



Science

## **A SOFT COMPUTING APPROACH FOR SMOOTH TRAFFIC FLOW ON ROAD NETWORK**

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DOI: <https://doi.org/10.5281/zenodo.573002>

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### **Abstract**

Route planning has an important role in navigation systems. In order to select an optimized route the traveller has to take various factors into consideration. Traffic congestion is an important factor which needs to be considered while route planning. As the numbers of vehicles are increasing on the road the traffic congestion is also increasing in an exponential manner. In a congested area the best approach to search for a route is to select an alternative path so that we can reach our destination and indirectly save some time. In the recent years route planning system has become an important area of research since the number of vehicles are increasing day-by-day but the traffic structure is un-expandable. In this paper a genetic algorithm is proposed to develop an alternate route which results in smooth flow of traffic. Genetic Algorithm's main aim is to create an optimized path.

**Keywords:** Genetic Algorithm; Vehicle Routing Problem; Optimal Path Planning.

**Cite This Article:** Mrinmoyee Chattoraj, and Dr. Udaya Rani.V. (2017). "A SOFT COMPUTING APPROACH FOR SMOOTH TRAFFIC FLOW ON ROAD NETWORK." *International Journal of Research - Granthaalayah*, 5(4), 311-319. <https://doi.org/10.5281/zenodo.573002>.

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### **1. Introduction**

Route planning algorithms is a necessary condition for a transportation system. Whenever the route selection is done in a dynamic way we consider the route which takes the minimum time. The traffic congestion on urban road plays a major role in route selection. As the number of vehicles on a road increases it leads to decrease the vehicle speed and thus increases the travel time for the journey. While selecting the route we always consider the updated traffic conditions and then help the traveller to select the optimal route. There are mainly two types of traffic congestion, recurring and non-recurring. Recurring congestion generally refers to the expected delay due to more number of vehicles at peak hours or at a particular place (at busy intersection). Non-Recurring congestion refers to unexpected traffic delays due to accidents or

other traffic incidents. Developing a control system to find a smooth flow of traffic is a critical research problem. Several methods like increasing the road tax ,increasing the tax according to the usage of vehicles, having separate lanes for buses, cars and two wheelers, expansion of existing road network, diversions of roads etc. were some of the techniques proposed to reduce traffic congestion. But due to exponential increase of vehicles and un-expandable traffic infrastructure still route planning is a major problem is research.

In case of Car Navigation Problem Route planning helps us to find an optimal path between the origin and destination on a road map. There are various well known algorithms like Dijkstra's algorithm and Bellman-Ford algorithm which helps us to find the shortest path from the source to destination in a weighted graph .Compared with this traditional search strategies Genetic Algorithm provides a favorable method for solving combinatorial Optimization Problems. This technology helps to integrate and develop intelligent control systems that deal with traffic congestions which is a major problem in urban areas.

## 2. Literature Review

Route planning algorithms is a necessary condition for a transportation system. Whenever the route selection is done in a dynamic way we consider the route which takes the minimum time. While selecting the route we always consider the updated traffic conditions and then help the traveler to select the optimal route. In this paper an upgraded genetic algorithm is proposed and used as live route direction algorithm. Many minute details of Genetic Algorithm like crossover according to locality, mutation according to greedy backward scheme and stable state replica have been designed to solve this problem, while many facts have been improved from previous works. The stable state replica have been introduced to defend the improved genetic individuals. After simulation the results show that the algorithm which has been proposed helps to find an optimal route which is applicable in real time and converges very fast to give us the required solution. As the size of the population increases the solution improves.

TSP is a problem which is extensively used as a fast search technique to give us the optimum solution .Many different methods was used to solve this problem. In this paper an attempt is made to solve this problem using Genetic Algorithm. An algorithm is proposed which uses a collection of genetic operators which is used to find an improved result. The basic three operators of genetic algorithm Selection, Crossover and Mutation are used to find the result. Different types of selection operators, Crossover operators and Mutation operators were used in a random fashion. Selection operator selects individuals, whereas crossover operators combines the features of two individuals. Mutation alters the value of the genes randomly according to its probability. In this paper it has been proved that by combining various genetic operators there is always a chance to get a better result since in genetic algorithm it is survival of the fittest. More substantial outcomes can be produced by various combinations of genetic algorithms.

