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EFFECTIVE CONGESTION CONTROL IN TRAFFIC MANAGEMENT USING WIRELESS SENSOR NETWORK

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Abstract—
The continuous increase in vehicular traffic has become an immense matter of concern, as the road network remains limited. In this situation especially, congestion control in wide network of intersections becomes necessary. Existing studies on traffic control algorithm mainly focused on determining the green light length in a fixed sequence of traffic. Therefore, an effective traffic management algorithm would help in resolving this issue. We have developed STSC: Sensor-based Traffic Signal Control, an improved version of adaptive Traffic Control Algorithm, which uses a decentralized system for its operation. In this algorithm we have considered four traffic phases at an intersection, which considers all the possible routes. For this we have used DSRC: Dedicated Short-Range Communications [1] between the vehicles and traffic controller to adjust the phases. The performance evaluation shows that our work can improve in current situation and effectively manage traffic in a wide range of traffic intersection [2].

I. INTRODUCTION

The advancements of technology have led to the fourfold increase in the power of gasoline engines. Vehicle has become a basic necessity these days. The number of vehicles is increasing at a tremendous extent in the recent times especially in urban areas. So an effective traffic management becomes very necessary. In today's scenario, an Indian driver has to spend approximately 60 hours per month on average in traffic congestion. Greatest reasons for this are poorly timed traffic signals and their inability to adapt to real time traffic [6], which leads to congestion and jams. Due to this there is loss of time, increasing frustration level of drivers, insufficient consumption of fuel, which is a non-renewable source of energy. It also results decreased effectiveness of emergency vehicles like Ambulance, Fire brigade, VIP Vehicles etc. Therefore an effective, unmanned and cost effective solution becomes very necessary. This project helps to adapt to real time traffic and accordingly give green pathways while keeping into mind that maximum priority is given to the emergency vehicles. To monitor real time traffic, an intelligent Wireless Sensors Networks (WSN)[5] is used. WSN consist of a lot of Traffic Sensor Node (TSN) [7] detectors, which is designed to fetch the number of vehicles on each lane, their type, their waiting time and their speed. The current situation uses fixed and predefined system for green traffic signal which is ineffective as it can work well in less busy intersection. This fails when the intersection is more crowded. So to eradicate the dynamic signal control method is used which adapts and works in real time.

II.METHODOLOGY USED IN PROPOSED WORK

We have proposed algorithm (STSC) to control the traffic using Wireless Sensor Networks.

A. Problem Notations

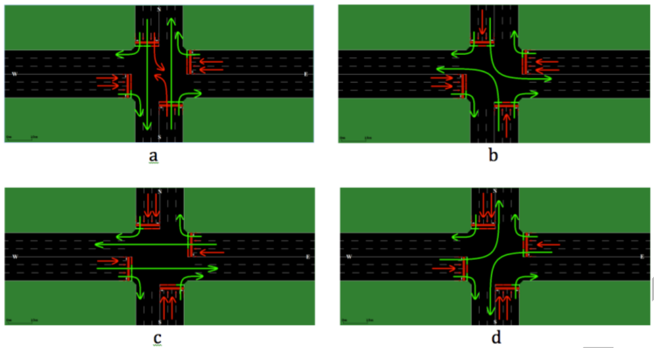


Fig. 1 The Four Phases of Traffic Light

We have proposed 4 phases of traffic lights. Green line indicates that movement is allowed in the phase that is green light and red line indicates that movement is not allowed in the phase that is red light. The right turn for any vehicle coming from any direction will remain green throughout the algorithm. Wireless sensors will detect the vehicle related attributes such as: number of vehicles on each lane, waiting time of vehicles, vehicle ID (detection for emergency vehicles) and their speed.

B. Variables Used

Vehicles can originate from the following directions:

Direction = {East, West, North, South}
Movement = {Straight, Left}
Phase = {a, b, c, d}

1**)** Number of Vehicles Waiting in a Lane: Given by vehicles detected by the sensor present on each lane.

nvl { direction, movement}

2) Total Number of Vehicles in a Phase: Calculated from nvl for each lane

nvphase_x = Sum of nvl that belong to phase x

3**)** Queue Empty Time for a Lane: Time to empty the queue after giving green light in a lane:

qetl = tci + tlv

where tci - time taken for vehicle to cross the intersection, and
tlv - time taken for last vehicle in queue to reach the front of that queue.

