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Margdarshak: A Smart Driverless Vehicle Using IR-Based Traffic and Sign Recognition

Rahul Soni, Raj Shrivastava, Vikash Banwari, Rashmi Gour, Durgesh Nagar, Dr.Ravi Shankar Mishra
Department of Electronics and Communication, Sagar Institute of Science and Technology, Bhopal, M.P

Abstract: Therapidadvancementofintelligenttransportationsystemshasled to growing interest in autonomous vehicles. This paper presents Margdarshak, a low-cost, sensor-based driverless car prototype designed to recognize and respond to traffic lights, speed limit boards,directionalsignboards,andobstacles.ThesystemutilizesIR transmitters and a TSOP-based IR receiver to interpret encoded signals from traffic elements. Lane following is achieved using infrared sensors, while ultrasonicsensors enable obstacle detection andavoidance.AnATmega328microcontrollerprocessesreal-time input from sensors and controls the vehicle's motion via a motor driver module. This prototype demonstrates the feasibility of creating a modular, scalable, andautonomous vehicle using simple embedded electronics, making it suitable for academic, smart city, and controlled-environment transport applications.

Unlike traditional autonomous vehicles that rely on image processing and costly AI modules, Margdarshak is built on a simplified IR communication mechanism that simulates traffic scenarios in a structured and repeatable manner. Each traffic signboardisembeddedwithanIRtransmitterthatsendsadistinct signal pattern representing specific actions like stop, turn, or set speed. These signals are received by the TSOP module, decoded by the microcontroller, and acted upon using motor drivers. By minimizing complexity and cost, this design serves as a learning platform for students and a stepping-stone toward more complex automation. The hardware setup includes IR sensors for line detection, ultrasonic sensors for proximity sensing, and relay modules for directional control. Testing shows accurate responses to red and green light signals, speed adjustments based on IR input, and precise turns at curve indicators. The modular design allows for easy future upgrades such as GPS, voice assistance, or camera- based AI. This paper highlights the effectiveness of combining basic embedded components with logic-based programming to buildanefficient,reliable,andreplicabledriverlesscarprototype with real-time environmental interaction
Keywords: IRsensors,TSOP1838,driverlesscar,embedded systems, autonomous vehicle, ATmega328

I. INTRODUCTION

In recent years, the demand for intelligent transportation systems has grown exponentially due to rising concerns over road safety, trafficcongestion,andincreasingvehicularaccidents.Accordingto the Ministry of Road Transport and Highways (MoRTH), India witnessed over 1.5 lakh road fatalities in 2022, with a significant portion attributed to human errors such as signal violation, speeding, and poor lane discipline. The development of autonomous vehicle technology provides a promising solution to address these challenges by minimizing human intervention and enhancing road safety through sensor-driven automation.

The Margdarshak project introduces a compact, low-cost, and sensor-basedprototypeofadriverlesscaraimedatrecognizing trafficlights,readingroadsignboards,andrespondingtoreal-time lane and obstacle conditions. Unlike complex AI-driven systems, this prototype uses simple yet effective components like IR transmitters and receivers, ultrasonic sensors, and an ATmega328 microcontroller to demonstrate key functionalities of a smart vehicle in a controlled environment.

Here,aresomekeyaspectsoftheMargdarshak:ASmart Driverless Vehicle

1) *IR-BasedSignalRecognition:* Traffic signboards are embedded with IR transmitters that emit encoded signals. These signals are detected by the TSOP1838 IR receiver on the car, which decodes the pattern and enables the vehicle to take appropriate actions like stopping, turning, or adjusting speed.
2) *AutonomousLaneFollowing:* Usingdownward-facingIRsensors,thecarcanfollowapredefined path (black line) by continuously detecting surface contrast. The microcontrollerprocessesthisdatatokeepthecaralignedwithinthe lane using motor adjustments.
3) *ObstacleDetectionandCollisionAvoidance:* Anultrasonicsensormountedonthefrontofthevehicledetectsany obstructioninitspath. Ifanobjectisdetectedwithinacertainrange, the vehicle stops or changes direction to prevent a collision.
4) *Real-TimeDecisionMakingandControl:* All sensorinputsare processed by anATmega328 microcontroller, whichexecutesdecisionlogicandcontrolsmotoractionsthroughan L298N motor driver. This enables dynamic, real-time control of speed, direction, and stopping, simulating actual traffic responses.

