

A CAD WAY APPROACH TO WRONG WAY DRIVING ANALYSIS AND ECONOMICAL SOLUTION USING IOT AND AI

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Abstract:

Wrong-way driving (WWD) is a serious problem for road safety that often results in fatal collisions, especially on national roads, intersections, and exit ramps. Poor signage visibility, careless driving, a lack of real-time preventive systems, and a lack of knowledge about road layouts are the main causes of these incidents in India. This study examines wrong-way driving behaviour and provides a cost-effective, state-of-the-art solution that makes use of the Internet of Things (IoT) and artificial intelligence (AI) for quicker detection and reaction.

In order to identify potential wrong-way entry points, traffic flow patterns, and accident-prone areas, a thorough field assessment was carried out along National Highway NH-52 as part of the study. Additionally, formal consultations with traffic officials were conducted at the Regional Transport Offices (RTOs) of Beed and Srirampur. These discussions yielded valuable information about the common causes of incidents involving wrong-way driving, the difficulties in enforcing the law, and the practical limitations of the current monitoring systems.

The suggested system design was greatly influenced by these real-world observations.

Based on the survey and institutional input, a sensor-based wrong-way driving detection system is recommended; sensors are the primary detection mechanism due to their affordability, reliability, and ability to function well in a range of environmental conditions. Cameras are only used as a secondary verification and evidence-support tool to reduce reliance on expensive vision-based systems. AI-based reasoning is used to confirm vehicle heading and minimize false detections, while IoT enables real-time alarm production to traffic control authorities for faster response.

The system employs a multi-phase safety strategy, starting with audio-visual alerts for drivers and progressing to non-destructive rumble strips to warn distracted drivers. An inventive controlled air-release spike mechanism is suggested as a last line of defence. Unlike conventional spike strips that cause an abrupt tire puncture, the proposed design allows for slow tire deflation through micro perforations. This reduces the possibility of further incidents and guarantees controlled deceleration. Direction-specific and speed-sensitive activation enhances operational safety even more.

Because the recommended approach places a high priority on human safety, cost-effective implementation, and legal viability, it can be selectively implemented at important highway locations, such as designated black spots and exit ramps. The study concludes that while addressing real-world problems observed in field surveys and RTO contacts, a sensor-first, safety-focused approach in conjunction with AI and IoT can significantly improve the avoidance of wrong-way driving.

Keywords: Driving Against Traffic, CAD-

Enhanced Road Design, Internet of Things, AI, Roadway Safety, Smart Transportation Networks.

I.INTRODUCTION

Road safety remains a critical international issue because traffic accidents result in massive economic and human casualties every single year. Wrong-way driving (WWD) serves as one of the most dangerous traffic violations because it increases head-on collision risks at exit ramps and complex interchanges which connect to highways.

India has multiple factors which create difficulties for drivers because of insufficient road signs and confusing lane markings and strange road designs and driver fatigue and driver negligence and drivers who intentionally take shortcuts. The study found that NH-52 contains multiple locations where drivers can enter restricted areas because of inadequate signage and absence of real-time warning systems.

The RTO representatives from Beed and Srirampur explained that enforcement authorities handle three specific issues which include inadequate preventive measures and their dependence on manual surveillance and the problem of delayed violation reporting. The existing WWD detection systems depend primarily on camera surveillance and manual monitoring systems which require expensive installation and continuous upkeep while facing operational difficulties during bad weather and dim lighting conditions. Unexpected car immobilization methods introduce excessive ethical and legal and safety challenges which make them unsuitable for usage on high-speed roads.

The proposed paper introduces a sensor-based system which detects and prevents WWD through the integration of artificial intelligence and Internet of Things technology. The proposed system uses directional sensors as its primary detection method because these sensors provide affordable and reliable performance across multiple environmental conditions.

The process of selective camera deployment serves to collect evidence and confirm evidence. The system uses IoT technology to establish immediate contact with traffic authorities, which leads to quicker response times. The system uses AI logic to determine vehicle direction, which helps decrease false detection errors. The device uses multiple safety measures that include tactile rumble strips and visual and audio alerts and a controlled air-release spike system which activates when necessary. The proposed design uses micro-perforations to create a gradual tire deflation process which protects against secondary accidents unlike conventional spike strips which cause immediate tire puncture.

By combining field observations, institutional insights, and intelligent technologies, this study proposes a practical, cost-effective, and safety-oriented solution suitable for deployment at critical highway locations, such as exit ramps and identified accident-prone zones.

A. Motivation

Wrong-way driving (WWD) stays one of the maximum dangerous and underestimated site visitor's violations on Indian highways, regularly ensuing in high-speed head-on collisions with severe or deadly results. No matter improvements in traffic monitoring structures, the frequency of such incidents maintains to rise due to elements including driving force negligence, negative visibility of signboards, unexpected street layouts, fatigue, and wrong get admission to manipulate at toll road go out ramps.

During a field survey performed on country wide dual carriageway NH-fifty two, numerous crucial locations had been found wherein incorrect-manner access become possible due to inadequate signage, doubtful lane demarcation, and absence of real-time caution systems. Those observations highlighted a full-size hole among theoretical site visitor's protection measures and their sensible implementation on highways. furthermore, visits to the regional shipping offices (RTOs) of Beed and Srirampur provided valuable insights into the limitations confronted by means of enforcement companies, such as delayed detection of violations, dependence on manual reporting, and absence of preventive mechanisms capable of responding instantly to wrong-manner using incidents.

Existing solutions largely depend on digicam-based totally surveillance systems, that are expensive, maintenance-in depth, and much less dependable underneath unfavourable weather and lighting fixtures conditions. Moreover, enforcement techniques that contain sudden vehicle immobilization pose serious safety and felony worries. This created a strong motivation to increase a value-powerful, dependable, and safety-oriented gadget that prioritizes coincidence prevention over punitive enforcement.

