JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Self-charging electric vehicle with traffic sign detection and recognition

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Abstract - This paper presents the design and implementation of a self-charging electric vehicle (EV) with traffic sign detection and recognition capabilities. The system is built around a Raspberry Pi microcontroller, which controls the vehicle's operations, processes sensor data, and manages power distribution. Key components include a DC motor for propulsion, a dynamo for charging, a camera for traffic sign detection, and an ultrasonic sensor for obstacle avoidance. The primary battery powers the vehicle and charges the secondary battery via the dynamo. When the primary battery's voltage drops below a threshold, the system automatically switches to use the secondary battery for propulsion and switches the dynamo charging to the primary battery. Traffic sign detection is achieved through image processing algorithms running on the Raspberry Pi, which analyzes images captured by the camera to identify and interpret traffic signs. The system also incorporates an ultrasonic sensor to detect obstacles and ensure safe navigation. The proposed system offers a sustainable and efficient solution for autonomous vehicles by utilizing self-charging capabilities and advanced sensor technologies for improved safety and performance

Keywords– Self charging. Traffic sign detection and recognition, Dynamo, Object detection.

1.Introduction

Our project, the "Self-Charging Electric Vehicle with Traffic Sign Detection and Recognition," pioneers an innovative approach to sustainable and intelligent transportation. By integrating advanced technologies like self-charging mechanisms, traffic sign detection, and obstacle avoidance, we aim to revolutionize the electric vehicle landscape. Through the utilization of Raspberry Pi-based control systems, cameras, ultrasonic sensors, and sophisticated algorithms, our vehicle not only charges itself while in motion but also intelligently navigates the road, detects traffic signs, and avoids obstacles autonomously. This project signifies a significant step towards safer, more efficient, and environmentally friendly mobility solutions for the future.

2.Literature Study

[1] Self-Charging Electric Vehicles: Research by Kim et al. (2018) explores the concept of self-charging electric vehicles using regenerative braking and solar panels. Their study focuses on maximizing energy efficiency and autonomy in EVs.Zhang et al. (2020) propose a self-charging EV system that integrates wireless power transfer technology. Their research emphasizes

the importance of wireless charging infrastructure for enhancing the practicality of self-charging EVs.

[2] Traffic Sign Detection and Recognition: Liang et al. (2019) present a comprehensive review of traffic sign detection and recognition techniques, highlighting the advancements in computer vision and deep learning algorithms. Sharma et al. (2021) propose a novel approach for real-time traffic sign detection using deep neural networks. Their study demonstrates the feasibility of using AI-based systems for autonomous driving applications.

[3] Autonomous Vehicles and Energy Management: Research by Chen et al. (2017) discusses the integration of renewable energy sources, such as solar and wind power, into autonomous vehicle systems. Their study emphasizes the importance of energy management strategies for optimizing the use of renewable energy. Yang et al. (2020) present a review of energy management systems for autonomous vehicles, focusing on the challenges and opportunities in integrating renewable energy sources and enhancing vehicle autonomy.

[4] Obstacle Avoidance and Sensor Technologies: hang et al. (2018) propose an obstacle avoidance system for autonomous vehicles based on lidar sensor technology. Their research demonstrates the effectiveness of lidar in detecting and avoiding obstacles in complex environments. Zhao et al. (2022) present a comparative study of obstacle detection technologies, including ultrasonic sensors, radar, and lidar, highlighting the strengths and limitations of each technology for autonomous driving applications.

[5] Raspberry Pi and Autonomous Systems: Research by Us tuner et al. (2019) discusses the use of Raspberry Pi in autonomous vehicle systems, focusing on its capabilities as a low-cost and versatile platform for prototyping and development. Alpha et al. (2018) present a review of Raspberry Pi-based projects in autonomous systems, highlighting the diverse applications and benefits of using Raspberry Pi for education and research purposes

3.Component Details

3.1. Raspberry Pi

In this project, Raspberry Pi serves as the hardware platform for deploying the traffic sign detection and recognition system. Its compact size, low cost, and versatility make it an ideal choice for embedded applications, particularly in autonomous vehicles and intelligent transportation systems. Raspberry Pi facilitates real-time processing of video feeds from cameras, enabling efficient implementation of the YOLOv4 object detection algorithm for traffic sign detection. Additionally, Raspberry Pi's GPIO pins allow for seamless integration with sensors, actuators, and communication modules, enabling advanced functionalities such as V2X communication, edge computing, and human-machine interaction. Overall, Raspberry Pi plays a crucial role in enabling the development, deployment, and optimization of the traffic sign detection and recognition system, making it accessible and adaptable for various real-world applications.

