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TRAFFIC MANAGEMENT IN VANET BASED ON MACHINE LEARNING

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Abstract

The continued increase in the number of vehicles in the transportation system calls for improving traffic safety and the efficiency of transportation infrastructure in general. With the advances in wireless communication network technology, the new emerging technology of what is known as Vehicle Dedicated Networks (VANET) has become an active area of research due to its high ability to improve road safety, road safety, and efficiency. In this paper, we present a methodology that manage traffics and reduce vehicle accidents and it consists of three stages, the first stage is collision detection according to vehicle position using k-means algorithm, the second stage is traffic management using SVM algorithm, and finally finding the optimal path for other vehicles to Crosses safely and smoothly through congestion area allowing emergency vehicles, ambulances, and firemen to get through if necessary. By using fuzzy logic.

Keywords: VANET, SVM, fuzzy logic, traffic safety, collision detection.

1. INTRODUCTION

With the increase in the population and the expansion and complexity of road networks, and with the increase in the number of road accidents and the victims of these accidents, there has become an urgent need to use a technology that reduces as much as possible from accidents and at the same time provides a kind of well-being for road commuters. With VANET (Vehicular Ad Hoc Networks). VANET networks provide an infrastructure for the development of new systems to enhance safety and comfort for drivers and passengers on road networks, established between moving cars that use wireless communication tools. As a component of the IT'S Intelligent Mobility Systems, this kind of network was created to improve the performance of transportation systems. The purpose of these networks is to increase road safety and convenience for road users. This is done by providing communication and coordination between vehicles to avoid accidents, informing in the event of a traffic accident, avoiding congestion cases, adjusting speed, securing the passage of emergency vehicles, avoiding invisible obstacles, in addition to safety applications. These networks also provide road users with access to weather information, Internet connectivity and multimedia applications [1, 2].

The Second paragraph presents the problem statement and we will describe the traffic management issue that we are trying to fix. In the third paragraph various issues related to traffic management are identified such as algorithms, methods and techniques. The fourth paragraph presents proposed methodology and the solution model in addition to

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mentioning the strategies that were used to enhance the idea well. In the fifth paragraph, the performance of the hybrid experimental algorithm is examined on the proposed problem and compared with the rest of the algorithms. In the sixth paragraph we present the simulation results to our system in comparison with other proposed techniques. In the final paragraph the research will be concluded and the work planned for the future will be mentioned.

1.1 Dataset

We used City Pulse Dataset Collection [3], it includes weather and traffic data. The vehicle traffic dataset was provided by the Danish city of Aarhus. It was compiled over a six-month period by counting the number of vehicles between two points, it also contains information about location of each traffic sensor. Between the two points set over a section of road, each pair of traffic sensors reports the average vehicle speed, vehicle count, estimated travel time, and level of congestion. The Weather dataset is collected from weather observations from the city of Aarhus for a duration of time between August - September 2014.

The two datasets have the following fields:

- Point_1_street.
- Point_2_street.
- Point_1_location (LAT, LONG)
- Point_2_location (LAT, LONG)
- Average vehicle speed
- Vehicle count
- Road Type
- Distance (Meters)
- Travel time
- Weather temperature
- Date
- Time

And we generated the following fields:

- Vehicle Location (LAT, LONG)
- Vehicle speed (KM/H)
- Airbag sensor
- Vehicle life time.

2. PROBLEM STATEMENT

Excessive or improper speed on the roads causes a third of traffic deaths worldwide, according to a recent report issued by the World Health Organization, and on the other hand, the lack of quick assistance that could have saved a human life for a few seconds is the main cause of death in accidents. It all depends on how quickly and react the stakeholders, which can make the difference between life and death. We are trying to find solutions for the aftermath of the collision, i.e. handling the collision itself, dealing with the

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congestion left by the collision, finding solutions to reduce it and facilitating the passage of emergency vehicles, ambulances, and firefighters if necessary. It is worth noting that in recent years, technologies such as VANET have provided an advanced solution to this problem.

