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Design And Implementation of a Smart Vehicle Safety System Using Arm Cortex – M3

[1]K. Akhila, [2]S. shilpa, [3]B. Usharani, [4]G. Ganesh Reddy
[1,2,3] UG Students, [4]Assistant Professor
[1,2,3,4] Department of Electronics and Communication Engineering
[1,2,3,4] Vignan's Institute of Management and Technology for Women, Kondapur (V), Ghatkesar (M), Medchal-Malkajigiri (D) – 501301

ABSRACT:

This paper presents the design and implementation of a smart vehicle safety system using an ARM Cortex-M3 based microcontroller (STM32). The system aims to enhance vehicle safety by detecting obstacles using ultrasonic sensors and providing real-time feedback to the driver. The system integrates two ultrasonic sensors for front and rear obstacle detection, a GPS module for location tracking, DC motors for vehicle movement simulation, and an LCD for displaying status information. The motor driver controls the motors based on sensor inputs. When an obstacle is detected within a predefined distance, the system alerts the user and can stop the vehicle automatically. The proposed system is cost-effective, reliable, and suitable for modern intelligent transportation systems.

Keywords: Smart Vehicle Safety, ARM Cortex-M3, STM32, Ultrasonic Sensor, GPS, Embedded System

I. INTRODUCTION

The rapid increase in the number of vehicles has led to a rise in road accidents worldwide. Most accidents occur due to human errors such as lack of attention and delayed reaction time. To improve safety, smart vehicle systems using embedded technology are being developed. This project presents a smart vehicle safety system using an ARM Cortex-M3 microcontroller. Ultrasonic sensors are used to detect obstacles in front and rear directions. The system provides alerts and automatically stops the vehicle to prevent collisions. A GPS module is used for real-time location tracking during emergencies. Thus, the proposed system offers a cost-effective and reliable solution for vehicle safety.

II. PROBLEM STATEMENT

Road accidents are increasing due to human errors and delayed reaction time. Existing safety systems are costly and lack real-time automatic control features. Many systems do not provide obstacle detection along with tracking and communication. Hence, there is a need for a low-cost, efficient vehicle safety system to prevent accidents.

III. EXISTING METHOD

The existing system focuses on obstacle detection without using GPS and GSM modules. It uses ultrasonic sensors to detect obstacles in front and rear directions. The microcontroller processes sensor data and controls the motor driver. When an obstacle is detected, the system stops the vehicle to prevent collisions. An LCD display shows distance values and warning messages.
However, the system lacks location tracking and remote communication features.

IV. LITERATURE SURVEY

S.NO	PUBLISHED YEAR	TITLE	TECHNIQUE/MODEL USED	KEY COMPONENTS	APPLICAT AREAS
1.	2020	Speed Breaker Detection	Federated Learning	Distributed ML Nodes	Road Conditioni Monitorin
2.	2020	Accident Detection Using Drones	Attention- Based DL	Sensors , neural network	EV Speed Control3
3.	2021	Real-Time Vehicle Detection	YOLOv4	Camera , CNN	Traffic surveillanc
4.	2023	Smart Electric Vehicle Safety system	Embedded Control	Sensor Microcontroller	EV-Safety
5.	2020	SDN-Enabled Traffic Alert System	SDN + Io V	SDN Controller,V2/V 21	Smart Citi
6	2021	Wrong Direction Vehicle Detection	Computer Vision	Camera , Motion Analysis	Traffic Saf
7.	2021	Accident Mitigation with Drowsiness Detection	ML+IOT(Hybrid)	Camera , IOT module	Driver Saf
8.	2021	Attention based speed governer	Attention based DL	Sensors , neutral networks	EV Speed control
9.	2023	Speed Violation Detection	CNN+IOT	Camera , Cloud Server	Traffic Enforceme
10.	2020	Free Way Accident Detection	ML based Traffic Analysis	Traffic Date , ML models	Highway S

V. PROPOSED METHOD

The proposed system enhances vehicle safety by integrating GPS and GSM modules with obstacle detection.
It uses ultrasonic sensors to detect obstacles in front and rear directions.
The STM32 microcontroller processes sensor data and controls the motor driver.
When an obstacle is detected, the system automatically stops the vehicle to prevent collisions.
The GPS module provides real-time location tracking of the vehicle.
The GSM module sends alert messages during emergency situations, improving overall safety

VI. SYSTEM ARCHITECTURE

The system architecture of the proposed smart vehicle safety system is based on the integration of sensing, processing, and control units using an ARM Cortex-M3 (STM32) microcontroller.

