DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

B.TECH MINI PROJECT (2022-2026 BATCH)

COLLISION AVOIDANCE SYSTEM
(Hairpin Turn)

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Content

Introduction

Road safety on steep inclines and sharp turns, particularly on Indian roads, is a critical concern due to limited visibility and challenging terrain. This project proposes the development of a collision avoidance system tailored for hairpin bends to mitigate accidents and enhance road safety. By utilizing a combination of sensors, communication modules, and real-time data processing, the system provides timely alerts to drivers about approaching vehicles, reducing the likelihood of collisions.

Survey 1

VEHICLE COLLISION AVOIDANCE SYSTEM

Authors :Dr. MADHU B K, KARTHIK KOTI, K SURABHI, NIKHIL U, YASHWANTH M

Year of Publication : 2020

Introduction

- The project focuses on developing a collision avoidance system for vehicles using ultrasonic sensors.

- The system detects obstacles and either alerts the driver or automatically applies brakes.

- This can help reduce accidents on hairpin bends and other critical road conditions.

System Overview

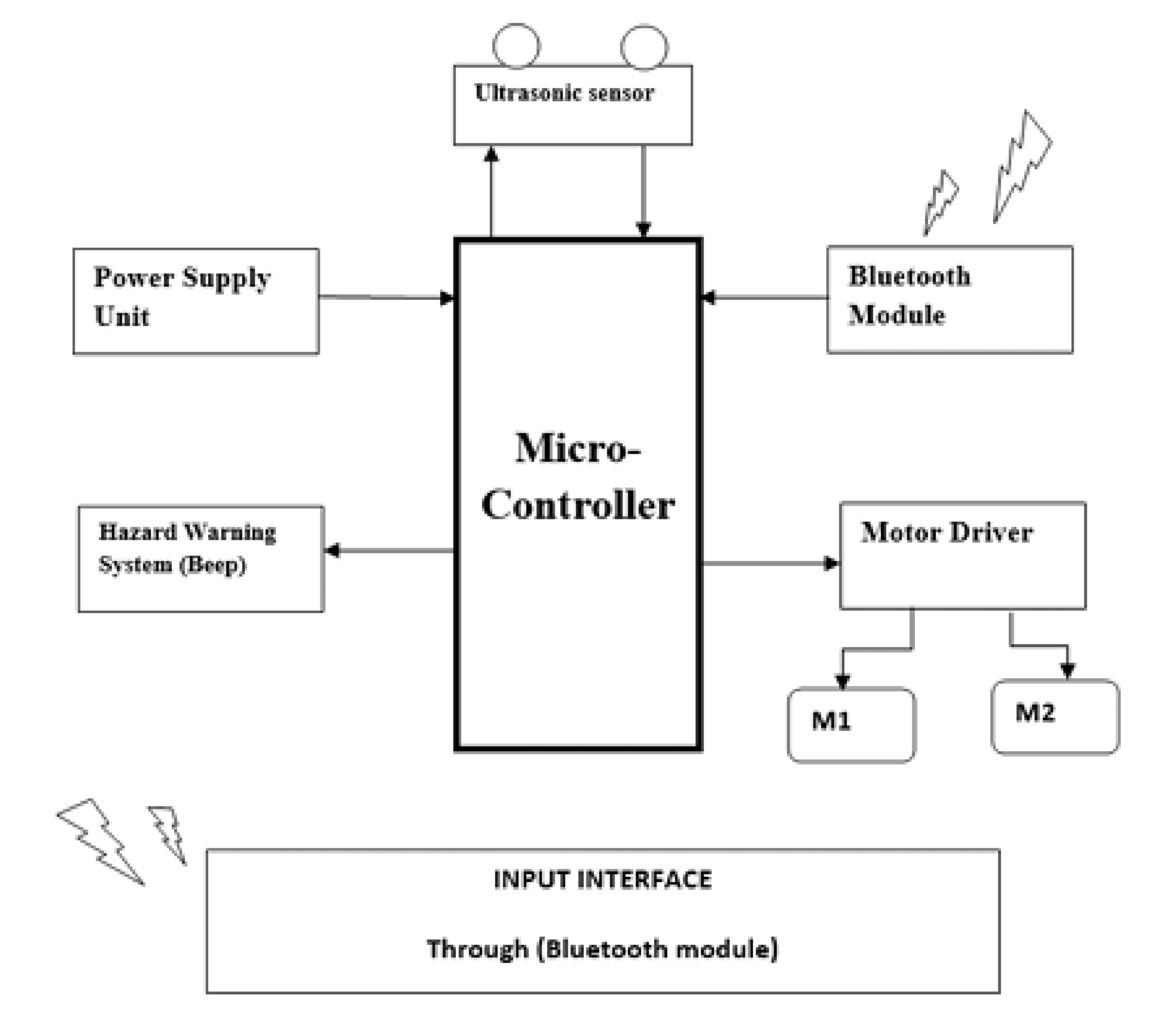
•The project focuses on developing a collision avoidance system for vehicles using ultrasonic sensors.