3. LITERATURE REVIEW

Several researchers have worked on traffic management and collision detection systems based on machine learning algorithms and we will review the most important of them.

Zeng and others in [4] introduced an eco-routing strategy for automobiles to discover a route that reduces fuel use and, as a result, implies significantly less air pollution. A fuel consumption model is created by the algorithm for each path. To determine the most environmentally friendly routes for vehicles. They used the OBUs of the vehicles in their algorithm.

Shengdong and others in [5] created a cloud-based method for reducing congestion on urban roads, they used deep learning techniques to predict the number of automobiles on the roadways in the future. This approach's primary goal is to balance the amount of traffic on the road.

Sun and others in [6] suggested a flexible system to alert drivers about lane changes, the algorithm needs details on the separation between vehicles, their rates of acceleration, and the nature of the route to transmit warning messages. As each motorist may respond to the signaling differently, the method also entails observing the driver's traits and reactions to create effective lane change alerts for the driver.

Peng and others in [7] collected the data on VANET by sensing pocket network and traffic analysis. They suggested that If the accident is about to happen, the driver might be informed. This includes recognizing potential obstacles, monitoring the behavior of vehicles, and estimating the possibility of an accident.

Akram Adib and others in [8] proposed a mobile robot that operates automatically in an unfamiliar environment by creating fuzzy logic to facilitate analysis and using prior reinforcement learning knowledge to facilitate action, the robot was able to select the best action in each condition. The study demonstrates that fuzzy logic and machine learning of the robot outperform fuzzy logic and Q-algorithm in terms of performance and convergence speed for navigation robots.

Jin and others in [9] suggested an algorithm for planning a highway route for emergency vehicles. Utilizing the Temporal Convolutional Network, this technique uses previous data on trip times and traffic density to forecast future traffic volumes.

Guidoni and others in [10] developed a traffic management system to detect congested roads and then reduce congestion, by sending vehicles locations to the cloud and then classify the roads based on the congestion ratio and finds alternative roads for stuck vehicles in the traffic congestion.

Sheikh and others in [11] proposed an automatic traffic collision detection technique based on VANET communications to monitor transportation systems scenarios. It was

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assumed that an incident had occurred when the time it took for vehicles to change lanes on average was longer than it was under non-incident circumstances. In comparison to other methods, simulation results indicated a 30% faster detection rate.

4. PROPOSED METHODOLOGY

4.1 VANET (Vehicular Ad Hoc Networks)

On-demand device-to-device networks come in the form of ad hoc wireless networks (VANET). Ad hoc describes a transient or improvised state.

We can create a wireless connection in ad hoc mode directly to a computer or other device without having to connect to an access point or Wi-Fi router. Ad hoc networks come in several forms. In essence, a dedicated vehicle network is an infrastructure free network. The method enhances comfort and safety while driving and enables automobiles to exchange security-related information.

Since the information provided in this system is essential over time, dependable and quick network connections are necessary.

The fundamental issue with VANET is informal networking. Utilities such as roadside units and mobile phone networks are less of a problem.

4.2 VANETs Architectures

There are basically five VANET architectures (Fig. 1).

