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Bike Speed Regulator

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Abstract :

This paper introduces a Bike Speed Regulator System designed specifically for motorcycles, aimed at enhancing rider safety by detecting and responding to the proximity of objects in front of the bike. The system utilizes advanced sensors, such as ultrasonic sensor to continuously measure the distance between the motorcycle and objects in its path. An algorithm processes this real-time data, applying predefined test conditions to determine if braking intervention is necessary.

The intelligent braking system engages when the algorithm detects conditions indicative of a potential collision, automatically applying the brakes to mitigate or prevent the impact. This innovative approach to motorcycle safety ensures a proactive response to environmental factors, contributing to accident prevention and rider well-being. The project aligns with the broader goal of implementing smart technologies in transportation,tailored to address safety concerns in motorcycle riding environments.

I. Introduction:

In the realm of road safety, advancements in car safety systems have marked substantial progress over the years, significantly contributing to the protection of passengers and reducing the severity of accidents. However, the narrative takes a distinct turn when it comes to motorcycles. Despite the strides made in automotive safety, motorcycles, with their unique dynamics and vulnerabilities, have not witnessed significant developments in safety systems. This glaring disparity poses a critical problem, as motorcycles represent a substantial portion of the global vehicular landscape, and their riders face distinct safety challenges on the road.

Current motorcycle safety systems, primarily rooted in adaptations from car technologies, fall short in addressing the unique challenges inherent to two-wheeled vehicles. While anti-lock braking systems (ABS) and traction control systems (TCS) contribute to stability, they lack the contextual awareness required in dynamic traffic situations. Motorcycles demand specialized attention, considering their distinct dynamics and the exposed nature of riders. Unlike car occupants, motorcyclists lack protective enclosures, heightening the significance of collision detection and avoidance systems, which are currently absent in mainstream safety technologies. The fundamental limitations of existing systems lie in their inability to comprehensively assess real-time environmental factors and dynamically adapt to the agility required in motorcycle operation.

The imperative for collision avoidance and automatic braking systems stems from the critical need to mitigate the devastating impact of road accidents. As traffic volumes escalate globally, the risk of collisions, especially in crowded urban environments, has intensified. These advanced safety systems are pivotal in enhancing road safety by providing a proactive layer of defense against potential accidents. Collision avoidance systems utilize sensors and real-time data to assess the surrounding environment, preemptively detecting obstacles or other vehicles in the vehicle's path. Automatic braking systems, in turn, offer swift and precise responses by autonomously engaging the brakes in emergency situations, significantly reducing the severity of collisions or, in some cases, preventing them altogether.

The paper addresses the critical gap in motorcycle safety systems by designing and implementing a distance-based braking system to regulate bike speed and avoid collisions involving motorcycles. The system assesses real-time data to detect potential collisions. When predefined conditions indicative of a threat are met, the system autonomously engages the brakes, offering a proactive safety measure to prevent or mitigate accidents.

II. Literature survey

In this section, we review research papers on automatic speed regulators and braking systems for motorcycles.

"Automatic Speed Control & Automatic Breaking System of Vehicle using Multi Sensor's Project" by A.V.S.S.K. Prasad et al. (2020)[1] This paper presents the design and implementation of an automatic speed regulator and braking system for a vehicle. The system uses a microcontroller, ultrasonic sensors, and a GPS module to measure the distance to obstacles and the speed of the vehicle. It then uses this information to automatically regulate the speed of the vehicle or apply the brakes.

"Automatic Braking System on Motorbikes Using the Concept of Kinematics Non-Uniform Slowing Down Motion For Safety of Motorcycle Riders on the Highway" by Md. Rafiqul Islam et al. (2019)[2] This paper proposes an automatic braking system for motorcycles that uses the concept of kinematics non-uniform slowing down motion. The system uses an ultrasonic sensor to measure the distance to obstacles and a hall effect sensor to measure the speed of the motorcycle. It then uses this information to calculate the appropriate braking force and applies the brakes accordingly.