4) Queue Empty Time for Phase: Time to empty the queue for each phase:

qetp = MAX(qetl)
for each qetl in that phase

5) Detection of Special Vehicle in a Lane: If there is an special or priority vehicle in a given lane

SV {movement, direction}

6) Waiting Time for Front Vehicle in Each Lane: This is used to avoid infinite wait condition that occurs when there are few vehicles in a lane

wt {movement, direction}

7) Maximum Waiting Time: This denotes the maximum time above which a vehicle does not have to wait in a lane to get the green light

wtmax

8) Maximum Phase Time: The maximum time a phase is allowed to get green light:

ptmax

9) Phase Time: Gives the phase time (ie green light time set for that phase) for a given phase

pt = MIN(qetp, ptmax)

C. Algorithm

1) Initialization: ptmax = 90 //Maximum phase time
wtmax = 120 //Maximum waiting time
nvl{movement, direction} for all lanes.

2) Calculation of Maximum Number of Vehicles in a Phase:

nvphase_a = nvl{North,Straight}+ nvl{South,Straight}
nvphase_b = nvl{North,Left} + nvl{South,Left}
nvphase_c = nvl{West,Straight} + nvl{East,Straight}
nvphase_d = nvl{West,Left} + nvl{East,Left}

3) Selection of Phase: **Check** for special vehicle case in each lane

SV {movement, direction}

If a special vehicle is detected then:
Assign green light to that phase immediately in which the vehicle is detected if there in case of only one special vehicle
If special vehicle are present on more than one phase then assign green light to that phase immediately which has move number of special vehicles
Else
Assign green light immediately to that phase which has maximum nvphase
Else If
Compute waiting time for each lane

wt {movement, direction}

If
there exists a path whose waiting time is greater than the maximum waiting time then, Assign green light to that phase in which the maximum waiting time has occurred
Else
Assign green light to the phase having maximum number of vehicles as computed in step (2)

4) Determination of Green Light Duration for the Selected Phase:

qetp = MAX(qetl) //queue empty time for selected phase
pt = MIN(qetp, ptmax) //phase time for selected phase

Set green light time for that phase equal to pt.

D. Challan Generation

Our algorithm takes input from the wireless sensors installed in the vehicles. We can collect the much needed information such as vehicle's current speed, current phase, vehicle ID, presence of vehicle on detector and penalize the defaulters. With the help of vehicle's speed and vehicle's ID, we can check whether any vehicle is crossing the speed limit of that particular lane. By having the phase information and vehicle's ID, we can check whether any vehicle has jumped the red light or not.

III. IMPLEMENTATION

We have used SUMO Simulator [4][9] to simulate our proposed algorithms. For the implementation of this algorithm, we have considered a single intersection in which traffic phases are selected according to STSC. Using STSC, the most appropriate traffic phase will be selected based on the real time traffic.