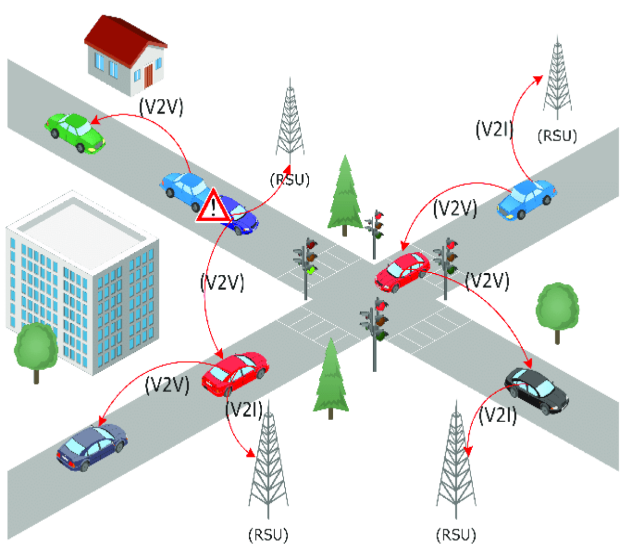

Fig 1: VANETs Architectures

4.2.1 Vehicle to Infrastructure (V2I)

Vehicle-to-infrastructure (V2I) technology is a framework for communication that enables multiple automobiles to exchange data with various devices that support a nation's transportation system.

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4.2.2 Vehicle to Vehicle (V2V)

Vehicle to Vehicle (V2V) communication in IT'S allows for the interchange of information between vehicles as well as with nearby smart infrastructures about speed, heading angle, position, and other environmental factors.

4.2.3 Roadside Unit (RSU)

Using a static sensing area along a road as its source, a roadside unit (RSU) gathers traffic data and transmits it to traffic control devices and a central traffic management center.

4.2.4 On board Unit (OBU)

OBU is a transmitter installed in or on a vehicle, it is in charge of providing the rider with all transmitted data.

4.2.5 Vehicle-to-everything (v2x)

Is the interaction between a vehicle and any entity that could have an impact on or be affected by it.

4.3 K-Means Clustering

With the help of this technique, databases are divided into K-clusters, the center of each cluster is used to calculate and generate data on the cluster's members. When a node switches from one cluster to another and establishes a new cluster with the other nodes, a set of clusters is formed by a random algorithm and the closest clusters are combined based on their similarity. The centers continue to fluctuate between regular calculations while the process of computing centers and distances continues [12] [13].

4.4 Support Vector machine

One of the most well-liked supervised learning algorithms, Support Vector Machine, or SVM, is used to solve Classification and Regression problems. However, it is largely employed in Machine Learning Classification applications [14, 15, and 16].

The SVM algorithm's objective is to establish the best line or decision boundary that can divide n-dimensional space into classes, allowing us to quickly classify fresh data points in the future. A hyperplane is the name given to this optimal decision boundary.

4.5 Fuzzy Logic

Fuzzy logic is a technique of problem-solving that is obtained from human logic and makes use of our ability to make sense of ambiguous data. Where the degree of truth of an idea might range from 0.0 to 1.0. If an idea has a degree of truth of 1.0, then it is totally true, otherwise it is completely false (having degree of truth 0.0). Fuzzy logic is intended to be used for reasoning about ideas with intrinsic ambiguity, such "road traffic" As an illustration, we may use the degree of truth of 0.9 to state that "The road traffic is good." For instance, in our study, we decided to divide the amount of traffic on the road into three categories: good, average, and bad.

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4.6 Vehicles Communications with RSUs

For the purposes of this study, we assumed that every vehicle is connected to a wireless module that enables communication with the RSUs positioned along the road and sharing of vehicle traffic-related information with nearby vehicles. The RSUs are about two kilometers away on the highway. These RSUs may provide equivalent compensation in the region. Projects are also built using RSU along and across roads. Each RSU consists of a GPS tracker for moving vehicles, a radio transmitter and receiver for establishing communication with other passing vehicles, and a computer for traffic-related information, such as measuring speed and lane distance, integrated with the vehicle in movement.

4.7 Basic concepts

The purpose of this paper is to focus on emergencies following road accidents, the figure (2) shows the flow of our proposed method. We used IEEE 802.11p as the communication protocol and we used MDORA as the MAC layer transmission method. We used IEEE 802.11p as the communication protocol and we used MDORA as the MAC layer transmission method [17].

