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Design And Analysis Of Anticollision System Of Heavy-Duty Vehicles.

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Abstract :-

Objective and Relevance: The project aims to create and evaluate an anticollision system tailored for heavy-duty vehicles like trucks, buses, and construction equipment. This project seeks to enhance safety, minimize accidents, and boost operational efficiency in the transport and logistics sectors. Key elements include improving safety, economic benefits, regulatory adherence, environmental advantages, technological progress, and reducing human error. The methodology integrates advanced technologies such as radar, lidar, ultrasonic sensors, and communication systems into a cohesive anticollision system. A microcontroller will handle data from these sensors to make real-time collision-prevention decisions. The project involves a literature review on existing systems, system design for sensor integration and control algorithms, and practical implementation with thorough testing. The system will issue warnings and initiate partial braking at 15 meters from an obstacle, intensify warnings and apply moderate braking at 11 meters, and activate full braking at 7 meters. The control system will process real-time data, evaluate collision risks, and implement avoidance strategies, incorporating adaptive learning capabilities and fail-safe mechanisms.

Introduction :-

The project aims to create and evaluate an anticollision system tailored for heavy-duty vehicles like trucks, buses, and construction equipment. This project seeks to enhance safety, minimize accidents, and boost operational efficiency in the transport and logistics sectors. Key elements include improving safety, economic benefits, regulatory adherence, environmental advantages, technological progress, and reducing human error. The methodology integrates advanced technologies such as radar, lidar, ultrasonic sensors, and communication systems into a cohesive anticollision system. A microcontroller will handle data from these sensors to make real-time collision-prevention decisions. The project involves a literature review on existing systems, system design for sensor integration and control algorithms, and practical implementation with thorough testing. The system will issue warnings and initiate partial braking at 15 meters from an obstacle, intensify warnings apply moderate braking at 11 meters, and activate full braking at 7 meters. The control system will process real-time data, evaluate collision risks, and implement avoidance strategies, incorporating adaptive learning capabilities and fail-safe mechanisms.

II. Problem Statement:

Unnoticed / non-illuminated Center Medians: Due to multiple reasons the center medians goes unnoticed by the driver's, and it leads to many accidents.

III. Warning Details of Anti-Collusion System:

Methods :

1. Literature Review: A comprehensive literature survey was conducted to gather information on current anticollision systems, relevant technologies, safety regulations, and best practices. This included reviewing research papers, industry reports, safety standards, and case studies to identify the key components and strategies for effective collision avoidance.

2. System Design: The design phase involved developing the overall architecture of the anticollision system. This included selecting appropriate sensors (radar, lidar, cameras, ultrasonic sensors), communication systems (Vehicle-to-Vehicle and Vehicle-to-Infrastructure), and control algorithms. The design also incorporated user interface elements for driver warnings and system feedback.

3. Sensor Integration: Sensors were strategically placed on the vehicle to ensure comprehensive coverage of the surrounding environment. The integration process involved calibrating sensors to work in tandem, ensuring accurate and reliable data collection.

4. Data Processing and Fusion: Advanced algorithms were developed to process and fuse data from multiple sensors. This step was crucial for creating an accurate real-time picture of the vehicle's surroundings and identifying potential collision threats.

5. Control Algorithm Development: Machine learning and AI algorithms were designed to predict potential collisions and make real-time decisions. These algorithms control the activation of warnings, partial braking, or full braking, depending on the severity of the detected threat. 6. Communication Systems: Implementing Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication protocols allowed vehicles to share information and coordinate movements, further enhancing collision avoidance capabilities.

7. Testing and Validation: The system underwent rigorous testing in both simulated environments and real-world scenarios. This included controlled tests to evaluate system performance under various conditions and edge cases.

8. Implementation and Integration: The final step involved integrating the anticollision system into heavy-duty vehicles. This required collaboration with vehicle manufacturers and fleet operators to ensure seamless implementation and functionality.

Components of Anti-Collusion System :

1. Sensors: Radar Sensors: Used for long-range detection of obstacles and vehicles, providing data on distance and speed. Lidar Sensors: Provided high-resolution 3D mapping of the vehicle's surroundings. Cameras: Used for visual recognition of objects, lane markings, and traffic signs. Ultrasonic Sensors: Utilized for short-range detection, particularly useful in low-speed scenarios.

2. Communication Systems: V2V Communication Modules: Enabled vehicles to share information about speed, direction, and location. V2I Communication Modules: Facilitated communication with road infrastructure, such as traffic lights and road signs.