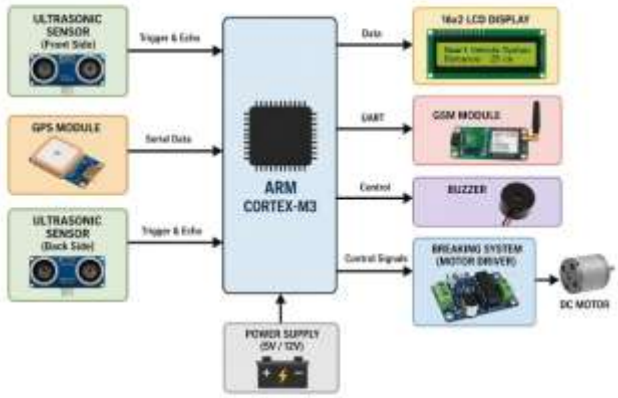


Fig 1: System Architecture

The ultrasonic sensors placed at the front and rear of the vehicle act as input devices, continuously sensing the distance of nearby obstacles. The sensed data is sent to the STM32 microcontroller, which serves as the central processing unit of the system. The controller processes the input data and makes decisions based on predefined safety conditions. Based on the processed data, control signals are generated and sent to the motor driver, which controls the DC motors for vehicle movement. If an obstacle is detected within the threshold distance, the controller stops or adjusts the motors to prevent collision. The LCD display is connected to the microcontroller to provide real-time information such as distance values and warning messages to the user. Additionally, the GPS module provides location data, and the GSM module enables communication by sending alert messages during emergency situations. All components are interconnected to form a real-time embedded system that ensures safe and efficient vehicle operation.

VII. WORKING METHOD

The proposed smart vehicle safety system operates by continuously monitoring the surroundings of the vehicle using ultrasonic sensors placed at the front and rear sides. These sensors transmit ultrasonic waves and receive the reflected signals to calculate the distance between the vehicle and nearby obstacles. The measured distance values are sent to the ARM Cortex-M3 (STM32) microcontroller for processing. The microcontroller compares the received distance with predefined threshold values to determine the presence of obstacles. If an object is detected within a critical range, the controller immediately generates control signals to the motor driver, which stops or slows down the DC motors to prevent collision. At the same time, a buzzer is activated to provide an audible warning to the user. The LCD display shows real-time distance measurements and warning messages, allowing the user to monitor system status easily. Additionally, the GPS module continuously provides the location of the vehicle, and the GSM module sends alert messages to predefined mobile numbers during emergency situations. Thus, the system ensures real-time obstacle detection, automatic vehicle control, and communication support, improving overall vehicle safety and reliability.

VIII. PROJECT IMPLEMENTATION

The proposed smart vehicle safety system is implemented using an ARM Cortex-M3 based STM32 microcontroller integrated with various hardware modules such as ultrasonic sensors, GPS module, GSM module, motor driver, DC motors, LCD display, and buzzer. The implementation process begins with the proper interfacing of all components with the microcontroller. The ultrasonic sensors are connected to the input pins of the STM32 to measure the distance of obstacles in front and rear directions. The LCD display is interfaced to the output port to provide real-time information such as distance values and warning messages. The motor driver is connected to control the DC motors, which simulate the movement of the vehicle. The GPS and GSM modules are interfaced with the STM32 microcontroller using UART communication. The GPS module continuously provides real-time location data, which is processed by the controller and can be used during emergency situations. The GSM module is programmed to send alert messages to predefined mobile numbers whenever a critical condition such as obstacle detection or possible collision occurs. A buzzer is also connected to provide an immediate audible alert to the user.