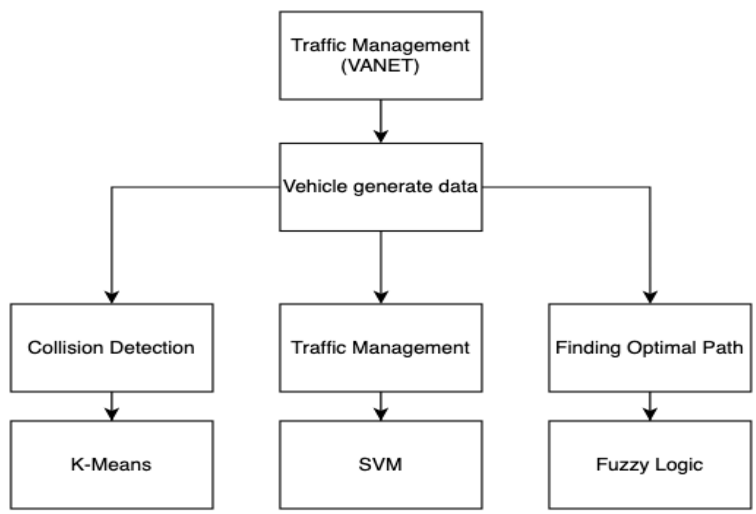

Fig 2: The flow of our proposed method

4.8 The proposed approach

The proposed system consists of three basic stages:

First, collision detection according to vehicle position using k-means algorithm, the second stage is traffic management using SVM algorithm, and finally finding the optimal path for other vehicles to Crosses safely and smoothly through congestion area by using fuzzy logic.

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4.8.1 Collision Detection Algorithm

This algorithm calculates and stores vehicle real-time data in a dynamic database tables.

The vehicle information contains:

- Vehicle Location
- Vehicle speed
- Vehicle distance (Lidar sensors)
- Airbags sensors
- Vehicle life time

When a collision is detected, the involved vehicles sends their information to the nearest RSU which in turn sends information to nearby RSUs so other vehicles can act and prevent a chain or a secondary collision, taking consideration of two types of actions will be done based on involved vehicles life measures.

The algorithm is as follows:

Input: Sender vehicle information.

Output: Identify the clusters for warning messages.

Steps:

- VNode plotting in the simulator.
- Forms the Ad-hoc Network of Vehicles and counting Vanets.
- Each VNode's Condition is running condition and establishing dynamic cluster.
- Get Distance from each VNode and
- Calculate inter vehicular distance.
- Collision warning condition
- If VNode exist inside congestion area send warning message else if VNode exist outside congestion area send alert message.
- End.

4.8.2 Traffic management

After the system detects the collision, determines the location of the accident, and sends alert and warning messages to other vehicles, the task of the second stage is to handle vehicle congestion inside and outside the accident area.

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The algorithm is as follows:

Input:

- Sender vehicle information.
- K-Means Clusters based on distance (Location)
- Other Vehicles information that belong to the clusters.

Output: Classification of roads within and around the accident area.

Steps:

- Determine crash impact force.
  - If vehicle life time is off and air bag is on and if the car speed was greater than 80 K.M and if vehicle distance is less than 1 meter then the crash considered as dangerous.
  - If the crash considered as dangerous then the traffic congestion area considered as traffic choked.
- Send message to all VNodes with the traffic situation of the collision area whether it’s choked or not.
- For each Cluster
  - Determine VNodes Count.
  - Determine the speed for each VNode.
  - Determine VNodes distribution along the road.
- SVM algorithm takes the VNodes locations and classify the roads surrounding the accident area whether it’s choked or not.

According to tests conducted by the Insurance Institute for Highway Safety (IIHS) [18], driving at speeds of 50 MPH (80 KMPH) or higher increases the risk of injury or fatality compared to driving at lower speeds.

4.8.3 Finding the optimal path

The shortest path problem (SPP) is one of the most important and fundamental combinatorial network optimization problems in graph theory [19, 20] where it is shown as a multiple real sub problem lifestyle application.

