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Intelligent Traffic Control Using Chronological Flow Analysis of Signal Gaps

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Abstract: Urban areas grapple with daily traffic challenges due to the burgeoning number of vehicles, overwhelming roadway capacities. This leads to issues like congestion, delays, and pollution, negatively affecting society. Although Smart Traffic Management Systems (STMS) have been implemented to mitigate these problems, they encounter constraints. This research focuses on traffic control by identifying congested areas and proposing improvements. Through Sequential Flow Analysis (SFA) and Vehicle Markov-chain Monte Carlo (VMCMC) methods, it assesses traffic flow dynamics, aiming to minimize waiting times. The approach emphasizes roadside-based traffic control measures and infrastructure-based equipment to enhance traffic management, flow, throughput, accuracy, travel time, and pollution control. By monitoring congested sequences and optimizing signal timing, the study seeks to alleviate traffic issues effectively. The utilization of efficient inference tools in time-series data analysis enhances system performance by directing attention from vehicles to signals and expediting sensor data transmission.

***Keywords**: Intelligent transportation system, Urban area, Traffic analysis, Sequential flow, and VMCMC.*

I. INTRODUCTION

During the most recent decades, the absolute number of vehicles around the globe developing provided Rapid development in the total populace has brought about a traffic congestion issue in the road. To oversee and control traffic flows, the states of the road traffic must catch. The road traffic state can be portrayed utilizing Speed, current, and density on a particular fragment of the road. The length of the particle may shift contingent upon the geometry of the way. While assessing the traffic state, various sorts of traffic models usually are utilized [1].

Conversely, the models can exclude all parts of the whole system. For a decent view of the real world, the models must be joined with estimated traffic state data, e.g., traffic counts and speed/travel time estimations. Numerous cities around the world can have the smart devices to take care of urban issues, such as traffic congestion, natural pollution, human services, and security surveillance, to improve the expectations for everyday comforts their overall population ordinary helps [2].

Traffic congestion, a prevalent issue in traffic management and transportation planning, occurs when an excessive number of vehicles on a roadway segment during specific times lead to slower speeds and increased travel durations. This presents a significant challenge in effectively managing traffic flow [3]. To address this challenge, smart sensors are strategically deployed throughout urban areas, integrated into vehicles, buildings, roadways, control systems, security surveillance, and various user applications. These sensors serve as vital sources of data, providing real-time information that is essential for city-wide monitoring and management [3].

Smart Cities utilize data to monitor urban aspects like parking availability, traffic management, route navigation, and intelligent transportation systems. Integration of Information Communication Technology (ICT) infrastructure, such as computers, broadband connectivity, and sensing systems, has played a key role in enabling these advancements. Traffic Internet of Things (IoT) solutions utilize this infrastructure to collect and coordinate traffic data efficiently, enabling comprehensive analysis and real-time decision-making. Consequently, contemporary Traffic Management Control (TMC) systems are evolving into intelligent vehicle systems based on IoT principles, fostering self-reliance and adaptability [4, 5].

Effective traffic flow management requires consideration of several performance metrics, including throughput, travel times, safety, fuel consumption, emissions, and reliability. Contemporary methods utilize a blend of roadside-based measures like traffic signals and dynamic route information boards, along with infrastructure-based equipment such as sensors and traffic control centers. However, the dynamic nature of traffic situations requires

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adaptable strategies, particularly concerning traffic light control [6]. Traditional fixed-period traffic light systems may not effectively address changing traffic conditions, necessitating the adoption of adaptive control algorithms [7].

Overall, the integration of smart sensors, ICT infrastructure, and IoT technologies represents a significant advancement in traffic management practices. By leveraging real-time data and adaptive control mechanisms, cities can enhance traffic flow, reduce congestion, and improve overall transportation efficiency, thereby promoting sustainable urban development and improved quality of life for residents. Additionally, a person may trap with continuous signal waiting time may arise. It analyzes the traffic signal approximate waiting time and travel time from one message to another to make sense of it. After that, the continuous flow of Jamming in one sign to another signal is found and proposed a Vehicle Markov-chain Monte Carlo (VMCMC) method to solve the user's traffic problem.

II. LITERATURE REVIEW

Sabeen Javaid, Ali Sufian, Saima Pervaiz, and Mehak Tanveer [8] a newly introduced intelligent traffic system incorporates Internet of Things technology and a decentralized approach to improve road traffic flow. It employs advanced algorithms to manage diverse traffic situations more accurately, addressing deficiencies in prior systems. This system utilizes traffic density data from cameras processed through Digital Image Processing techniques, alongside sensor data, to optimize signal management effectively. Moreover, it includes an algorithm to forecast future traffic density, reducing congestion. Additionally, RFIDs are integrated into emergency vehicles such as ambulances and fire trucks to prioritize their movement, enhancing efficiency on the roads.

