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Smart road management system for prioritized autonomous vehicles under vehicle-to-everything (V2X) communication

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Abstract
This paper works on smart transportation strategy for emergency autonomous and normal autonomous vehicles under the vehicle-to-every-things circumstance. All vehicles are fully autonomous, and all EAV communicate with the help of autonomous intersection management to handle traffic situations. When an autonomous emergency vehicle enters the road, then an autonomous intersection management system assigns this vehicle a high priority and all other autonomous vehicles with low priority. Following the priority queue principle and FIFO rule, all vehicles run smoothly so that there will not be too many collisions occurring on the road. Simulation works are conducted by using Simulation of Urban Mobility (SUMO), in which all proposed strategies are performed on different Pakistani routes By-pass Multan, M2-motorway, and Nishtar routes. According to our strategy Simulation result, the M2-motorway route takes 8.50 sec to complete its route for autonomous emergency vehicles, and normal autonomous vehicles take 10.55 sec to complete the route. The results identify that the proposed algorithm for different autonomous vehicles significant in reducing the average time delay caused by the algorithms and the corresponding variance, which shows the efficiency and fairness of the proposed strategy in autonomous intersection management.

Keywords Vehicle-To-Everything Communication · Emergence Autonomous Vehicles · Smart Transportation System · SUMO

1 Introductions

The Smart Road Management system is a well-developed and current emergent autonomous cars management system that monitors road traffic. The success of smart transportation systems depends on the availability of innovative transportation services.

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Modern traffic signal controllers and smart transportation systems (STS) [1] are increasingly appealing to improve current traffic infrastructure performance. Our smart transportation systems (STS) are becoming increasingly appealing to improve the current traffic infrastructure performance. Congestion avoidance or reduction can aid in the conservation of transportation-related energy. Although many smart traffic controls technologies have advanced significantly in theory, the vast majority have yet to be fully developed for use in the field [2]. A self-driving car is an important component of a smart transportation system. An upcoming autonomous vehicle's operation is taken over totally or partially by the vehicle itself. The vehicle is completely under human control [3]. Some specialized duties, such as managing the vehicle's steering wheel and acceleration, are handled without human intervention. The vehicle's role is determined by its immediate surroundings; in some cases, the driver must be prepared to manage the vehicle. Due to unique traffic circumstances or laws, vehicles have full control in some scenarios. All driving takes are handled by the car in all conditions, where vehicles undergo every safety-critical driving function in varied driving scenarios. The Smart Transportation System [4] is a traffic management system that manages all types of vehicles on the road. The use of new autonomous cars on roadways has several advantages. Autonomous vehicles will reduce traffic congestion by at least 50% on highways, freeways, and road intersections. Due to their computational intelligence, autonomous cars may avoid road accidents more swiftly than human drivers. When traffic congestion is minimal, the time it takes for autonomous cars to emerge will be slower. Furthermore, autonomous cars will increase their energy efficiency by 20% due to their speed, efficiency, and control systems. Finally, the advent of driverless vehicles offers a fantastic travel experience [5].

However, a big challenge is to handle the Emergency prioritized autonomous Vehicle (EAV) on a smart transportation system for vehicle-to-everything (V2X) communication [3]. Emergency autonomous vehicles, including the V.I.P. vehicle, etc. EAV should be given a clean passage while efficiently maintaining the autonomous traffic flow. To solve these problems, by using Autonomous Intersection Management System (A.I.S.M.). A controlling all autonomous vehicles' communication and handling of these autonomous vehicles entering the smart road. Autonomous Intersection Management System (AIMS) works as a database having all information about vehicles on the road [4]. It handles vehicle communication and the distance between the vehicles for efficient traffic flow. The use of V2X-based signal prioritization to boost the mobility of public transportation, emergency vehicles, and freight is a potential use of V2X-based signal prioritization. V2X-enabled roadside infrastructure can recognize a vehicle's unique characteristics and take the most appropriate action. With the reduced travel time and fuel consumption at a junction, the solution can alter the signal timing (extend or force green light) based on the priority of each vehicle. Major roadblocks hamper public transportation, emergency vehicle preemption, and integrated freight priority. V2X technology is required between the vehicle to vehicle and road infrastructure. V2X technology uses information from vehicle optical sensors and detectors on the road infrastructure and shares it in real-time. The traffic information required for safe driving is exchanged with the vehicle, and this helps autonomous driving cars to respond to an unexpected situation instantly [5]. The motivation for doing this research is to design different algorithm-based strategies for traffic flow for EAV and NAV on the smart road without collisions. AISM automatically assigns high priority to our EAV in the queue, and all other NAV vehicles assign low priority (FIFO). Then, low-priority vehicles are automatically assigned high priority after giving way to EAV (VIP vehicle), and then these normal autonomous vehicles (NAV) work according to old strategies (FIFO). The contribution of this paper are as follows.

1) We propose algorithm-based strategies in different real-time road environments in which we handle EAV and NAV by using V2X communication. For this, we are taking three different real-time routes from Pakistan, and one international by using OpenStreetMap (OSM) [6].
2) AISM handle all types of vehicles and their road networks, it works like a database that contains all information regarding all vehicles which are entered in our smart road.
3) AISM assigns high and low priority on the base of vehicles, manage route junction, and assign routes to all vehicle so that no collision occurs on the route. All vehicles run smoothly without any disturbance occur on smart road.
4) The Simulations are conducted using Simulation of Urban Mobility (SUMO) [7].
5) These simulation works are performed on three different real routes these routes are taken from different Pakistan cities. From Multan city we are taken Bypass Multan route and Nishtar route and one route are taken from M2-motorway Lahore.
6) Simulation of Urban Mobility and the results show that the proposed strategy could significantly reduce the average delay time caused by the EAV and NAV, compared with the widely used priority queue and FIFO techniques.