For navigation systems it is very important to do planning of the road maps. Various algorithms have been proposed to find an optimal solution but the efficiency of these conventional algorithms decreases as the size of the road map increases. As the response time for the queries increases with the increase in input size, the efficiency decreases drastically. Thus in this paper a clipping procedure is used to increase the efficiency of the route search. As the networks are

clipped the accuracy of the road networks would decrease. This algorithm shows that the efficiency increases with small loss. As future work a large network of roads can be selected to check the efficiency and compare it with the current situation.

It is considered that in cities and town's traffic jamming is considered as a big challenge. There are GPS to plan routes but generally the time taken to travel differs by the time when you are really travelling. This difference in travel time is due to traffic overcrowding. In this paper a discussion has been done on how to be aware of traffic jamming and then decide the route to be selected.

The current system can operate in two modes:

- 1) Try to attain a social optimum by considering the time taken by individual driver.
- 2) Optimize individual travel time.

In this case with the help of sensor data we find an approximate value for the function that causes the delay for the taxi and try to find a social optimum value. An assumption can be made that if a huge volume of traffic can be controlled then our savings in terms of time, fuel consumption etc. will also increase.

One of the most universal AI application is route planning. Delay in traffic is considered due to the current traffic as well as the past traffic delay. For example in the morning traffic congestion is less compared to those within peak hours. We can collect live traffic by loop indicators, cameras etc. Real traffic situation at a particular time cannot predict the future traffic condition. For example If a car takes half an hour to complete a particular trip the same trip may not take the same time after an hour. This is a major problem in predicting future traffic. This problem can be minimized by considering the past traffic data for the same time and same condition. Route Planning is done using.

- Density and Travel Time
- Cost Function: Two costs are considered
  - Linear Cost and
  - Exponential Cost

In this case the Planning Algorithm used is A\* which is revised to deal with the travel times. In this an attempt is made to predict the future traffic and then accordingly plan a suitable route. For each path a route plan is updated for the car which is done by updating each edge velocity. Finally we can observe that a prediction for the traffic can be done to be alert about the traffic.

### 3. Genetic Algorithm

Genetic Algorithm (GAs) are adaptive search algorithms that are based on the biological theory of evolution. It automatically gathers the necessary information about the search space and automatically by the help of self-adaptive techniques finds a random optimal path.

The optimal path in network route selection can be found with the help of genetic algorithm using the following steps: Efficient coding of the chromosomes, generating initial population, selection of fitness function and various genetic operations such as crossover and mutation. In

case of car navigation system since multiple optimal route needs to be specified according to driver's satisfaction so it is not possible to find a real time solution using deterministic algorithms. Genetic Algorithms finds a number of multiple solutions as it is always possible to generate approximate solutions regardless of time. The user can then select a desirable route from the given set of solutions. Since the problem of route searching takes a lot of computation cost our research focus on finding a fast route search algorithm which minimizes the total time, cost of travelling and increases the driver's comfort. Along with the factors such as chromosome size, population size, fitness function selection and genetic operators such as crossover and mutation, the speed of the genetic algorithm also depends on the scheme of the chromosome and the genetic operators that are used. Few techniques help to increase the speed of the Genetic Algorithm. They are as follows:

- Making the structure of the gene and chromosome as simple as possible.
- Reducing the size of the chromosome if possible.
- Few effective crossover and mutation operators should be allowed.
- The source and destination node should not be entered in random selection of nodes.

This research aims at developing a Genetic Algorithm (GA) which improves the search technique and finds an optimal solution for the shortest path which takes the minimum time to travel from the source to destination. The general data flow diagram of a Genetic Algorithm is given in Fig-1 below.