•The system detects obstacles and either alerts the driver or automatically applies brakes.

•This can help reduce accidents on hairpin bends and other critical road conditions.

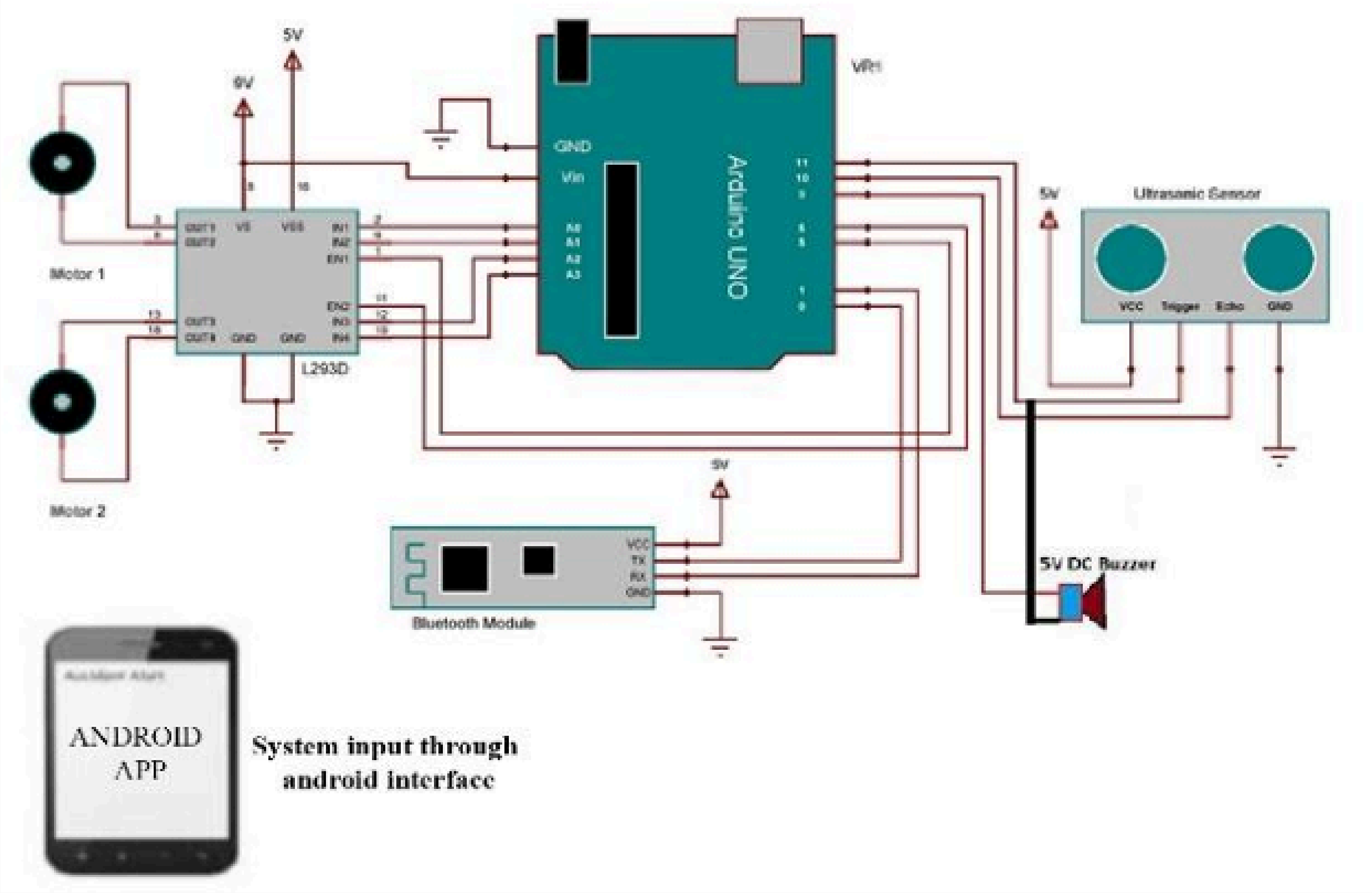
Working Principle

- Ultrasonic waves are sent and received to measure distance.
- If an obstacle is detected:
- LED turns on
- Buzzer sounds
- Motor stops (for prototype)
- Brakes engage (in real-world application)
- If the driver fails to respond, the system automatically applies brakes to prevent a collision.