This work is organized as follows: Section 2 contains the literature review. Section 3 presents the methodology of the study. Section 4 discusses the results. In last, conclusion and future work is described in section 5.

2 Literature review

The existing techniques for Smart Transportation System for Prioritized Emergence Autonomous Vehicle (E.A.V.) with Vehicle-To-Everything (V2X) Communication are efficient, but there should be some improvements for the sake of accuracy. Most of the work is done to handle autonomous vehicles. However, little work is done on handling autonomous emergency vehicles. Autonomous vehicles have revolutionized and improved the transportation system, according to [8]. This article thoroughly examines the best-in-class strategies for exhibiting AV frameworks in short-reach or close automobile situations. It focuses on late investigations that use sensor combination computations based on profound learning for insight, limitation, and planning. Furthermore, there may be unrecognized heterogeneity due to boundary effects that differ between contexts and people. To address these concerns, two drivers involved in a similar backside incident between passenger vehicles advocated for constructing a bivariate order probit model with irregular bounds to investigate factors that influence injury severity. When both the inner crash connection and unobserved parameters are taken into account, the proposed model outperforms two different ordered probit models with fixed parameters [8]. They're made to help/replace human drivers in maneuvering cars, lowering the risk of road accidents caused by human mistakes and enhancing street traffic safety. Before they can be broadly utilized, E.V.s have their own set of health and security hazards that must be addressed. However, various factors that influence traffic conflicts, such as speed differential, traffic thickness, speed, and weather conditions, are typically overlooked by this methodology. Recognizing traffic conflicts when there are so many variables is challenging because it necessitates the reconciliation and mining of heterodox data, the inaccessibility of traffic conflicts, and conflict forecast models capable of extracting significant and precise data without wasting time.

In congested locations, a game-theory-based priority control strategy for designing successful crossings for autonomous automobiles. Autonomous vehicles pass by roadside equipment, which shares data and makes decisions for the management of their passing traffic (RSU) [9]. The priority control algorithm ensures that automobiles do not collide at junctions. The study's primary goal was to eliminate delays in these situations. When combined with maximum pressure control, the autonomous intersection management approaches known as AIM-ped will produce the total throughput [6]. Proposes a multi-modular smart traffic control system (STSC) as the smart city's foundation, the applied in a wide range of smart transportation framework applications in brilliant city applications. An RSU Controller, an OBU, a signal regulator, and a cloud focus are all part of the proposed S.T.S.C. The S.T.S.C. framework is built to interact with the V3.0 metropolitan traffic control protocol, making it compatible with most traffic signal controllers and enabling quick and cost-effective transmission. A new traffic signal plan is built particularly for the EVSP circumstance when an EV approaches the crossing point; it can illuminate every automobile near the crossing point, easing traffic flow and boosting security without incurring additional hardware expenditures. The ability of the [10] framework to handle vehicular network (V2X) capacity is critical to smart city development because it allows for several smart transportation administrations. Intelligent transportation technologies (ITS) should be developed to reduce traffic congestion and boost public transit efficiency [11]. This paper proposes and implements a smart traffic signal control (STSC) framework for a variety of smart city transportation applications, such as emergency vehicle signal preemption (EVSP) and public transportation signal priority (TSP), adaptive traffic signal control (ATSC), and message broadcasting [12]. The proposed STSC framework is based on the RSU. Regulator, which contains the framework design, middleware, and control calculations. It is possible to do so with today's traffic signal controllers, resulting in a fast and cost-effective transmission. A new traffic signal plan has been developed specifically for the E.V.S.P. circumstance, and it can tell all cars at the confluence which direction the emergency vehicle (EAV) is approaching, improving traffic flow and enhancing safety. V2X correspondences are an emerging worldview for the Intelligent Transportation System (ITS) [13]. Which uses a comprehensive set of correspondence instruments in all of the devices and infrastructure associated with a traffic signal, checking, and routing to improve traffic productivity and the dependability of convenient information conveyance. The goal of this research project is to develop a Social V2X Communication Model that will improve traffic efficiency in today's ITS environment by providing a crucial data set at the correct time utilizing super-fast coordinated cell 5G developments. This is accomplished through the presentation of social behaviors in V2X correspondence as well as the organization of automated data and reconnaissance. Setting off needed operations for integrated systems administration innovations (Mobile Edge Computing/Fog Computing, Software Defined Networking, etc.) that rely on super-fast and ultra-low latency 5G circumstances. Cloud Computing) of coordinated substances like street clients (Vehicles, Buses, and Trucks are examples of it).