"Vehicle Speed Detection using Arduino" by B.S.N. Murthy et al. (2018)[3] This paper presents a simple and inexpensive method for detecting the speed of a vehicle using an Arduino microcontroller and a hall effect sensor. The system is used to implement an automatic speed limiter for a motorcycle.

"Automatic speed control system for motorcycles" by Robert E. Young (1985)[4] This paper describes an automatic speed control system for motorcycles that was developed in the 1980s. The system uses a vacuum operated motor to control the throttle of the engine. The motor is controlled by a microprocessor that receives input from a speed sensor and a distance sensor.

"Automatic Braking System for Motorcycle" by P.V.M.S. Reddy et al. (2015)[5] This paper presents an automatic braking system for motorcycles that uses a combination of ultrasonic sensors, a camera, and a microcontroller. The system is designed to detect and avoid obstacles in the path of the motorcycle.

Louw et al. (2017) have conducted a study using a driving simulator that involved 75 drivers exposed to various screen manipulations that varied the amount of visual information available from the road environment and automation status, with the results obtained in the form of an analysis of time, type, and response rate. Driver collision avoidance, as well as investigating how this is affected by the criticality of the ongoing situation. the conclusion obtained from the results of the study states that the design of the braking system should focus on achieving kinematically early avoidance initiation, rather than a short takeover time [6]

Anang and Familiana, In 2019, made a brake control system to automatically focus on the brake pedal by using the concept of straight motion kinematics change regularly to avoid sudden braking caused by too short a distance and driving speed that is too high [7]

Sitthiracha et al. l (2020) have researched rear-end collisions caused by motorcyclists due to too short a distance. His research proposes a model based on the piecewise linear braking profile of a motorbike and a kinematic equation to calculate the stopping distance in the worst-case scenario[8].

III.Proposed System Architecture and Implementation:

Components

1)Arduino Uno: Popular open-source microcontroller board. Based on ATmega328P, has digital/analog I/O, USB connectivity, and easy programming for diverse projects.

Fig 1 Arduino Uno.Adapted From [9]

2)Accelerometer(ADXL345):Measures three-axis acceleration. Analog output. Ideal for motion-sensing projects, robotics, and gaming.

Fig 2 Accelerometer(ADXL345).Adapted From [10]

3)Neo-6M GPS Module: GPS receiver for accurate positioning. UART communication. Used in tracking, navigation, and location-based projects.

Fig 3: Neo6M GPS Module.Adapted From[11]

4)Relay Module: Controls high-power devices with low-power microcontrollers. AC/DC switching for home automation, industrial automation, and robotics.

Fig 4: Relay Module.Adapted from [12]

5)LCD (Liquid Crystal Display): Displays characters or graphics. Embedded systems use it for real-time information display with microcontrollers like Arduino.

Fig 5: LCD. Adapted From [13]

6)ESP8266: Wi-Fi module for IoT projects. Affordable, small, and programmable. Facilitates internet connectivity in applications like home automation and sensor networks.

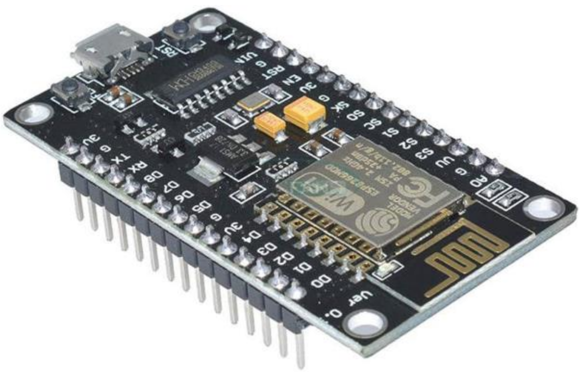

Fig 6: ESP8266. Adapted from [14]

Implementation

A. Distance Detection System:

1. Sensor Placement: The distance detection system employs ultrasonic sensors strategically placed on the bike to capture the surrounding environment.
2. Working Principle:
a. Real-time distance measurement: Ultrasonic sensors emit sound waves, and the time taken for the waves to bounce back is used to calculate the distance from obstacles.
b. Data Processing: Raw distance data is processed through algorithms to ensure accurate and real-time distance measurements.
3. Integration with Speed Regulation: The distance information is fed into the speed regulation system. When an obstacle is detected within a predefined range, the system triggers the speed regulator to decelerate the bike.