Hardware Components

- Microcontroller (Arduino) – Processes sensor data and controls vehicle response.
- Ultrasonic Sensors – Measure the distance to obstacles.
- Servo Motor – Engages braking in the prototype model.
- LED & Buzzer – Provide audio-visual alerts to the driver.
- Bluetooth Module – Enables wireless communication with the system.



Software Design

- Embedded C programming for microcontroller operation.
- Android application to monitor and control the system remotely.
- Algorithm-based decision making for automatic braking.
- Data processing to ensure quick and efficient response to obstacles.

Testing & Observations

•Simulation and real-time testing confirmed proper system functionality.

•Observations:

•LED and buzzer activate based on object distance.

•Vehicle speed is reduced when an obstacle is detected.

•System applies automatic braking in case of critical danger.

•Environmental noise interference slightly affects sensor accuracy.

Conclusion

- Successfully demonstrates collision detection and warning.
- Reduces accidents and improves road safety.
- Future Scope: Implementation of AI-based predictive collision avoidance for enhanced accuracy.

Advantages

✅ **Accident Prevention** – Helps reduce collisions by providing early warnings and automatic braking.

✅ **Cost-Effective** – Uses affordable components like ultrasonic sensors and microcontrollers, making it budget-friendly.

✅ **Simple and Efficient** – Works on a basic embedded system, ensuring ease of implementation.

✅ **Low Power Consumption** – Operates efficiently with minimal energy requirements.

✅ **Scalable** – Can be integrated with advanced vehicle safety systems for real-world applications.

Disadvantages

❌ **Limited Detection Range** – Ultrasonic sensors have a short range and may not detect obstacles far away.

❌ **Noise Interference** – Environmental factors like rain, dust, and road vibrations can affect sensor accuracy.

❌ **Delay in Response** – Microcontroller processing and sensor limitations may cause slight lag in detection.

❌ **Not Suitable for High Speeds** – The system is more effective at low speeds and may struggle with fast-moving vehicles.

Survey 2

Overview of Ultrasonic Sensor in Collision Avoidance system

Authors : Mohanad ABDULHAMID , Otieno AMONDI

Year of Publication : 2020

Introduction

•The paper describes the use of ultrasonic sensors in a rear-end collision avoidance system.

• The ultrasonic sensor measures the gap between vehicles in the same lane and direction.

•If a dangerous proximity is detected, the system alerts the driver and triggers braking if necessary.

Components and connections Overview

The ultrasonic sensor has four pins:

•VCC (Power supply).

•Ground.

•Trigger Pin (Sends an ultrasonic pulse).

•Echo Pin (Receives the reflected pulse).

WORKING PRINCIPLE

Sending the Signal:

•The microcontroller sends a trigger pulse to the ultrasonic sensor.

•The sensor emits ultrasonic pulses.

Receiving the Signal:

•When the pulse hits an obstacle (another vehicle), it reflects back.

•The echo pin of the sensor goes high when the reflected signal is received

Calculating Distance

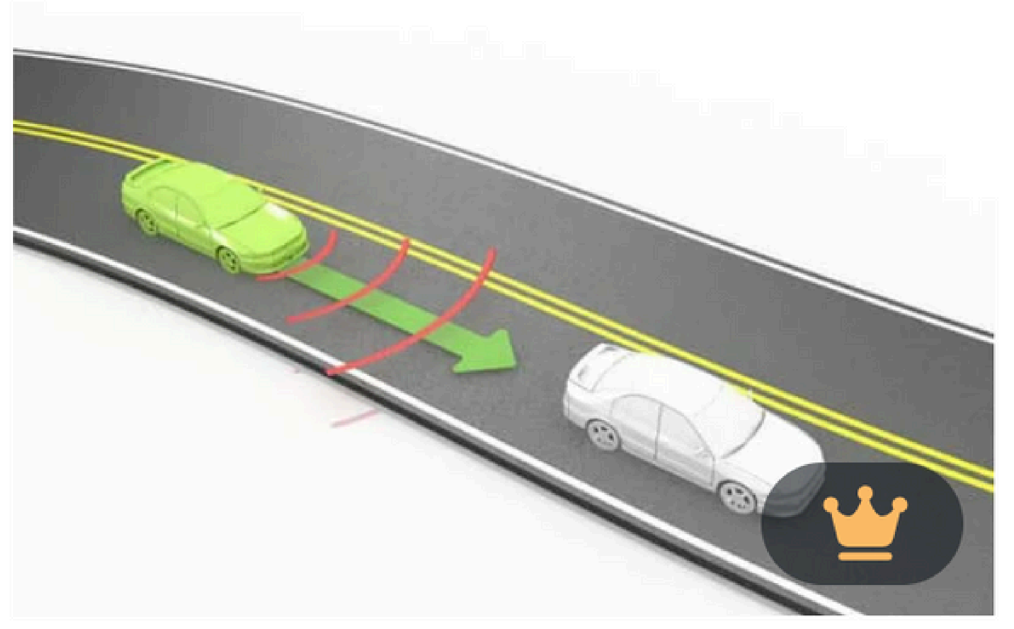
•The system measures the time taken for the pulse to return.