Roadside Unit (RSU), a wide variety of network units (MEC/Fog Server, V2X Application Server (AS), SDN switches, and SDN controllers), and a wide range of network units (M.E.C./Fog Server, V2X Application Server (AS), SDN switches, and SDN. controllers). Under the proposed paradigm in the social internet of vehicles (SIOV) environment, vehicle to vehicle (V2V) interchanges, vehicle to pedestrian (V2P) interchanges, vehicle to infrastructure (V2I) interchanges, and vehicle to network (V2N) interactions would all be enabled. Cellular frameworks are used to deal with an ever-increasing need for vehicular communication aimed at applications like improved driver assistance and, eventually, completely autonomous driving, as described in [14]. Cellular vehicle to anything (C-V2X) has become more essential with the announcement of the first set of 5G (fifth generation) framework standards. The more complicated 5G frameworks will be able to support even more moving objects. This research will show how to use only a few fundamental associations to allow cellular frameworks to accept a large number of moving Machine Type Communication (MTC) [15] items while keeping framework adaptability. To cluster vehicle ad hoc networks (VANETs), the Normalized Multi Dimension-Affinity Propagation Clustering (NMDP-APC) plot was created [16]. Furthermore, this study offers a framework progression that comprises a collection of techniques that are completely compatible with C-V2X frameworks. We used theoretical research to demonstrate detailed simulations and mathematical experiments, focusing on sensitive edge-based Support Vector Machine (SVM) calculations. The simulation results revealed that altering essential SVMs changed the expected execution and that the granularity parameter we utilized efficiently regulates the size of V.A.N.E.T. clusters even while cars are moving [17]. A functional traffic signal and control system is a basic and vital test in our ever-growing urban regions. The major goals of today's intelligent traffic light foundations are to raise street limit utilization, manage traffic streams, reduce emanation, improve traffic security, and supply drivers with the best start-to-finish transportation experience possible. These models rely largely on creating traffic signal or traffic light regulator frameworks, which adjust and carefully plan individual traffic lights to reach city-wide traffic task destinations [18] dynamic constant data exchange between all players in the traffic controlling environment and cultivating useful metropolitan information) could undoubtedly be the next stage of this development [19] explores the potential outcomes of cutting-edge V2X networks for future independent driving that are both safe and secure. After a thorough writing review, we introduced cutting-edge V2X in the associated examination sector. Future V2X developments based on 802.11bd and 5G N.R. were specifically mentioned. The issues and limitations of existing V2X based on 5G and edge registration were investigated in this study. In terms of protection, security, and system administration, blockchain has emerged as a feasible alternative for tackling the obstacles and difficulties outlined by current and cutting-edge V2X advancements. We investigated and studied the usage of blockchain in cutting-edge V2X communications, which provides new capabilities, applications, and services for advanced V2X networks [20]. Finally, this study identifies numerous open research issues and possible areas for future research based on impending breakthroughs such as big data, artificial intelligence, and earlier 5G. Table 1 explain detail summary of recent papers.

3 Material and methods

This section contains the methodology of the study.

3.1 Problem formulation

Handling an emergency priority car on the road in a real-world situation is a major task. The smart transportation system architecture for priority vehicles includes bulky traffic control and management, vehicle platooning, and trajectory optimization. Managing emergency-priority autonomous cars (emergency vehicles, VIP vehicles) is a significant difficulty in heavy highway traffic. Several routes are necessary for various components of the route design and implementation process to comply with protocol requirements.

Table 1 explain detail Summary of modern literature

Author	Objective	Techniques
Shahab et al. 2021 [21].	Improved Control Strategy for Three-Phase Microgrid Management with Electric Vehicles Using Multi-Objective Optimization Algorithm	Multi-Objective Optimization MOO
Wei-Hsun et al. 2020 [12].	Design and Implementation of a Smart Traffic Signal Control System for Smart City Applications	T.S.C., Emergency vehicle signal preemption (E.V.S.P.)
Takashi Koshimizu et al. 2020 [13].	Multi-Dimensional Affinity Propagation Clustering Applying a Machine Learning in 5G-Cellular V2X	Vehicular Ad hoc Network (V.A.N.E.T.) NMDP-APC
Manuel Eugenio Morocho-Cyamcela et al. 2020 [14].	Machine Learning to Improve Multi-hop Searching and Extended Wireless Reachability in V2X	Fully-convolutional networks (F.C.N.s)
Shuja Ansari et al. 2020 [15]	Chaos-based privacy-preserving vehicle safety protocol for 5G Connected Autonomous Vehicle networks	Connected Autonomous Vehicles (CAVs)
Yuying Li et al. 2020 [16].	Intersection management for autonomous vehicles with vehicle-to-infrastructure communication	Vehicle-to-infrastructure communication, traffic light
Baz et al. 2020 [22].	Intersection Control and Delay Optimization for Autonomous Vehicles Flows Only as Well as Mixed Flows with Ordinary Vehicles	The Game theory priority queue algorithm, AV/AV, and AV/OV
Olayode et al. 2020 [23].	Application of artificial intelligence in the traffic control system of non-Autonomous vehicles on signalized roads into.	Artificial neural network algorithm.
Islam et al. 2019 [24].	The Algorithm for the Ethical Decision Making at Times of Accidents for Autonomous Vehicles.	Priority queue-based min-heap sorting algorithm
Juan Contreras-Castillo et al. 2017 [20].	Internet of Vehicles: Architecture, Protocols, and Security	Internet of Vehicles (IoV)
Shrikant Tangade et al. 2016 [25].	Scalable and Privacy-Preserving Authentication Protocol for Secure Vehicular Communications	Vehicular ad hoc networks (V.A.N.E.T.s)

Prioritized vehicles should be granted clear access while the autonomous traffic flow is maintained. This study aims to develop a smart road management system for the prioritized emergence of autonomous vehicles (Fig. 1).

