AITMS: An Adaptive approach for a ‘smarter’ Traffic Regulation

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Abstract**—** Adaptive Intelligent Traffic Management System (AITMS) is an approach to analyze and suggest optimal route in dynamic traffic scenarios. The system undertakes integrated transportation planning for effective tackling of engineering and management issues. The planning is based on the real time parameters like road conditions, signal delays, weather conditions, opening of new access points and traffic congestion. The demand profile like trip length, user comfort and priority will be in accordance to the road infrastructure density, its functionality and hierarchical connectivity.

AITMS implements the Highway Hierarchical algorithm that encompasses decision support system to suggest the optimal route for the current traffic conditions. The system also handles exceptional real time situations like accidents, festivals and rallies using reinforcement learning strategies. The key components of AITMS are the database system, simulation platform and its usage for evaluating performance under various circumstances, and user input to make the system learn. This will also promote a way for environmental sustenance in mixed traffic, improper land use development and non-planned road network conditions. AITMS aims to make the intelligent traffic monitoring system a reality and provides a way to save fuel and time.

AITMS obtains and analyzes the traffic-related data and simulates the various control strategies to develop a smarter traffic surveillance system

Keywords- Highway hierarchies algorithm, Reinforcement learning, Q-Learning, Decision support system

I. INTRODUCTION

Intelligent Transportation Systems (ITS) have been developed in many countries around the globe to reduce the impending traffic problems and to increase the overall traffic throughput consequently. However, India’s ITS cannot be entirely modelled on the existing successful ITS of other nations due to the evident geographical and economic differences among the countries. The design for intensive ITS program for India hinges on the

- Technology: The development and implementation of advanced technologies like sensors, detectors, and communication devices depends on the cooperative work between the Government’s academic research institutions and industries.
- Modelling of Indian Traffic: A proper understanding of traffic system is important in the successful implementation of reliable ITS systems and so the existing models developed for western countries are not sustainable for the Indian traffic. Thus there is need for a system which suits the Indian Traffic Environment.

Adaptive Intelligent Traffic Management System (AITMS) helps us to provide the commuters the optimal routes to their target locations to minimize the traffic delays. The dynamic decision support system improves road safety, reduces pollution level and saves fuel costs. It calculates the traffic density between the given source and destination. Then by analyzing the available road network data and the user priorities an optimal path between the two given locations is suggested. The system makes the traffic control decisions based on road characteristics and traffic conditions. The factors that influence this decision-making are traffic density, road mishaps, construction work, political rallies, festival or marriage processions, travel time, average speed, road dimensions, flooding and others.

Thus, the proposed model is an attempt to give a better insight into the dynamic traffic scenario and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.

II. LITERATURE SURVEY

Intelligent Transportation Systems are developed in many countries to reduce congestion and increase overall traffic throughput. Most such systems maintain efficient traffic flow by controlling traffic signals and highway ramp meters using sensors and CCTV cameras. Intelligent Transportation systems (ITS) in foreign countries are a tested route to mitigate traffic management problems. ITS is developed to make proper use of technology for improving transportation systems. The major objective of ITS is to evaluate, develop, analyze and integrate new technologies and concepts to achieve traffic efficiency, improve environmental quality, save energy, conserve time and enhance safety and comfort for drivers, pedestrians.

According to the survey conducted, the well-known Dijkstra's algorithm is used for finding shortest path between the source and the destination. Dijkstra's algorithm solves the single-source, shortest-path problem on a weighted graph. To use this algorithm within the context of real-world transportation data, this algorithm is modified with respect to user settings and road profile. The performance of Dijkstra's algorithm is further improved by using better data structures such as d-heaps. But the algorithm should be able to model the locations anywhere along an edge, not just on junctions. Also these improvement increase the time complexity of the algorithm as finding the exact shortest path on a nationwide network dataset is time-consuming due to the large number of edges that need to be searched. Thus, to improve the performance a hierarchy of transportation systems is used to find the optimal route. The algorithm provides for route optimization by simultaneously searching from the origin as well as the destination locations, as well as connection or entry points into higher-level roads. It then searches the higher-level roads until segments from both origin and destination meet.

