

A New Genetic Algorithm Based Lane-By-Pass Approach for Smooth Traffic Flow on Road Networks

Shailendra Tahilyani
Department of Electronics & Communication
Babu Banarasi Das University
Lucknow, India

Manuj Darbari and Praveen Kumar Shukla
Department of Computer Science & Engineering
Babu Banarasi Das University
Lucknow, India

Abstract— Traffic congestion in urban areas is a very critical problem and increasing day-by-day due to increment in number of vehicles and un-expandable traffic infrastructure. Several intelligent control systems have been developed to deal with this issue. In this paper, a new lane bypass algorithm has been developed for route diversion resulting in smooth traffic flow on the urban road networks. Genetic algorithms are utilized for the parameter optimization in this approach. Finally, the results of the proposed approach are found satisfactory.

Keywords- Genetic Algorithms, Fuzzy Logic, Neural Network, Activity Theory.

I. INTRODUCTION

Urban Road traffic congestion [1] is a situation that is characterized by high number of vehicles on a road that leads to low speed and longer time taken for a journey. Population growth and exponential growth in number of vehicles have increased the problem of congestion on the country's freeways and highways. Traffic congestion can be classified in two types recurring and non-recurring [2]. Recurring congestion is associated with expected delays, resulting from large number of vehicles at the same time (during peak commuting) at the same place (at busy intersection). Non-recurring congestion is associated with unpredictable delays that are created by spontaneous traffic incidents, such as accidents.

The development of control systems to deal with the congestion for smooth flow of Traffic in urban areas is a critical research issue. Several conventional methods [3-10] have been applied to reduce the problem of traffic congestion. Some of these are, road pricing, supporting the green traffic, parking enforcement, fuel levies, expansion of existing road network, elimination of roundabout and many more. But due to non-linear and unpredictable nature of the traffic movement and the high cost associated with the expansion of existing infrastructure of road networks, the conventional methods are not found very suitable.

Meanwhile, the technology has been integrated to develop some intelligent control systems to deal with the traffic congestion issues, more specifically in urban areas.

Different approaches have been integrated to model and simulate the real time traffic control system, like activity

theory [11-13], neural network [14-16], fuzzy logic [17-18], petri nets [19-20], genetic algorithms [21] and their hybrid approaches.

This paper has been divided into 4 sections. In section II, the basic concepts of the proposed system are described. The new proposed algorithm is discussed in Section III. The results analysis of the proposed systems is carried out in the Section IV. Section V is the conclusion and future scope of the proposed approach.

II. BASIC CONCEPTS FOR PROPOSED SYSTEM

The Road Network in the urban areas can be considered as a graph. In this graph, edges are classified into two categories: 1. Major Lanes, 2. Minor Sublanes. During peak hours of the traffic movement, the Minor Sublanes can be utilized to overcome any situation of traffic congestion on the major roads of the road network. The prediction of the traffic congestion and transfer of this information is carried out by the proposed algorithm. The information passing and presentation are done by the VMS (Variable Message Sign Board).

A sample road network in the Lucknow City is presented in Fig. 1.

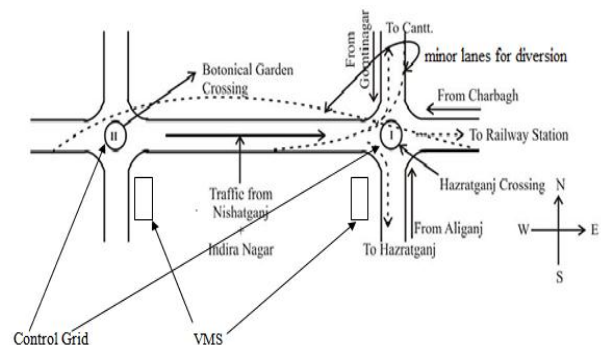


Fig. 1 A Sample Road Network in the Lucknow City

The major activities in the proposed approach are identified as follows:

- 1) Identification of Route Network in the city, showing the relationship between all the roads (routes).

- 2) Identification of Traffic Jams and then identification of alternative minor sub lane route information.
- 3) Coordination among all the decision (alternative traffic routes) to ensure the smooth traffic flow from source to destination.

The road network is described graph with links $z \in Z$ and junctions $j \in J$. For each signalized junction j , we define the sets of incoming I_j and outgoing O_j links. The signal control plan of junction j is based on a fixed number of stages that belong to the set, whereas v_2 denotes the set of stages where link 2 has right of way. Finally the saturation flow S_2 of link $z \in Z$ and the turning movement rates $t_{x,y}$, where $x \in I_i$ and $y \in O_j$, are assumed to be known and constant.