As a result, different edges indicate several lines being transposed. A traffic light system and linkages between lanes are utilized on SUMO road networks to indicate which routes can be used to crossings. As a result, three types of road networks will emerge grid, circular, and random. Each of these generations offers options for adjusting the network's attributes. On the M2 motorway network, autonomous cars regulate traffic flow. By preparing the way for the autonomous cars, they relieve the traffic stress on the central management unit. Other vehicles also follow the FIFO rule, ensuring that V.I.P. cars do not cause too much disruption. Prioritized vehicles may include V.I.P. vehicles. Prioritized vehicles should be given a clean passage while efficiently maintaining the autonomous traffic flow. AIMS is developed to handle this problem, so when an autonomous emergency vehicle comes on the road, this system assigns a path to that prioritized emergency autonomous vehicle. Intersections represent nodes, and roads represent roadways in road networks, which are used to model real-world networks. The intersection is subject to shape, position, and right-of-way laws. Edges are one-way, connecting two nodes with the same number of lanes. All vehicle statistics, the maximum speed allowed for these vehicles. As a result, different edges indicate several lines being transposed. A traffic light system and linkages between lanes are utilized on road networks to indicate which routes can be used to crossings.

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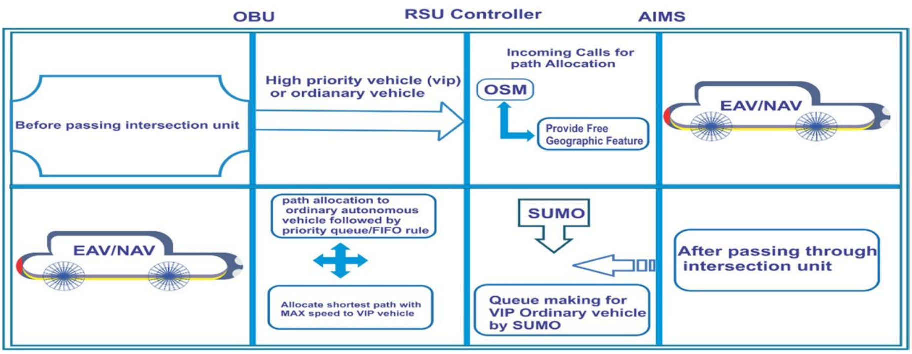

Fig. 1 Block DIagram of Emergency Autonomous Vehicle and Non-Autonomous Vehicle

3.2 Simulation of urban mobility

Imports and generates traffic representations and demand sources (SUMO). Each vehicle is given a unique number, a departure time, and a network path. Variables are assigned to these cars, and the vehicles are displayed in the simulation. OpenStreetMap (O.S.M.) is a worldwide map that is available for free. O.S.M. places a premium on local knowledge and allows anyone from all over to contribute. Edges are one-way, connecting two nodes with the same number of lanes. Different kinds of vehicles will be able to move without colliding (Fig. 2).

- The work of the model is to manage the road system.
- When an emergency vehicle enters the control area of an intersection and asks for space from other vehicles, all are in a hurry.

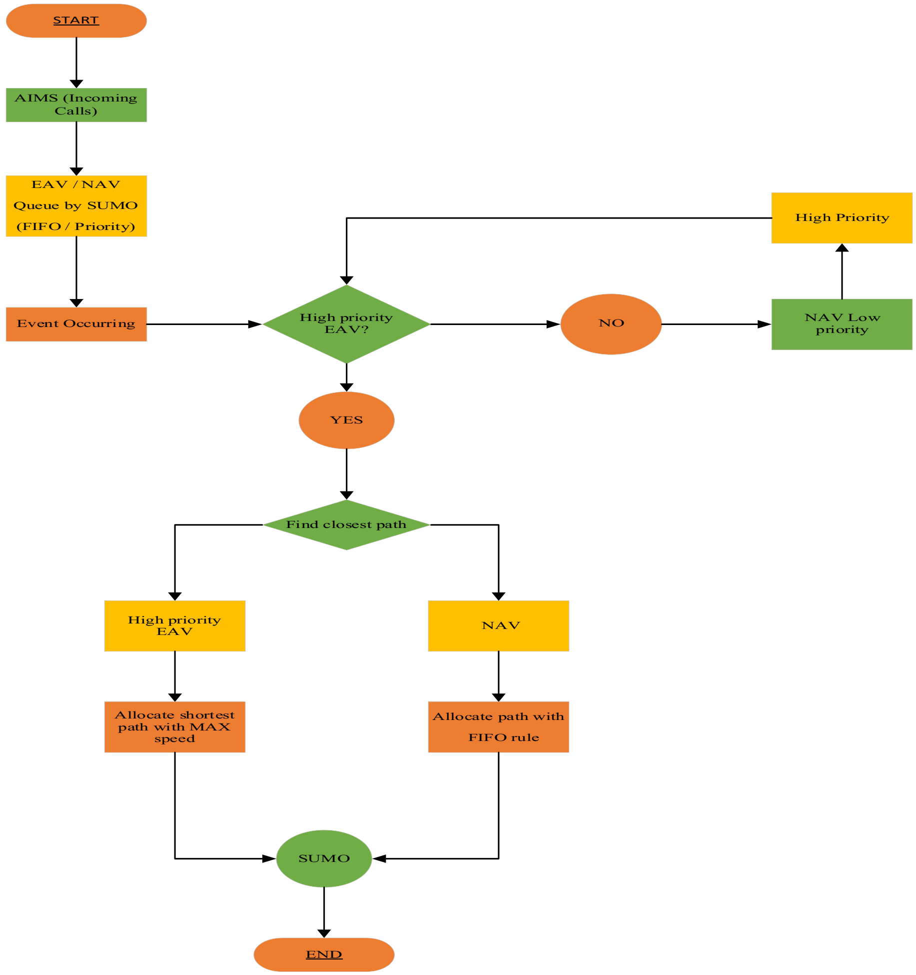

Fig. 2 Flow Diagram of EAV/NAV

- It is impossible to make a clear path for that vehicle, so AIMS is developed to handle this problem.
- So when an emerging autonomous vehicle comes on the road,
- This system assigns a way to that prioritized emergency autonomous vehicle following the priority queue and FIFO rule by providing a safe route to all these normal autonomous and emergence autonomous vehicles. With an assigned acceleration or slowdown rate, the Traffic Management unit delivers a permission or refusal message to that autonomous vehicle.