After discovering the collision and identifying the roads entering and leaving the area, and classifying whether the roads is passable for traffic or not, the main task of the final stage is to help the vehicles that is stuck in and around the congestion area to get out quickly facilitating the passage of emergency vehicles, ambulances, and firefighters if necessary by finding the optimal path for each VNode that stuck in the collision area and the surrounding roads to get out of the accident area taking consideration the date and time of the collision and the weather status. The time of the accident and the weather condition have a significant impact on the condition of the roads surrounding the area of the

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accident. For example, at peak hours, the main roads are crowded, and in bad weather, the secondary roads may not be suitable for the passage of cars.

To find the best path, several factors must be taken, like weather condition, road max speed, day and time of week and traffic level.

Fuzzy sets will be used for the parameters and these fuzzy sets are mention in table (1).

Table 1: Fuzzy sets

Factors /Fuzzy Sets	Weather Condition	Day Type	Time	Road Type
1	Rainy	Normal	Peak time	Main Street
2	Normal	Week End	Off peak	Work Street
3	Sunny			Secondary Street

The algorithm is as follows:

Input:

- Sender vehicle location
- The weather status
- Time status

Output: Identify the optimal path for each VNode.

Steps:

- Specify fuzzy sets for each weight parameter of the road.
- Set of rules was put into effect. For every linguistic term in the output set, they were split up into groups (bad, average, good)
- Examples of the fuzzy rules:

Table 2: Fuzzy sets example

Fuzzy Sets	Road condition	Weather Condition	Traffic level	Vehicle Speed	Road Quality
1	Average	good	low	fast	good
2	Average	average	high	fast	average
3	Good	bad	high	slow	bad

5. EXPERIMENTS

After identifying the components of the proposed detection system and its performance evaluation criteria, practical implementation of these components is necessary to ensure that this system can work. Hence it is useful to compare the results with related research applied to the same data set to see the added improvement of the system proposal.

An urban scenario display in figure (3) was created to imitate urban conditions and test the performance of the suggested technique.

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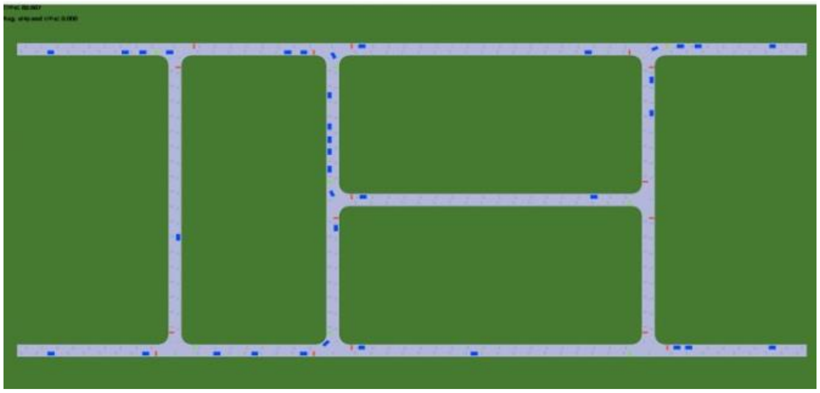
Fig 3: Simulation of an Urban Area



The urban scenario's simulation parameters are shown in table (3).

Table 3: Simulation Parameters

Parameters	Values
Simulation area	200*100
Type of topology	Grid topology
Vehicles Number	40
Clusters Number	5 clusters

Table (4) shows example of the simulated roads and its weights and the parameters that affect the decision of finding the optimal path.

Table 4: Table of Simulated Roads' Weights

ID	Weather Condition	Day Type	Time	Road Type	Traffic level
1	Normal	Normal	Off peak	Good	Good
2	Normal	Week End	Standard	Average	Average
3	Normal	Week End	Peak	Bad	Bad
4	Sunny	Normal	Off peak	Good	Good
5	Sunny	Normal	Peak	Average	Average
6	Sunny	Week End	Peak	Bad	Bad
7	Rainy	Normal	Standard	Average	Good
8	Rainy	Week End	Off peak	Bad	Average
9	Rainy	Week End	Peak	Bad	Bad

Figure (4) shows the output of the k-means clustering algorithm by applying 5 clusters, and Figure (5) shows the output of the SVM clustering algorithm. Where the finding optimal path diagram shown in figure (6).