3. Microcontroller: A powerful microcontroller was selected to process sensor data, run control algorithms, and manage communication between system components.

4. Software: Machine Learning Models: Trained on large datasets to predict potential collision scenarios and make real-time decisions. Control Algorithms: Developed to activate warnings and braking systems based on sensor data analysis. Data Fusion Software: Combined data from different sensors to create a coherent and accurate environmental model. 5. Actuators: Braking System Actuators: Controlled by the microcontroller to apply partial or full braking as necessary. Warning Systems: Included visual (LEDs) and auditory (buzzers) signals to alert the driver of potential collisions.

6. Power Supply: Reliable power sources were used to ensure uninterrupted operation of all system components.

IV. Calculation :-

Total stopping distance = Human perception distance + human reaction distance +braking distance + distance covered in 1msec

Braking distance,

$$D_{\text{Braking}} = \frac{v^2}{2\times\mu\times g}\ \text{m} \quad \ldots\ldots..(1)$$

Where,

V = Velocity before applying brakes

μ = coefficient of friction = 0.7 (for dry surfaces)

g = acceleration due to gravity (9.81)

D_{Braking} = Braking distance,

Here the human perception time and human reaction time are equal to "zero" because it is an automatic braking system.

$$D_{\text{Braking}} = \frac{4.167^2}{2\times0.7\times9.81} = 1.26\ \text{m}$$

Total stopping distance = 1.26 m

Total braking distance = 1.26

IMPACT FORCE CALCULATION :

Mass of the vehicle = 22 kg

Velocity of the vehicle = 15km/h = 4.167m/sec

Braking distance = 1.26 m

By motion equation

$2as = v^2 - u^2$.......(2)

Where,

v = final velocity

u = initial velocity

a = acceleration

s = braking distance

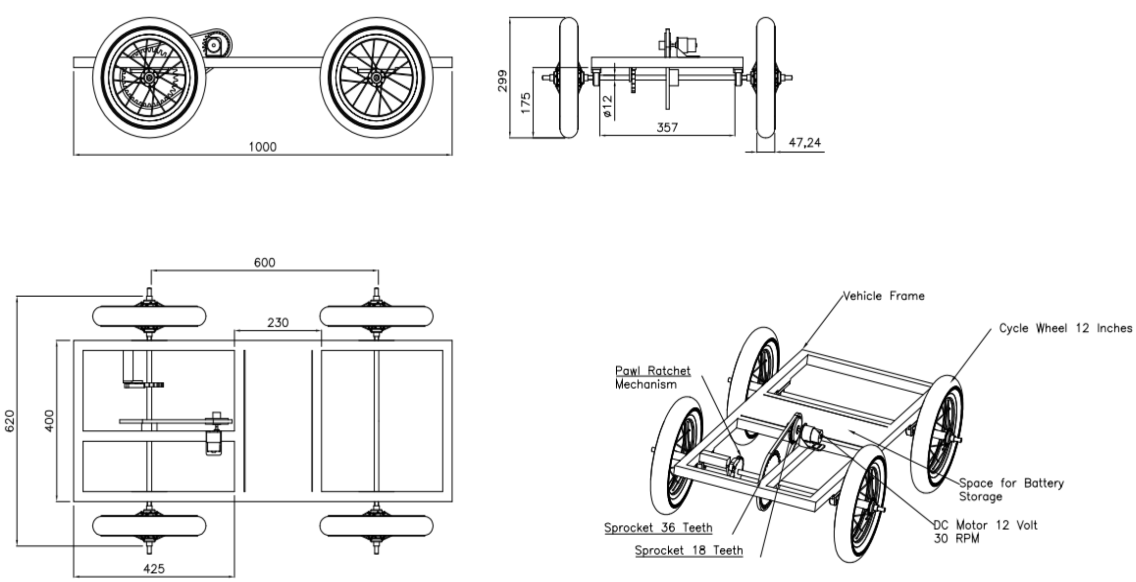
$$2\times a \times 1.26 = 0^2 - 4.167^2$$

$$a = -6.89\ m/sec^2$$

Force, F = mass× acceleration ……(3)

= 22× (-6.89)

F = 151.58 N



Testing Table:

For Input Parameters:

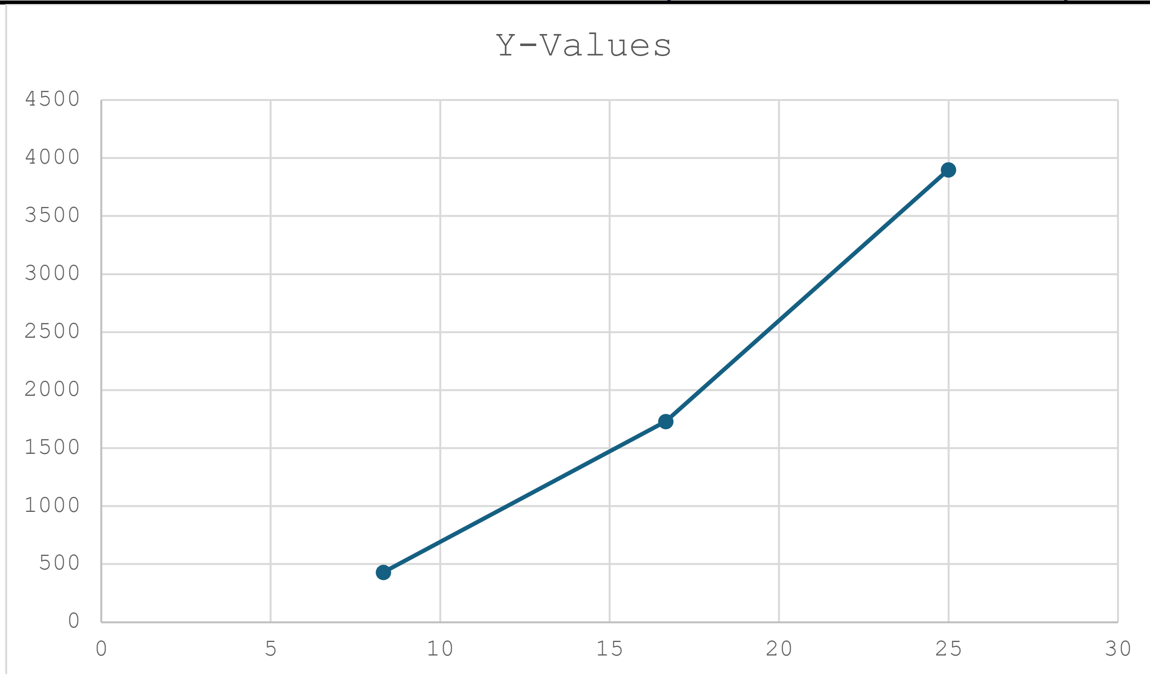
Parameters		**Low**	**Medium**	**High**
Speed(km/hr)		30	60	90
Load(kg)		900	1000	1200
Road inclination(θ)		0	20	35

Breaking Force Calculation:

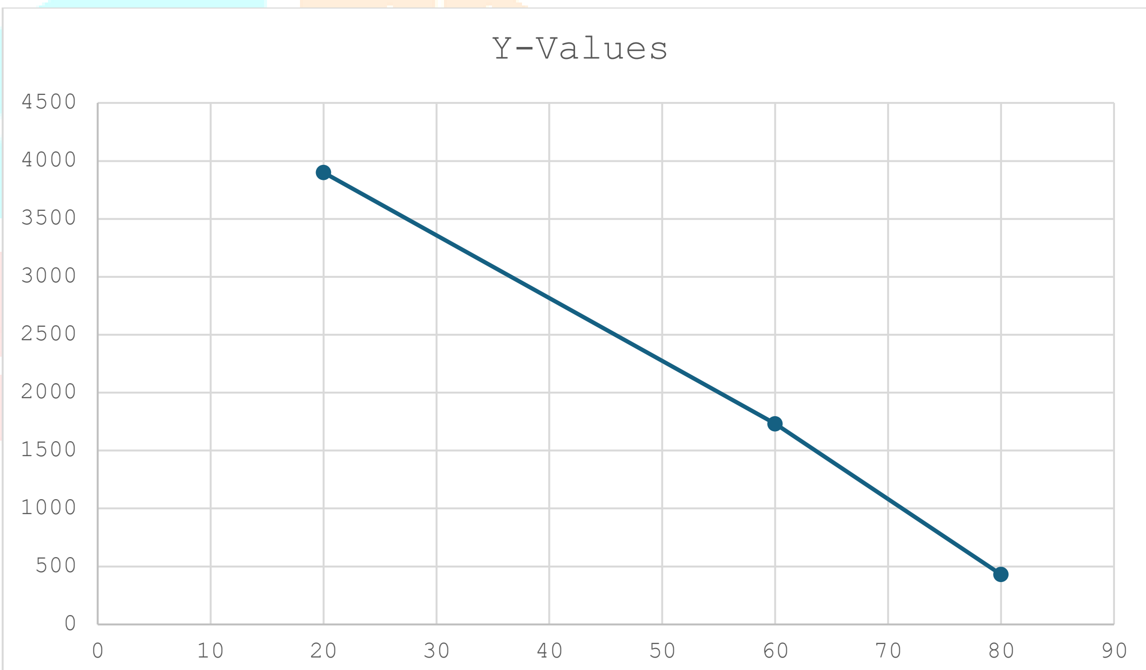
F=(0.5×m×v*2)/d

- **For m=1000kg**

	V(m/s)	**D=100m**	**D=80m**	**D=60m**	**D=40m**	**D=20**
Fb(N)	**8.33**	**350**	**430**	**580**	**850**	**1730**
Fb(N)	**16.66**	**1380**	**1730**	**2300**	**3500**	**7000**
Fb(N)	**25**	**3125**	**3900**	**5200**	**7800**	**15625**