II. LITERATUREREVIEW

A. Sensor-Based Navigation Approaches

Earlier research in autonomous vehicles has focused on image processing,GPS,andAI-basedsystems.Theseapproaches,while accurate, require high computational power and are expensive to implement, limiting their use in budget-constrained educational prototypes or small-scale environments.

B. Use of Infrared and TSOP Modules

Severallow-costmodelshaveutilizedIRsensorsandTSOP receivers for basic automation like obstacle avoidance and remote control. However, these implementations were limited in scopeanddidnotsupportcomprehensivefeatures such as speed control, traffic signal detection, or lane following.

C. Limitations in Previous Works

ProjectsbasedsolelyonIRorultrasonicmodulesoftenlackedreal- time decision-making or integration between different sensors. Many line follower robots, for example, could not interpret road signs or adapt speed based on environmental inputs.

III. PROPOSEDMETHODOLOGY

A. System Overview

The proposed system simulates a driverless car that navigates by interpreting IR signals, detecting lanes, avoiding obstacles, and adjusting speed based on real-time input. Thearchitecture includes IRtransmittersonsignboards,TSOPreceiversonthecar,ultrasonic sensors,IRlanesensors,andacentralATmega328microcontroller to process all data.

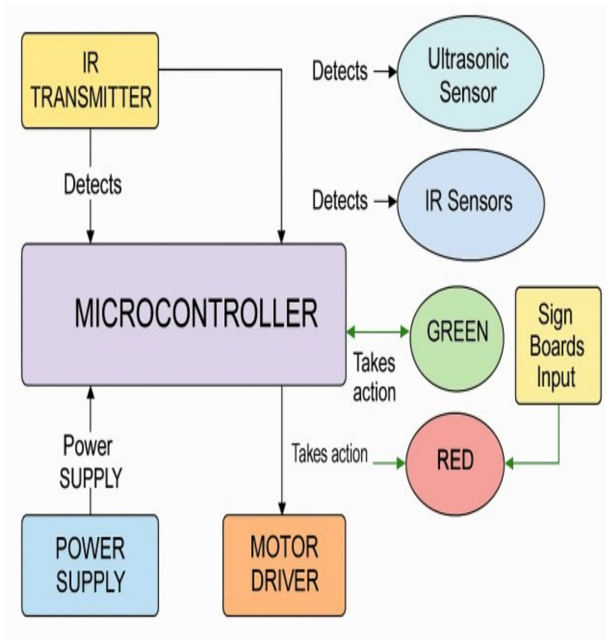

Fig.1.BlockDiagramoftheMargdarshakDriverlessCar System

B. Traffic Signal and Sign Recognition

Signboards equipped with IR transmitters emit encoded signals representing traffic lights, speed limits, or directional turns. The TSOP1838 IR receiver detects these signals and sends them to the microcontroller. Depending on the decoded signal, the car either stops (red), moves (green), adjusts speed, or turns in a specified direction.

C. LaneDetectionandAlignment

ThreeIRsensorsareplacedontheundersideofthevehicletofollowablacklinerepresentingthelane.Thesesensorsdetectlightanddark contrasts, helping the microcontroller decide if the car should steer left, right, or move forward to stay aligned within the lane.

D. ObstacleDetectionandAction

An ultrasonic sensor is mounted on the front to detect any obstacle within a specific range. If an object is detected closer than a set threshold, themicrocontrollerhalts themotorusing arelay oradjusts the path, preventing collisions and ensuring safe navigation.