The software implementation is carried out using Embedded C programming. The program is designed to continuously read the echo signals from the ultrasonic sensors and calculate the distance using time-based measurements. The calculated distance is compared with predefined threshold values stored in the program. If the detected distance is less than the safety limit, the microcontroller generates control signals to the motor driver to stop or slow down the motors, thereby preventing collision. Simultaneously, warning messages are displayed on the LCD, and the buzzer is activated. The system operates in real time, ensuring quick response to changing environmental conditions. Proper power supply and voltage regulation are maintained to ensure stable operation of all components. The entire system is tested under different scenarios to verify its performance, including obstacle detection accuracy, motor response, and communication functionality. The implementation demonstrates that the system can provide an efficient, reliable, and low-cost solution for enhancing vehicle safety.

ADVANTAGES

- Provides real-time obstacle detection
- Prevents collisions automatically
- Low-cost and easy to implement
- Uses simple and reliable components
- Supports GPS-based location tracking
- Enables emergency alerts using GSM
- Energy-efficient system
- Compact and easy to install
- Can be extended with advanced features
- Improves overall vehicle safety
- The proposed system provides real-time obstacle detection using ultrasonic sensors, which continuously monitor the surroundings and help in identifying nearby objects accurately.
- It automatically prevents collisions by controlling the vehicle movement, reducing the dependency on driver reaction time and minimizing human errors. flow chat

VIII. FLOW CHART

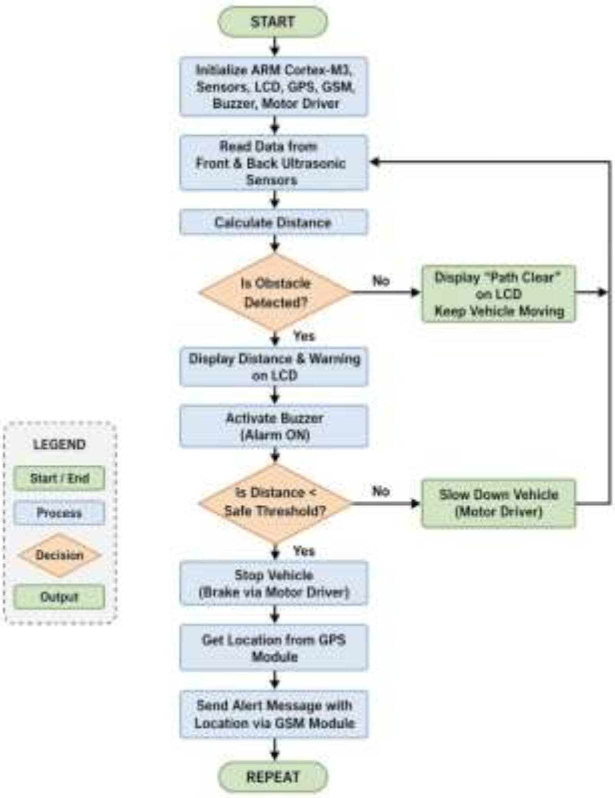
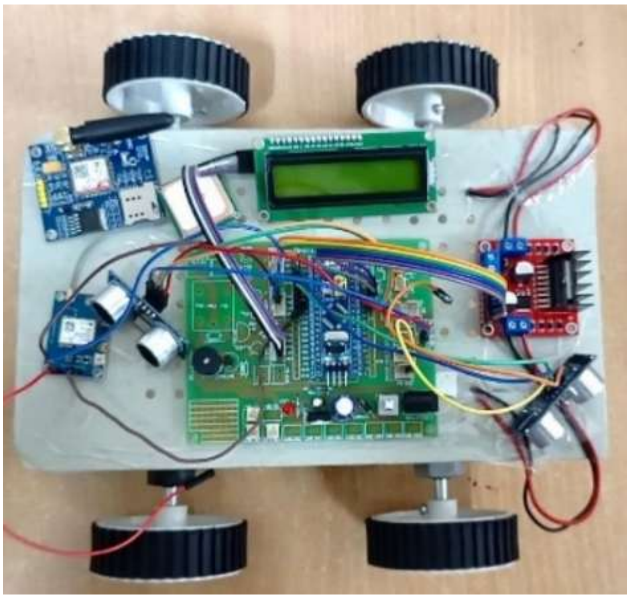


