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Secure consensus Algorithm for Intelligent Transport Systems in IoV

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Abstract: Road safety is seriously threatened by foggy weather as it often results in reduced visibility and an increased likelihood of collisions.Â Traditional fog warning V2V communication systems fail for real-time purposes because they rely on infrastructure-based solutions or high-latency blockchain networks. To surpass these limitations, the current research proposes a real-time fog detection and vehicle-to-vehicle (V2V) warning system that integrates OpenCV-based image processing for detecting fog and SUMO (Simulation of Urban MObility) to adjust vehicle speed under low-visibility conditions dynamically.

The technology records visual information in real-time, analyzes it to assess the presence and intensity of fog, and then sends out a warning. Affected vehicles in the SUMO simulation gradually slow down to prevent collisions after receiving an alarm when fog is detected. Without requiring costly hardware updates, the technology may be adjusted for different types of roads because it is less expensive, lighter, and more scalable than sensor-based systems. Algorithms are simulated using the methodological tools mentioned above.

In addition, simulation of realistic traffic behavior in adverse visibility conditions is enabled by the SUMO-based simulation environment, providing valuable feedback on how automobiles should respond under real-world scenarios. As experimental results reveal, dynamic speed adjustment during foggy conditions significantly enhances road safety through reduced possibilities of accidents and minimization of sudden braking.

I. INTRODUCTION

Road safety is grossly impaired by foggy conditions, which reduce vision and increase the chances of accidents. Other vehicles, traffic lights, and road barriers become hard to identify for drivers in such conditions, leading to frequent sudden braking and multi-vehicle crashes. Fog accidents are likely to be more serious due to slower response times and inaccurate distance estimating, as per research. Classic methods of fog detection use human driver reports, fixed roadside sensors, or weather stations, and they only give generalized warnings rather than real-time location-specific alerts. Further, the performance of current Vehicle-to-Vehicle (V2V) alert systems used for safety warnings is of limited application in critical driving conditions because they are generally subject to network delays or expert hardware.

To mitigate these issues, this study provides a real-time fog detection and V2V alert system based on modeling vehicle responses using SUMO. and computer vision-based image processing for the determination of the amount of fog. The system automatically regulates vehicle speeds upon detecting fog. It accomplishes this by interpreting real-time video feed data with OpenCV-based algorithms to assess visibility conditions. In areas affected by fog, this anticipatory approach ensures safer driving speeds by mitigating sudden braking. With only camera-based detection and without requiring any extra roadside infrastructure, this method is cheaper and more scalable than conventional sensor-based fog detection systems. To improve traffic movement and minimize collisions, the vehicles that receive fog alerts adjust speed dynamically throughout the SUMO simulation. With the deployment of low-latency fog warnings, the system proposed here is meant to enhance road safety by enabling an instant response to hazardous conditions.

Following the use of SUMO traffic simulation in this study, it is possible to simulate the drivers' behavior, vehicle interaction, and fog-induced accident risk realistically. A variety of road situations, such as city streets, highways, and crossings, may be used to test the system and see how traffic responds to low visibility. Future improvements will enable the system, an adaptive smart traffic management tool, to recognize more hazardous weather conditions like snow and rain. The technology enhances smart and adaptive traffic safety solutions with automated speed adjustments, efficient V2V warning communication, and real-time fog detection. Subsequent advancements could be real-world implementations to establish its effectiveness in real-world driving conditions and machine learning-based classifiers to improve accuracy.

II RELATED WORKS

Numerous studies have looked at different approaches to fog recognition, vehicle-to-vehicle (V2V) communication, and traffic simulations to increase low-visibility traffic safety. Traditional methods primarily involve weather stations, warning systems, and solid-state sensors on the sides of roadways to identify cars with fog and alerts. Nevertheless, these techniques frequently lack actual vehicle-specific alerts and don't necessitate a significant infrastructure investment. These restrictions have been addressed in recent years by concentrating on computer vision, image processing, and simulation-based techniques to increase the precision and effectiveness of fog recognition and traffic control.

1. Fog Detection using Computer Vision

Due to its cost-effectiveness and flexibility, fog detection based on computer vision has increasingly become widespread. Based on live camera feeds, scientists have estimated fog density using image processing techniques such as contrast estimation, edge detection, and color-based estimation. Wang et al.'s research in 2021 utilized edge detection techniques and histogram-based contrast enhancement to estimate visibility conditions and detect fog accurately under varied illumination conditions. In comparison to more conventional sensor-based techniques, Li et al. (2022) improved detection accuracy by utilizing deep learning models trained on images from traffic cameras to assess fog severity levels. These methods illustrate how image processing and AI models can effectively assess fog conditions without the need for additional sensors.