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Fig 4: The Output of K-Means Clustering Algorithm

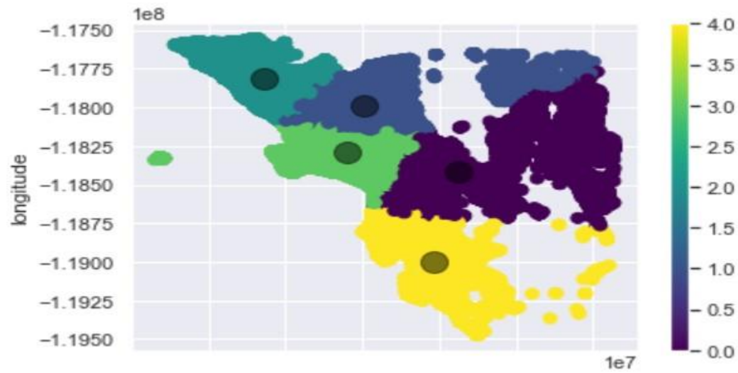

Fig 5: The Output of SVM Clustering Algorithm

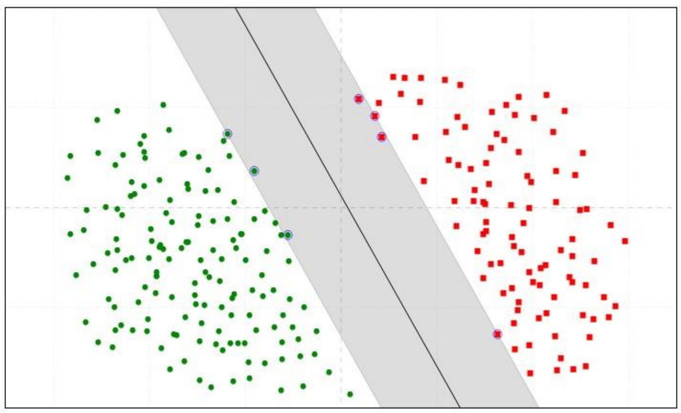

Fig 6: Fuzzy Logic Flow Chart Diagram

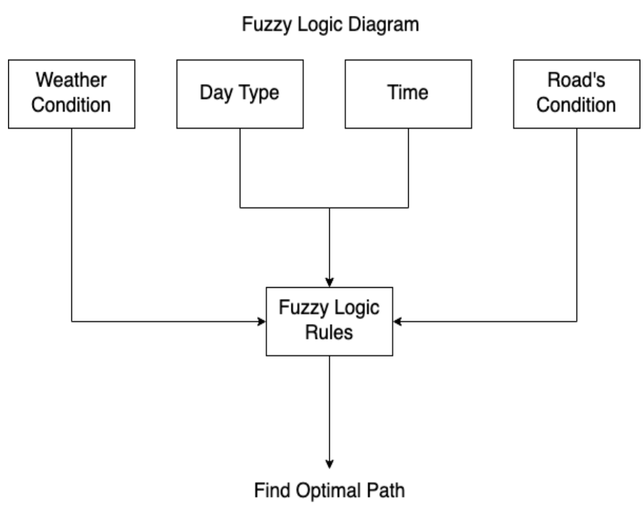

Figure (7) shows the vehicles activities of the simulated congestion area as a function of time; the curve shows the current number of vehicles on the congestion area. The curve