III. SYSTEM ARCHITECTURE

a. PRODUCT OVERVIEW

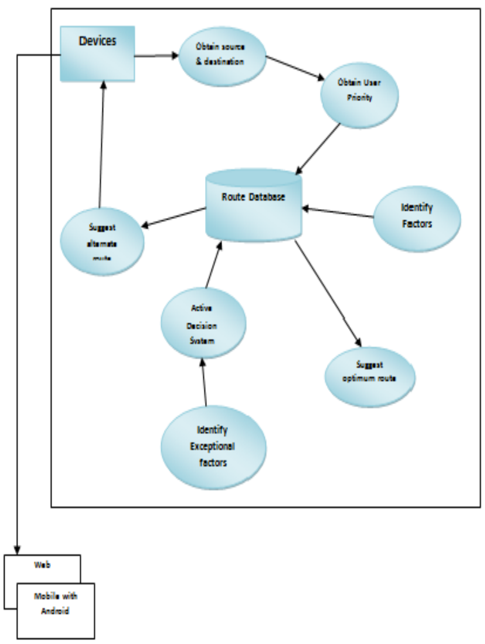


Fig 1

B. ASYMPTOTIC ANALYSIS

Let, S be the system, then
S = {I, O, F, Fc, Sc}
where,
I is a set of all inputs,
I = {I1, I2, I3, I4}
I1 = Source of journey.
I2 = Destination of journey
I3 = User Profile
I4 = Time of journey
O is a set of all outputs,
O = {O1}
O1 = Set of all paths sorted according to user priority.
For finding cost of any route, we consider the concept of linear regression.
The formula of linear regression is,
$Y = X\beta + \acute{\varepsilon}$.
We modify the above formula for our system as,
$Y = \Sigma y1i + \Sigma y2j$
where,
$y1i = X\beta + \acute{\varepsilon}$
where,
X = (p x 1) leg matrix.
β = (1 x p) parameter vector for leg.
i = index for all legs
έ = Exceptional factors (Accidents, Rallies, Festivals etc.)
έ can be calculated as,
$\acute{\varepsilon} = X\beta$
where,
X = (p x 1) exceptional cases matrix.
β = (1 x p) manipulating vector for exceptional cases.

Sample leg matrix:

	Leg 1	Leg 2	Leg 3	Leg 4
Source	1	2	3	4
Destination	2	3	4	5
Distance	0.11	0.18	0.021	0.12
Traffic Condition	7	6	5	5
Road Condition	3	3	3	3
Speed limit	40	40	40	40

Table 1

Sample β matrix:

	Distance	Traffic condition	Road condition	Speed Limit
Distance Priority	14	4	4	8
Time Priority	4	14	2	4
Comfort Priority	2	4	14	2

Table 2

Cost of legs:
y11 = 0.11*14 + 7*4 + 3*4 +40*8 = 361.54
y12= 0.18*14 + 6*4 + 3*4 + 40*8 = 358.52 and so on.

Cost matrix:

Priority/legs	y11	y12	y13	y14
Distance	361.54	358.52	352.29	353.68
Time	264.44	250.72	236.08	236.48
Comfort	150.22	146.36	142.04	142.24

Table 3

For calculation of έ:
Sample exceptional cases matrix:

	Leg 1	Leg 2	Leg 3	Leg 4
Accidents	5	5	5	5
Festivals	4	4	4	4
Rally	4	4	4	4
Weather conditions	2	2	2	2
Weekends	5	5	5	5

Table 4

Sample β matrix:

Priority	Accidents	Festival	Rally	Weather condition	Weekend
Distance	8	8	8	8	8
Time	10	10	10	5	5
Comfort	4	4	4	20	4

Table 5

Note: All the factors are rated on the scale of 0 to 10, by the amount of delays produced by those factors

Cost matrix:

Priority	Leg1	Leg2	Leg3	Leg4
Distance	160	160	160	160
Time	165	165	165	165
Comfort	112	112	112	112

Table 6

$y2j = X\beta + \acute{\varepsilon}$
where,
X = (p x 1) node matrix.
β = (1 x p) parameter vector for node.
έ = Exceptional factors
j = index for all nodes

Sample Node Matrix:

Parameters		NODE ID		
	N1	N2	N3	N4
Signals	2	2	1	0
No of incoming ways	3	3	3	3
No of outgoing ways	3	2	1	1
Signal Delay	60	90	90	0
Congestion Level	8	8	5	5

Table 7

- Signal Delay: in seconds
- Congestion level: rated on the scale of 0 to 10. 0 indicates no congestion, 10 indicates higher scale of congestion.