Abida Sharif, Jianping Li, et al. [9] suggested a budget-friendly Smart Traffic System (STS) aimed at enhancing traffic service delivery with instant traffic updates. This system involves installing economical vehicle detection sensors every 500 meters along roads, leveraging the Internet of Things (IoT) to swiftly gather and transmit public traffic data for processing. The real-time streaming data is forwarded for Big Data analysis, enabling predictive analysis to provide solutions based on analytical insights.

Zhiyi Li, Reida Al Hassan et al. [10] investigate the transportation sector's disruptions in urban areas, necessitating enhanced operational strategies to meet the demands of smart cities. Mamata Rath [11], facilitating rapid data transmission and corresponding actions. Under the envisioned approach, a mobile agent-based controller, operating within VANET.

Khan, Muhammad Adnan, et al. [12] developed a framework for smart cities, emphasizing robust infrastructure and the adoption of cutting-edge technology. Their system model integrates cloud data, social networking (SN) services, and smart sensors to support intelligent city functions. Fuzzy logic proves to be a proficient method for modeling traffic and transportation processes, with the Mamdani Fuzzy Inference System utilized for complex traffic modeling and problem-solving, demonstrated through MATLAB simulation results.

III. PROBLEM STATEMENT

They were vehicles increasing day by day; as a result, traffic is becoming an essential problem in big cities all over the world. The problems people face due to traffic congestion is enormous. Intelligent Transport System (ITS) faces many challenges like providing adequate transportation, reliable, meaningful information to drivers in high time traffic congestion, low transportation effectiveness, economic well-being, and jeopardized conditions. It can be unraveled through imaginative and modern methods of taking care of most new procedures that have arisen as of late in incorporating data innovation, devices, and media transmission with roads and traffic management. Many researchers implement many techniques to solve this traffic problem, but they also face some of the issues mentioned above. And also, they face continuous trapped in signal to signal basis.

IV. PROPOSED WORK

Traffic congestion poses a significant challenge in many cities due to the rapid increase in the number of vehicles on the roads. There are primarily three types of traffic congestion. The first is recurrent traffic congestion, which occurs at the same location at the same time every day. The second is non-recurrent traffic congestion, which arises randomly like a spontaneous event. The third is sequential traffic signal trapping, where individuals repeatedly get caught at consecutive traffic signals. This paper focuses on addressing the third type of congestion. Congestion primarily occurs due to the insufficient capacity of roadways to efficiently accommodate the volume of traveling vehicles. To initiate the congestion relief process, it is essential to identify the sources of congestion.

Traffic congestion has become a significant issue these days. Traffic congestion mainly happens in metropolitan cities. Expanded air contamination, commotion contamination, mishaps, delay in movement time, and so forth are a portion of the issues that are looked by individuals living in these megacities. Traffic jams have severely affected the lives of residents. The conventional traffic lights conveyed in cities are not adequate to satisfy the needs of an ever-developing town. These traffic lights have specific foreordained time interims for transforming from the red stage to the green scene. And if the person is waiting in a signal, he/she crosses the signs, and hence if another sign located nearby distance means again that person trapped in the message, and continuously it will happen many times. So, to avoid this, this paper proposes a Vehicle Markov-chain Monte Carlo (VMCMC) method to analyze the person's traffic flow and provide a better approach to skip the continuous traffic.

a. Vehicles Detection

In-Vehicle detection,of every vehicle, gets recommendations from the traffic controller using road-vehicle correspondence and considers the messages from the neighboring vehicles using vehicle correspondence together with the data from the essential vehicle control layer. Traffic control layer which is a piece of the roadside framework is the one used by all vehicles. The traffic layer has few disseminated controllers, which decides warning guidelines for the vehicles in its neighborhood and sends these directions to the vehicle.

