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ALL IN ONE ROBOT CAR

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Abstract: This paper proposes a novel approach to address the limitations of existing robot car systems by integrating multiple functionalities into a single prototype. Our methodology, termedthe all-in-one system, aims to enhance both functionality and user experience by offering a comprehensive solution adaptableto various tasks and scenarios. The advanced robot car system presented in this paper combines an Arduino Uno microcontroller with a smartphone application, offering users three primary driving modes: Bluetooth module-supported remote control via a specific smartphone app, ultrasonic sensor-driven obstacle avoidance, and IR sensor-enabled lane detection.Additionally, voice control is integrated to facilitate user interaction, ensuring a seamless control experience. Thisintegration of technologies not only enhances the system's flexibility in different situations but also guarantees an optimal user experience. The system's capabilities encompass a wide range of tasks, including autonomous lane changing, obstacle avoidance, and remote-control functions. Such development opens possibilities for intriguing new directions in hobby projects and smart transportation system improvements, in alongside promising educational research and activities. Furthermore, this research contributes to reducing accidents caused by human errors while driving. Additionally, it holds promise for advancements in various fields such as agriculture and medicine. For instance, the technology can be adapted to develop autonomously controlled vehicles for agricultural tasks,improving efficiency in farming operations. Moreover, in the medical field, similar principles can be applied to construct vehicles like wheelchairs, offering increased independence for individuals with mobility impairments.

Index Terms* – *Arduino Uno, IR Sensors, Ultrasonic Sensors, Lane Following, Obstacle Avoidance, Bluetooth

I. INTRODUCTION

The swift advancement of robotics technology has led to a greater focus on creating versatile and powerful autonomoussystems [1] that can maneuver through complex settings. In this respect, integrating advanced software programs with hardware components, like microcontrollers, has shown to be a viable path toward improving control and navigationalskills in robotic vehicles. This study presents a revolutionary robot automobile system that seamlessly combines the computing capability of an Arduino Uno microcontroller with the user- friendly interface of a smartphone application, offering a unique approach to this concept.

The primary feature of the suggested system is its ability tooffer a flexible range of functions, propelled by three main driving modes. First, the robot car can follow lanes using infrared sensors built into the system, which allows it to drive itself along pre-established routes precisely and accurately. Second, to ensure safe passage through dynamic surroundings, ultrasonic sensors are used for obstacle avoidance, which enables the vehicle to identify and avoid obstructions in its route. Thirdly, the system enables users to quickly and easily exercise remote control over the robot automobile via Bluetooth module [2] interaction with a dedicated smartphone application.

Moreover, the inclusion of voice control functionality is a significant progression in user engagement, enabling users to effortlessly communicate commands to the robot automobile using basic phrases. In addition to improving user experience, this control mechanism broadens the system's potential uses and makes it usable by individuals who have different levels of technical proficiency.

The proposed robot automobile system offers educators, researchers, and individuals an extremely comprehensive and adaptable platform for robotics education by combining different advanced technologies. In addition to its immediate uses in labs and schools, technology has an opportunity to transform side projects and further continue the creation of sophisticated transportation systems.

In this work, we explore the concept, execution, and testingof the suggested robot automobile system, presenting an analysis of how it operates in various circumstances and emphasizing its possible influence on the robotics technology domain. By conducting this research, we hope todemonstrate how combining an Arduino Uno with smartphone apps could change the way autonomous vehicles are controlled and navigated, opening the door for further developments in this rapidly developing field.

II. RELATED WORKS

Rishabh Kumar conducted a study in 2021 [1] titled "Designof autonomous line follower robot with obstacle avoidance,"which represents a significant contribution to robotics. Kumar's work involves the development of an autonomous line follower robot with obstacle avoidance capabilities, showcasing innovative design and functionality. The paper elaborates on the implementation of a line follower robot adept at distinguishing between black and white lines, with adaptability to lines of diverse colors by leveraging their unique properties. Additionally, the robot integrates obstacle detection functionality, enabling navigation through congested curves by continuouslysensing data from its surroundings. This research underscores advancements in autonomous robotics, offeringpractical applications across various scenarios.