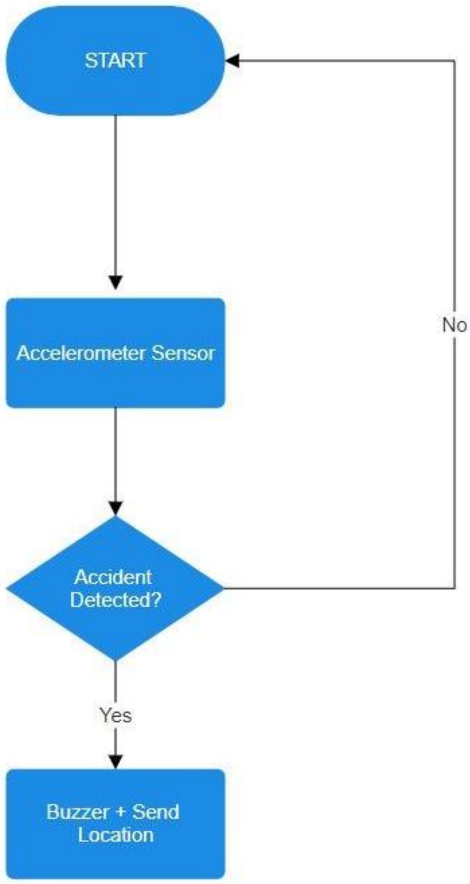

Fig 7:Accident Detection System

B. Braking System:

1. Gripper Mechanism:
a. Design and Functionality: Grippers are attached to the braking system, applying pressure to the bike's wheels when activated.
b. Materials Used: Durable and heat-resistant materials are employed for the gripper mechanism to ensure effective and safe braking.
2. Control Algorithm:
a. Decision-making process for brakes: The system utilizes a control algorithm that considers the distance information from the sensors. It decides when and how much braking force is necessary to ensure a smooth deceleration.
b. Considerations for Smooth Deceleration: To prevent sudden stops and enhance rider safety, the algorithm is designed to apply brakes progressively based on the detected distance.

C. Accident Notification System:

1. Overview: The accident notification system is designed to detect potential accidents and notify family members.

2. Triggering Mechanism:

a. Detection of a Fall or Impact: The system uses accelerometers and gyroscopes to detect sudden changes in orientation or acceleration, indicating a fall or impact.

b. Validation to Avoid False Alarms: To prevent false notifications, the system incorporates algorithms that validate the severity of the detected event before triggering the notification.

3. Notification Process:

a. Communication Protocol: In the event of a validated accident, the system uses a predefined communication protocol to send notifications.

b. Information Included in the Notification: The notification includes relevant information such as the rider's identity, GPS location, and a timestamp.

D. GPS Integration:

1. Role in Accident Notification: The GPS module plays a crucial role in providing accurate location information for the accident notification system.

2. Location Tracking: The GPS module continuously tracks the bike's location, ensuring real-time and precise location reporting in case of an accident.

3. Accuracy and Precision: The integration of GPS technology ensures high accuracy and precision in determining the bike's location, enhancing the effectiveness of the accident notification system.