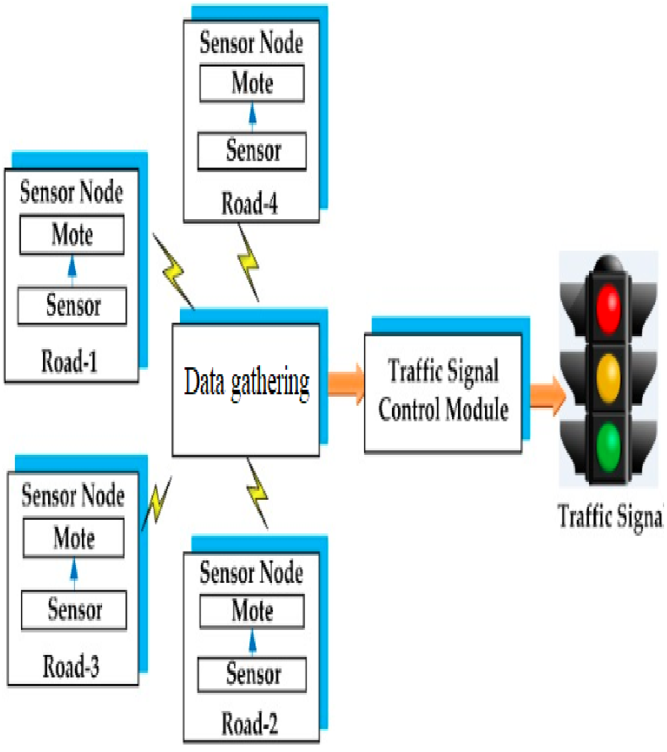

Figure 1: Data collection from roadside sensor

The data assortment module of the TMC accumulates the data, analysis the traffic parameters, and afterward imparts it to the traffic sign control module of the TMC. The vehicle detection process should be performed moving vehicle near the signal and also analyze the waiting area near the message by using VASCAR. Visual Average Speed Computer and Recorder (VASCAR) is a method for calculating the Speed of vehicles and the signal waiting for analysis. This region, which contains the most traffic, can implant both light and large vehicles, and the principal objective of the proposed work is to keep away from the point of view difficulties, and an inappropriate sort checks. A traffic signal guarding mode here is green, yellow, and red defined as (Gmode, Ymode, Rmode) is designed after the control completed.

After finding the vehicle analysis, the mechanism of analyzing the vehicle sequence is calculated by

$$S_i \ (S=1\ldots.\ i) \qquad (1)$$

and then the flow at the next signal count moment is

$$\text{Signal Count } C_i\ (i+1)\ (i=1\ldots\ldots k) \qquad (2)$$

Because traffic flow is characterized by uncertainty, nonlinearity, and complexity, it becomes challenging to ascertain its patterns. The K-nearest approach involves identifying the nearest neighbors within a dataset and grouping them together to create clusters.

b. Traffic Analysis

To enhance traffic signal monitoring and decrease travel time on congested roads, coordination of traffic signal phases is essential. Increasing signal frequency can reduce travel time but may also exacerbate congestion. Coordinated signals can positively impact emission control and environmental concerns. Sharing data enables drivers and traffic authorities to improve situational awareness of traffic conditions. Intelligent Transportation Systems (ITS) play a vital role in this field, utilizing road sensors developed with embedded systems expertise.

$$\text{Traffic flow} = \frac{\text{No.of Vehicle}}{\textit{Road length}} \qquad (3)$$

The traffic signal system operates based on the traffic density along the roadside, with sensors detecting vehicle sizes. Three lights - green, yellow, and red - are positioned at roadside intersections to manage traffic flow.

Algorithm 1: VMCMC Algorithm

Step 1: Start ()

Step 2: Vehicle_Mang_Controller() Initialize Block

Step 3: Vehicle_Moini_Unit ()

Step 4: On-Road Sensors ()

Step 5: Vehicle Nodes communicate their location data

Step 6: Calculating the signal time and sequential flow

Step 7: Processing traffic data from the cloudlet

Step 8: Estimating the sequential flow analysis of the vehicle.

Step 9: Analyse Time travel by VASCAR

Step 10: Check CHRONOLOGICAL analysis, C.

Step 11: If C==1

Step 12: For (i=0; i<=5; i++)

Step 13: Then

Step 14: Count CHRONOLOGICAL analysis C= C+i, C++

Step 15: END IF

Step 16: END FOR

The Average Waiting Time (AWT) for a vehicle at convergence in a conventional system is erratic. Plans that are smart and versatile to traffic flow are constantly being created and utilized for building an ITS.

c. Analyzing the sequential flow of signal waiting

Efficient vehicular traffic control at road intersections remains a concern in modern urban areas worldwide. Existing systems often rely on preset timing circuits for traffic signal operation, which proves ineffective as they fail to adjust to real-time traffic volumes. Consequently, vehicles frequently experience unnecessary delays at intersections, even when traffic on opposing roads is minimal. Traffic congestion arises not only from daily patterns but also from nonrecurring incidents such as accidents, construction, weather, and events. To address these challenges, this paper proposes a system that calculates vehicle speed based on signal-to-signal timing, aiming to minimize waiting times and alleviate traffic issues. Vehicle Markov-chain Monte Carlo (VMCMC) methods are used here to analyses the traffic flow. It gives levels of popularity to productive deduction apparatuses in a time-arrangement investigation. VMCMC is alluded to as the state-space model and portrayed as a Markov procedure where the inner state straightforwardly watched. It assesses the traffic execution to the anticipated exclusively by the present state and is free of past states.