•If the measured distance is below a threshold, the system activates a warning.

Response Mechanism:

•The system triggers a LED and buzzer warning when the vehicle gets too close.

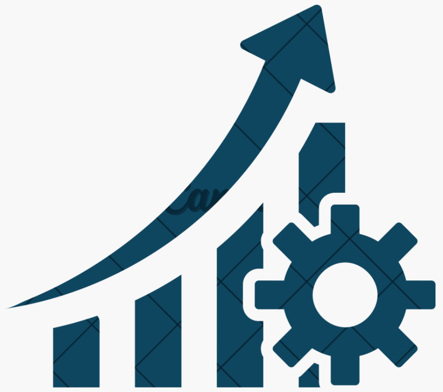
•If the distance continues to decrease, the braking system is activated.



Observations from Simulations

- At greater distances, the LED remains off and the motor runs normally.
- As the distance decreases, the LED lights up, and the buzzer turns on.

Limitations and Improvements



•Although it works without much flaw there are chances that The sensor detects short-range distances accurately, but noise interference can affect performance.

•Future improvements could involve integrating multiple sensors for better coverage and using advanced filtering techniques to minimize false detections.

CONCLUSION

- The use of an ultrasonic sensor in a rear-end collision avoidance system effectively enhances vehicle safety by continuously monitoring the distance to obstacles.
- The system successfully detects proximity and triggers alerts or braking mechanisms to prevent collisions
- Through simulation, it is observed that the sensor reliably identifies objects within a defined range, activating warnings and stopping the vehicle when necessary.

Survey 3

Vehicle Detection and Collision Avoidance in Hairpin Curves

Author : Prajwal V R

Year of Publication : 2020

Introduction

- The project focuses on developing a collision avoidance system for vehicles using object detection.
- The system detects vehicle type, it’s distance and the speed at which it is approaching.
- These details are displayed onto the screen.
- This can help reduce accidents on hairpin bends and other critical road conditions.

SYSTEM OVERVIEW

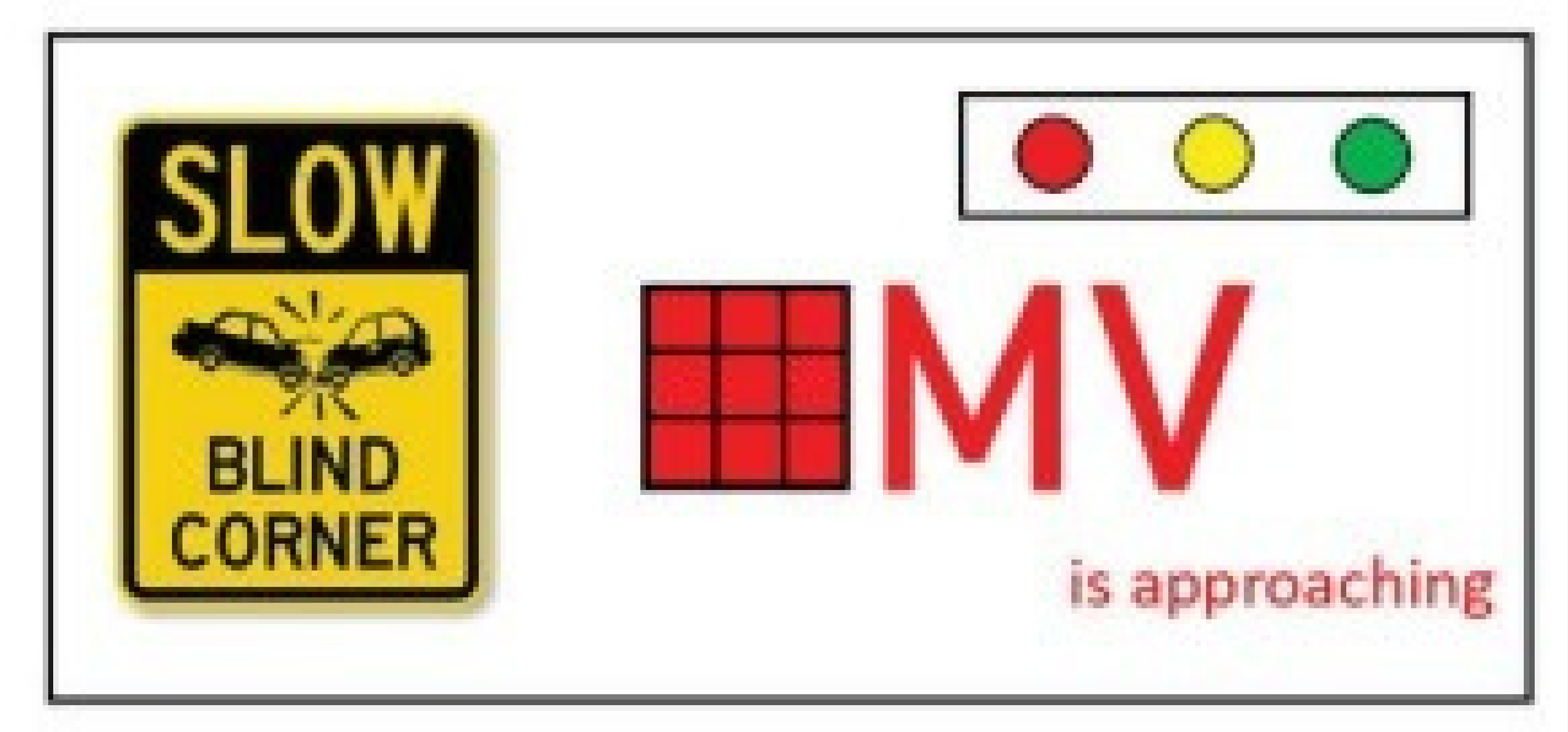
- Uses an Arduino Mega 2560 microcontroller to process sensor data.
- Camera Positioned at both ends of the hairpin curve, adjusted for clear vehicle detection.
- MATLAB processes the image, detects & classifies the vehicle (Light or Heavy)
- LED Display Board shows vehicle type.