By definition, the constraint

$$\sum_{i \in F_n} g_{n,m} + L_n = C \text{ holds at junction } n, \text{ where } g_{n,m} \text{ is the}$$

green time of state m at junction n and L_n is the total lost time at junction n . It follows the constraints,

$$g_{m,n} \geq g_{n,m,\min} \quad m \in F_n$$

Consider the following N Dimensional road network for result analysis in this paper.

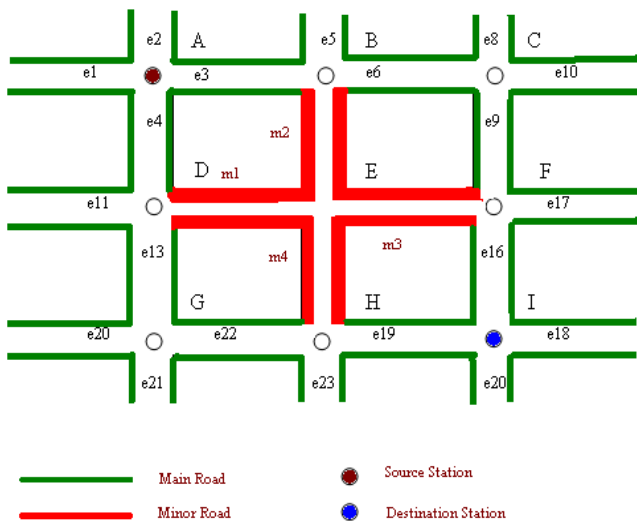


Fig. 2 N Dimensional Road Network

A, B, C, ..., I are the junctions (Places) at the traffic road network (and connected by road connectives (Transition)). The modeling of each junction will be done as discussed in the first section. The phases and movements will be done in the same way.

The proposed approach for route diversion and selection is based on the Genetic Algorithm, an evolutionary techniques for the purpose of optimization in complex ill-defined search spaces. Genetic Algorithms are search and optimization techniques based on Darwinian's principle of Natural Selection. The basic idea behind the natural selection is "select the best, discard the rest". The optimization strategies by

genetic algorithms are implemented by simulating evolution of species through the natural selection.

The fundamental technique behind the GA includes the three steps: 1. Evaluation of individual fitness, 2. Formation of gene pool, intermediate population through the selection mechanism, 3. Recombination through the crossover and mutation operators.

The working of the GA can be well expressed by the following data flow diagram, clearly.

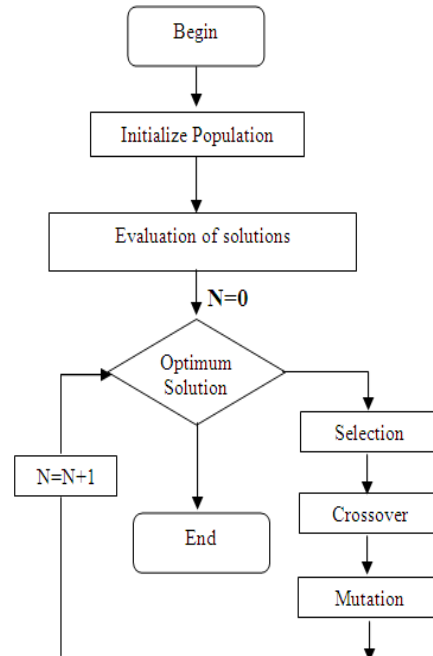


Fig. 3 Working of Genetic Algorithms

III. PROPOSED SYSTEM

The problem is identified and mathematically formulated as:

Set of junctions $J = (A, B, C, D, E, F, G, H, I)$

Set of connectives $E = (e_1, e_2, e_3, \dots, e_{23})$

Set of Minor Sublanes $M = (m_1, m_2, m_3, m_4)$

The traffic flow will be decided by the set of connectives from source to destination. Few of the connectives are the bypass connectives that are used by transfer office by pass when the major connectives are full with traffic jam.

In this approach, the VMS technology is used. The commuters will find the signal for route diversion before one crossing through minor sub lane generation if there is any traffic jam at the next crossing. But overall it is also considered that the path from source to destination should be as minimum as possible.

To deal with this problem, the sensors will be placed at each junction for intimating the traffic jam to the previous junction by VMS.