In 2016 [2], D. Chakraborty, K. Sharma, R. K. Roy, H. Singh, and T. Bezboruah conducted a study titled "Androidapplication-based monitoring and controlling of movement of a remotely controlled robotic car mounted with various sensors via Bluetooth." In this research, they developed a robotic car utilizing Bluetooth technology for communication along with sensors. By establishing successful communication between the robot and a smart device, the authors achieved remote control and monitoring capabilities. They utilized the phone's camera to observe thesurroundings of the robotic car, including living entities. Additionally, the authors implemented obstacle avoidance mechanisms using an ultrasonic ranging sensor to prevent collisions with obstacles facing the other way. This comprehensive approach of combining smartphone features, Bluetooth technology, and sensors demonstrates the potential for creating versatile and remotely controllable robotic systems for various applications.

The paper "Self-driving car ISEAUTO for research andeducation,[3] " authored by Raivo Sell, Anton Rassõlkin, Mairo Leier, and Juhan-Peep Erdnits, delves into the collaboration between Tallinn University of Technology and an Estonian automotive company. Together, they have pioneered the development of the self-driving car ISEAUTO, serving as a pivotal platform for research and educational endeavors. With contributions from both academia and industry, alongside student involvement, ISEAUTO spearheads research initiatives and educational projects focused on advancing automated vehicle technology. This collaborative endeavor underscores thesignificance of interdisciplinary cooperation in propelling the field of autonomous driving technology forward.

Wajiha Shah, Muzamil Ahmed, Qudsia Memon, Shahzeb Ali, and Azam Rafique Memon conducted a research study in 2016, delivering the paper titled "Self-Driving and DriverRelaxing Vehicle [4]." This paper introduces two applications of autonomous vehicles designed to allow drivers brief periods of relaxation. Additionally, the paper presents a concept centered on a modified Google car, featuring a dynamic destination where the car automaticallyreaches a static destination. In this prototype, the self-driving car tracks a moving vehicle along a predetermined path, highlighting innovative advancements in autonomous vehicle technology.

Bipin Advani, Ankita Mistry, Narendra Patel, and Neeru Pathak conducted a research study in April 2021, resulting in the paper titled "Self-Driving Car: Using OpenCV2 and Machine Learning [5]." The objective of this research is to provide a molecular vision of a self-driving car by leveraging advancedtechnologies such as OpenCV2 and Machine Learning. Through extensive research efforts, the authors have equipped the autonomous vehicle with lane detection, objectdetection, traffic light recognition, and traffic board detection capabilities. This work represents a significant advancement in autonomous vehicle technology, showcasing the potential of integrating computer vision andmachine learning techniques for enhancing driving automation.

The paper authored by Yılmaz, Esra & Tariyan Özyer, Sibel(2019) details the design and implementation of a robotic car with real-time obstacle detection and avoidance capabilities[6]. This research, conducted in [2019], showcases a systemthat utilizes Bluetooth for seamless communication andcontrol. At the heart of the robotic car is the Arduino Uno, functioning as the central processing unit and establishing communication with an Android-based device. The hardware components integrated into the robot's design include an ultrasonic sensor, PIR sensor, Bluetooth module,and buzzers. The primary objective of the system is to enableboth remote and autonomous control of the robotic car whileensuring real-time detection and avoidance of obstacles.

Tippannavar, Sanjay & S D, Yashwanth conducted a research study in 2023 titled "Self-Driving Car for a Smart and Safer Environment – A Review." Their paper [7], published in the Journal of Electronics and Informatics, emphasizes the significance of self-driving cars in enhancing driving safety through automated traffic detectionand real-time monitoring. The study delves into the utilization of technologies such as LiDAR, Radar, GPS, andcameras in autonomous vehicles to sense their surroundings and mitigate the risk of accidents. Furthermore, the researchaims to develop an effective LiDAR detecting system for self-driving cars to autonomously navigate routes and reachdestinations. It underscores the potential technological revolution anticipated in the next 10 years by self-driving cars and advocates for the development of low-cost prototypes to enhance road safety.

R. Krauss conducted a study presented at the 2016 American Control Conference (ACC) in Boston, MA, USA, titled"Combining Raspberry Pi and Arduino [8] to form a low- cost, real-time autonomous vehicle platform." The paper introduces a low-cost autonomous vehicle platform thatcombines Raspberry Pi, Arduino, and a Zumo robot chassis.This platform enables hard real-time control, wireless data streaming, and a web interface for control tuning and debugging purposes. The system is specifically designed forcontrols education, demonstrating its effectiveness in a feedback control course.