E. MotorandMovementControl

The ATmega328 sends movement commands to an L298N motor driver, which controls the DC gear motors. Based on input from sensors, the microcontroller controls the motors for turning, stopping, or changing speed using PWM signals and directional logic

IV. RESULT

The implementation of the Margdarshak driverless car prototype demonstrated accurate and reliable responses to various simulated trafficconditions.TheTSOP1838IRreceiversuccessfullydetected and decoded signals from IR transmitters placed on signboards, allowingthecartostopatredlights,proceedongreen,adjustspeed based on speed limit instructions, and turn according to directional commands.TheIRsensorsaccuratelyfollowedthedesignatedlane by detecting surface contrast, and the ultrasonic sensor effectively halted the car upon obstacle detection. The ATmega328 microcontrollerprocessedsensordatainrealtimeandexecuted commands without delay. Overall, the prototype performed smoothlyinindoorconditionsandprovedthefeasibilityofbuilding a functional, low-cost autonomous vehicle using simple embedded hardware.

V. USECASES

Theusecasesaredivided into four categories-

1) SmartCampusMobility

Theprototypecanbeimplementedinuniversityorindustrial campuses to automate short-distance transportation. Small autonomous vehicles can follow predefined paths, obey IR- based signboards, and stop at pedestrian crossings, minimizing manual efforts and improving on-campus safety and efficiency.

2) WarehouseandFactoryAutomation

In warehouses and factories, this system can automate the movement of goods along specific routes. The vehicle can follow floor markings, adjust speed in specific zones, and avoid obstacles using ultrasonic sensors, improving productivitywhilereducingaccidentsandlabordependency.

3) .EducationalandResearchApplications

This project serves as an excellent platform for academic learning in robotics, embedded systems, and IoT. It helps students and researchers understand sensor integration, autonomouscontrol,andreal-timedecision-making,makingit ideal for lab experiments and project-based learning environments.

4) TrafficControlDemonstrationModels

Urban planners and engineers can use this model to simulate smart traffic systems. By placing IR signals at different intersections and monitoring how the vehicle reacts, traffic flow,signaltiming,andaccidentpreventionstrategiescanbe demonstrated in a classroom or exhibition environment.

VI. CONCLUSION

The development and successful implementation of the Margdarshak prototype demonstrates the potential of integrating simplesensorsystemswithmicrocontroller-basedlogictosimulate the core functionalities ofan autonomous vehicle. Thisproject was driven by the vision to create a low-cost, scalable, and effective solution for interpreting traffic signals, managing speed, and navigating lanes autonomously. Unlike modern commercial autonomous vehicles that rely heavily on costly GPS modules, camera-basedsystems,andAImodels,Margdarshakreliesoncost- effective and widely available components such as IR transmitters, TSOP1838 IR receivers, ultrasonic sensors, and ATmega328 microcontrollers. This makes it not only an affordable solution for developing countries but also a strong academic and educational prototype to teach automation and embedded system concepts.

The system architecture enables the vehicle to take real-time decisions such as stopping at red signals, moving on green, turning as per signboard directions, following lanes using IR sensors, and haltingwhenanobstacleisdetected.Thesuccessfulsynchronization of all sensor modules with logical programming validates the efficiencyoftheoveralldesign.

Theperformanceofthevehiclewas testedinvariouscontrolledscenarios,anditaccuratelyrespondedto simulated road conditions. Furthermore, the vehicle's ability to adapt speed basedon IRsignal inputhighlightsitspotential foruse in structured and semi-structured environments like university campuses,industries,andautomatedtransportroutes.Theseamless integration of motor driver modules with relay control and power regulation circuitry further enhancesthestability and robustnessof the system.