2. V2V Communication for Fog Alerts

Vehicle-to-vehicle (V2V) communication is required for linked vehicles to exchange information like speed changes and fog alerts. Existing research has investigated dedicated short-range communications (DSRC) for real-time message broadcasts, cellular networks, and ad hoc wireless communication. For example, Ahmed et al. (2020) suggested a DSRC-based warning system that alerts surrounding vehicles to fog warnings so they can modify their speed appropriately. DSRC networks, however, have poor coverage and significant latency in rural areas. In a different study, Kumar et al. (2021) talked about using 5G networks for V2V communication, which would allow alerts to spread more quickly. Despite their effectiveness, network-based solutions are less suitable for broad use because they typically require specialized hardware and constant connectivity.

3. Traffic Simulation for Foggy Conditions

Traffic flow and accident avoidance techniques under adverse weather conditions have been extensively studied using simulation tools like SUMO (Simulation of Urban MObility), VISSIM, and OpenTraffic. Researchers can analyze how vehicles react to fog alerts and speed modifications because of the realistic simulation of traffic by SUMO. Zhang et al. (2019) combined SUMO with a fog detection method to simulate vehicle behavior under varying levels of fog. The outcomes suggested that, as compared to sudden braking, intermediate speed decrease maneuvers considerably minimized the risk of accidents. Patel et al. (2020) incorporated a machine-learning decision model within SUMO to maximize vehicle speed based on environmental conditions to increase overall traffic efficiency.

4. Limitations of Current Methodologies

Present-day fog detection and V2V warning systems still grapple with numerous challenges despite colossal advances. Sensor-based approaches are unsuitable for widespread implementation since they entail costly hardware implementations. The effectiveness of network-based communication systems for real-time use is typically constrained by latency problems or dependency on extraneous infrastructure. Furthermore, the lack of dynamic speed adaptation in most traffic management systems results in severe braking and hazardous driving conditions during fog.

5. Contribution of the Proposed System

The current study uses SUMO traffic simulation in combination with OpenCV-based image analysis to provide a real-time fog detection and V2V warning system in order to address these problems.

Compared to traditional sensor-based methods, it is more affordable and scalable because it records visibility using a camera. By adjusting vehicle speeds in response to real-time fog detection, the SUMO system reduces the likelihood of collisions and improves traffic flow. This study offers a low-latency, infrastructure-independent method for improving road safety during inclement weather by utilizing computer vision to identify fog and SUMO for behavioral modeling.

II. III EXISTING SYSTEM

The central server, GPS location-based tracking, or infrastructure-based methods are the pillars of most existing vehicle-to-vehicle (V2V) communication-based fog detection and warning systems. Some systems track environmental parameters such as temperature, humidity, and fog intensity using fixed sensors along roads. During the occurrence of high-level fog, a central traffic control system gets alerted, and it subsequently informs nearby vehicles of the danger. Cellular networks (such as 4G/5F) or specialized short-range communication (DSRC) are two very popular methods for vehicle-to-vehicle notification exchange. Since these rely on constant network availability, they are typically less effective in areas with high latency or weak signals. Some systems additionally install LiDAR or radar-based sensors in cars to identify objects in low visibility situations, but they are costly and not widely used.

The real-time nature of most of the existing fog alert systems is limited by their network dependence. Moreover, they do not support dynamic speed adjustments in traffic simulations like SUMO. A decentralized, more efficient, and real-time solution that dynamically reduces vehicle speed upon detection of real-time fog is therefore needed.

IV PROPOSED SYSTEM

Compared to traditional approaches that depend on external infrastructure, centralized cloud services, or expensive sensor-based systems, the suggested system processes real-time data inside the simulation and incorporates a real-time fog detection and vehicle speed adjustment mechanism inside a simulated traffic scenario. The system evaluates road visibility and decides the occurrence of fog based on computer vision principles. However, network access restricts the real-time nature of the majority of fog alert systems now in use. Furthermore, traffic modeling programs like SUMO do not support dynamic vehicle speed restriction. This calls for a decentralized, effective system that dynamically reduces vehicle speed in response to real-time fog detection. The initial phase of the system is to establish SUMO to replicate the way vehicles travel over a network of roads. By OpenCV-based image processing, images of the road are inspected following periodic shooting by a camera module or existing image dataset that can be preloaded. The technique monitors levels of vision and contrast within an image in order to quantify fog density. To provide a safer driving experience within the simulated environment, vehicles in the affected area slow down automatically if the density of the fog increases beyond a set limit..Through this approach, expensive sensors, GPS monitoring, or cloud computing are unnecessary.The technology is an autonomous, adaptable, and cost-effective method to enhance highway safety during foggy conditions through the integration of real-time fog sensing with SUMO's simulation of traffic flow. It also enables researchers and traffic authorities to study varying conditions of fog and their impacts on traffic flow, which can contribute to developing better traffic management strategies