A. K. Jain conducted a study presented at the 2018 Second International Conference on Electronics, Communicationand Aerospace Technology (ICECA) in Coimbatore, India. The paper titled "Working model of Self-driving car using Convolutional Neural Network, Raspberry Pi and Arduino [9]" introduces a functional model of a self-driving caremploying Convolutional Neural Network (CNN), Raspberry Pi, and Arduino. It comprehensively outlines thehardware components, software, and neural network configuration utilized in developing the model, which exhibits the capability to navigate various types of tracks, including curved and straight tracks. A camera module mounted on the car captures real-world images, which are then sent to the CNN for direction prediction, encompassingmovements such as right, left, forward, or stop. The model has undergone successful design, implementation, and testing phases, with potential for future enhancements aimedat improving reliability.

Authors C. Thirumarai Selvi, N. Anishviswa, G. Ashok Karthi, K. Darshan, and M. Gowtham Balaji presented a paper at the 2021 Fifth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), published on November 11, 2021. The paper [10] discussesthe construction of a voice-controlled car with a camera utilizing components such as Arduino Uno, Bluetooth module, motor driver circuit, camera, and microSD card module. The system enables control through specific voice commands recognized by a mobile application, facilitating movements like LEFT, RIGHT, FORWARD, BACK, STOP, and KEEP WATCH IN ALL DIRECTIONS. The project's primary objective is to assist individuals who are unable to walk by providing wireless control within a limitedrange using Bluetooth technology. Additionally, the paper highlights future prospects for IoT integration and object recognition through artificial intelligence, expanding thefunctionality and accessibility of the system.

III. SYSTEM ARCHITECTURE

The system structure of the All-in-One Robotic Car, utilizingvarious sensors, is depicted in Fig 1. In this paper, the All-in-One Robotic Car consists of four modes: Lane Following, Obstacle Detection, Manual Drive Mode, and Voice Control.

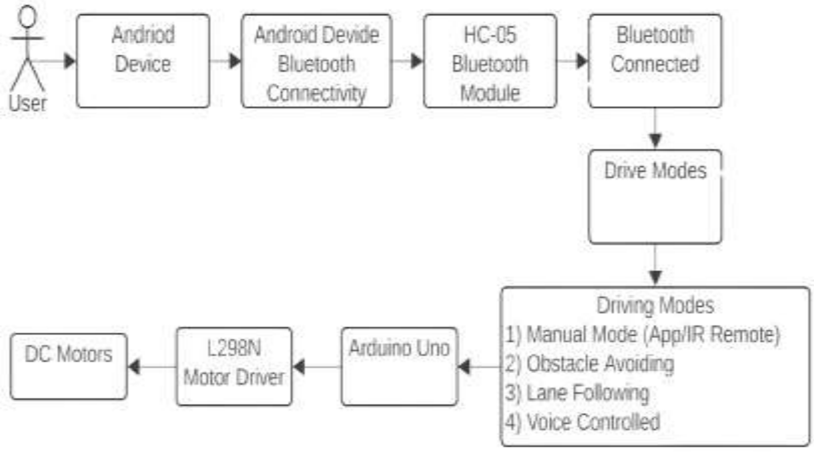

Fig 1 System Architecture

3.1 Lane Following Mode

The robotic car utilizes Arduino as its microcontroller andis equipped with infrared (IR) sensors for lane detection as shown in Fig.2. By interpreting variations in IR radiation bounced off lane markings, the Arduino processes this datato determine the car's position within the lane. This enablesthe vehicle to autonomously adjust its steering, ensuring smooth and accurate lane following capabilities.