Let the commuter is travelling from station A to I as shown Fig. 4. Now consider the situation, where the commuter

identifies traffic congestion at junction G through VMS where he is on the route e4 at junction D. Now to deal with this situation the control system would generate the signal for route diversion through minor lane by pass and the commuter would get the signal to choose the route m1 and m4 to reach his destination.

The procedure of route diversion should be integrated with the approach traffic phase and movement decision approaches.

A. Algorithm ROUTE DIVERSION through minor sub-lane

For the route diversion the proposed algorithm is as follows:

- ROUTE DIVERSION* (α_{VMS} , αM_{VMS})
1. Start
 2. Generate α_{VMS} for each junction at different intervals of time.
 - $\alpha_{VMS} = \text{Traffic Flow} / \text{Mean Velocity}$
 - The value of Traffic Flow will be estimated by the Sensors and Mean Velocity is calculated at different time intervals.
 - Repeat steps 3 to 5 until the desired destination,
 3. Collect the values of α_{VMS} (update them on time intervals) for all junctions in different paths from a specified source to destination, at a control centre.
 4. Generate the maximum value of α_{VMS} from which the traffic congestion will start and it is denoted by αM_{VMS} .
 5. Apply minimization function F_{min} on the values of α_{VMS} to get the next node, iteratively.
 6. If $F_{min}(\alpha_{VMS}, \alpha M_{VMS}) \geq \alpha_{VMS}$ then
 - Send the signal to previous junction's VMS for route diversion, if the selected junction is different from the regular path,
 - otherwise
 - Follow the main route decided previously.
 7. End.

B. GA ROUTE Diversion Algorithm

This route diversion process can be seen as an optimization problem and its extended version can be produced using genetic algorithm. This proposal is as follows:

- GA- ROUTE DIVERSION* (α_{VMS} , αM_{VMS})
- {
 - Initialize all the paths as first population (e_1, e_2, \dots, e_n)
 - Evaluate the fitness of the each path as per the function
 - $F_{min}(\alpha_{VMS}, \alpha M_{VMS})$
 - Set the termination criteria
 - $F_{min}(\alpha_{VMS}, \alpha M_{VMS}) \geq \alpha_{VMS}$
 - while the termination criteria is satisfied
 - {
 - Select the most optimized path
 - Crossover (Various combinations of paths)
 - }

- Mutation (Change a particular path in the route)
- Evaluate the new population
- }

IV. RESULT ANALYSIS

The two cases are considered here for result analysis. Let the source station is A and destination station is I.

The selected route by commuter is (A, B, C, F, I). Now according to the space capacity of the junction, $\alpha M_{VMS} = 9.5$ (for junction C). Here, TABLE I shows the traffic flow, mean velocity and calculated values of α_{VMS} at different time intervals in a day.

TABLE I : TRAFFIC FLOW & MEAN VELOCITY [JUNCTION C]

Time	Traffic Flow	Mean velocity (km/h)	α_{VMS}
7:00 AM	10	60	0.16
7:30 AM	20	40	0.50
8:00 AM	40	30	1.33
8:30 AM	60	25	2.40
9:00 AM	100	20	5.00
9:30 AM	150	15	10.00
10:00AM	200	10	20.00
10:30 AM	250	05	50.00

Case 1

At time 9:00 AM,

$F_{min}(\alpha_{VMS}, \alpha M_{VMS}) = F_{min}(5, 9.5) < \alpha_{VMS}$

Hence according to the algorithm, no diversion is required through the minor sub lane by- pass. This case is shown in Figure 4.

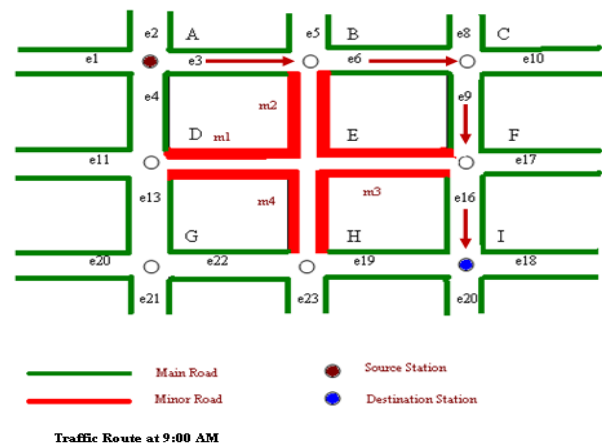


Fig. 4 Case 1

Case 2 At time 9:30 AM,

$F_{min}(\alpha_{VMS}, \alpha M_{VMS}) = F_{min}(10, 9.5) > \alpha_{VMS}$

Hence according to the algorithm, the minor lane by pass would be generated and the commuter will get the signal to divert the route at minor lane m2. This case is shown in Figure 5.