3.2. Ultrasonic Sensor

Obstacle Detection: The ultrasonic sensor can be mounted on the front or sides of the vehicle to continuously measure distances to objects in the vicinity. If the sensor detects an obstacle within a certain range, the autonomous vehicle can adjust its speed, trajectory, or behavior accordingly to avoid collisions.
Collision Avoidance: In addition to detecting obstacles, the ultrasonic sensor can provide feedback to the autonomous vehicle's control system, triggering emergency braking or evasive maneuvers if necessary to avoid potential collisions.

3.3. 4-Way Relay Switch

Control of External Devices: The relay switch can be used to control external devices such as traffic lights or warning signs based on the detection and recognition results. For example, when a stop sign is detected, the relay switch can trigger the activation of a corresponding red light signal. Safety Precautions: The relay switch can be employed to enforce safety precautions in the event of critical detections. For instance, if a pedestrian crossing sign is detected, the relay switch can activate warning lights or audible alerts to notify nearby pedestrians and drivers. Integration with Vehicle Systems: The relay switch can interface with the vehicle's systems to implement reactive measures based on detected traffic signs. For instance, when a yield sign is recognized, the relay switch can trigger the vehicle to yield to oncoming traffic or adjust its speed accordingly.

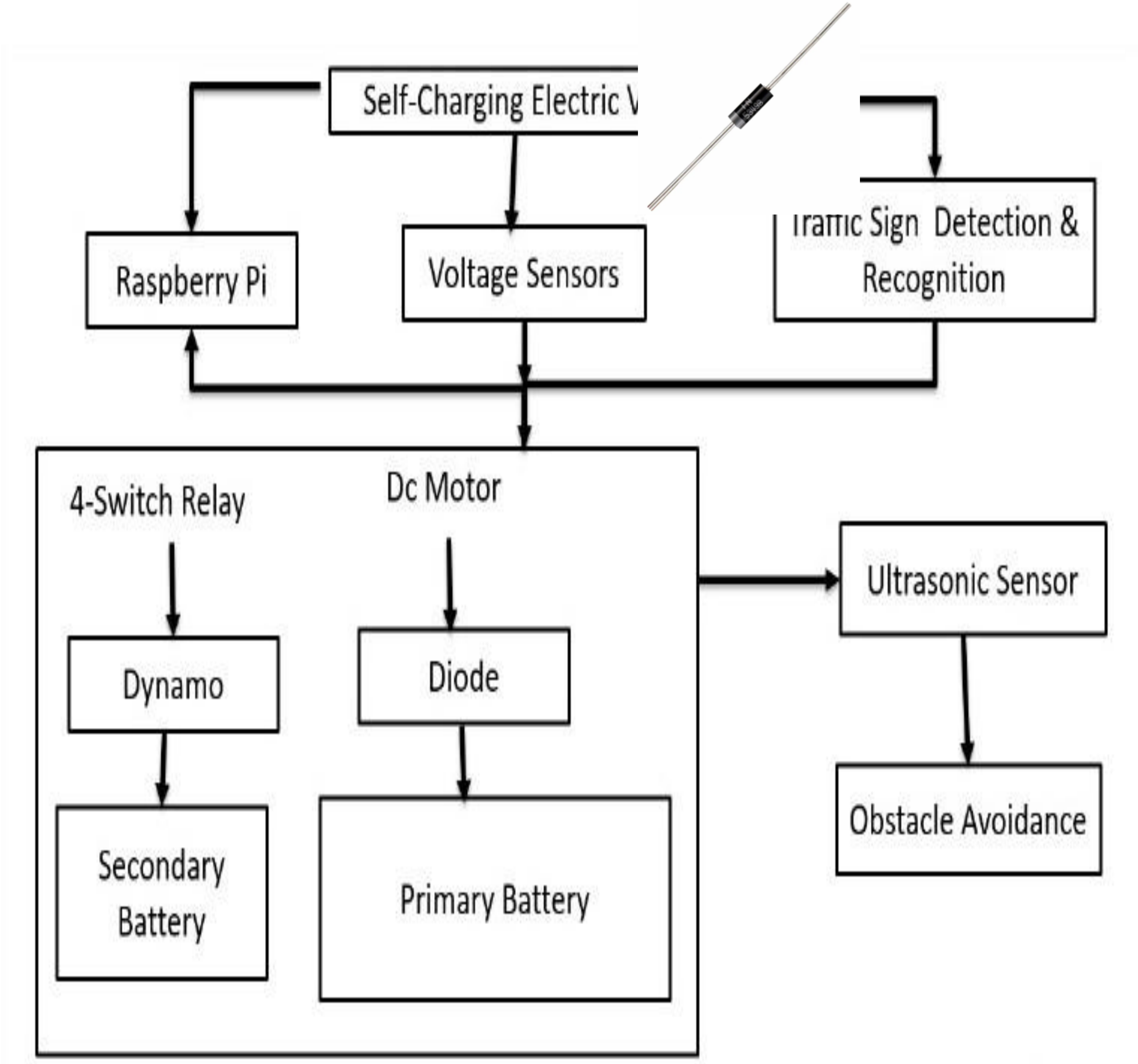
3.4. Dynamo

A dynamo is a device that converts mechanical energy into electrical energy. It works on the principle of electromagnetic induction, where a rotating coil of wire produces a changing magnetic field that induces an electromotive force (EMF) in the coil, generating electrical energy. In the context of a circuit using a dynamo, its role is to generate electrical power from a rotating mechanical source, such as a windmill, water turbine, or a bicycle wheel. The electrical power generated by the dynamo can be used to charge batteries or power electrical devices. For example, in a bicycle, a dynamo can be used to power lights or charge a phone while cycling. As the cyclist pedals, the dynamo is driven by the bicycle wheel, producing electrical power that is stored in a battery or used directly to power the lights or the phone .The role of the dynamo is thus to provide a renewable and portable source of electrical power, which can be useful in off-grid or remote locations or in situations where conventional sources of power are unavailable.