The inducement behind this mission is to suggest a sensor-based totally incorrect-manner driving detection system, wherein sensors serve as the number one detection mechanism due to their robustness and

affordability, while cameras are used simplest for verification and proof help. Through integrating AI for intelligent choice-making and IoT for real-time communication, the gadget goals to make sure quicker reaction and progressed coordination with traffic authorities. Furthermore, a human-centric layout philosophy aimed at reducing secondary injuries is reflected in the multi-stage safety strategy that includes warnings, rumble strips, and a regulated air-release spike mechanism.

Based on first hand subject observations and discussions with the shipping ministry, this endeavour is motivated by the need to bridge the gap between actual international visitor protection concerns and workable engineering solutions. Through affordable design, technology integration, and responsible enforcement, the suggested device hopes to contribute to safer highways.

Twelve crucial wrong-way entry points were found during field studies along NH-52, and they were distinguished by:

- Insufficient illumination of signs at night (42% of cases) at median openings, 33% of directional markers are absent.
- Ramp geometries that are confusing (25%)

Systemic enforcement flaws, such as delayed violation detection, reliance on manual monitoring, and lack of real-time preventive systems, were discovered through RTO discussions.

B. Contribution of the Study

By tackling the issue of improper way riding with a sensible, low-budget, and safety-oriented method, this study makes several practical and scholarly contributions to enhancing street safety. The following is a summary of this painting's significant contributions:

1. Identification of actual international problems through an area survey

alongside the national highway NH-52, a thorough area study was carried out to identify infrastructure boundaries, traffic float issues, and capacity wrong-manner entry considerations. The results of this survey provided real-world insights that promptly influenced the design of the gadget, ensuring that the suggested solution is based on practical highway scenarios rather than merely theoretical presumptions.

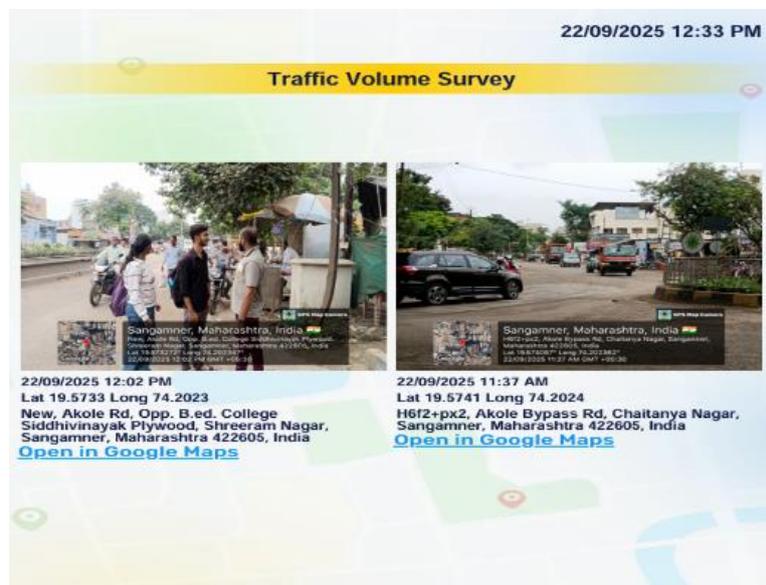


Figure.1: Field survey for traffic flow assessment

2. Including Institutional Knowledge from RTO Officials

Visits and conversations with the regional transport offices (RTOs) of Beed and Srirampur provided invaluable information about typical reasons why people ride the wrong way, situations that make enforcement difficult, and response limitations that authorities must deal with. A system that aids tourist officials through early detection and real-time indicators has been laid out using these insights.



Figure.2: Interaction with RTO officials at Beed

3. Sensor-primarily based number one Detection architecture

The number one detection architecture is sensor-based.

The paper suggests a sensor-first detection paradigm in which reliable and inexpensive sensors serve as the main means of detecting vehicles that behave incorrectly.

This lessens reliance on camera-only systems, increasing dependability in inclement weather and reducing deployment maintenance costs overall.

4. Supportive Use of Cameras for Verification and proof not like conventional structures, cameras are used simplest as a secondary verification and evidence collection tool, minimizing false detections and addressing privacy and value worries. This hybrid approach balances reliability with monetary feasibility.

5. Multi-degree protection oriented reaction strategy. A dependent response mechanism is introduced, along with audio-visual warnings, rumble strips, and a very last controlled intervention. This staged method prioritizes motive force consciousness and correction earlier than making use of restrictive measures, decreasing the thereby likelihood secondary accidents.

6. Progressive managed Air-launch Spike design

The paper introduces a revolutionary spike mechanism that allows slow tyre deflation thru micro-perforations rather than sudden puncture. Velocity-touchy and direction-particular activation enhances protection, making the enforcement mechanism more applicable from each prison and ethical views.

7. Integration of AI and IoT for quicker reaction

Artificial Intelligence is hired for decision validation and fake detection discount, even as IoT allows actual-time alert transmission to traffic manage government. This integration ensures quicker response instances and stepped forward coordination at some stage in incorrect-manner using incidents.

8. Competitively priced and Scalable Deployment model

The proposed gadget emphasizes cost-effectiveness and modular deployment, making it appropriate for selective installation at accident-prone places inclusive of highway go out ramps and diagnosed black spots, rather than requiring huge-scale infrastructure modifications.