Algorithm 2: Status Calculation

INPUT: PREV_SIG= previous signal, CURR_SIG= Current signal, Count C, Time T

getStatus(vehicle)

Step 1: **Start procedure** ISWAITING_IN_SIGNAL(COUNT)

Step 2: CURR_SIG = getStatus(Vehicle, previous sequence flow, waiting time)

Step 3: PREV_SIG = getDistance, getTime(previous C, Current C)

Step 4: check C

Step 5: **IF** C > 5 then

Return Value = MORE_Signal

Step 6: **else**

Step 7: Return Value = SIGNAL_COUNT

Step 8: **end if**

Step 9: **end procedure**

Recognizing vehicle developments, understanding traffic designs, conduct, how traffic congestions show up, and incrementing time and space can profit the expectation of short and long haul traffic circumstances; it can also reduce congestion.

Algorithm 3: Heterogeneous Analysis

Step 1: Find the vehicle analysis

$(x_i, y_i) = Item_i$ $//$x specifies the vehicle,

$//$y specifies the time $Received from\ VASCAR$

Step 2: Move to the next level and obtain the following item as

$(x_{i+1}, y_{i+1}) = Item_i$+1

Step 3: Find the distance between signals.

$euc_i = \sqrt{(xi_{+1} - x_i)^2 + (y_{i+1} - y_i)^2}$

Step 4: IF $euc_i \leq cluster_i$

Step 5: $Cluster_i = Item_i$

Step 6: END IF

This effective method requires proficient inference tools for time-series analysis. It garners significant attention as vehicles promptly transmit monitored data through sensors to signal the system.

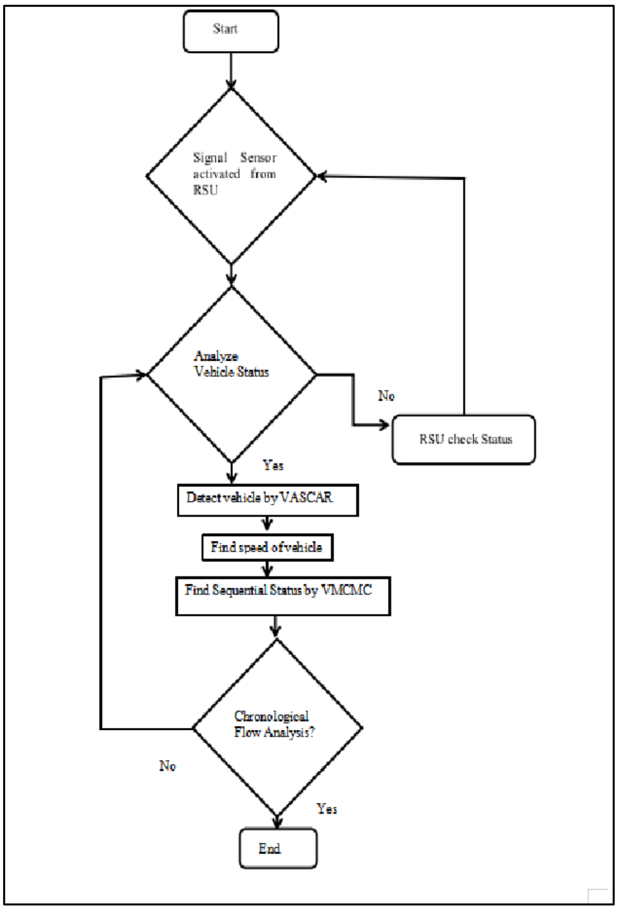

Figure 2: Proposed VMCMC Flow

V. EXPERIMENTAL RESULT

This section displays the simulation findings, illustrating the performance of the sequential signal flow analysis involving RSU (Road-Side Unit) nodes and standard vehicle nodes configured with various network parameters. The simulation covers three traffic scenarios with varying numbers of vehicles, and the results are obtained by extracting output values from trace records generated during simulation. The data has been refined as necessary using NS2 Simulators.