3.3 Intersection management

Because intersection management is such an important site where cars might collide, there are many different types of meetings. There are 12 tracks in this show. Each lane has its I.D. (x= 1, 2….12), which is clockwise. In each lane, there is only one outgoing way. They will be the vehicle's path in the junction area, each with its road. Under a vehicle-to-everything (V2X) scenario, the Smart Road Management System prioritizes autonomous cars (Fig. 3).

1. Each road's beginning points and stop line are 500 meters apart before the crossing.
2. The vehicle-to-vehicle range is fixed for all other vehicles.
3. The interval between the centerline and the intersection's center is 15 meters.
4. Assume that the I.M. unit is positioned in the intersection's center, and its transmission distance is 200 meters.
5. The vehicle's speed limit is 45 km/h.
6. When a VIP vehicle assigns high priority, all vehicles are arranged, giving a path to high priority vehicles.

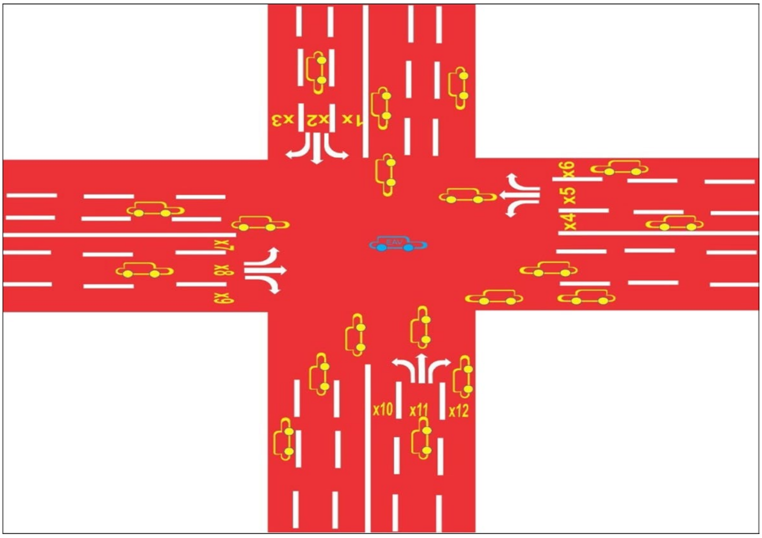

Fig. 3 EAV and NAV are handled by A.I.S.M

7. All (AV) provide low priority, but after moving out high priority vehicles, they automatically assign low priority vehicles to high stress, which works according to the FIFO rule.
8. When a VIP vehicle gives high priority, its max speed is assigned to this high priority vehicle to reach its destination as soon as possible.
9. VIP Autonomous vehicles are assigned specific routes. In this route, all VIP vehicles are run.
10. When Emergence Autonomous Vehicles (VIP) enter this network, other vehicles running on this route give way to Emergence Autonomous Vehicles/VIP by arranging themself on different routes.

3.4 Route confliction

There will be a conflict between these two routes if there is an intersection of routes at some point in the traffic intersection region. The lane the car will occupy may be seen in the above diagram, as can the vehicle's journey. So, whether these two lanes conflict or not, there is a point to ponder. The intersection of these two roadways creates a conflict managing situation for all vehicles.

Under a vehicle-to-everything (V2X) scenario, the Smart Road Management System prioritizes autonomous cars. The smart road management system is an independent vehicle management system that is current and well-developed for all forthcoming autonomous cars on the road. Emergency autonomous vehicles and normal autonomous vehicles traveling on By-pass, M2-motorway and Nishtar highways are given a time delay. The goal is to plan the safest and fastest route to an emergency autonomous vehicle for crossing while minimizing time delays and accidents caused by vehicle collisions.

3.5 Technique

Then it checks the priority of the vehicle if it is an emergence autonomous vehicle or the normal autonomous vehicle by applying the priority queue principle and FIFO rule.

1. When this event happens, a decision is made for that vehicle if the vehicle is not an emergency prioritized autonomous vehicle. It obeys the priority queue principle and FIFO rule, and all autonomous vehicles will move by this rule.
2. If the vehicle appearing on the road is an emergency autonomous vehicle /V.I.P., then the responsibility of AIMS is to provide the closest path with max speed to that vehicle by arranging the way for the normal autonomous Vehicle and Emergency prioritized autonomous vehicle.

In the end, sumo will show the path of all moving autonomous vehicles.

3.6 Traffic management plan

In our research, we are following these strategies to control EAV/ NAV traffic on the road.

In pseudo-code

(1) Initial condition: The information list is currently blank.