C. Organization of the Paper

The rest of this paper is organized as follows. Section I introduces the history of the incorrect-manner using problem and highlights the inducement at the back of the proposed study. Section II affords a review of current literature related to wrong-way riding detection and prevention systems. phase III describes the hassle declaration and descriptions the key demanding situations diagnosed through area surveys carried out on national dual carriageway NH-fifty two and interactions with local transport offices. Section IV explains the proposed sensor-primarily based method, including gadget architecture, AI-based totally selection common sense, and IoT-primarily based verbal exchange framework. Phase V discusses the modern controlled air-launch spike layout and the multi-degree protection mechanism adopted to limit coincidence risks. Phase VI

presents a monetary analysis and discusses the feasibility of deploying the proposed machine beneath real-global conditions. Segment VII affords the results and dialogue based totally on logical evaluation and system performance evaluation. phase VIII concludes the paper with key findings and contributions, at the same time as section IX outlines the future scope of the proposed work.

II.SURVEY OF LITERATURE

The growing incidence of deadly collisions added on by way of volatile riding practices like incorrect-way using (WWD) has drawn extra attention to avenue protection research in current years. Researchers had been capable of create automated systems for tracking, figuring out, and stopping such infractions thanks to the enlargement of shrewd transportation systems (ITS), as well as trends in synthetic intelligence, sensor technology, and real-time communication.

Road safety audits and twist of fate analysis research shape the muse for knowledge infrastructure-associated causes of traffic violations. A street safety audit carried out on the Beed pass road in Aurangabad metropolis highlighted that improper get admission to manipulate, insufficient signage, and inadequate street geometry considerably make a contribution to incorrect-manner using incidents [1]. The observe emphasized the significance of systematic discipline inspections and real-global observations in identifying coincidence-inclined locations. Similar conclusions were drawn in research studying avenue twist of fate patterns in Maharashtra, wherein countrywide highways have been found to make a contribution disproportionately to deadly crashes [2].

Numerous researchers have focused on black spot identification and rectification on national highway NH-52. Research based totally on IRC crash cluster evaluation the use of Google Maps, along with the work of Sunny Tawar and Sachin Dass, verified the effectiveness of spatial mapping strategies for identifying high-danger places [3]. At the same time as bodily rectification measures inclusive of stepped forward signage, lane markings, and geometric remodel decreased accident frequency, these studies noted that static interventions on my own are insufficient to prevent dynamic violations like wrong-way driving.

With the development of artificial intelligence, vision-based incorrect-manner automobile detection systems have won prominence. Real-time detection techniques using YOLO and centroid monitoring algorithms achieved excessive accuracy in identifying wrong-way cars from video streams [4]. Similarly, AI-powered incorrect-aspect car detection systems using deep learning validated progressed detection overall performance below controlled situations [5]. But, these research reported barriers associated with lights variations, climate conditions, occlusion, high computational requirements, and accelerated installation expenses.

Research via Zillur Rahman, Amit Mazumder Ami, and Muhammad Ahsan Ulla explored AI-driven site visitors tracking systems able to detecting abnormal automobile behaviour, which includes wrong-manner motion [6]. Their findings highlighted the effectiveness of computer imaginative and prescient for actual-time surveillance at the same time as also figuring out challenges including fake detections and scalability in massive dual carriageway networks. Extra studies on sensible site visitor's surveillance structures strengthened that digital camera-simplest procedures are much less dependable in fog, rain, and night time-time situations [7].

to overcome the restrictions of imaginative and prescient-primarily based systems, researchers have proposed sensor-primarily based detection mechanisms the use of infrared sensors, ultrasonic sensors, inductive loop detectors, and radar-based totally systems. Sensor-based techniques were discovered to be greater reliable beneath various environmental situations and require decrease computational assets [8]. But, standalone sensor systems may generate false positives due to pedestrians, animals, or slow-transferring motors, indicating the need for smart validation mechanisms.

Latest studies emphasize the mixing of AI and multi-sensor fusion to enhance detection accuracy and reduce false alarms [9]. Device gaining knowledge of algorithms permit validation of vehicle route, velocity, and motion patterns, enhancing gadget robustness. furthermore, the application of Iota-based totally conversation

frameworks allows real-time alerts to traffic management centres and enforcement corporations, considerably reducing reaction time [10].

Numerous researchers have explored enforcement mechanisms consisting of automated limitations, warning structures, and spike strips. Traditional spike strips, at the same time as powerful in stopping cars, have raised serious safety and legal issues due to sudden tyre puncture and lack of car control [11]. enterprise studies, which include the incorrect-way driving research guide via Carmona technologies Corp., recommends a layered safety method combining detection, warning, and controlled intervention as opposed to competitive enforcement [12].

Global studies on incorrect-manner using prevention systems in addition emphasize the importance of multi-degree safety mechanisms, together with develop warnings, dynamic message symptoms, and pace control strategies [13]. studies on smart dual carriageway systems has also tested that selective deployment at vital locations together with exit ramps and interchanges is extra powerful than big-scale uniform installation [14]. In spite of good sized research, maximum current research attention either on detection accuracy or post-twist of fate evaluation, with confined emphasis on economically feasibility, human protection, and real-global deployment demanding situations, mainly in the Indian motorway context. There's a substantive studies hole in growing a sensor-based primary detection system supported by way of cameras, included with AI and IoT, and complemented by using a secure enforcement mechanism that minimizes secondary injuries.

The existing observe addresses those gaps by way of offering a sensor-first incorrect-manner riding detection machine, supported with the aid of digital-based verification and IoT-enabled real-time alerts. The system design is informed with the aid of area surveys performed on NH-fifty two and interactions with nearby delivery places of work (RTOs) of Beed and Srirampur, making sure realistic relevance. Moreover, an innovative managed air-launch spike mechanism is brought to make sure sluggish tyre deflation and managed deceleration, thereby improving protection and legal acceptability. This included method objectives to offer a scalable, good value, and safety-oriented solution for incorrect-way driving prevention.