Distance(cm)	Speed(km/hr)	**Brake Status**
>50	-	**No Brake**
40<x<50	>80	**Brake**
40<x<50	<80	**No Brake**
30<x<40	>60	**Brake**
30<x<40	<60	**No Brake**
20<x<30	>50	**Brake**
20<x<30	<50	**No Brake**
10<x<20	>30	**Brake**
10<x<20	<30	**No Brake**
<10	>20	**Brake**

Table 1:Control Algorithm

Control algorithm:

The system relies on an ultrasonic sensor to detect obstacles and a speedometer to measure bicycle speed. The ultrasonic sensor transmits a sound pulse and measures the time it takes for the echo to return. The time difference between the transmitted trigger pulse and the received echo pulse is converted to distance (d) using the following equation:

d = (t_echo - t_trigger) * c / 2

Where:

- d - distance to the obstacle (meters)
- t_echo - time of echo pulse reception (seconds)
- t_trigger - time of trigger pulse transmission (seconds)
- c - speed of sound (approximately 343 m/s at room temperature)

A control algorithm then analyzes the measured speed (s) and distance (d) to determine the appropriate braking action. This algorithm can be implemented using :

1. Threshold-based Logic: This approach defines pre-defined critical zones based on speed and distance combinations. A common implementation of this logic uses a series of conditional statements, such as:

Braking_Applied =
if (d < 10 && s > 20) OR (10 < d < 20 && s > 30) OR (20 < d < 30 && s > 50) OR (30 < d < 40 && s > 60) OR (40 < d < 50 && s > 80)
then 1 (apply brakes)
else 0 (don't apply brakes)

In this example, the control algorithm applies the brakes (Braking_Applied = 1) if the following conditions are met:

- Distance (d) is less than 10 meters AND speed (s) is greater than 20 meters per second (approximately 72 km/h).
- OR if distance (d) is between 10 and 20 meters AND speed (s) is greater than 30 meters per second (approximately 108 km/h).

This logic can be further expanded with additional conditions to create a more comprehensive decision-making process.

The control algorithm can trigger the brakes with a:
Fixed Braking Force: Apply a predetermined braking force for all triggering conditions. Proportional Control (Optional): Calculate a braking force proportional to the situation's urgency (closer distance or higher speed). This approach can provide a more nuanced braking response.

By implementing these control algorithms, the system leverages sensor data to make informed decisions about brake application, enhancing safety for riders.