(2) The link is established whenever a vehicle near R.S.U. But all information regarding vehicles is stored when the vehicle enters A.I.S.M. Its identification vehicle number is "i," and the route indicate by routes: I.D. (X_1, X_2, X_3….X_{12}). The emergency vehicle is checked initially by the A.I.S.M. unit. Suppose there is not even a prospective emergency vehicle. The automobile will get a null signal from the A.I.S.M. unit, so the shortest route is assigned to this EAV so that it completes its route successfully. If the route is busy so A.I.S.M. assigns a possible route to the emergency vehicle.
(3) Find all vehicles currently on the possible VIP vehicle routes by searching the information list. If there is no vehicle, send the matching maximum departing time $\mathbf{Y}_{\mathbf{max}}$ back to it. Set max to null on the emergence route.
(4) Depending on the outcomes of the A.I.S.M. unit thorough review, the vehicle's speed is changed using the A.I.S.M. unit. If the answer is no, it must arrive at the junction no later than $\mathbf{Y}_{\mathbf{minutes}}$ later. The message is not set to NULL.

It is worth noting that A.V.s can use various speed adjusting strategies. The rule is that the vehicle shall pass through the junction as quickly as feasible but no later than the time limit. Y maximum A safe time gap might also be considered. Finally, the truck transmits its predicted time of arrival.

The I.M. unit, of time, departing from the junction.

(5) The AISM system expands the knowledge list by adding i routes. Any type of vehicle Leaving the junction should send a signal to the I.M. unit so that it may be activated.

The information in the list can be deleted.

(6) Steps (2) to (4) should be repeated (5).

System for Managing Autonomous Intersections

- It functions similarly to a database management system.
- It is saved in here when a road vehicle enters. We are also modifying the Vehicle's speed and acceleration.
- The Database assigns an I.D. to each vehicle.
- If the road is vacant, it is allocated one then maximum speed, but in the interest of safety, he uses; nevertheless, if the road is congested, each vehicle is given a fixed time, and it operates in the FIFO rule.
- When a V.I.P. vehicle enters the road, it takes precedence over other vehicles and is given the highest speed and shortest path.
- All other FIFO trucks have a low priority, but when priority vehicles leave, they have a high priority while still adhering to the FIFO rule.

In pseudo-code explain each step, in which EAV/ NAV traffic control on the road by using FIFO rule and priority queue.

Input:

VIP vehicle B, autonomous vehicle A, and the approaching vehicle

The journey of I.D. "i" I.D. path

Output:

On the i's autonomies car, the maximum departing time is y max.

Steps:

1: if there is an emergency vehicle on the path in A, so

2: y max = NULL

V.I.P. emergency prioritized autonomous vehicle

3: else

4: for each emergency vehicle x*k* in *A*

5: Get the lane x*k* from *B and the leaving time yk.*

6: end

7: y *max* = max{y*k*}

priority queue principle and FIFO

8: end

Algorithm 1 Pseudo-Coding description that how to find out the maximum departure time of an Emerging autonomous Vehicle

3.6.1 Pseudo-code for the algorithm executed by the I.M. unit

In order to provide a safe path for cars, AIMS assesses the priority of arriving vehicles using the priority queue and FIFO rule. For prompt delivery, the earliest possible time is preferred. The vehicle is in charge of changing speeds and estimating the amount of time it will take to pass through the junction. It also covers the outcomes terminologies used to compute AIMS performance. This system works for the arrangement of the vehicle on the road to make an intersection-free environment. The acceleration and time loss show that the system's abrupt decisions create a clear path for all vehicles (Fig. 4).

To detect traffic flow, supervised machine learning approaches might be utilized. Fully labeled training and testing data are used to manage the vehicles on the road by arranging the Emergency prioritized autonomous vehicles if we give the testing data into the model. This proposed solution demonstrates that the simulation results using SUMO are far more efficient than the prior traffic light management system. This system will manage the road, which will assign the way to V.I.P. priority autonomous emergency cars. Autonomous cars will proceed onto the road after receiving an okay or rejection message from the junction management unit if the priority queue and FIFO rule are followed. They illustrate that when an autonomous vehicle joins the road and AIMS receives an incoming call, it examines the car's priority and assigns the path based on that priority.