A. Present Machine

At gift, the prevention and detection of incorrect-manner driving on highways and concrete roads rely on a mixture of passive site visitors control measures, guide enforcement, and technology-assisted monitoring structures. These structures are applied independently or in restricted integration, depending on visitor's volume, budget, and criticality of the area.

1. Traditional site visitors manipulate Measures

The most widely used existing gadget includes static visitors symptoms, along with "No access", "wrong way", and directional arrows, alongside street markings, reflective studs, and median barriers. In a few locations, rumble strips are set up near go out ramps or carrier roads to alert drivers via vibration and sound. Although those measures are within your means and easy to put into effect, their effectiveness in large part depends on driver focus and compliance. In real-life situations, wrong-way driving nevertheless takes place due to motives inclusive of poor visibility at night, motive force fatigue, intoxication, unfamiliarity with avenue format, or deliberate violations. Static measures additionally lack the capability to hit upon violations or offer real-time warnings to authorities.

2. Guide Surveillance and Enforcement

In many areas, site visitor's police or motorway patrol groups screen vital locations, particularly for the duration of peak hours or at regarded coincidence-susceptible spots. Enforcement actions include guide checking, automobile interception, and penalty imposition.

However, manual tracking is labour-extensive, inconsistent, and impractical for continuous 24×7 operation, mainly on lengthy countrywide highways consisting of NH-52. Response time is often not on time, and enforcement normally happens after the violation has already took place, reducing its preventive effectiveness.

3. Digicam-based monitoring structures

Superior site visitor's management structures hire CCTV cameras and automatic variety Plate recognition (ANPR) for surveillance and violation detection. Latest systems utilize laptop imaginative and prescient and AI algorithms to discover bizarre vehicle moves, such as incorrect-manner using.

While camera-based totally systems provide visible affirmation and evidence series, they be afflicted by numerous practical boundaries. Their overall performance is affected by bad lighting fixtures, fog, rain, dirt, glare, and occlusion. Additionally, those systems require high computational strength, non-stop records transmission, and regular maintenance, making them pricey for large-scale deployment on highways.

4. Sensor-primarily based Detection systems

A few places use vehicle detection sensors, which includes inductive loop detectors, infrared sensors, radar, or ultrasonic sensors, on the whole for site visitors counting and pace dimension. Those structures are reliable beneath negative weather conditions and require less processing strength.

However, in most present implementations, sensors aren't particularly configured for directional violation detection. Standalone sensor systems may additionally generate false triggers due to animals, pedestrians, or non-motorized site visitors if now not intelligently filtered.

5. Bodily Enforcement systems (Spike Strips and limitations)

In severe instances, guide or computerized spike strips are used by enforcement organizations to forestall cars during chases or protection threats. Traditional spike strips puncture tyres instantly, causing rapid air loss.

Despite the fact that powerful in preventing motors, these systems pose critical protection risks, such as loss of automobile control, secondary collisions, and legal liability. Due to those dangers, spike strips are not often used as permanent installations for incorrect-way riding prevention on highways.

6. Boundaries of current systems

In spite of more than one manipulate measures, the present systems suffer from the subsequent obstacles:

- Lack of actual-time computerized detection and caution
- Dependence on driving force compliance and manual enforcement
- High fee and environmental sensitivity of camera-simplest structures
- Safety issues associated with aggressive physical enforcement
- Bad integration between detection, alerting, and enforcement
- confined applicability in Indian highway conditions.

7. Want for development

The assessment of current structures suggests a clean want for a value-powerful, dependable, and protection-orientated solution that may:

- Come across wrong-manner riding in actual time.
- Function effectively beneath Indian road and weather situations.
- Minimize dependence on cameras.
- Offer multi-degree intervention in place of sudden enforcement.
- Combine with AI and IoT for indicators and decision-making.

Those barriers encourage the improvement of the proposed sensor-primarily based wrong-way driving detection and prevention system, which addresses the shortcomings of present procedures at the same time as making sure motive force and public protection.

Table.1. Comparison between the Existing system and Proposed System

Parameter	Existing Systems	Proposed Sensor-Based AI-IoT System
Detection Method	Static signs, CCTV cameras, or manual monitoring	Directional sensors as primary detection with camera as secondary support
Primary Technology	Passive traffic control and vision-based monitoring	Sensor fusion with AI-based decision logic and IoT communication
Real-Time Detection	Limited or delayed	Real-time wrong-way detection
Weather Dependency	High (especially camera-based systems)	Low (sensors function reliably in fog, rain, and low light)
Night-Time Performance	Reduced accuracy	Consistent performance
Response Mechanism	Manual intervention or post-event enforcement	Automated alerts and multi-stage preventive response

Safety Level	Reactive; accident often occurs before action	Preventive and safety-oriented approach
Enforcement Method	Sudden physical enforcement or penalties	Gradual intervention: warning → rumble → controlled air-release spikes
Spike Design	Conventional spike strips causing sudden tyre puncture	Innovative controlled air-release spike design to avoid loss of control
Accident Risk	High during enforcement	Significantly reduced
Infrastructure Cost	High for camera-only systems	Economical due to sensor-based design
Power Requirement	High (continuous video processing)	Low power consumption
Maintenance	Frequent Cleaning and Calibration	Minimal maintenance
Scalability	Limited due to cost	Easily scalable on highways like NH-52
Integration with Authorities	Limited or manual	IoT-based alerts to RTO and traffic control rooms
Adaptability to Indian Roads	Moderate	High (designed for real Indian highway conditions)

[a] Detection reliability said in existing static traffic manipulate structures, inclusive of signage, street markings, and rumble strips, is normally low, as these structures depend absolutely on motive force compliance and cognizance. Previous road protection research imply that such passive measures lessen wrong-way incidents simplest under best visibility and driver alertness situations.