Y-Values
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
30

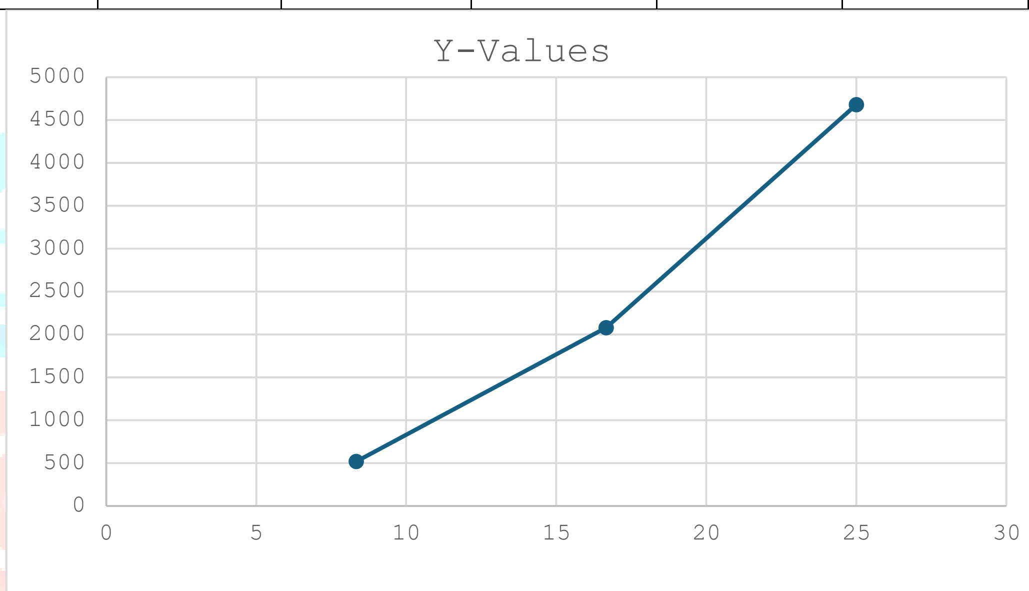
Fb vs v

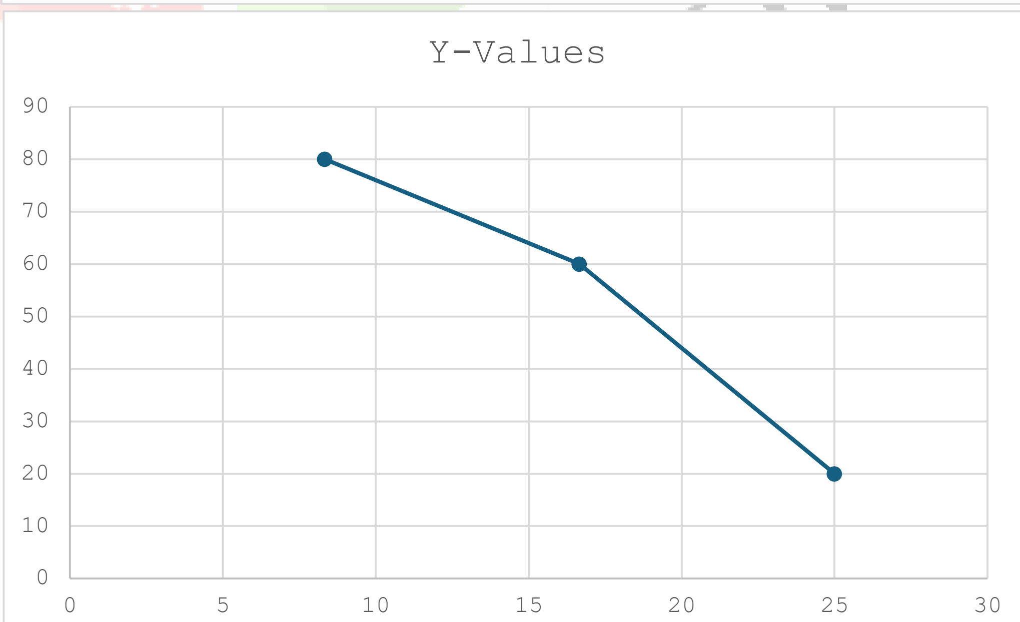

Y-Values
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
10
20
30
40
50
60
70
80
90

Fb vs D

- **For m=1200kg**

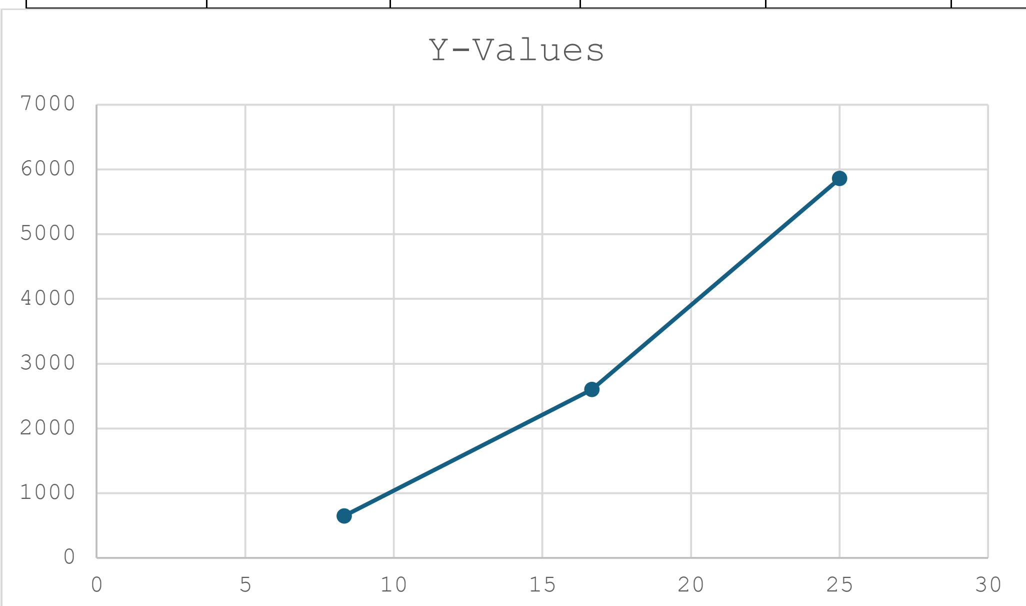
	V(m/s)	D=100m	D=80m	D=60m	D=40m	D=20
Fb(N)	8.33	420	520	690	1050	2080
Fb(N)	16.66	1660	2080	2750	4160	8320
Fb(N)	25	3750	4680	6250	9370	18750





- **For m=1500kg**

	V(m/s)	D=100m	D=80m	D=60m	D=40m	D=20
Fb(N)	8.33	520	650	860	1300	2600
Fb(N)	16.66	2080	2600	3470	5200	10400
Fb(N)	25	4680	5860	7800	11720	23400