WORKING PRINCIPLE

- A night vision camera captures real-time video of vehicles approaching the hairpin curve.
- MATLAB 2019a processes the video feed using image acquisition & object detection algorithms.
- Vehicles are categorized as Light Motor Vehicle (LMV) or Heavy Motor Vehicle (HMV) using a modified color detection algorithm.

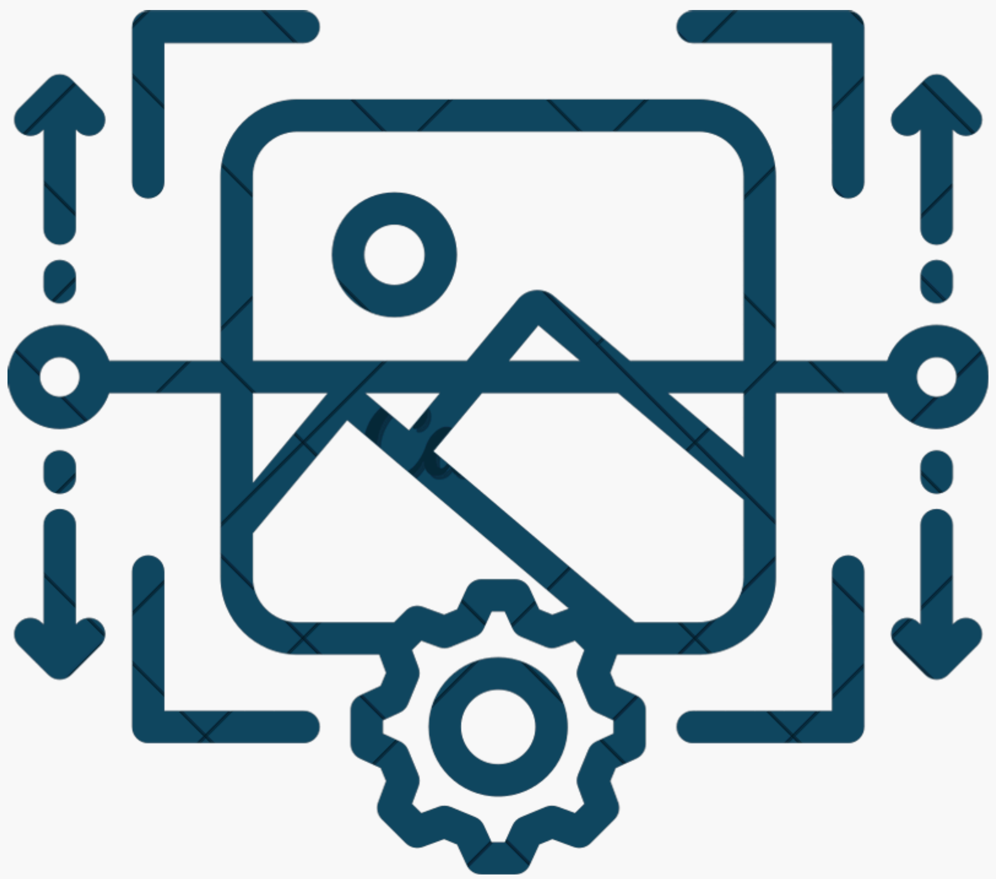
WORKING PRINCIPLE

•The processed data is sent to the Arduino MEGA 2560 microcontroller, which updates the LED display board.
•LED Board Displays:‘L’ for Light Vehicles (Green signal for safe passage)
•‘H’ for Heavy Vehicles (Red signal to wait)



SOFTWARE DESIGN

- MATLAB 2019a for image processing and object detection.
- Color detection algorithm used for vehicle classification.
- Arduino-MATLAB interfacing for real-time signal processing.
- Microcontroller receives processed data
- Real-time processing of sensor data for immediate response.



Advantages

- Reduces Accidents – Early warning through LED display prevents collisions.
- Effective Traffic Management – Allows smooth two-way traffic wherever possible.
- Real-time Vehicle Classification – Differentiates between Light & Heavy Vehicles.
- Prioritizes Uphill Vehicles – Heavy vehicles are given right of way for smooth flow.
- Reduces Traffic Congestion – Traffic signals optimize vehicle movement, reducing waiting time.

Disadvantages

•Dependency on MATLAB & Arduino – System requires proper integration & power supply.
•Camera Placement Issues – Needs precise positioning for accurate detection.
•Limited to Certain Road Conditions – Works best in controlled traffic; may not handle extreme congestion efficiently.
•Sensor & Hardware Limitations – May face issues in extreme weather (heavy fog, rain).
•Potential Delays in Processing – Image processing time could slightly impact real-time decision-making.

CONCLUSION

•Vehicle Detection and Collision Avoidance System helps reduce accidents and traffic congestion in hairpin curves.

•Uses night vision cameras, MATLAB processing, and Arduino-controlled LED displays for real-time vehicle classification.

•Ensures effective traffic management by prioritizing vehicle movement based on their classification (Light/Heavy).

Survey 4

Research on Collision Avoidance Systems for Intelligent Vehicles

Authors :Guosi Liu , Shaoyi Bei , Bo Li , Tao Liu , Walid Daoud , Haoran Tang , Jinfei Guo and Zhaoxin Zhu

Year of Publication : 2023

Introduction

•**Objective**: Develop an adaptive collision avoidance system that enhances vehicle safety in diverse driving scenarios.

•**Motivation**: As traffic density increases and driving conditions vary, traditional collision avoidance systems may not adapt well to real-world emergencies. Our approach uses real-world data and advanced control strategies to overcome these limitations.

•**System Overview**: -Data Analysis: - Utilizes the NGSIM dataset to analyze driver collision avoidance behavior. - Identifies key parameters: vehicle speed, road adhesion, and overlap rate between vehicles.

Two-Layer Fuzzy Control Strategy:

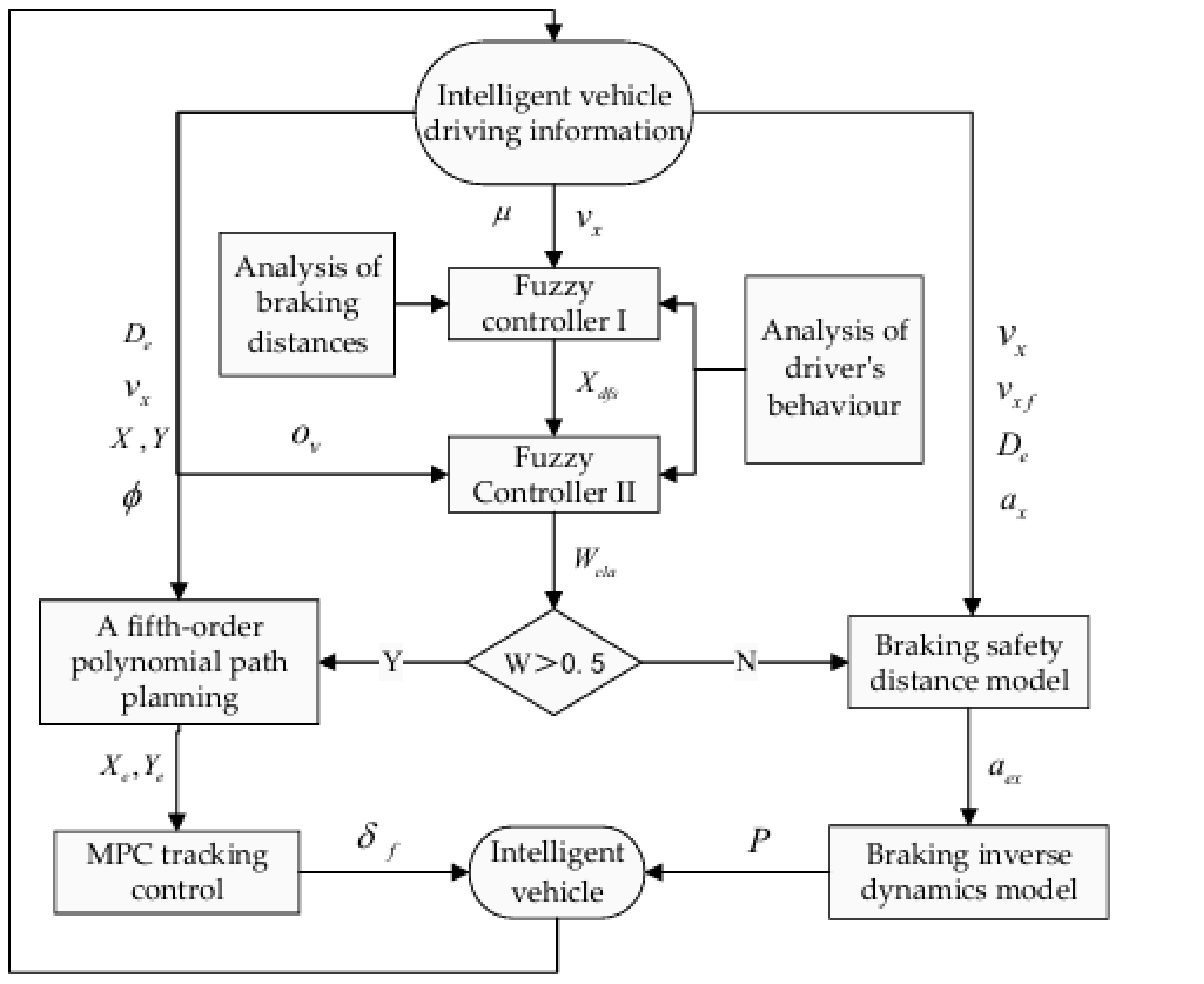


Figure 9. Flow chart of the collision avoidance switching system operation.

Two-Layer Fuzzy Control Strategy:

1. Fuzzy Controller I:

•Inputs: Vehicle speed and road adhesion coefficient.

•Output: Longitudinal braking hazard coefficient.

•Function: Assesses braking risk based on current driving conditions.

•2. Fuzzy Controller II:

•Inputs:Longitudinal braking hazard coefficient (from Controller I) and vehicle overlap rate.

•Output: Willingness to change lanes.

• Function: Determines whether to execute a braking maneuver or a lane change.

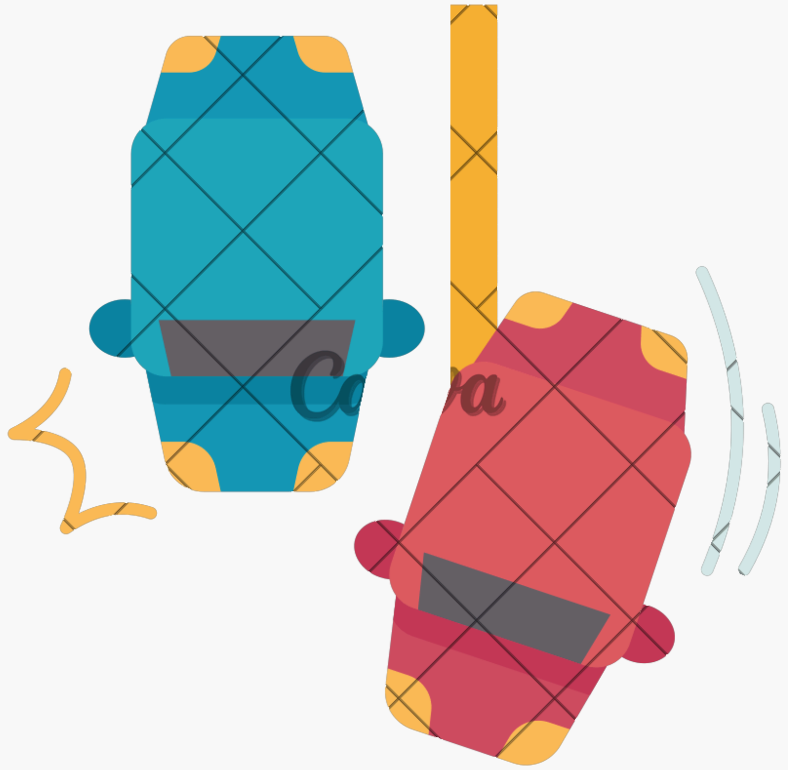
Real-Time Execution:

The control decision (brake vs. lane change) is implemented via:

•A braking safety distance model.