V METHODOLOGY

1.FOG DETECTION MODULE

This module makes use of OpenCV image processing methods to determine the occurrence of fog. A baseline is initially set by taking a reference image under clear weather conditions. In simulation, real-time images are constantly taken and examined for color and sharpness. Image sharpness is evaluated based on the Laplacian variance, representing visibility levels, and color distortion is checked to detect the washed-out colors typically found in fog. If both the sharpness and color parameters are below threshold values, the system validates the occurrence of fog. The detection logic is realized in Python via the OpenCV package, which allows real-time monitoring of road environments continuously. In order to enhance detection precision, color and sharpness thresholds are adjusted

2.SUMO TRAFFIC SIMUATION MODULE

In order to simulate vehicle movement in a real traffic scenario, the SUMO Traffic Simulation Module utilizes the Simulation of Urban MObility (SUMO) framework. It defines the path followed by vehicles, the road network, and how they react under various weather conditions. It interacts with SUMO through the TraCI (Traffic Control Interface) to adjust traffic parameters dynamically in case of fog. To simulate the impact of fog on traffic speed and driving behavior accurately, vehicle speeds are particularly reduced to simulate low visibility conditions. With SUMO providing microscopic traffic simulation to model specific vehicle behaviors in detail, this setup enables testing and performance assessment in real time.

Real-time data from the fog-detecting system is timed with the simulation, allowing dynamic alterations in vehicle properties such as acceleration, deceleration, and lane-change behavior.

Overall, the module provides a dynamic and cost-effective environment for the safe testing of varying traffic scenarios and analysis of weather impact on road safety.

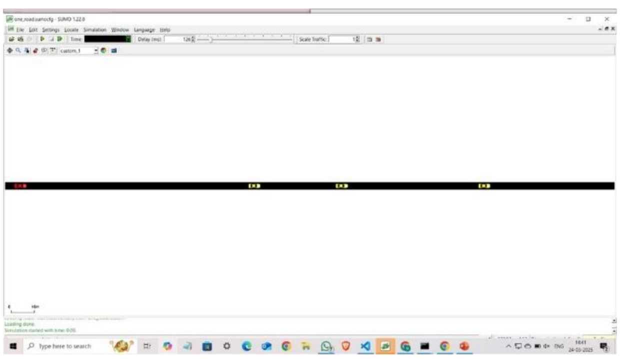
3.V2V FOG Alert and Speed Control Module

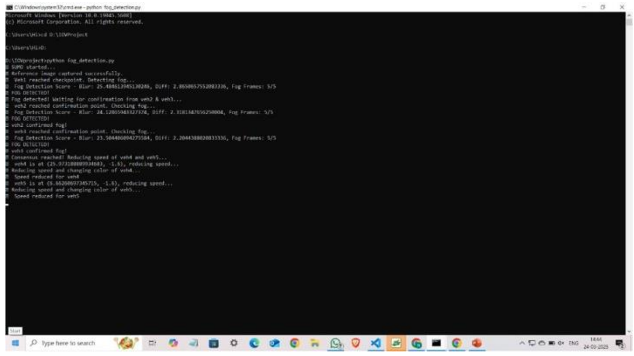
Vehicle-to-vehicle communication is controlled by the V2V Fog Alert and Speed Control Module, which senses the presence of fog. When a vehicle detects fog, it informs a central server, which in turn informs other close-by vehicles or checkpoints to authenticate the conditions. A majority voting method is utilized to come up with a conclusion regarding the presence of fog in order to obtain accurate confirmation. When a commonality is reached, warnings are transmitted to approaching vehicles, instructing them to decelerate. This approach minimizes false positives by means of cross-validation by many cars and maximizes road safety by facilitating quick and trustworthy responses. The module also guarantees that speed limits are imposed only after fog has been safely identified so as to ensure smooth traffic flow and avoid unnecessary delays.

VI CONCLUSION

In brief, the intended V2V fog alarm system efficiently enhances traffic safety in fog by integrating vehicle-to-vehicle (V2V) communication, SUMO traffic simulation, and computer vision. The system verifies image clarity and color variation using OpenCV to detect fog precisely. After checking for fog, SUMO facilitates real-time management of vehicle speed to adjust with decreased visibility. Vehicles based on a consensus-based method guarantee correct warnings and reduce false warnings. About conventional roadside infrastructure, the approach offers an affordable and expandable solution. It makes driving safer and keeps traffic flowing freely by adjusting speeds only as required. Generally, the device presents an intelligent, autonomous way of managing fog-related traffic hazards.

SAMPLE OUTPUT IMAGES





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