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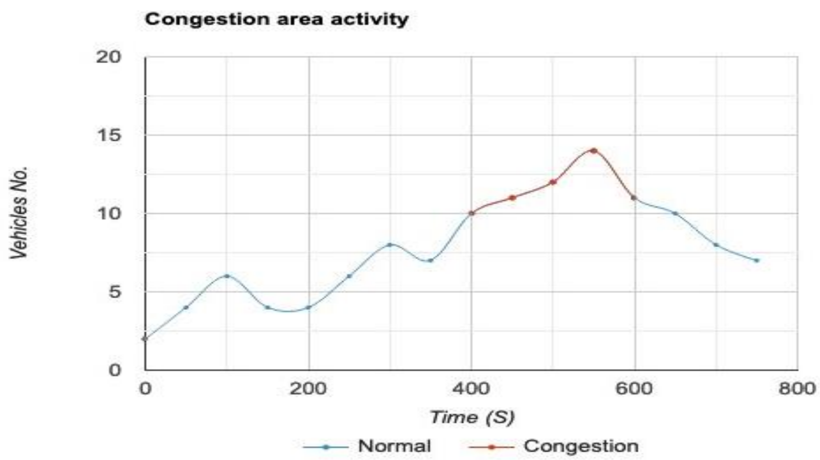
also shows the congestion period allowing us to determine the approximate congestion time.

Fig 7: Details of the congestion area vehicles activities



6. SIMULATION RESULTS

6.1 Performance Test Criteria

In this section, using three criteria, false alarm rate (FAR), detection rate (DR), and classification rate (CR) we compare the performance of the proposed method with that of other widely used techniques including KNN and the hybrid method presented by M. Sheikh [11] [21].

$$\text{FAR} = (Fn/Ini) \times 100\% \qquad (1)$$

Where FAR is the rate at which normal data is misclassified as a collision situation, Fn is the number of false alarm cases, and Ini is the total number of non-incident cases [11].

$$\text{DR} = (\text{Id}/\text{Ai}) \times 100\% \qquad (2)$$

Where DR is the true collision detection rate, Id is the number of incident cases detected and Ai is the total number of incident cases reported [11].

$$\text{CR} = (\text{Ti}/\text{Ci}) \times 100\% \qquad (3)$$

Where CR is the classification rate, which is used to determine the incident detection, Ti is the number of events correctly classified and Ci is the total number of events [11].

Table 5: Table of Performance Test Criteria

FAR	DR	CR	
KNN	0.191	0.937	0.909
M. Sheikh's approach [15]	0.018	0.952	0.925
proposed method	0.092	0.946	0.920

Table (6) shows the various approaches taken to solve similar works. The system is developed to handle accidents on the road, day and night. It should be highlighted that

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the suggested approach will help to protect individuals as much as possible in addition to guaranteeing the driver's safety.

Table 6: The comparison table between our system and other related works

Ref	Collision Detection	Traffic Management	Find Optimal Path
[4]	×	×	√
[5]	×	√	×
[6]	×	√	×
[7]	√	×	×
[15]	√	√	×
proposed method	√	√	√

We conclude from the tables (4, 5) that our results are very similar to that of M. Sheikh's article [11], but our approach deals with three stages (as one system), which is dealing with vehicle’s collision, as well as dealing with traffic congestion, as well as choosing the optimal path for all vehicles within the specified geographical area, as well as emergency and ambulance vehicles.

7. CONCLUSION AND FUTURE WORK

This study offered a new methodology and described it in details. It is an overview of how we employed VANETs for industry-related communication, and we used simulation and modeling to verify our results using Python, MATLAB and anaconda. We used two different machine learning algorithms and fuzzy logic techniques to handle each stage of the all problems, the system offers a perfect solution to handle traffic management starting from the accident itself through handling traffic congestion and ending with finding optimal path for each involved vehicle and most importantly is to rescue People who need assistance By opening the way for emergency vehicles. Finally, we will use the Internet of Things (IOT) with a 5G wireless network in order to collect results and highly accurate accident and traffic data, which is effectively applied to determine the best route.

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