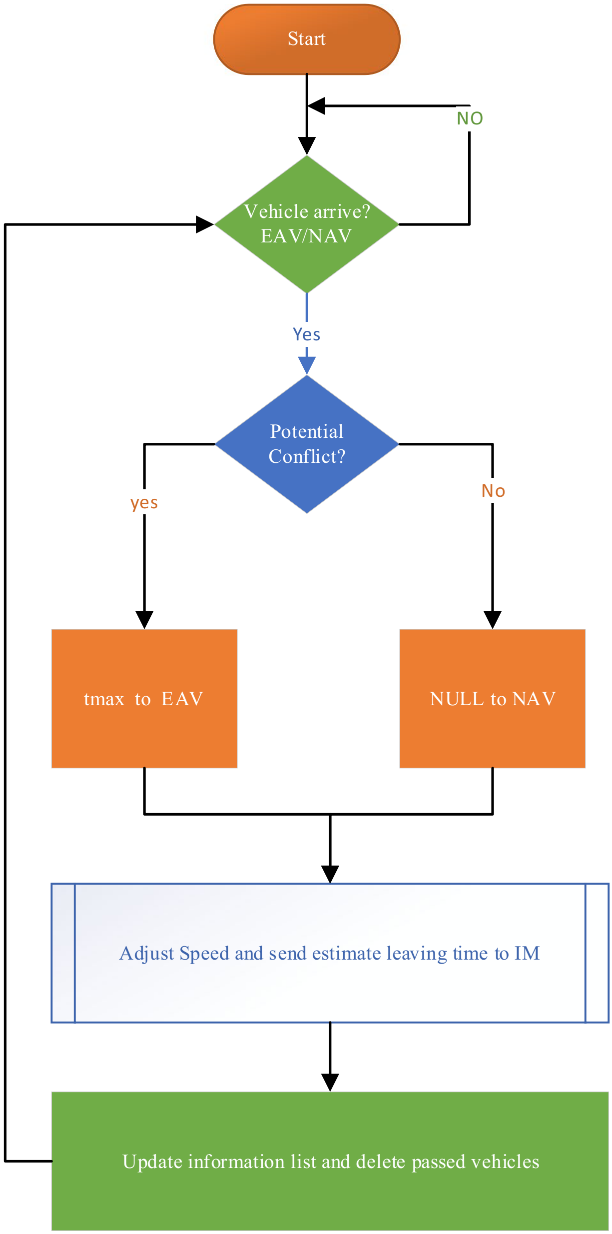

Fig. 4 Intersection Management Unit works

3.7 Collision for two autonomous vehicles

A conflict point is a location where two or more cars may clash. Assume that two cars arrive at the EAV1 and NAV1 junction sites. At the junction, a car must slow down to make a decision. The vehicle must then wait for AIMS to decide to move the car, known as delay time (Fig. 5).

As a result, there should be a safety buffer between the vehicles' arrival times at the conflict area. If EAV1 is the first to approach the junction, the extent of NAV1's slowing will be equal to the delay time (D.T.). Because of this, the delay period varies depending on the kind of trajectory and from one vehicle to the next. Y1 and Y2 vary in real-time, as does t, depending on the vehicle's speed and size.

EAV1	north emergence autonomous vehicle.
NAV1	eastbound normal autonomous vehicle
D1	the distance between EAV1 and the point of conflict with NAV1.
D2	the radius between NAV1 and the EAV1 is a conflict point.
Y1	the time it takes for EAV1 to reach the collision point with NAV1.
Y1 = D1/x1 Y2	the time it takes NAV1 to reach the point where it conflicts with EAV1.
D2/x2 = T2 x1	EAV1's speed. x2: NAV1's speed.
NAV1	must offer a 3-second safety buffer for EAV1 to pass first.

Time delay

$$y = Y_1 - Y_2 + \Delta Y_{12} \tag{1}$$

The average delay times

$$\overline{Y} = \frac{\sum_{i=1}^{N} y_i}{N} \tag{2}$$

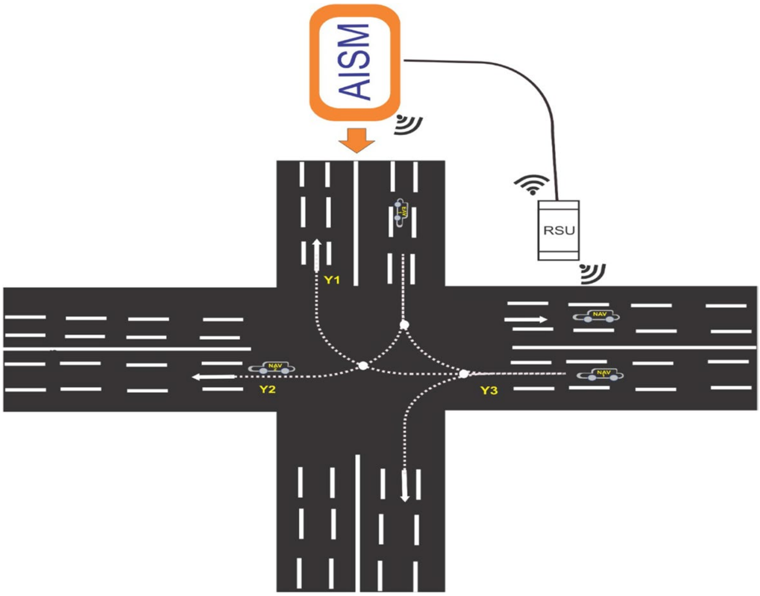

Fig. 5 Explains Smart Route Management handle EAV/NAV in an intersection

Y_1 time needed for EAV1 to reach the conflict point with NAV1.
Y_1 D1/x1 T2: time needed for NAV1 to reach the conflict point with EAV1.
Y_2 D2/x2 x1: speed of EAV1. x2: speed of NAV1.
ΔY_{12} safety margin time that NAV1 have to provide for EAV1 to pass first.

As a result, to estimate the calculations for the best vehicle trajectory, the simulation of this technique will provide current trajectory optimization and maximum pressure control. The intersection efficiency is evaluated using a simulation approach based on pedestrian demand. Because pedestrian and vehicle delays are negatively associated, this algorithm will alter the conflict trajectory between pedestrian demand and vehicle mobility. When demand for automobiles and pedestrians grows, the algorithm can adjust to meet the demand by allowing cars to pass through the crossroads on opposing paths. The simulation looked at three distinct traffic volume and speed combinations. The study's primary goal was to eliminate delays in these situations. When combined with maximum pressure control, the autonomous intersection management approaches known as AIM-ped will produce the total throughput.

4 Results and discussions

In Table 2 explain average time delay on three different routes on the basic of emergency autonomous vehicle and normal autonomous vehicles. This comparative analysis describes that the time loss for emergency autonomous vehicles matters a lot, the M2- Motorway route is very efficient in handling the emergency autonomous vehicle passing on the route.