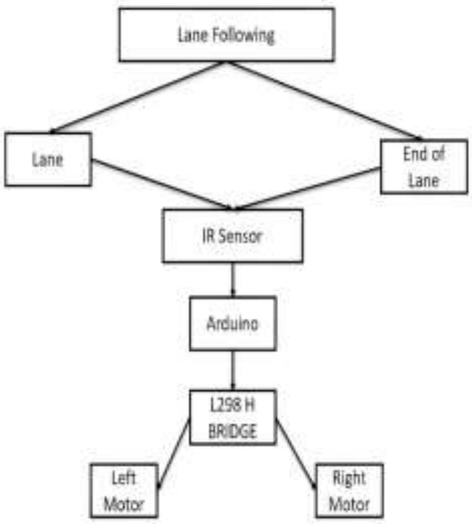

Fig 2 Block diagram of Lane Following

3.2 Obstacle Detection Mode

Ultrasonic sensors are integrated into the robotic car, whichis driven by an Arduino microcontroller and can autonomously avoid obstacles as shown in Fig. 3. Through the use of a specialized smartphone app, users can switch onobstacle avoidance mode, which enables the vehicle to drive itself while dodging objects that the ultrasonic sensors detect. The smooth combination of Arduino and ultrasonic sensors improves the car's autonomy and enables obstacle-free navigation without the need for hands-on assistance. Furthermore, the integration of ultrasonic sensors enhances the safety and reliability of the robotic car by providing real-time detection and avoidance of obstacles in its path. This capability ensures that the vehicle can navigate through complex environments with ease, minimizing the risk of collisions and damage. Additionally, the seamless communication between the Arduino microcontroller and the ultrasonic sensors facilitates efficient data processing and decision-making, allowing the car to react swiftly to changing situations.

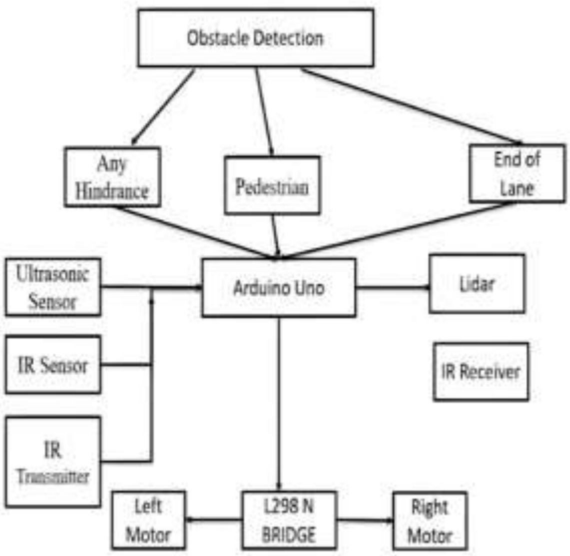

Fig 2 Block diagram of Obstacle Detection

3.3 Manual Drive Mode

Using a mobile app interface, users can manually controlthe robotic car as represented by Fig 3, which is powered byan Arduino microcontroller and an HC-05 Bluetooth module. By tapping buttons on the app, users can remotely navigate the car by using the HC-05 module for wireless communication. The vehicle also has an infrared receiver, which allows for additional operating versatility when usingan IR remote.

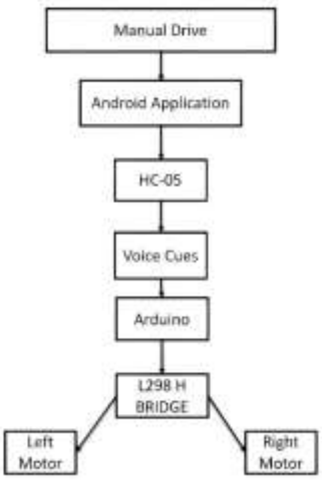

Fig 3 Block diagram of Manual Drive

3.4 Voice Control

With the help of a special app, users can easily control the Arduino-powered robot car with voice commands as depicted in Fig 4. Upon activating the microphone feature on the app and uttering commandssuch as "Go Forward," the car will complyingly travel in the designated path until further instruction is provided. Navigatingbecomes easier and more convenient as a result of this smooth interaction between the user and the vehicle.