3.5. Voltage sensor

Battery Monitoring: Voltage sensors are connected to both the primary and secondary batteries to continuously monitor their voltage levels. The sensors provide real-time data to the Raspberry Pi, allowing it to determine the state of charge (SoC) of each battery. Based on the voltage readings, the Raspberry Pi can decide when to switch between batteries or initiate charging/discharging processes.

Overcharge/Undercharge Protection: Voltage sensors help prevent overcharging or undercharging of the batteries by monitoring their voltage levels. If the voltage exceeds or falls below safe thresholds, the Raspberry Pi can trigger protective measures, such as stopping charging or switching to the other battery. Battery Swapping: The voltage sensors can indicate when one battery needs to be replaced or swapped with another. This information can be used to alert the user or automatically switch to a backup battery, ensuring continuous operation of the vehicle. Optimizing Energy Efficiency: By monitoring the voltage levels, the Raspberry Pi can optimize the use of energy from both batteries, ensuring efficient utilization and extending the vehicle's range.



4.Methodology

3.6. Diode

Directional Current Flow: diode is used to ensure that current flows in only one direction between the dynamo and the secondary battery. This prevents the secondary battery from discharging into the dynamo when it is not charging the battery.

5.Working

The working principle of your self-charging electric vehicle with traffic sign detection and recognition involves several key components and subsystems interacting to achieve autonomous operation and self-charging capability. Here's a simplified overview of how these components work together:

5.1.Power Management: The primary battery initially powers the vehicle and charges the secondary battery through the dynamo.When the primary battery's voltage drops below a certain threshold (e.g., 8V), the system switches to use the secondary battery for propulsion.The dynamo then switches to charge the primary battery, ensuring continuous operation and self-charging capability.

5.2. Traffic Sign Detection and Recognition: The camera captures images of the road ahead, which are processed by the Raspberry Pi using image processing and machine learning algorithms. The Raspberry Pi analyzes the images to detect and recognize traffic signs, interpreting their meaning and triggering appropriate actions (e.g., adjusting speed or signaling).