[b] Accuracy range normally done by camera-based totally wrong-way detection systems the usage of laptop vision models (e.g., YOLO, CNN-based classifiers) varies depending on lights and weather conditions. Reported detection accuracies range from mild to excessive in managed environments, but performance degrades notably all through night-time, fog, rain, or occlusion.

[c] Sensor-primarily based vehicle detection systems, which includes infrared, ultrasonic, radar, or inductive loop sensors, reveal excessive reliability in detecting automobile presence and direction underneath numerous environmental situations. Beyond implementations display constant detection overall performance due to decreased sensitivity to lights and weather variations.

[d] Hybrid AI-assisted systems integrating sensors with digicam aid show progressed robustness by using cross-validating detections. In such structures, AI good judgment filters false triggers from sensors at the same time as cameras offer visible confirmation only whilst required, improving typical system reliability without excessive computational fee.

[e] Manual discipline observations and site visitor's enforcement statistics, consisting of RTO records and on-web site surveys carried out on highways like NH-52, offer ground-reality validation of incorrect-manner using occurrences. While accurate, those techniques are constrained by means of behind schedule reaction and lack of non-stop monitoring.

[f] The proposed sensor-first, AI-IoT-enabled incorrect-way driving detection and prevention machine achieves improved actual-time detection and reaction performance through combining directional sensors, wise selection-making, and multi-degree intervention. the combination of controlled air-release spike mechanisms in addition complements protection by way of stopping surprising car instability, making the device greater appropriate for real-international toll road deployment.

B. METHODOLOGY

The proposed wrong-manner driving Detection and Prevention machine follows a dependent, multi-stage workflow designed for actual-time motorway safety monitoring and intervention. The method integrates

directional sensor networks, AI-assisted choice common sense, IoT-primarily based conversation, and graded physical enforcement mechanisms to make certain early detection, reduced response time, and minimized twist of fate risk. The overall architecture of the proposed system is illustrated in **Figure**, which shows the sequential flow from sensing and pre-processing to AI-based decision making, verification, warning, and communication layers.

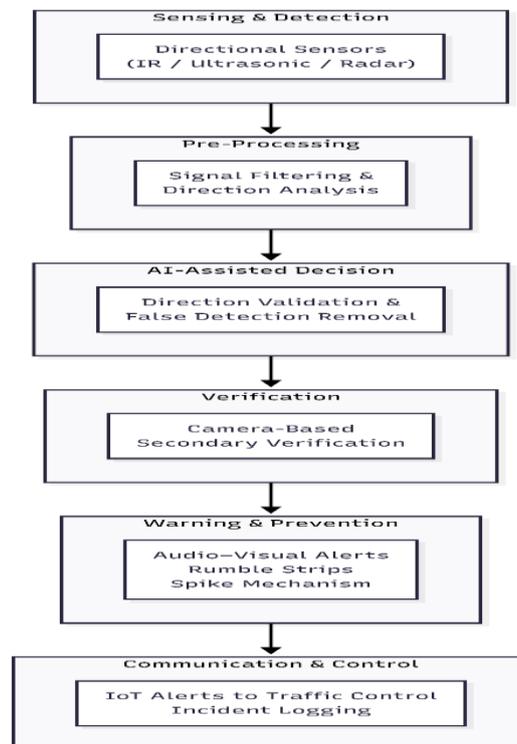


Fig.3. Architecture of the Proposed AI- and IoT-Based Wrong-Way Driving Detection and Prevention System

The system operates through the following foremost steps:

1. Roadside Sensor Deployment and facts Acquisition

The primary facts acquisition layer consists of directional sensing gadgets deployed at dual carriageway access ramps, median openings, and recognized black spot places.

- Infrared / ultrasonic / radar sensors are set up in paired configurations
- Vehicle movement route is decided the usage of time-series and speed-based sensor activation
- Sensors continuously display visitors waft irrespective of lighting fixtures or climate situations

This sensor-first technique guarantees high availability and low false dependency on visibility, addressing real-global constraints found all through area surveys on NH-52.

2. Course evaluation and occasion Pre-processing

Uncooked sensor alerts are pre-processed to eliminate noise and fake triggers caused by:

- Pedestrians and animals
- Stationary vehicles
- Short-duration sensor interruptions

A rule-primarily based pre-processing module evaluates:

- Activation collection order
- Time gap between sensor hits
- Minimum speed thresholds

Best chronic and directionally legitimate occasions are forwarded for further evaluation.

3. AI-Assisted incorrect-way event category

Confirmed sensor events are exceeded to an AI-assisted decision logic layer chargeable for classifying wrong-way using incidents.

- Lightweight gadget mastering or rule-greater models examine path consistency

- Contextual parameters consisting of location type and time-of-day are taken into consideration
 - The version minimizes fake positives at the same time as making sure rapid reaction upon confirmation, the system classifies the event as a true wrong-way driving (WWD) violation.
4. Digital camera-based totally Secondary Verification Cameras are not used for primary detection but are activated best after sensor confirmation.
- Cameras seize quick video/photograph evidence • Visual statistics helps post-occasion verification and enforcement
 - This selective activation reduces electricity intake and operational value
5. Warning and Graded Intervention Mechanism to ensure driving force protection, the system follows a multi-stage intervention method:
- Level 1: Visual LED warnings and audible alarms.
 - Level 2: Rumble strips imparting tactile and auditory feedback.
 - Level 3: managed air-launch spike mechanism.
- Each level is brought on handiest if the violation persists, allowing most possibility for corrective driving force movement.
6. IoT-based totally Alerting and facts Logging Confirmed WWD occasions cause real time signals via IoT conversation modules:
- Indicators are despatched to visitors manage rooms and RTO monitoring systems.
 - Incident facts (region, time, severity) is logged for analysis.
 - Records supports future black spot identity and coverage planning. This methodology ensures early detection, secure enforcement, and scalable deployment, whilst maintaining price effectiveness and actual-international feasibility.