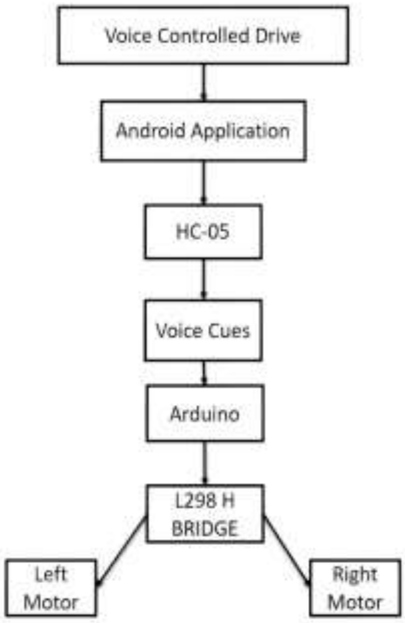

Fig 4 Block diagram of Voice Control

IV. TECHNICAL SPECIFICTIONS

4.1 Arduino Uno

The Arduino Uno depicted in Fig. 5has 14 digital input/output pins, six of which are used for PWM (Pulse Width Modulation) outputs, a reset button, a 16 MHz ceramic resonator, USB connectivity, a power jack, and an ICSP (In-Circuit Serial Programming) header. Project seekers can interface with a wide range of sensors, including actuators, Lidar sensors, ultrasonic sensors, and a variety of other electronic components, thanks to the Arduino Uno's versatility. Moreover, the Arduino Uno's compatibility with various sensors and actuators makes it an ideal platform for prototyping and experimentation in robotics, automation, and electronics projects. Its flexible design and abundant input/output pins allow project seekers to explore a diverse range of applications and functionalities.

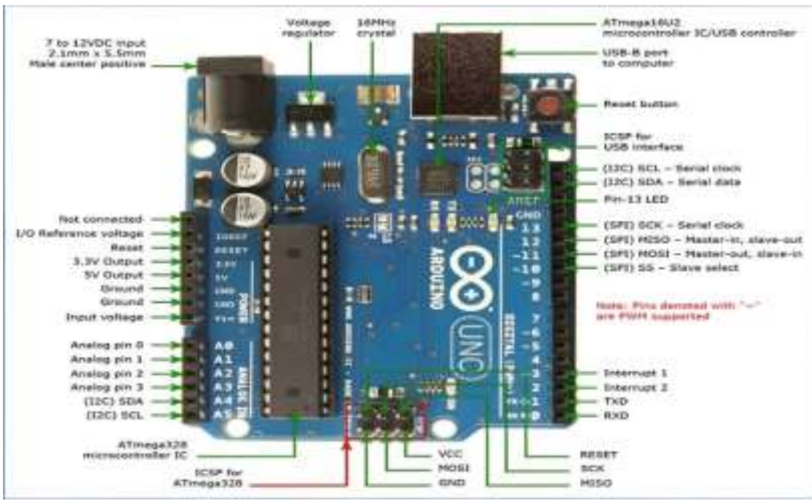

Fig 5 Arduino Uno

4.2 L298 Bull General Edge Bridge

Bridge depictedin Fig. 6 is a TTL logic signal-receiving high voltage/high current motor drive chip. Typically, itis utilized with various motors, solenoids, etc. The most common application for the L298 Bull General Edge Bridge is controlling the direction and speed of stepper and DC motors. The main function of the bridge is to control the CD motors' speed, which in turn controls when the motors are enabled and disabled. It is composed of two H- Bridges that allow for separate motor control. Furthermore, it incorporates protection diodes to help prevent damage from the electromotive force produced by the motorcycles' backs. To prevent overheating, it also features a thermal shutdown protection and current sensing capabilities.