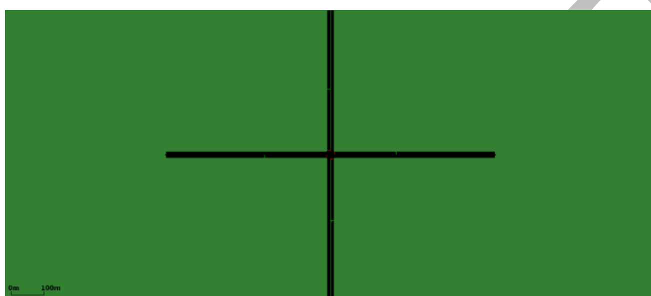


Fig. 2 The intersection developed in SUMO simulator along with detectors

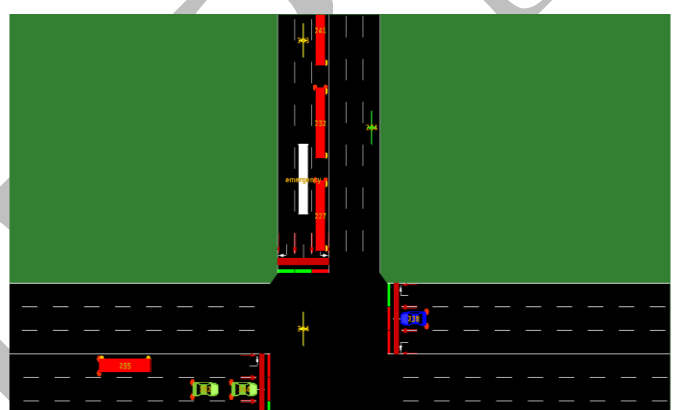
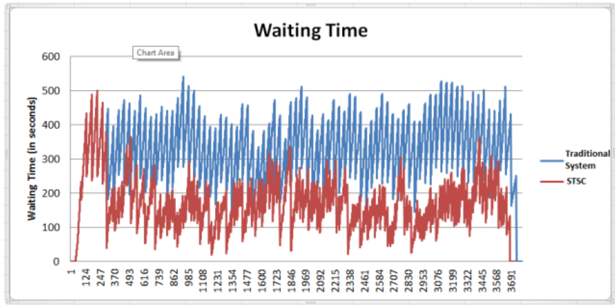


Fig. 3 Detection of Emergency Vehicles

The above figure represents different type of vehicles flowing across the intersection. The number on each vehicle represents the vehicle ID of that vehicle. The yellow indicator on some vehicles represents the direction in which the vehicle wants to take a turn. The red indicator tells that the vehicle is currently braking. Based on the calculations performed by STSC, phase a of traffic light is chosen above as there is an emergency vehicle with emergency as its vehicle ID which is coming from north and willing to go to south, in which vehicles coming from north and willing to go to east and vehicles coming from south and willing to go to west are moving. Vehicles coming from any direction and willing to take the right turn are free to do so throughout the simulation. Rest all other vehicles are waiting for their lane to signal green light. The above figure is generated in SUMO Simulator while simulating STSC algorithm.

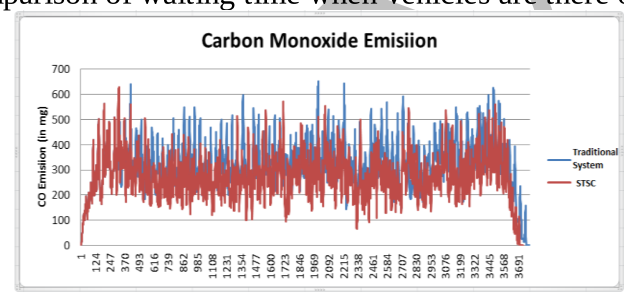
III. PERFORMANCE EVALUATION

In this section, we evaluate our algorithm's performance using some traffic factors such as waiting time, fuel consumption, carbon monoxide. We have considered four phases to compare the waiting time between Static and Dynamic Traffic Control. The following graphs are the result of using the STSC algorithm:



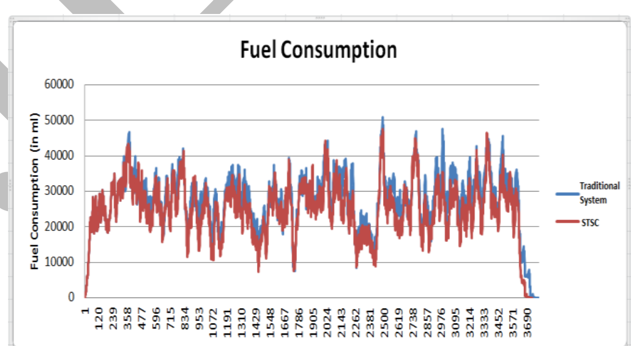
Graph 1: Comparison of waiting time between Traditional System and STSC when vehicles present on all phases

The graph shows the comparison of waiting time when vehicles are there on all the four phases.



Graph 2: Comparison of emission of Carbon Monoxide between Traditional System and STSC.

The above graph shows the comparison of emission of Carbon Monoxide in both the systems which is one the main contributors in the green house effect.



Graph 3: Comparison of consumption of fuel by vehicles in Traditional System and STSC.

The above graph indicates that there is a slight improvement in fuel consumption by vehicles when STSC was used over Traditional System.

IV. CONCLUSION and FUTURE WORK

In this research paper we have proposed the algorithm "Sensor Based Traffic Signal Control". This algorithm offers higher rates of scalability and optimization. According to our evaluation, the average waiting time has been reduced to minimum possible time units, the maximum being 120 seconds for any vehicle. Our proposed algorithm also has maximum priority for emergency vehicles and automatic challan generation system to traffic violators. All this is calculated based on the current traffic situation. In the future this research work can be extended for the prediction of vehicles that are not equipped with sensors.

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