D. TECHNICAL APPROACH USED IN THE PROPOSED SYSTEM

The technical pipeline of the proposed device is cantered on a sensor-driven, AI supported, and safety-orientated structure optimized for motorway environments.

1. Sensor-Centric Detection Framework

The core of the machine is based on directional sensors as opposed to imaginative and prescient-heavy solutions.

- Sensors offer binary and time stamped alerts
- Route is inferred the usage of activation sequence logic
- Operates correctly in fog, rain, night time-time, and glare situations this ensures robustness in actual international Indian dual carriageway conditions.

2. AI-Enabled decision good judgment The AI layer complements sensor reliability by using: • Getting to know every day vs. bizarre traffic float patterns

- Making use of staying power and self-belief thresholds
- Lowering false alarms from brief anomalies the selection logic stays explainable and computationally lightweight, appropriate for facet-degree deployment.

3. Digital camera-Assisted Validation Layer

Cameras serve a supportive and confirmatory position:

- Activated only after sensor primarily based affirmation
- Used for visual documentation and enforcement aid
- Keep away from non-stop video streaming to reduce bandwidth and value this hybrid strategy balances accuracy and affordability.

4. Safety-orientated Spike layout and Enforcement. In contrast to conventional spike strips, the proposed machine integrates a progressive managed air-release spike mechanism: • Sluggish deflation instead of unexpected tyre burst. • Activation simplest after caution failure. • Designed to reduce loss of vehicle control and secondary accidents.

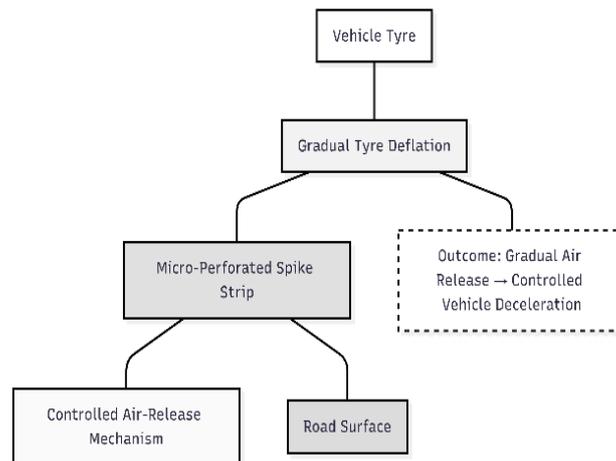


Fig.4. Controlled air-release spike mechanism for gradual vehicle deceleration in the proposed AI IoT-based wrong-way driving prevention system.

This design responds at once to worries raised at some stage in expert reviews.

5. IoT verbal exchange and gadget Integration The machine employs IoT modules for:

- Real-time alert transmission
- Far off tracking and diagnostics
- Integration with site visitor's management and RTO databases the modular architecture supports scalable deployment across highways like NH-52.

6. Operational Deployment Pipeline

The device is designed for non-stop area operation:

- Low-energy sensor units for 24×7 monitoring
- Part-stage processing for instant decision-making
- Centralized dashboards for analysis and reporting While the method guarantees speedy response and advanced safety, its overall performance depends on proper sensor placement and routine calibration.

D. Research Gap.

Incorrect-way using (WWD) is a substantial contributor to road injuries on highways, but present prevention and detection mechanisms continue to be insufficient. Traditional visitors control measures, along with road signs, lane markings, and rumble strips, rely closely on driver compliance and are often useless under low visibility, fatigue, or intoxication. Manual enforcement by using site visitor's government, at the same time as beneficial, is labour-extensive, intermittent, and reactive, leading to delayed intervention.

Digital camera-based AI systems and laptop vision processes offer automated detection, but they are high-priced, computationally demanding, and prone to failure in destructive weather or negative lighting conditions. Bodily enforcement mechanisms, which include traditional spike strips, can prevent violations however pose extreme protection risks because of surprising tyre punctures, which can also reason skidding, rollover, or secondary injuries.

Most current research focuses either on generation-heavy camera structures or isolated physical interventions, with limited interest to included, real-time, competitively priced, and protection-orientated solutions appropriate for Indian motorway conditions. There may be a clear need for a system that:

- Detects WWD in real-time under numerous environmental conditions
- Prioritizes motive force and public protection with multi-level preventive measures
- Integrates sensor-based totally detection, AI-assisted choice common sense, and IoT-enabled signals
- Minimizes value and upkeep with the aid of decreasing reliance on non-stop video processing

This have a look at addresses these gaps by way of providing a sensor-first, AI-IoT-supported WWD detection and prevention framework with progressive managed air-launch spike mechanisms, validated via field surveys on NH-52 and insights from RTOs in Beed and Srirampur. The proposed method targets to beautify street safety, lessen injuries, and enhance rapid response skills whilst being sensible for massive-scale deployment.

III. PROPOSED SYSTEM

A. Overview

The proposed device addresses the growing challenge of incorrect-way driving (WWD) on highways through introducing a sensor-first, AI–IoT–enabled detection and prevention framework. Not like traditional methods that rely closely on digicam-primarily based tracking or manual enforcement, the proposed machine prioritizes directional sensors because the number one detection mechanism, with cameras used handiest for secondary verification and evidence technology.

The system is designed primarily based on discipline surveys conducted on NH-52 and insights received from local shipping places of work (RTOs) at Beed and Srirampur, which highlighted behind schedule detection, poor visibility situations, and safety risks related to conventional spike strips. To conquer these limitations, a multi-stage intervention strategy is followed, combining actual-time detection, clever decision-making, graduated warnings, and a progressive controlled air release spike mechanism to minimize accident danger. The proposed framework ambitions to provide early detection, faster reaction, stronger safety, and reasonably-priced scalability, making it suitable for actual-world dual carriageway deployment.