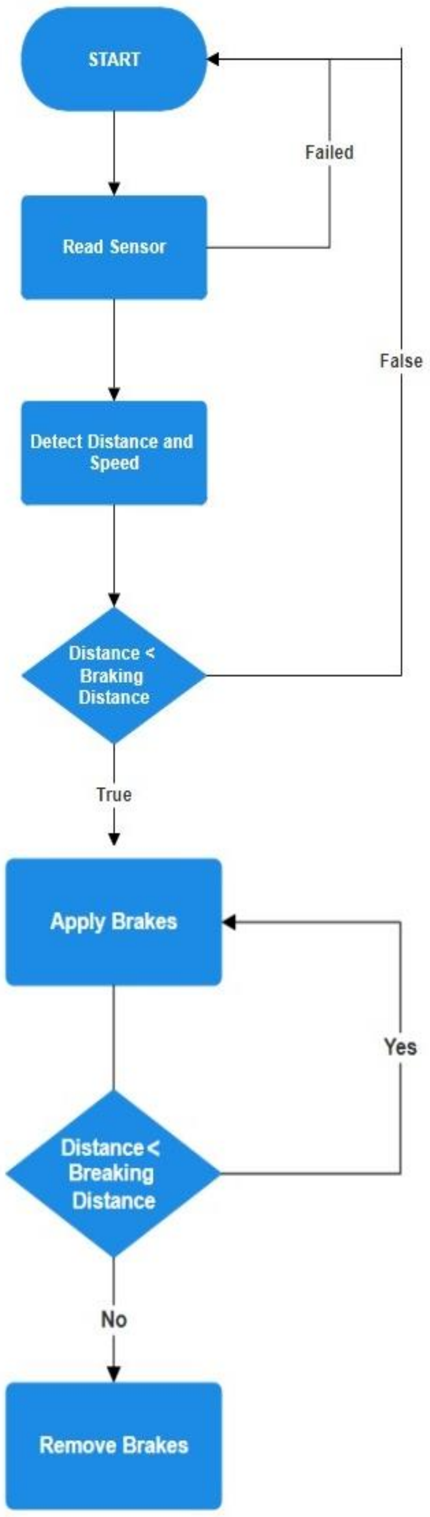

Fig 8: Braking System Design

IV. Operational View

The operational view of the intelligent bike speed regulator ensures a user-centric and responsive experience. Automatic activation at the bike's start engages the distance detection and speed regulation mechanisms, emphasizing smooth acceleration and deceleration. In emergencies, the braking system activates gradually, prioritizing safety. The control panel offers manual override capabilities for immediate user intervention. The accident notification system employs accelerometers and gyroscopes to recognize falls, triggering automated alerts with precise GPS coordinates. Continuous GPS tracking enhances location accuracy. The system deactivates safely upon the bike's stop. Intuitive feedback and user-friendly controls underscore the regulator's commitment to seamless integration, rider empowerment, and heightened safety awareness.

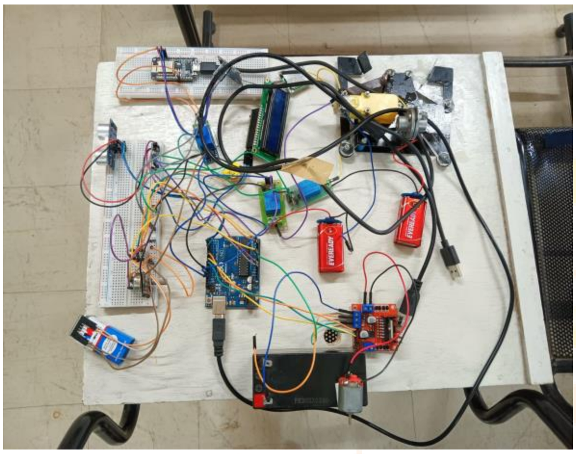

Fig 9: Operational view

V. Results and Discussion:

The implementation of the Smart Distance-Based Braking System yielded promising results, demonstrating its efficacy in enhancing motorcycle safety. The real-time distance measurements provided by the integrated sensors showcased accurate and reliable data, forming the basis for the system's decision-making process. The braking system's response time in emergency scenarios was notably swift, effectively reducing the speed or preventing collisions entirely. The system's adaptability to varying traffic conditions and distances ensured a dynamic and context-aware approach to rider safety.

Distance (cm)	Speed (km/hr)	Brakes Applied?	Time (ms)	Need for Break?
15	30	No	0	No
16	24	No	0	No
20	68	Yes	648	Yes
36	75	Yes	725	Yes
45	22	Yes	209	No
18	56	Yes	595	Yes
29	18	No	0	No
32	32	No	0	No
17	20	No	0	No
48	55	No	0	No
33	72	No	0	Yes
8	64	Yes	907	Yes
14	10	No	0	No
26	50	Yes	500	Yes
49	30	Yes	465	No
5	45	Yes	548	Yes
17	85	Yes	900	Yes
50	15	No	0	No
37	69	No	0	Yes
25	50	Yes	733	Yes
24	48	No	0	No
15	52	Yes	780	Yes
22	40	Yes	500	No
8	15	No	0	No
45	30	No	0	No
37	20	No	0	No
18	35	Yes	490	Yes
40	45	Yes	570	No
28	100	No	0	Yes
12	28	No	0	No