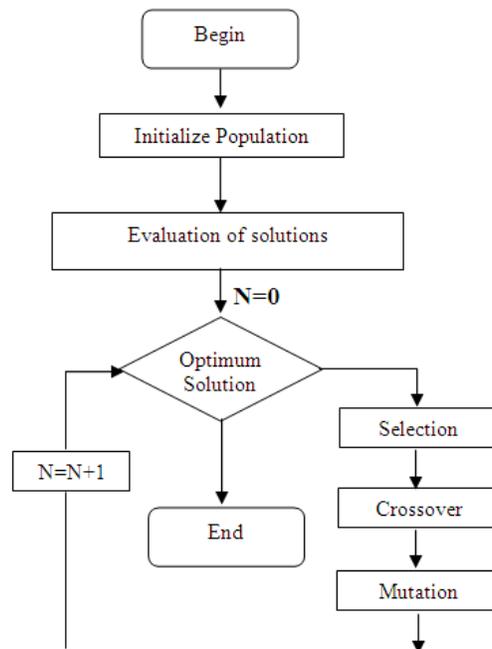


Figure 1: Data Flow Diagram of a Genetic Algorithm

#### 4. Basic Concepts of the Proposed System

The Road network can be considered as a directed graph  $G = (V, E)$  where  $V$  denotes the set of vertices, which are the junctions in the road network and  $E$ , the set of edges which are the lanes. The edges are classified into two categories, the major lanes and the minor lanes. During peak

hours of traffic congestion the minor lanes can be used to overcome the situation of traffic congestion on the major lanes. The proposed algorithm is to predict the traffic congestion in the various lanes and transfer this information so that the optimal path can be selected. A sample road network of Bangalore is shown in Fig-2 below



Figure 2: Road Network of Bangalore City

The proposed system carries out the following major activities:

- 1) The Route network in the city is identified and then the relationship between the routes is found.
- 2) The traffic congestion is identified and an alternate minor lane route information is provided.
- 3) All decisions are in co-ordination with each other so that the traffic flows smoothly from source to destination.

## 5. Problem Formulation

To find a route (R) from source vertex  $s$  to destination  $t$  we define it as a collection of vertices.

$$R(s, t) = \{ s = v_1, v_2, \dots, v_j = t \}$$

The total length from the source vertex  $v$  to the destination  $t$  is the sum of the weight of the edges from  $s$  to  $t$ . previously our aim was to get the minimum value for  $\sum w(e_{ij})$  where  $e_{ij}$  is the set of edges which are selected from the source to destination and  $w(e_{ij})$  is the weight of the edges from  $i$  to  $j$ . Each edge  $e_{ij}$  is also associated with two functions

- Time function  $t(e_{ij})$  :  
It is the time taken without traffic.
- Delay function  $d(e_{ij})$  :  
It is the extra time taken considering traffic.

$$T(e_{ij}) = t(e_{ij}) + d(e_{ij}) \text{ ----- (1)}$$

A path from the source to destination will be considered as a combination of links and the sum of the weights of the individual links will be the total weight of the link. Our objective will be to minimize the total time. Hence the objective function will be expressed by formula (2)

$$\min f(i) = \sum_{j=1}^{l-1} \frac{D(g_{i(j)}, g_{j(j+1)})}{V(g_{i(j)}, g_{j(j+1)}) * (1 - T(g_{i(j)}, g_{j(j+1)}))} \text{ --- (2)}$$

### ***Fitness Evaluation***

Fitness number is an important metric that helps us to select our solution. An individual with higher fitness has more probability of being selected than an individual with lower fitness. We consider our fitness number to be the reciprocal of the objective function .Hence the formula for fitness function will be

$$F(i) = \frac{1}{f(i)} \text{ --- (3)}$$

Where

F(i)=fitness function of the i<sup>th</sup> chromosome.

g<sub>i(j)</sub>=j<sup>th</sup> gene of the i<sup>th</sup> chromosome.

l=length of the chromosome.