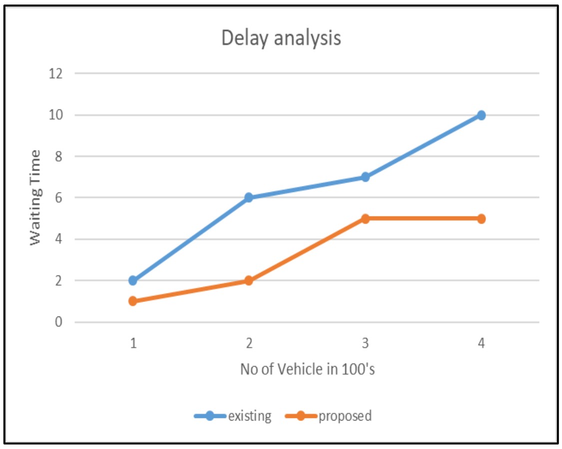

Chart 1: Delay analysis

Chart 1 shows the delay analysis of the proposed and existing correlation. The gathered data can be utilized to anticipate the traffic developments, traffic congestions, evaluated travel time, most ideal course, and so on. This data, when made accessible to people in general, facilitates traffic management in the city and thus prompts a smooth flow of traffic, prompting less congestion.

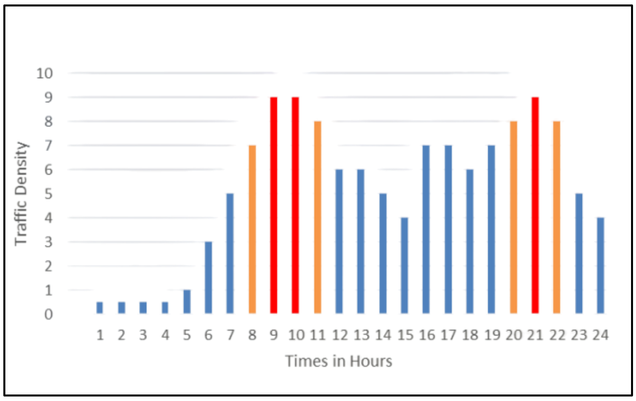

Chart 2: Traffic Density Analysis

Traffic density determined as the number of vehicles over time. The quantity of vehicles is determined by

$$\text{Density}_i = \frac{V_i}{T} \qquad (4)$$

density_i: Traffic density of vehicle type i

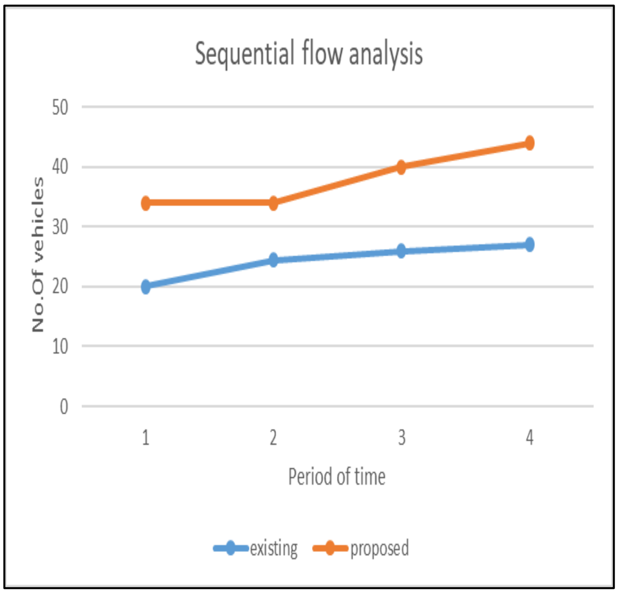

Chart 3: Sequential flow analysis comparison

The number of vehicles that passed in the road must be analyzed using a sequential flow basis. In chart 3 shows the comparison of subsequent flow analysis of the existing and proposed method.

VI. CONCLUSION

All urban areas face traffic congestion issues, particularly in the midtown zones. Typical cities can be changed into "smart cities" by harming information and Communication technologies (ICT). The worldview of IoT can assume a significant job in the acknowledgment of smart cities. In many cities, they were continuous signals placing in the roadways. So in day to day life, a person is waiting for a sequence of the messages. To avoid the constant waiting time in the signal, this paper proposes a VMCMC method. This method prevents the continuous flow of signal waiting time. Our approach provides the traffic performance to the predicted solely by the current status of the signal and the previous status of the message. It can easily have identified and provide a better avoidance of traffic.

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