Table 2: Results after Testing

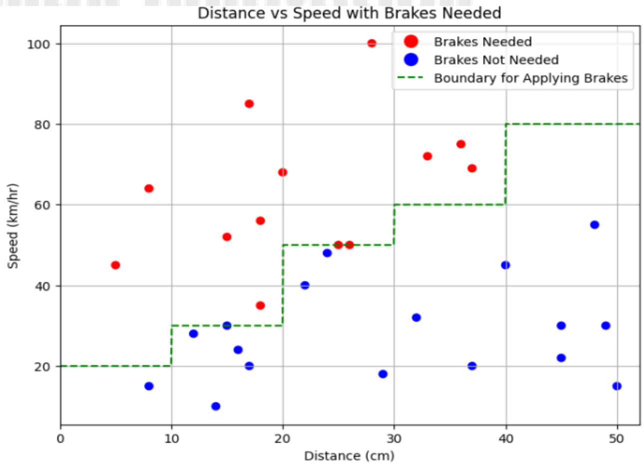

Fig 10: Graph showing the need for braking according to Control Algorithm

Our analysis of the automatic braking system's performance from Fig .11 revealed a high degree of accuracy in predicting braking requirements and actual brake application across a range of speed conditions. However, our investigation identified discrepancies in the system's behavior in a few instances, where the predicted need for braking did not align with the observed application of brakes. Despite these isolated occurrences, the overall performance of the system remained robust, demonstrating its effectiveness in enhancing safety by proactively addressing potential collision risks.

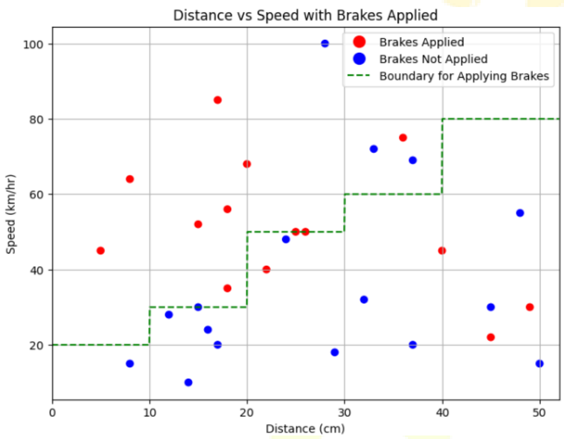

Fig 11: Graph Showing the results after testing

The results underscore the significance of motorcycle-specific safety solutions, as the Smart Distance-Based Braking System successfully addressed the limitations of conventional safety systems. The ability to autonomously engage the brakes based on real-time distance assessments represents a proactive approach to accident prevention. It also considers potential refinements, such as integrating machine learning algorithms to enhance the system's ability to adapt to diverse road scenarios. Collaborative efforts with motorcycle manufacturers and regulatory bodies are crucial to standardize and implement such innovative safety measures, emphasizing the importance of continuous improvement in motorcycle safety technologies to mitigate the risks associated with two-wheeled transportation.

VI. Interfacing With other devices

Interfacing an automated bike braking system with various devices offers significant advancements in both safety and accessibility within urban transportation. By integrating with devices such as Raspberry Pi, smartphones, and smartwatches, the system gains additional capabilities beyond its standalone functionality. For instance, interfacing with a Raspberry Pi enables data logging, remote monitoring, and integration with other IoT devices, thereby enhancing its utility in smart city initiatives and research data collection. Connecting to smartphones provides real-time alerts, GPS integration for navigation, and user-friendly interfaces, offering benefits in personal safety, fitness tracking, and traffic analysis. Moreover, interfacing with smartwatches allows for discreet notifications, hands-free operation, and personalized alerts tailored to individual preferences. This integration not only enhances accessibility for users, including those with disabilities, but also facilitates seamless integration into daily routines, promoting safer and more convenient urban commuting experiences.

VII. Conclusion

The Bike Speed Regulator System emerges as a pivotal technology with the potential to significantly mitigate collisions and prevent accidents in the realm of motorcycle safety. This innovative system leverages real-time distance measurements and intelligent braking mechanisms to proactively address the unique safety challenges faced by motorcyclists. By incorporating advanced sensors and algorithms, the system ensures timely and precise responses to potential collision scenarios, thereby enhancing rider safety and reducing accident severity. Moreover, the system's integration with GPS and accident notification features underscores its comprehensive approach to modern transportation safety. As urban traffic volumes continue to rise, the adoption of such advanced safety systems is crucial in safeguarding motorcyclists, promoting responsible riding behaviors, and fostering a safer road environment. The project aligns with broader goals of implementing smart technologies in transportation, aiming to set new standards for motorcycle safety and contribute significantly to reducing road fatalities and injuries.

VIII. References

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