D=distance between two nodes.

V=velocity allowed between two nodes.

T=traffic density between two nodes.

## **6. Proposed Algorithm**

Consider the following road network which is represented as a connected graph with N nodes. The metric used for optimization is the cost of the path between the nodes which includes the distance, velocity and the traffic density. The goal is to path the path with minimum total cost from the source to the destination node.

The proposed algorithm considers any path from the source to destination as a feasible solution and the shortest path is considered as the optimal. Initially a random population is generated which consists of admissible (feasible) as well as inadmissible (unfeasible) solutions. The parent chromosomes are generally selected from the admissible paths which can reach the destination. Consider the Road Network given in Fig-3.

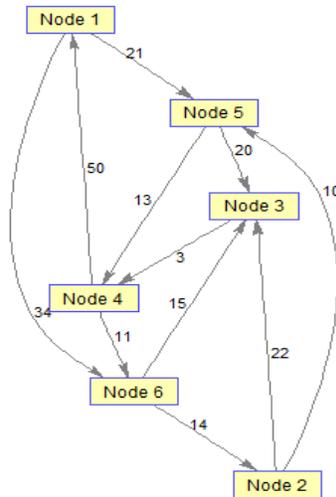


Figure 3: Road Network

In the road network shown in Fig-3 each node has been given a number which denotes the road junctions and is used to encode the paths from source to destination. For example 1-5-3-4-6-2 is a feasible solution with source code Node 1 and destination Node 2, which may or may not be an optimal solution. The chromosome is represented by string bits instead of binary representation. Whenever crossover and mutation occurs, the string with higher fitness values are selected as parents. For example using the network in Fig-3 we consider

Parent1: 1-5-4-6-2

Parent 2: 1-5-3-4-6-2

At Node5 the underlined parts of each strings are exchanged. After crossover occurs repeated strings are removed and then mutation occurs. One feasible solution of the road network in Fig-3 is given below.

dist = 48

path = 1 6 2

pred = 0 6 5 5 1 1

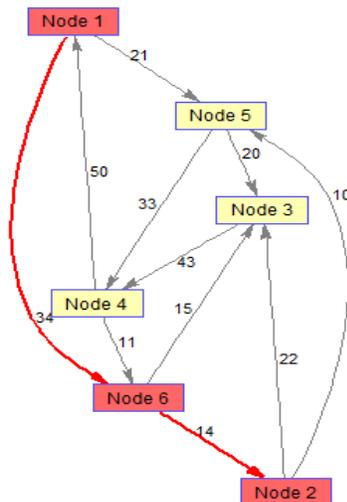


Figure 4: A Feasible solution for Road Network

The proposed genetic algorithm will be as follows

### **Algorithm Optimal Route \_GA**

Step 1: Enter the map of a particular place and the map database.

Step 2: Enter the Source and Destination points.

Step 3: Do the chromosome coding for the route.

Step 4: Generate a population of individuals or routes.

Step 5: Set Generation=1.

Step 6: Use the fitness function to evaluate the initial parent population.

Step 7: Loop until termination criteria is satisfied.

Step7.1: **Select** chromosome for reproduction.

Step7.2: **Create** offsprings using reproduction operators such as Crossover and Mutation.

Step 7.3: **Replace** parent population by offspring population.

Step 7.5: **Return fittest chromosome** from the last parent population and increment the generation number.

Step 8: Increment Generation number.

Step 9: Output the best individual found which is the optimized solution.

Step 10: End

## **7. Conclusion and Future Scope**

This paper introduces a new approach to deal with the traffic congestion on the road networks using a genetic algorithm. The chromosome length depends on the number of nodes present in the network. The MATLAB software finds the shortest path. This particular network is simulated to solve the network with only 6 nodes with the first one as the source node. In future Genetic Algorithm has to be investigated by increasing the number of nodes and decreasing the chromosome length.

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