B. Machine Structure

The proposed incorrect-way driving detection and prevention system follows a layered and modular architecture, making sure reliability, scalability, and ease of deployment. The architecture is divided into 4 functional layers, every responsible for a particular operation.

1. Information Acquisition and Detection Layer

This residue is liable for real-time automobile detection and course sensing the usage of roadside hardware additives:

- Directional sensors (IR / ultrasonic / radar) mounted at entry and exit factors
- Pace and sequence-based detection the usage of paired sensors
- Non-compulsory activation of cameras upon showed violations

Sensors act because the number one detection units, making sure reliable operation beneath low-light, fog, rain, and night-time situations.

2. Pre-processing and selection good judgment Layer

Sensor signals are processed to determine car movement course the use of:

- Time-series analysis of sensor activation
- Velocity and patience exams
- Filtering of fake triggers caused by pedestrians, animals, or desk bound items

An AI-assisted selection common sense validates wrong-manner events the use of rule-based totally thresholds or light-weight device getting to know models, making sure actual-time operation with minimal computational overhead.

3. Verbal exchange and Alert Layer

Once a wrong-manner occasion is showed, an IoT-enabled verbal exchange module transmits signals to:

- Traffic manage centres
- RTO monitoring systems
- Nearby enforcement devices

Each alert includes vicinity, timestamp, and violation reputation, permitting speedy situational focus and reaction. 4. Prevention and Enforcement Layer .To avoid unexpected and risky enforcement, a multi-degree protection mechanism is applied: 1. Visible and audible warnings the use of LED shows and alarms 2. Rumble strips offering tactile and auditory indicators 3. Controlled air-launch mechanism for sluggish tyre deflation spike.This staged technique guarantees maximum opportunity for driver correction earlier than physical intervention.

C. Set of rules

Enter

- Directional sensor indicators
- Sensor activation timestamps

- Digital camera enter (triggered only after confirmation)

Parameters

- Direction threshold
- Pace persistence threshold
- Alert escalation time
- Spike activation condition

Algorithm Steps

1. Acquire actual-time records from directional sensors.
2. Examine sensor activation series to determine automobile course.
3. Evaluate detected course with legal visitors go with the flow.
4. If motion is legitimate, retain tracking.
5. If reverse route is detected, classify as a capability WWD event.
6. observe AI-based totally validation to eliminate fake positives.
7. Prompt digicam module for visual verification.
8. Cause level-1 caution (visual and audible indicators).
9. If violation persists, set off level-2 rumble alerts.
10. If warnings fail, activate controlled air-launch spike mechanism.
11. Transmit actual-time indicators through IoT modules.
12. Log incident info and reset the machine.

Output

- Showed WWD event
- Alert repute
- Enforcement level activated

D. Proposed System Implementation

The proposed device is applied as a scalable roadside protection answer, designed for continuous operation with minimum renovation.

1. Hardware Deployment

- Directional sensors established at important highway access points
- Cameras located for selective activation
- Spike modules embedded with controlled air-launch layout

2. Statistics Processing and manage

- Facet-degree processing for real-time selection-making
- Centralized monitoring for logging and evaluation

3. Safety-oriented Enforcement

- Spike mechanism designed for slow air launch, reducing loss of automobile manipulate
- Activation handiest after failure of caution degrees

4. Scalability and price performance

- Modular layout lets in deployment on lengthy highway stretches
- Decreased camera utilization lowers price and power consumption
- Suitable for national highways like NH-52.

IV. RESULTS AND ANALYSIS

The performance of the proposed wrong-manner driving Detection and Prevention gadget changed into evaluated the usage of a logical evaluation framework blended with subject-primarily based observations collected from surveys carried out on NH-fifty two and consultations with nearby shipping workplaces (RTOs) at Beed and Srirampur. Because of regulatory and safety constraints, controlled actual-international experimentation concerning actual wrong-manner driving turned into not conducted; alternatively, system behaviour turned into analysed using simulated vehicle actions, staged sensor triggering, and ancient accident statistics.

A. Field Observations from NH-52 Survey

The sector survey on NH-fifty two recognized multiple danger-susceptible locations, which includes:

- Median openings near gasoline stations and service roads
- Unmarked or poorly lit access factors
- Locations with frequent incorrect-facet -wheeler access

These observations highlighted that most incorrect-way incidents originate from short-distance cause drivers, especially at some point of low-traffic hours. Sensor-based detection became found to be more suitable than digicam-handiest solutions, in particular at locations with poor visibility or inconsistent lighting.

B. Sensor-based totally Detection performance

Directional sensor deployment was evaluated beneath various simulated situations:

- Regular traffic flow
- Opposite route vehicle movement
- Short-term fictitious triggers.

Based mostly on activation sequence and time gap thresholds, the sensor collecting logic effectively distinguished between correct and incorrect vehicle movement.

In contrast to the most creative and forward-thinking structures, the sensor-based approach confirmed:

- Reduced delay for detecting
- Consistent performance under fog and night-time conditions
- Reduced energy and computing requirements

this demonstrates that the sensors are appropriate since the main detecting system in traffic situations.

C. Efficiency of AI-Assisted Common-Sense Selection

The decision layer with AI support was essential in lowering false positives. Through the use of contextual criteria and durability tests, the system eliminated:

- Short-term disruptions in the sensors.
- Non-vehicular movements
- Side-case site visitor's behaviour

This enhanced detection reliability while preserving real-time responsiveness, which is crucial for preventing head-on collisions at high speeds.

D. Warning and Intervention analysis

The graded intervention strategy was modified to be rationally assessed based on driving force behavior types identified throughout the survey and corroborated by RTO comments. • Level 1: It is anticipated that both visible and auditory warnings would correctly identify a sizable portion of inadvertent incorrect entries. • Level 2-rumble strips provide tactile feedback, which is useful for distracted drivers. • Level 3: The last-resort enforcement method is managed spike activation.