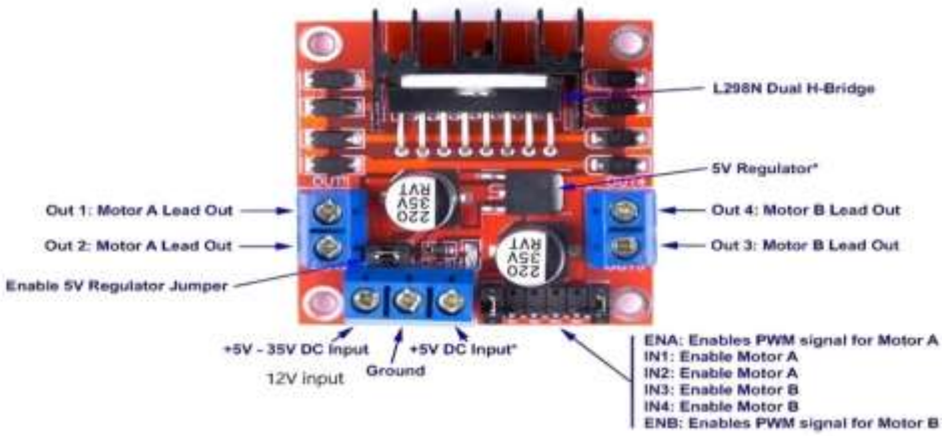

Fig. 6 L298 Bull General Edge Bridge

4.3 BC Gear Motors

Regarding automation and robotics, BC Typically, gear motors as shown in Fig. 7 are used to transmit and control power effectively, as well as to provide torque. The gear motor's primary function is to combine a motor andgearbox, thereby increasing torque and decreasing speed. They frequently employed since they can precisely regulate the device's speed.

Fig. 7 BC Gear Motors

4.4 Infrared Sensors

The radiation that is emitted by objects is detected by infrared sensors as shown in Fig.8. These sensors detect motion by observing changes in pattern; this capability is valuable in many applications such as interactive installations, automated lighting systems, security systems, etc. In addition, infrared sensors can measure distances; active infrared sensors emit infrared radiation and measure the time it takes for the signal to return after reflecting off an object.

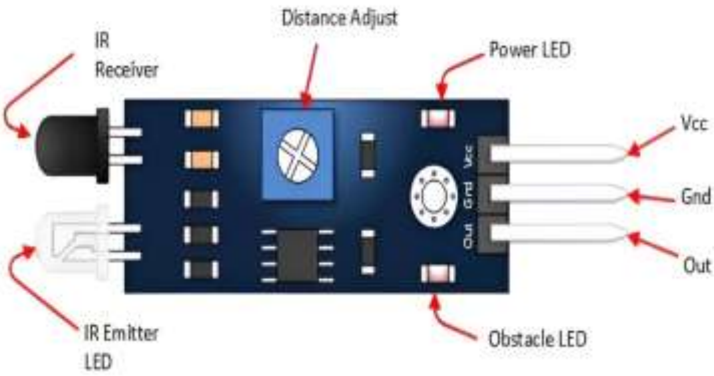

Fig. 8 Infrared Sensors

4.5 Ultrasonic Sensor

An ultrasonic sensor module asshown in Fig. 9 is vital to a mobile/remote-controlled car's ability to avoid obstacles. It works by releasingultrasonic waves into space and timing how long it takes for them to return after colliding with anobject. The car's microcontroller, Arduino, receives this information and analyses it to calculate the obstacle's distance. The microcontroller uses this data to tell the vehicle to stop orchange course in order to avoid collisions, improving the car's ability to navigate autonomously. Additionally, the ultrasonic sensor module typically consists of a transmitter and receiver pair, allowing for precise measurement of distances. This technology enables the car to adapt its speed and direction in real-time, enhancing safety and efficiency during navigation. By integrating this sensor into the car's control system, it gains the capability to detect objects within its vicinity, facilitating smoother and more reliable autonomous operation. Overall, the inclusion of an ultrasonic sensor module significantly augments the car's obstacle avoidance capabilities, making it adept at navigating complex environments.