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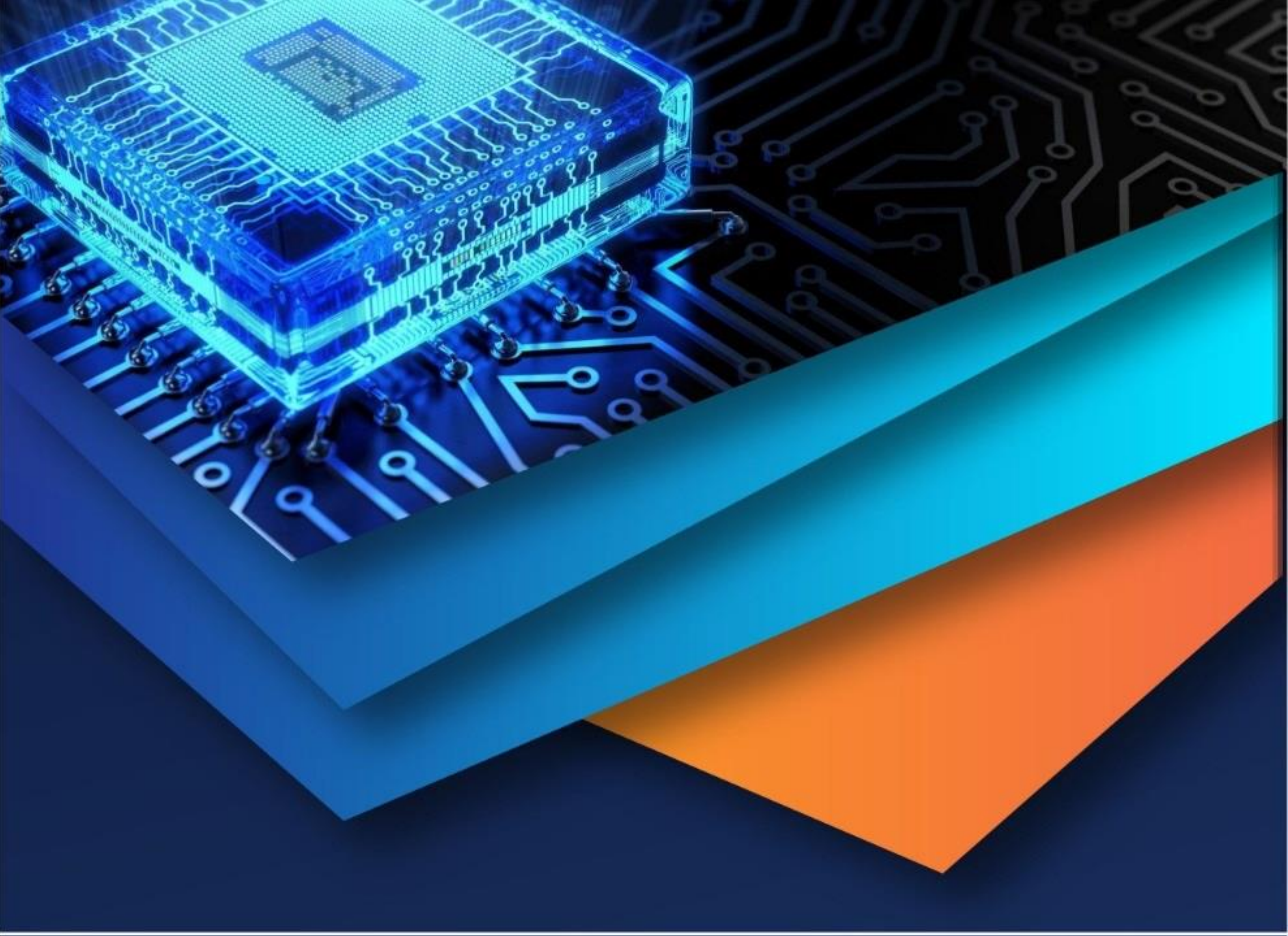

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