Table 2 shows that the delay time emergence of autonomous vehicles is much better for M2- Motorway Road. On the M2 motorway network, autonomous cars regulate traffic flow. By preparing the way for the autonomous cars, they relieve the traffic stress on the central management unit. Other vehicles also follow the FIFO rule, ensuring that V.I.P. cars do not cause too much disruption. However, according to our situation, the time it takes for an autonomous emergency vehicle to complete an M2-motorway route using the priority queue method is 8.50 seconds, whereas standard autonomous cars take 10.55 seconds. The M2-Motorway Road has a better wait time for Emergency and autonomous vehicles, saving nearly 2.5 seconds. The success of the junction management technique is measured by the average delay time of all vehicles and their variation. The I.M.'s efficiency is demonstrated by the average delay time, and the variation in delay time may be used to assess the strategy's fairness.

However, the bypass route EAV performance are not much better. So, according to our simulation result, bypass routes are not show better result for EAV because these routes' intersections and junctions are complex, so the I.M. unit does not assign the shortest part for E.A.V, and both routes work on the FIFO rule that why NAV performance is a little bit better than EAV (Fig. 6).

Time loss for autonomous vehicles, this comparative analysis describes that the time loss for emergency vehicles matters a lot, so by the proposed technique, the M2- Motorway

Table 2 Explains about three different routes and comparative working analysis on the basis of average time loss.

Sr No.	Routes under consideration	EAV	NAV
01	M2 - motorway	8.50 sec	10.55 sec
02	Nishtar road	3.89 sec	4.08 sec
03	Bypass route	11.31 sec	6.63 sec

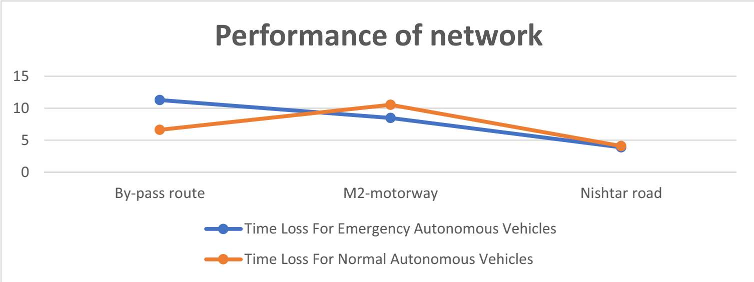

Fig. 6 Explains the average time loss of both EAV/ NAV.

Road is very efficient in handling the emergency vehicles passing on this route. The graph shows that the delay time for Emergency Autonomous vehicles is much better for M2-Motorway Road. However, E.V. performance is not much better on the By-Pass routes. Both ways are complex and busy. The autonomous automobile performed admirably on the m2 highway. Before the intersection, the distance between the start point of each road and the stop line is 500 meters. AIMS creates a path for the emergency vehicle in a short amount of time (Fig. 7).

The efficiency of the intersection management technique is quantified by the average delay time of all vehicles along with their changing velocity, resulting in acceleration change. The delay time varies with the type of trajectory; it also varies from one vehicle to another because Y1 and Y2 change in real-time.

5 Conclusion and further work

V2X communication is used in the smart transportation system to handle the VIP prioritized autonomous vehicle on the roads in a real environment. Unlike previous systems, the traffic burden from the central control unit is reduced by planning the way for autonomous

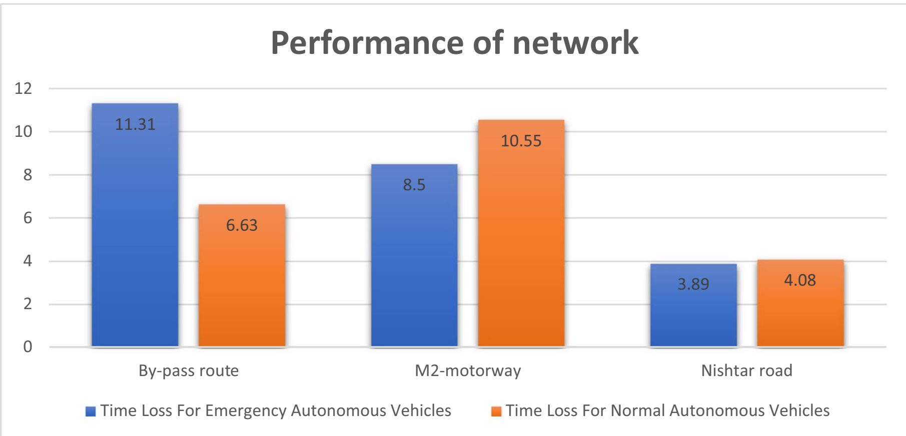

Fig. 7 Explain average time loss of both EAV/ NAV

cars. The real time routes are collected from different areas of Pakistan cities (bypass and Nishtar routes from Multan city and m2 motorway). AIMS checks the priority of incoming vehicles by following the priority queue and FIFO rule for providing a safe route to vehicles. In this network, disturbances occur due to VIP vehicles, so automatically, high priority assigning to these VIP vehicles with max speed. In this situation, all other cars make way to these VIP vehicles in the shortest time possible, and these VIP vehicles arrive at their destination in the shortest time possible. All other cars run this network according to the priority queue, so there is little disruption when VIP vehicles enter the M2 motorway network, and all vehicles run smoothly and have a short time delay and reduce the collision. In the future, an enhanced junction management system for bus vehicles and flying cars on the road might be suggested to optimize the trajectory.

Data availability The authors declare that all data supporting the findings of this study are available within the article.

Declarations

Conflicts of interest The authors declare no conflict of interest.

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