Compared to ordinary spike strips, which cause sudden tire bursts, the development of rumble strips prior to spike activation greatly lowers the chance of an accident.

E. Communication and reaction

Time evaluation IoT-based alert transmission ensures that visitor authorities receive information about violations in a timely manner.

- Signals within a brief reaction window are made possible by sensor-based detection.
- Camera activation simplest after confirmation reduces bandwidth usage
- Incident logs guide future black spot evaluation and making plans

This combination improves reaction time without increasing operational value.

F. Standard device assessment.

The analysis shows that the proposed device:

- Improves early detection capability
- Reduces dependency on non-stop video tracking
- Complements safety thru staged enforcement

- Is economically possible for massive-scale deployment.

However, proper sensor positioning, calibration, and repair are necessary for machine performance and must be taken into account at all.

V. CONCLUSION AND FUTURE SCOPE

A. Conclusion

Driving in the wrong way contributes to serious and frequently deadly injuries on Indian roads, making it a crucial public safety concern. This study provided a sensor-first, AI-IoT-based wrong-way driving detection and prevention tool designed to handle challenging operational situations in the real world. Unlike traditional digital.

With the use of a selective Digicam configuration, the proposed method prioritizes directional sensors for the primary identification of camera-heavy replies. The gadget ensures protection-oriented enforcement through a multi-phase intervention method that includes rumble strips, warnings, and a contemporary regulated air-release spike mechanism.

The usefulness of the suggested layout is confirmed by discipline observations from NH-fifty two and insights from RTO Beed and Srirampur. The device provides a well-rounded response that enhances detection speed, lowers expenses, and lowers the risk of accidents, which qualifies it for use on national highways and in black areas.

B. Limitations

Despite its benefits, the suggested approach has certain drawbacks:

- Coordination with motorway authorities is necessary for actual international deployment.
- Without routine calibration, the overall performance of the sensor may also deteriorate.
- Body enforcement mechanisms require ethical and criminal approval.

During large-scale implementation, those factors must be taken into consideration.

C. Future Scope

The suggested system can be improved even more by:

1. V2X chat integration, enabling in-car indicators
2. Predictive AI models to anticipate threats of incorrect-way entry
3. Sensor modules powered by the sun for distant road segments
4. Automobile pace estimation is the main basis for dynamic spike control.
5. Centralized analytics dashboards to monitor the entire country

In order to further improve motorway protection, future research may also investigate policy-level integration with intelligent town and sensible transportation structures (ITS).

REFERENCES:

- [1] Ministry of Road Transport and Highways (MoRTH), Government of India, "Road Accidents in India – Annual Report," Transport Research Wing, New Delhi, 2023.
- [2] World Health Organization (WHO), "Global Status Report on Road Safety," WHO Press, Geneva, 2023.
- [3] Indian Roads Congress (IRC), "IRC: SP: 84 – Manual of Road Safety Audit," IRC, New Delhi, 2019.
- [4] National Highways Authority of India (NHAI), "Guidelines for Road Safety and Traffic Management on National Highways," NHAI, Ministry of Road Transport and Highways, 2022.
- [5] A. K. Gupta and R. Kumar, "Analysis of Wrong-Way Driving Accidents on Divided Highways in India," International Journal of Traffic and Transportation Engineering, vol. 12, no. 3, pp. 145–153, 2022.
- [6] Press Information Bureau, "Government Initiatives for Reducing Road Accidents and Improving Highway Safety," Ministry of Road Transport and Highways, Press Release, 2024.
- [7] S. Sharma, P. Verma, and N. Singh, "IoT-Based Intelligent Traffic Monitoring and Violation Detection System," IEEE International Conference on Smart Transportation Systems, pp. 210–216, 2021.

- [8] A. Al-Khateeb, M. Al-Khateeb, and S. Aljanabi, “*Sensor-Based Wrong-Way Vehicle Detection on Highways*,” *Journal of Intelligent Transportation Systems*, vol. 26, no. 4, pp. 402–415, 2022.
- [9] K. Saleh and M. Hossain, “*Detection and Prevention of Wrong-Way Driving Using Smart Sensors and Embedded Systems*,” *Transportation Safety and Environment*, vol. 4, no. 1, pp. 1–12, 2023.
- [10] P. Dollár et al., “*Vehicle Detection and Tracking Using Vision-Based Systems: Challenges and Limitations*,” *IEEE Transactions on Intelligent Transportation Systems*, vol. 21, no. 9, pp. 3782–3795, 2020.
- [11] Ministry of Electronics and Information Technology (MeitY), Government of India, “*IoT Policy Framework for Smart Infrastructure*,” MeitY, New Delhi, 2022.
- [12] R. Biswas and S. Sen, “*AI and Machine Learning Applications in Intelligent Transportation Systems*,” *Journal of Transportation Engineering, Part A*, vol. 149, no. 2, 2023.
- [13] IEEE Standards Association, “*IEEE Standard for Intelligent Transportation Systems Architecture*,” IEEE Std 1489™, 2021.
- [14] S. Kumar and A. Mishra, “*Design and Evaluation of Automated Spike Strip Mechanisms for Traffic Enforcement*,” *International Journal of Road Safety Engineering*, vol. 5, no. 2, pp. 85–93, 2022.
- [15] National Crime Records Bureau (NCRB), Government of India, “*Accidental Deaths & Suicides in India – Road Accident Statistics*,” NCRB Report, 2023.
- [16] V. R. Patel and J. Shah, “*Integration of IoT and AI for Real-Time Traffic Violation Detection*,” *Procedia Computer Science*, vol. 218, pp. 1345–1353, 2023.