Genetic algorithm in Vehicle Routing Problem

Submitted by:

Hamad Mohammed Abouhenidi

Introduction

Distribution management revolves around the vehicle routing problem. This is under the consideration of several organizations and companies to collect or deliver people or goods due to implications and problems faced by them. This is due to the situation, which are not the same in different places. All places have their own conditions and due to this, the constraints and objectives under consideration are strongly variable. Most of software development and algorithmic research that is done on this area are limited to prototype problems. Through developing of flexible systems this can be implemented and test on different context.

It can be explained as a situation in which there are several vehicles, which are directed to deliver certain goods by passing through different checkpoints/locations to the customers with the minimum route cost. This plan is in such a way that only one vehicle will approach and serve the customer at one location only once and end its route from the first location from where it started. These approaches and situations are developed to improve the problem handling technique in a new population as compared to earlier population.

The solutions that are developed for the problem are coded and solutions, which are given to the operators, are coded. These codes provide and increase the performance of GA, however, if the coded which is not appropriate then there will be very poor performance in their result. In simple words, system or vehicle has to travel on a designed pathway to minimize the cost associated with travelling, however, one condition is that the vehicle will deliver and pick the goods at one point only one time, and finish the route at the same point where the route was started.

Vehicle Routing Problem

It is and integer and combinational optimization programming dilemma, which exhibits to several clienteles with flotilla of vehicles. VRP is the mechanism that design the collection routes from different or one area to distinct and scattered customers or cities to the issues, which are under consideration. Vehicle routing problem plays an important role under the logistics and physical distribution. This context is used by locating the customers for delivering the products and services to their owners who made the demand for such goods. VRP is used to reduce the cost of transportation. Deterministic and heuristic approaches are formulated to tackle the situations related to vehicle routing problem. (Masum, Shahjalal, Faruque, & Sarker, 2011)

Genetic Algorithm Approach

Inspiration of Genetic algorithms is from the theory of evolution, which was given by Darwin. Evolution to provide the solution to the problem is solved by it. Genetic algorithm is technique, which is linked with the progressive ideas of genetics and natural selection. Optimization problems are solved through random search, which are the representative of intelligent exploitation. Genetic algorithms are not random but they use chronological data and information to find and locate in the area to improve the performance in the required context, which is under the focus. (Berger & Barkaoui, 2003)

This algorithm uses the principle of survival of the fittest to improve the search, which is toward the advancement to the solutions under the population. Fitness function is used to check the quality of every solution, which is calculated, and this search is not only for the one generation, it proceeds systematically from one generation to number of generations according to the fitness proportion. The solutions, which are used in one population, are not used to solve the problems of its own but it is used to solve the problems of new population. This is to check that the population would be better if compared to old one, which is worked with the hope. The reproductions of solutions who are supposed to provide the best solutions are based on their fitness. These solutions tested repeatedly until satisfaction is achieved. (Fisher, 1995).

Steps of Genetic Algorithm

Genetic Algorithm can be systematically analyzed in following points

- **Start/Begin**

Initialize → Candidates should be random from the population to provide the solutions

Evaluate → every candidate from the population

- **Replicate**

Select → parents from the population

Recombine → group of parents from the population

Mutate → the consequential children from the population

Evaluate → children

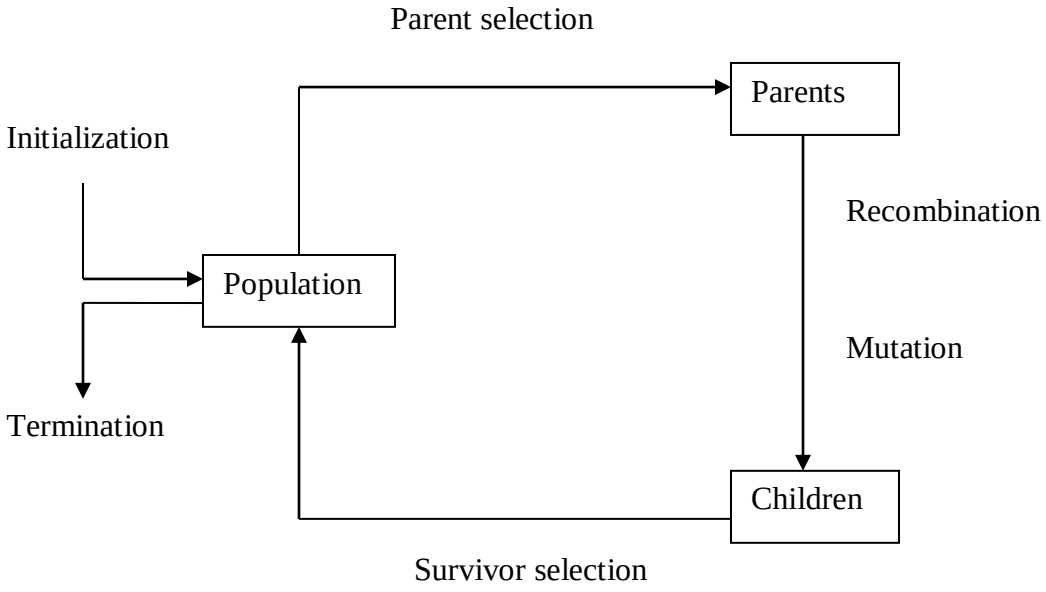
Select → people or population for future generation