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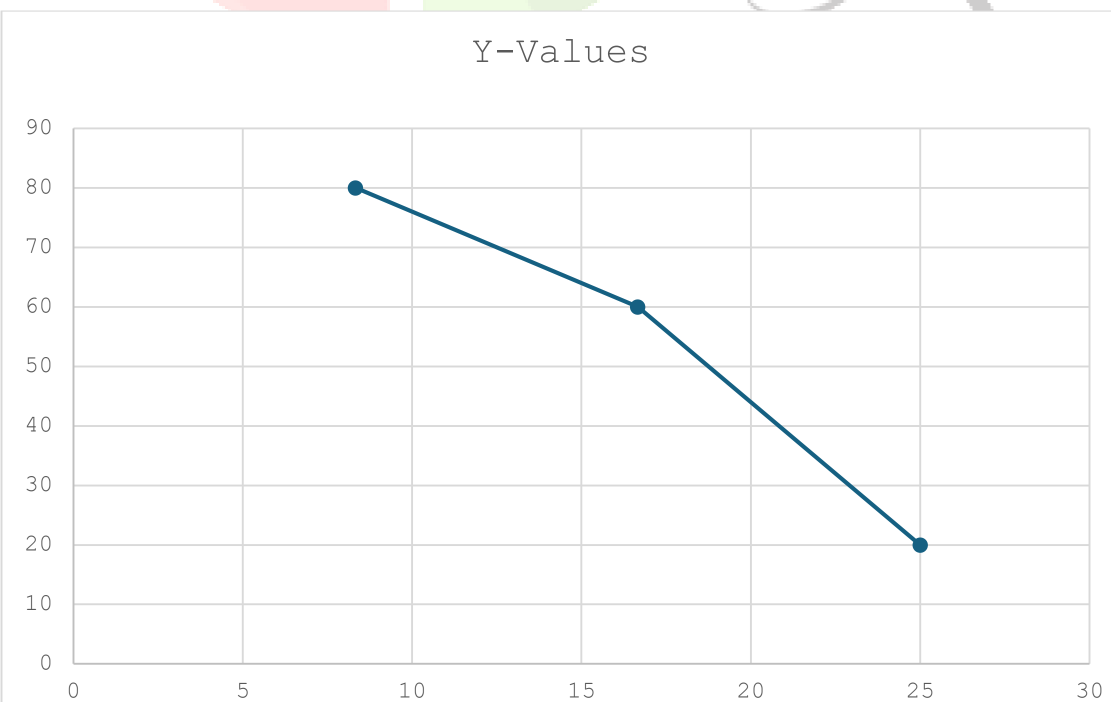

VI. Results:-

1. Sensor Performance: The integrated sensor suite, comprising radar, lidar, cameras, and ultrasonic sensors, demonstrated high accuracy in detecting obstacles and other vehicles under various conditions. Each sensor type contributed uniquely to the system: Radar Sensors: Successfully detected objects at long ranges and provided accurate speed and distance measurements. Lidar Sensors: Generated detailed 3D maps, crucial for understanding the vehicle's immediate environment. Cameras: Effectively identified lane markings, traffic signs, and other visual cues. Ultrasonic Sensors: Performed well in close-range detection scenarios, such as low-speed maneuvers.

2. Data Fusion and Processing: The data fusion algorithms successfully combined information from different sensors, creating a comprehensive and accurate real-time model of the vehicle's surroundings. The fusion process reduced false positives and improved the system's reliability in identifying potential collision threats.

3. Collision Avoidance: The control algorithms, driven by machine learning and AI, were effective in predicting potential collisions and initiating appropriate responses: Warning Systems: Visual and auditory alerts were activated correctly, providing timely warnings to the driver. Automated Braking: The system successfully initiated partial braking at distances less than 11 meters and full braking at distances less than 7 meters, effectively preventing simulated collisions.

4. Communication Systems: The V2V and V2I communication modules enabled seamless information exchange between vehicles and infrastructure, enhancing situational awareness and coordination. This feature was particularly useful in high-traffic scenarios and complex environments.

5. Testing and Validation: The system was rigorously tested in both simulated environments and real-world conditions. The simulations included various scenarios such as sudden stops by the vehicle ahead, unexpected obstacles, and merging traffic. In real-world tests, the system consistently demonstrated its capability to prevent collisions, even under adverse weather conditions and high traffic density.

6. Driver Interaction: Feedback from test drivers indicated that the warning systems were intuitive and effectively drew attention without causing distraction. The automated interventions were smooth and did not induce panic, enhancing the overall driving experience.

VII. Conclusion :-

The design and analysis of the anticollision system for heavy-duty vehicles demonstrated significant advancements in vehicle safety technology. The successful integration of multiple sensors, sophisticated data processing, and effective communication systems resulted in a reliable and efficient collision avoidance solution. While challenges remain, particularly in adverse weather conditions and system latency, the overall benefits ranging from enhanced safety and reduced economic losses to environmental sustainability underscore the value of this technology. Future work will focus on refining these systems, addressing current limitations, and ensuring broader adoption across the transportation industry.

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