Fig 2. System Flowchart

IX. RESULT



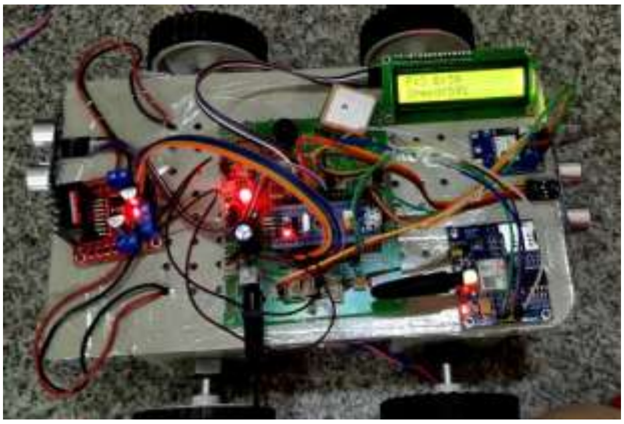


Fig 3. Result

X. FUTURE SCOPE

The proposed system can be enhanced by integrating IoT for real-time monitoring and control. Advanced sensors such as cameras and LiDAR can improve obstacle detection accuracy. Machine learning techniques can be used for intelligent decision-making. The system can also be integrated with mobile applications and cloud storage for better user interaction. Thus, it can be extended to advanced driver assistance and autonomous vehicle systems in the future.

XI. CONCULISON

The proposed smart vehicle safety system using an ARM Cortex-M3 microcontroller has been successfully designed and implemented. The system effectively detects obstacles using ultrasonic sensors and prevents collisions by automatically controlling the vehicle. The integration of GPS and GSM modules enhances the system by providing location tracking and emergency communication. The system is cost-effective, reliable, and easy to implement using simple components. Overall, it improves vehicle safety and reduces the risk of accidents.

XII. REFERENCES

[1] ARM Ltd., ARM Cortex-M3 Technical Reference Manual, ARM Holdings, 2010.

[2] STMicroelectronics, STM32F1 Series Datasheet, 2018.

[3] J. Fraden, Handbook of Modern Sensors: Physics, Designs, and Applications, 4th ed., Springer, 2010.

[4] HC-SR04 Ultrasonic Sensor Datasheet, 2015.

[5] SIM800 GSM Module Datasheet, SIMCom Wireless Solutions, 2016.

[6] NEO-6M GPS Module Datasheet, u-blox AG, 2017.

[7] K. Ogata, Modern Control Engineering, 5th ed., Prentice Hall, 2010.

[8] M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, The 8051 Microcontroller and Embedded Systems, 2nd ed., Pearson, 2007.

[9] S. M. Metev and V. P. Veiko, Laser-Assisted Microtechnology, Springer, 1998.

[10] Research Papers on Smart Vehicle Safety Systems, IEEE Xplore Digital Library.

AUTHOR PROFILES

1. K. Akhila

Katla Akhila is currently pursuing a Bachelor of Technology (B.Tech) degree in Electronics and Communication Engineering. Her areas of interest include Embedded Systems, Microcontrollers, and IoT-based applications. She has worked on projects related to vehicle safety systems and electronic circuit design. Her technical skills include Embedded C, Arduino, and STM32 programming. She is interested in developing innovative solutions in the field of automotive and embedded technologies.

2. S. Shilpa

Sunkari Shilpa is currently pursuing a Bachelor of Technology (B.Tech) degree in Electronics and Communication Engineering. Her areas of interest include Embedded Systems, Microcontrollers, and Communication Systems. She has worked on projects related to smart vehicle safety and electronic system design. Her technical skills include Embedded C, Arduino, and STM32 programming. She is interested in developing innovative solutions in the field of embedded and automotive technologies.

3. B. Usharani

Beerla Usha Rani is currently pursuing a Bachelor of Technology (B.Tech) degree in Electronics and Communication Engineering. Her areas of interest include Embedded Systems, Digital Electronics, and Communication Systems. She has been involved in projects related to microcontroller-based system design and smart applications. Her technical skills include C programming, circuit design, and working with embedded platforms such as Arduino and STM32. She aims to build a career in core electronics and emerging embedded technologies.

4. G. Ganesh Reddy

G. Ganesh Reddy is working as an Assistant Professor in the Department of Electronics and Communication Engineering at Vignan's Institute of Management and Technology for Women. He has expertise in Embedded Systems, IoT, and VLSI Design. He has guided numerous undergraduate projects and is actively involved in research and academic development activities.