- **Until**

Termination Condition is acceptable and satisfied

- **End**

The Genetic Algorithm can be analyzed and interpreted in form of following information:



It can be clearly seen from a chart that this plan falls in to the group of generate and test algorithms. Heuristic is a representative of evaluation function for the estimation of quality solution and the process of research are linked with the selection and variation handler. Genetic Algorithm has different features. (M.Gendreau, Laprte, & Potvin, 1994)

- Genetic Algorithm is based on the population
- Genetic Algorithm uses a method in which the information of one solution is recombined in such a form that it can be used in a new context.
- Genetic Algorithm is stochastic

Comparison of Genetic Algorithm with other Algorithms:

A genetic algorithm is based on population genetics mechanism and natural selection. There is difference between traditional approaches of optimization techniques that currently exist and genetic algorithms. The basic roots of genetic algorithm lie in the processes of biology; that refer to adaption and survival. The overall result is the development of efficient algorithm that has greater flexibility for searching complicated spaces like designing of a looped network pipe. A binary alphabet is usually used for coding of genetic algorithms. In implementing genetic algorithms, set of decision variable is coded that describes the trial solution as a chromosome. Trial solution is evaluated in genetic algorithms and the value is measured by fitness of the string. A collection of trial solutions is regenerated and evaluated from different solutions of

trials, called population. New populations are created from old population with the use of genetic algorithm. A powerful and simplest genetic algorithm consists of three operators including reproduction, secondly crossover and then mutation. The survival of selection process that is fittest is done by reproduction operator. Bits segments are partially exchanged between two strings in order to produce strings that are regarded as offspring strings. (Alba & Dorronsoro, 2009)The flipping of bit values on occasional basis is called mutation and this prevents from the loss of a useful potential genetic trait. A coded string having a finite length represents a set of decision in genetic algorithm technique. There are many advantages of genetic algorithms over other techniques of mathematical programming. Some of the advantages with reference to the optimization of pipe network are following:

Genetic Algorithms directly deal with the solution population at a given time. These populations of solutions are spread across the space and the chances of reaching at different global optimum regions are increased significantly. Each solution of population has some set of discrete pipes and diameters are not required to be round off for getting the final solution. Genetic Algorithms can identify different solutions of pipe networks that are closely linked to reduction of cost structure. These approaches are corresponded to various designs that these can be compared in terms of unquantifiable objectives. (Sun & Yuan, 2006)Genetic Algorithms use the fitness information or objective function. However, other methods are dependent on existence and derivatives continuity or some other auxiliary information. A number of attractive advantages are associated with genetic algorithms. These are given as follow:

Advantages:

- Every optimization problem can be solved by using genetic algorithms and it can be described with encoding of chromosome.
- Multiple solutions are provided by genetic algorithms while solving problem.
- The execution technique of genetic algorithm is not influenced by surface error. For this, multi-dimensional problems can be solved as well as non-parametrical, non-continuous and non-differential problems.
- Structural genetic algorithm can provide the options to solve many issues of structure and parameter problems by genetic algorithm means at the same time.
- Genetic algorithm is quite simple approach and it is easy to understand. No knowledge of mathematics is required to understand and use this technique.
- The genetic algorithms approaches can be transferred easily to current models and stimulations. The basic reasons behind the use of genetic algorithms are:
- Multiple local optima are there
- Derivative methods cannot be applied, as the function of objective is not smooth
- Parameters are quite large in numbers
- The objective function of genetic algorithm is not stochastic or noisy.

