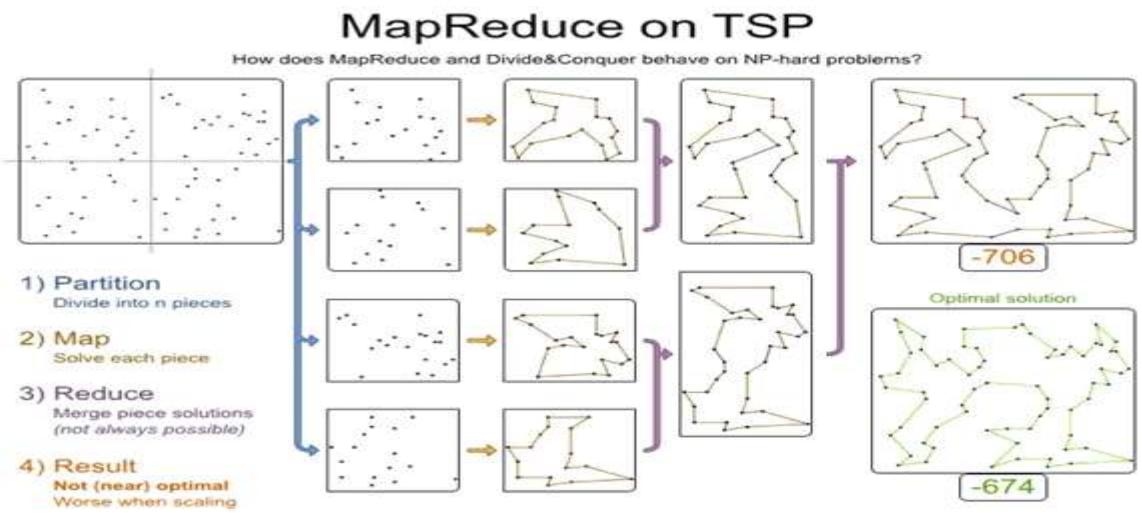

Fig 6: Approach of TSP by Map Reduce

However, the result showed even if the shortest path was obtained at each co-ordinate, and they were merged optimally, the solution was not optimal.

Hence, I came forward to examine if the result shifts to optimality if we combine Genetic Algorithm, Map Reduce and Combination.

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