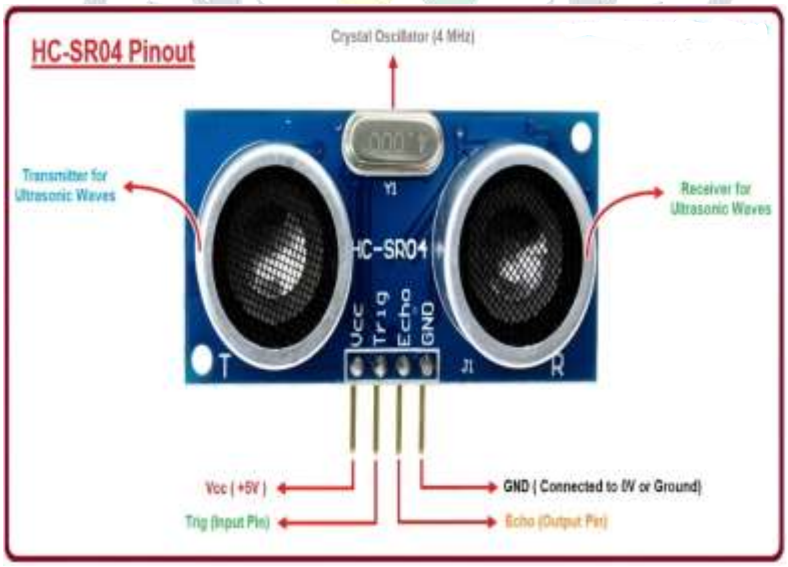

Fig. 9 Ultrasonic Sensor

4.7 HC-05 Bluetooth Module

A wireless connection can be established between a mobile device and a remote-controlledvehicle using the HC-05 Bluetooth module as shown in Fig10. The module acquires commands via Bluetooth from a mobile application. It then connects with the car's Arduino microcontroller to control the servos or motors, allowing fordirectional movements. With this configuration, users can use their smartphones to remotely operate the car and get real-time status updates and ensure that users remain informed about the vehicle's condition and performance, enhancing the overall experience of remote operation. Additionally, the wireless connection offers flexibility and convenience, enabling users to operate the vehicle from a distance without the constraints of physical wires.

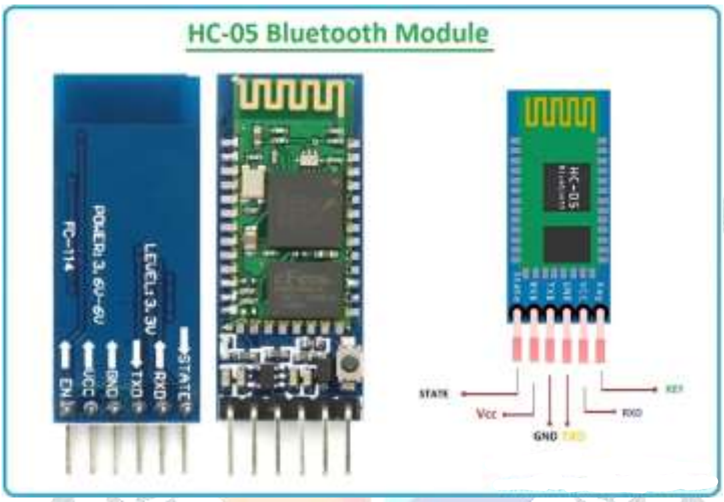

Fig. 10 HC-05 Bluetooth Module

4.8 Servo Motors

A servo motor as shown in Figure 11 is a multipurpose rotary actuator that can precisely control an angular position. It is used in many different industries, including industrial automation,robotics, and model aero planes. Its capacity to carryout deliberate movements is one of its main characteristics, as it reacts by precisely modifying its angular position in response to particular input signals. Because of this characteristic, servo motors are essential in applications where precise control and movement are crucialfor completing tasks precisely.

Fig 11 Servo Motors

4.9 Arduino IDE

For programming and creating projects with Arduino microcontroller boards, the Arduino Integrated Development Environment (IDE) is a fundamental software platform. It simplifies the coding,compiling, and uploading of code to Arduino boards and was designed with ease of use in mind. Rapid prototyping and development tasks are made easier with the Arduino IDE's built-in functions and libraries, which support a streamlined version of the C++ programming language.Thanks to features like syntax highlighting, a serial monitor,and a tone of examples and tutorials, people with different skill levels can create interactive electronic projects and Internet of Things applications with the Arduino IDE.

4.10 MIT App Inventor

It streamlines Android appdevelopment with its web-based interface as shown in fig 12, consisting of the App Inventor Designer and Block Editor. Developers can easily select and organize components for their apps, from basic UI elements to advanced features like sensors and data storage. The platform allows gradual testing throughout development, ensuring smooth functionality before finalization. Once completed, apps can be packaged into independent APK files for installation on Android devices, making app creation accessible to developers of all skill levels without complex coding requirements. Furthermore, the process of packaging developed applications into APK files simplifiesdistribution and deployment, enabling users to easily installand access the apps on their Android devices. This streamlined approach eliminates the need for extensive coding knowledge or programming expertise, democratizing app development and empoweringindividuals to bring their ideas to life in the form of functional and user-friendly applications. With the ability toseamlessly package and distribute apps, developers canfocus on refining and enhancing their creations, ensuring a smooth user experience and widespread accessibility acrossvarious Android devices.