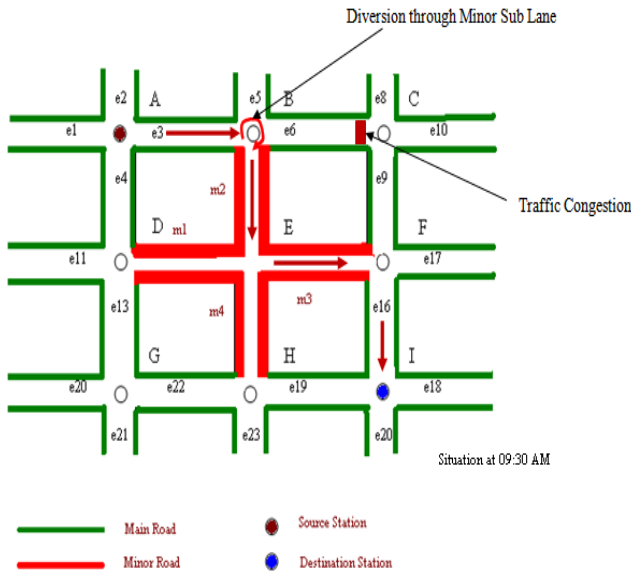


Fig. 5 Case 2

The variations of α_{VMS} are represented as follows at both the junctions,

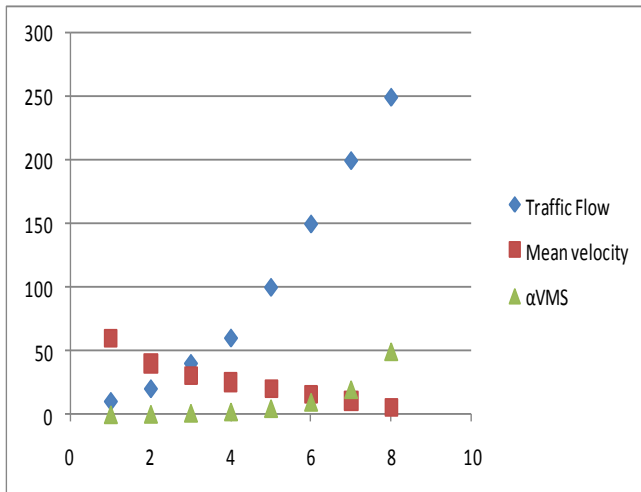


Fig. 6 Traffic Flow, Mean Velocity and α_{VMS} at Junction C

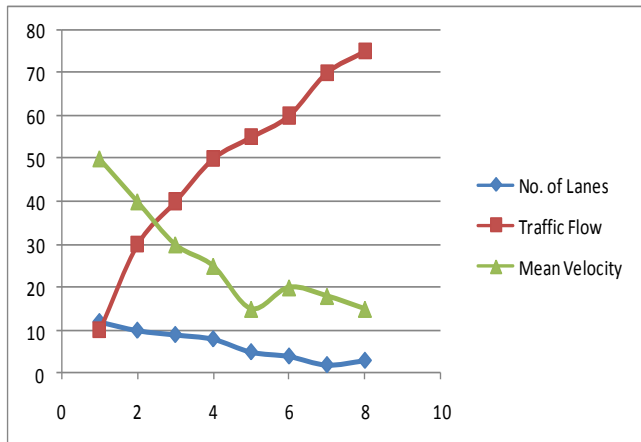


Fig. 7 Simulation result (Showing importance of Minor Role)

The results are shown in Figure 6 and 7 and indicate that the closure of minor roads could improve the travel time. The estimation of routing is usually performed by calculating the feedback costs associated with each link network-wide for every pre-specified interval (5 min in this case). This causes the vehicles to opt for major links, thereby achieving better optimization and lesser travel delay time. However, when multiple lanes were closed, a slight degradation is seen during the first peak traffic period, which subsequently settles down in the later peak periods to a slightly higher delay value than in the normal operation.

V. CONCLUSION AND FUTURE SCOPE

This paper introduces a new approach to deal with the traffic congestion on the road networks. A new lane by pass based approach is introduced using genetic algorithms. The results are found satisfactory.

In future, the authors would like to expand this approach for IVHS (Intelligent Vehicle Highway System) by integrating Multi Agent Systems.

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