For using derivative based methods, a large number of parameters can be a problem and there is no proper definition of gradient. Using genetic approach, a non-terrible solution can be found and it can be improved with methods that are derivative based. The meaning of large parameters has a broader scope of definition now.

Disadvantages:

There are also certain disadvantages of genetic algorithms. Many optimization problems cannot be used by using genetic algorithms. The problems that cannot be resolved by genetic algorithms are called genetic algorithms. This lack of ability to provide solution is due to poor structure and mechanism of fitness functions that develop bad blocks of chromosome rather than the fact that cross over are blocked by only good chromosomes.

It is not ensured whether a genetic algorithm will possible find a global optima or not. When there are many subjects in populations, only then it can happen.

Genetic algorithm like many other artificial techniques of intelligence fails to assure constant response time of optimization. With the old gradient methods, the distance between the longest and shortest response time of optimization is quite larger. The use of genetic algorithm in practical use is limited by this failure and it is quite unfortunate.

The controls that are performed in actual time by the use of genetic algorithm are limited. This limitation is due to the convergence and random solutions.

Success of the population cannot be specifies on the individual population. Without adopting the test and practices on stimulation, the use of AG is not appropriate to be used for controls in real system.

A number of significant features of genetic algorithms make it different from traditional optimization and search methods. This is depicted in the following four points:

- Parallel search is done by using genetic algorithms from a population of different points. Genetic algorithms have the ability of not being trapped into optimal local solution as it happens in the traditional methods. Search is done from a single specific point in traditional methods.
- Rules of probabilistic selection are used in genetic algorithms rather than deterministic rules.
- Chromosomes are encoded by parameters of potential solutions and these are used in genetic algorithms. Parameters are not directly used in genetic algorithm.
- Fitness score is used in genetic algorithms and the fitness score is obtained from different objective function without auxiliary information or derivatives.

The concept of evolution that comes from developing generations of populations with fitness statistic is followed in genetic algorithm. The best example is the use of objective function in programs of mathematics.

Genetic algorithms are most appropriately applied to the problems of large extent, non-linear and somehow discrete by nature. This adds high degree of flexibility in the solutions. However, optimality is not guaranteed by genetic algorithms but these can be much closer to global optimum. Local optima are not involved due to the probabilistic nature of solutions.

Genetic algorithm can better handle the integer variables rather than continuous variables handled by traditional methods of optimizations. This characteristic is due to granularity of gene strings that are variable with model structure of genetic algorithm.

A variable with a possible range of values is implemented with a binary string and the string indicates values like x1Î [0,15]. If there are four characters of gene string then this means that 16 possibilities should be considered for search. The number of possible values increases as continuous variable increase. The upper and lower bound values support the search significantly with the information of other variables. The convergence of the model solutions can be greatly affected by these factors.

Bibliography

Alba, E., & Dorronsoro, B. (2009). *Cellular Genetic Algorithms.* Springer.

Berger, J., & Barkaoui, M. (2003). A Hybrid Genetic Algorithm for the Capacitated Vehicle Routing Problem. *Defence Research and Development Canada* , 646-656.

Fisher, M. (1995). *Vehicle routing: Handbooks of Operations Research and Management Science.*

Floudas, C. A., & Pardalos, P. M. (2009). *Encyclopedia of Optimization.* Springer.

Golden, B. L., Raghavan, S., & Wasil, E. A. (2008). *The Vehicle Routing Problem: Latest Advances and New Challenges: latest advances and new challenges.* pringer.

Hoekstra, A. G., Kroc, J., & Sloot, P. M. (2010). *Simulating Complex Systems by Cellular Automata.* Springer.

Laporte, G., Gendreuau, M., Potvin, J.-Y., & Semet, F. (2000). Classical and modern heuristics for the vehicle routing problem. *International Transactions in Operational Research , 7*, 285-300.

M.Gendreau, Laprte, G., & Potvin, J.-Y. (1994). Metaheuristics for the vehicle routing problem. *Management Science, 40:1276-1290,1994. , 40*, 1276-1290.

Masum, A. K., Shahjalal, M., Faruque, F., & Sarker, I. H. (2011). Solving the Vehicle Routing Problem using Genetic Algorithm. *International Journal of Advanced Computer Science and Applications , 2* (7), 126-131.

Sun, W., & Yuan, Y.-X. (2006). *Optimization Theory and Methods: Nonlinear Programming.* Springer.