Fig 12 App Framework

V DESIGN AND IMPLEMENTATION

The robot car as shown in fig 13 is made up of an Arduino Uno microcontroller, a L298N motor driver,a servo motor, an ultrasonic sensor (HC- SR04) for distance measurement, four DC motors for motion, two 3.7V batteries for power, a HC-05 Bluetoothmodule that allows for wireless communication, an IRsensor for line tracking, and an IR transmitter and receiver for remote control.

Users are instructed to download our customized mobile application (APK) to their Android devices during the implementation phase. Users then need to make sure that their device has Bluetooth enabled. Users must pair their smartphone or tablet with the HC-05 Bluetooth module and enter the default password, "1234" or "0000", to connect it with the robotic automobile.

After pairing successfully, users can access the mobile application's interface, which provides a variety of features, once the connection has been established. With the use of on-screen buttons, users can operate the robotic car from a distance and easily switchbetween driving modes like lane following, obstacle avoidance and back to manual drive mode which is controlled by the app itself. It is also possible for usersto operate the vehicle with voice commands, giving directions such as "Go forward" or "Turn left". Until the next order is given, the automobile complies and travels in the designated direction.

Additionally, the solution offers an additional controloption for improved user involvement by allowing users to operate the robotic automobile with an IR remote. The robotic car's numerous capabilities and seamless components make it a versatile and interesting platform for remote control and self- navigating, meeting the needs of robotics education, research, and industry applications.

Fig 13 Car Prototype

VI RESULT

Incorporating an array of advanced functionalities, our proposed robot car system stands at the forefront of technological innovation. By seamlessly integrating anArduino Uno microcontroller with a dedicated smartphone application, users are empowered with versatile control options. These include Bluetooth-supported remote control, ultrasonic sensor-driven obstacle avoidance, IR sensor- enabled lane detection, and intuitive voice command functionality. This amalgamation not only enhances adaptability across diverse driving scenarios but also guarantees an unparalleled user experience. With capabilitiesranging from autonomous lane changing to obstacle avoidance and remote control, our system represents a significant leap forward in smart transportation solutions.Moreover, it promises to catalyze novel directions in both hobbyist projects and educational research endeavors within the realm of robotics and automation.

VI CONCLUSION

In summary, the presented robotic car system represents a significant advancement in the field of autonomous vehicles,offering a myriad of functionalities and features that cater to diverse user needs. By integrating cutting-edge technologies such as the Arduino Uno microcontroller, smartphone application, and various sensors, the system achieves a remarkable level of versatility and performance. One of the key highlights of this system is its user-friendly interface, facilitated by the smartphone application, which allows for seamless remote control via Bluetooth connectivity. Users caneffortlessly switch between driving modes, including lane following, obstacle avoidance, and manual control, providingthem with flexibility in different scenarios.

Moreover, the incorporation of sensors such as ultrasonic and IRsensors enables the robotic car to navigate its surroundingswith precision and accuracy. The ultrasonic sensor ensures effective obstacle detection and avoidance, while the IR sensor enhances lane detection capabilities, contributing to safer and more efficient navigation.

The addition of voice control further enhances user interaction, allowing for intuitive and hands-free operation ofthe robotic car. This feature not only simplifies the control process but also adds a layer of convenience for users, especially in dynamic environments where manual input maybe challenging.

Looking ahead, there is ample potential for further advancements and refinements in the system. For instance, the integration of advanced communication modules like Wi-Fi could extend the operational range and enhance connectivity capabilities. Additionally, ongoing research and development efforts could focus on optimizing the system's performance, reliability, and adaptability to a wide range of real-world applications.

Overall, the all-in-one robotic car system presented in this study holds promise for revolutionizing various fields, including hobby projects, smart transportation systems, and educational research. Its multifunctional design and intuitive interface make it a valuable asset in the pursuit of safer, moreefficient, and technologically advanced autonomous vehicles.

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[5] Self-Driving Car: Using OpenCV2 and Machine Learning Bipin Advani1, Ankita Mistry1, NarendraPatel1, Neeru Pathak2 1Undergraduate Research Scholar, Dept. of Electronics and Telecommunication Engineering,Thadomal Shahani Engineering College, Mumbai – 50, Maharashtra, India 2Assistant Professor,Dept.of Electronicsand Telecommunication .

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