Sample β matrix:

Priority	Signals	Incoming ways	Outgoing ways	Signal delay	Congestion
Time	6	2	2	15	4

Table 8

Cost of Node:
y21 =6*2+2*3+2*3+15*60+4*8=956
y22 = 6*2+2*3+2*2+15*90+4*8=1404

Cost matrix:

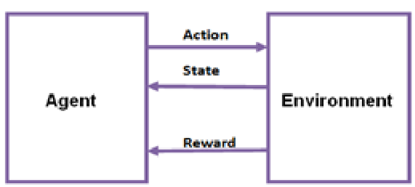
Priority	y21	y22	y23	y24
Cost for time	956	1404	1384	28

Table 9

Now cost of each route can be calculated as:
$Y = \Sigma y1i + \Sigma y2j$
Y = 1424 + 640 + 3772 = 5836

C. CENTRALITY

Reinforcement Learning is an Artificial Intelligence technique that helps to choose optimal actions based on states of its environment in order to achieve its goals. The reward is given by the environment after executing an action which helps the agent achieve its goal. High reward value is assigned if the action leads to the goal and negative reward value is given if the action takes the agent away from the goal. To obtain high reward, a reinforcement learning agent must prefer actions that it has tried in the past and found to be effective in producing reward. But to discover such actions, it has to try actions that it has not selected before. The agent has to exploit what it already knows in order to obtain reward, but it also has to explore new actions in order to make better action selections in the future. The agent must try a variety of actions and progressively favor those that appear to be best. Each of these actions must be tried many times to gain a reliable estimate of its expected reward.



Q-learning is one of the reinforcement learning methods. Q-learning operates by performing an action, receiving rewards and updates its internal states. The action selection policy will be affected based on the reward value. The main objective is to learn an optimal action from every reward, state and selected action. The agent can perceive a set of distinct states *S* from its environment and is able to perform a set of actions *A*. At each discrete time step, the agent senses the current state s, choose an action *a and* perform the action. The environment then responds by giving the reward *r* and succeeding to the new state, δ(s,a) where δ is a state transition function given state *s* and action *a*. Q value is the reward *r*(*s*,*a*) received by performing action *a* from state *s*, plus the value (discounted by γ=(0..1))

Q(*s*, *a*) <– 0 for each (*s*, *a*)

s <– current state

Do Forever:

- Select and execute an action *a*
- Receive reward *r*(*s*,*a*)
- *s'* <– δ(*s*,*a*)
- Update the new Q value

$$Q(s,a) \leftarrow r+\gamma \max_{a'} Q(s',a')$$

$$s \leftarrow s'$$

In the system under consideration, the authors have done the reward assignment by increasing the rank of users that provide road network information. A certain minimum rank is necessary to assure the concerned users a guaranteed authority to get their suggestions updated to the database.
The system has been designed by implementing Q-learning algorithm.

D. CONCLUSION

AITMS is a probable solution to mitigate the traffic congestion and provide for a better vehicular traffic administration. The system designed assures integrated traffic analysis and helps to reduce the fuel consumption and travel time, thus providing well managed road traffic conditions. The Highway Hierarchical algorithm is a faster technique as compared to the widely known Dijikstra's algorithm for bulky data. And so, the complex road networks and the huge traffic data considered need the system design to implement the Highway Hierarchical algorithm for the analysis of the traffic scenario and the different user priorities. The algorithm uses highway hierarchies of real world road networks to speed up the optimal route provision. This application can be put on cloud so that we can charge the user for its use and thereby earn money. For the time being we have implemented the project for the Pune City, in the future we want to make it applicable for the Maharashtra State or even for the country.
Moreover, the Artificial Intelligence technique of Reinforcement Learning enables machine learning and helps in building an efficient adaptive traffic management system. Thus, AITMS is a successful attempt towards a smarter planet.

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