•A Model Predictive Control (MPC)-based lane change model.

These models ensure a quick and precise response to potential collisions.



How It Works:

•Step 1: Analyze real-world driver behavior with the NGSIM dataset to extract key parameters.

•Step 2:- Fuzzy Controller I evaluates the braking hazard by normalizing vehicle speed and road adhesion data.   - Fuzzy Controller II combines this hazard coefficient with the overlap rate to assess the need for a lane change.

•Step 3:- The system decides in real time: - If braking hazard is high and overlap rate is favorable: Initiate lane change. Otherwise: Activate the braking system.

•Step 4:- The decision is executed through integrated models (MPC for lane change and braking safety distance), ensuring enhanced safety and responsiveness.

Simulation Results:

• Improved Reaction Time: Faster response to hazardous situations.

• Reduced Activation Distance:The system activates sooner to avoid collisions.

•Robust Adaptability:Seamless operation under varying road conditions and speeds.

Conclusion:

• Our advanced collision avoidance switching system marks a significant step forward in intelligent vehicle safety technology. By combining real-world data analysis with a robust two-layer fuzzy control strategy and advanced execution models, the system offers a promising solution for enhancing driver safety in emergency situations.

Problem Defintion

Road safety on steep inclines and sharp turns, particularly on Indian roads, is a critical concern due to limited visibility, challenging terrain, and unpredictable traffic conditions. Conventional collision avoidance systems, relying on ultrasonic sensors or basic braking mechanisms, often struggle with real-time adaptability, environmental interference, and limited detection range. Existing approaches incorporating image processing and lane change models enhance detection but may not effectively handle diverse road conditions, high traffic density, or low visibility environments.
This project aims to develop an adaptive collision avoidance system specifically designed for hairpin bends, integrating sensor-based detection, real-time data processing, and intelligent signaling mechanisms to provide timely alerts and facilitate smooth traffic movement. The system will address limitations in sensor accuracy, visibility constraints, and traffic congestion by implementing a hybrid approach using multi-sensor fusion and advanced traffic management strategies. The goal is to reduce accidents, optimize vehicle flow, and enhance road safety in hazardous driving conditions.

Summary

Sl No.	Paper Name	**Published Year**	**Author Name**	**Pros and Cons**
1	**Vehicle Collision Avoidance System**	**2020**	**Dr. MADHU B K1, KARTHIK KOTI2, K SURABHI3, NIKHIL U4, YASHWANTH M 5**	**Pro: The proposed system ensures automatic braking, reducing reliance on human responsiveness and preventing collisions even if the driver fails to react in time. Con: The system's effectiveness is limited by sensor accuracy and environmental conditions, which may impact obstacle detection and lead to false positives or missed obstacles**
2	COLLISION AVOIDANCE SYSTEM USING ULTRASONIC SENSOR	2020	Mohanad ABDULHAMID Otieno AMONDI	Pro: The system provides an effective low-cost solution for collision avoidance using an ultrasonic sensor, making it accessible for real-world applications. Con: The system is not real-time due to environmental noise affecting sensor accuracy, which can lead to missed detections and potential safety risks.

Summary

Sl No.	Paper Name	**Published Year**	**Author Name**	**Pros and Cons**
3	**Vehicle Detection and Collision Avoidance in Hairpin Curves**	**2020**	**Prajwal V R**	**Pro: The system effectively reduces traffic congestion in hairpin curves by allowing two-way traffic when possible, enhancing both safety and efficiency. Con: The reliance on camera-based vehicle classification may face challenges in low visibility conditions, such as fog, rain, or nighttime driving.**
4	Research on Collision Avoidance Systems for Intelligent Vehicles Considering Driver Collision Avoidance Behaviour	2023	Guosi Liu 1, Shaoyi Bei 2,*, Bo Li 2,* , Tao Liu 3, Walid Daoud 4 1 , Haoran Tang 2, Jinfei Guo 2 and Zhaoxin Zhu 2	Pro: The proposed collision avoidance switching system enhances adaptability by incorporating driver behavior analysis and real-time decision-making using a two-layer fuzzy controller. Con: The system's reliance on lane change collision avoidance may be less effective in high-traffic conditions where changing lanes is not always possible.

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Thank you