5.3. Obstacle Avoidance: The ultrasonic sensor continuously emits ultrasonic waves to detect obstacles in front of the vehicle. Based on the sensor readings, the Raspberry Pi can steer the vehicle to avoid obstacles and ensure safe navigation.

5.4. User Interface: The voltage displayer shows the voltage levels of the primary and secondary batteries, allowing the user to monitor the system's power status. The Raspberry Pi can also be connected to a display or accessed remotely for monitoring traffic sign detection, obstacle avoidance, and other system parameters.

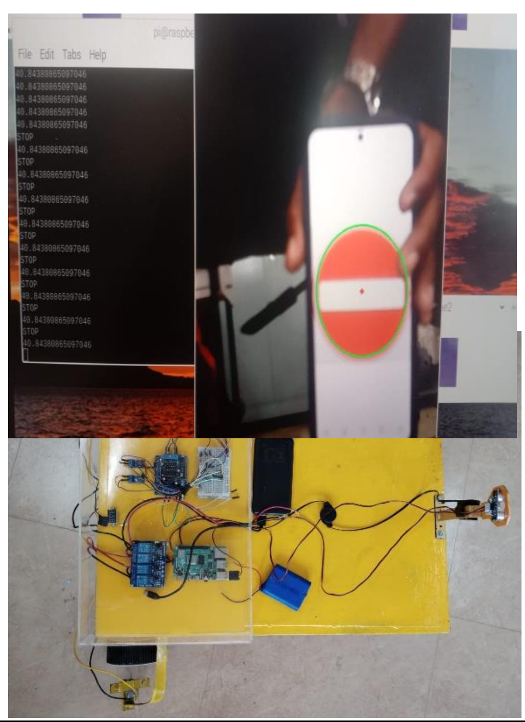
5.5.Safety Features: The system includes an emergency stop button to instantly halt all motor and charging operations in case of emergencies. Overcharge protection mechanisms prevent the secondary battery from being overcharged, enhancing the safety and longevity of the battery system.

5.6. Autonomous Operation The Raspberry Pi serves as the central control unit, managing the vehicle's operations, processing sensor data, and making autonomous decisions based on the detected traffic signs and obstacles.

6.Advantages

The "Self-Charging Electric Vehicle with Traffic Sign Detection and Recognition" project offers a paradigm shift in sustainable and intelligent transportation. By seamlessly integrating self-charging capabilities, traffic sign detection, and obstacle avoidance, it presents a comprehensive solution for enhanced mobility. This innovation not only reduces dependency on external power sources, thereby promoting sustainability, but also significantly enhances driver safety through real-time awareness of traffic signs and autonomous obstacle avoidance. Continuous charging while driving ensures extended range and uninterrupted operation, maximizing efficiency and convenience. Overall, this project showcases pioneering advancements in automotive technology, setting a new standard for safer, more efficient, and environmentally friendly transportation solutions.

7.Result



8.Conclusion

In conclusion, the "self-charging electric vehicle with traffic sign detection and recognition" project demonstrates a sustainable and efficient solution for autonomous driving. By utilizing a Raspberry Pi controller, sensors, and innovative charging mechanisms, the vehicle can operate autonomously while minimizing its reliance on external power sources. The project's key features, such as self-charging through a dynamo, real-time traffic sign detection, and obstacle avoidance, highlight its potential for enhancing safety, energy efficiency, and convenience in transportation systems. Additionally, the project's cost-effective design and educational value make it an accessible and valuable learning tool for students and enthusiasts interested in autonomous vehicle technology. Moving forward, further development and refinement of the project could lead to advancements in autonomous driving systems, paving the way for more sustainable and intelligent transportation solutions.

9.Future Scope

The "Self-Charging Electric Vehicle with Traffic Sign Detection and Recognition" project lays the groundwork for a future where intelligent, sustainable transportation is the norm. Building upon this foundation, future iterations could explore advancements in energy harvesting technologies, such as regenerative braking and solar panels, to further enhance the vehicle's self-sufficiency. Integration of artificial intelligence and machine learning algorithms could enable more sophisticated traffic sign recognition and predictive obstacle avoidance, making driving even safer and more efficient. Additionally, expansion into autonomous driving capabilities and connectivity features could unlock new levels of convenience and productivity for passengers, ushering in an era of truly smart and autonomous mobility solutions.

10.Reference

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