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EMBEDDED BASED AUTOMATED VEHICLE SYSTEM

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Abstract— ***This paper endeavors to pioneer a transformative approach to vehicular automation, leveraging embedded technology to revolutionize transportation. This paper aims to develop a comprehensive system that seamlessly integrates sensors, actuators, and artificial intelligence (Al) algorithms to enable vehicles to perceive, decide, and act autonomously. The system incorporates a Raspberry Pi as the central processing unit, coupled with an RPi camera, GPS module, ultrasonic sensor, L293D motor driver, and DC geared motor. So, basically building upon previous inventions, the project aims to create an advanced automated vehicle system that uses these components for enhanced navigation, obstacle detection, and motor control purposes which in detail controls the life threatening situations on the roads and makes the roads safer to travel.***

By harnessing the power of embedded systems, the proposed solution seeks to enhance transportation safety, efficiency, and reliability.

Key Components: Raspberry pi, AI algorithms, enhanced navigation, obstacle detection, embedded systems.

INTRODUCTION

The paper represents a pioneering endeavor in the realm of vehicular automation, aiming to redefine transportation through the innovative application of embedded technology. As society transitions towards a future characterized by increased connectivity, efficiency, and sustainability, the need for advanced automated vehicle systems becomes increasingly apparent. By harnessing the power of embedded systems, this project seeks to address this need by developing a comprehensive solution that promises to revolutionize the way we perceive and interact with transportation.

The introduction of this paper sets the stage by providing context for the significance and relevance of automated vehicle systems in contemporary society. With the proliferation of emerging technologies such as artificial intelligence, machine learning, and sensor technologies, the landscape of transportation is undergoing a profound transformation. Automated vehicle systems, in particular, hold the promise of enhancing safety, reducing congestion, and mitigating environmental impact, thereby ushering in a new era of mobility.

Embedded systems, characterized by their compact size, low power consumption, and real-time processing capabilities, serve as the cornerstone of this project.

These systems form the backbone of the automated vehicle infrastructure, enabling seamless communication, decision-making, and control within the vehicle ecosystem. By integrating sensors, actuators, and Al algorithms into a unified embedded framework, this system aims to overcome existing limitations in transportation automation and pave the way for more intelligent, adaptive, and responsive vehicles.

Furthermore, the paper outlines the objectives of the system, which include exploring the evolution of automated vehicle systems, reviewing relevant literature on embedded systems and artificial intelligence, discussing the working principles of embedded-based automated vehicle systems, and examining the challenges and opportunities associated with their implementation. By delineating these objectives, the paper provides a roadmap for the subsequent sections, guiding readers through the key themes and topics that will be addressed.

LITERATURE REVIEW

In Study [1], the authors Shinpei Kato, Shota Tokunaga, Yuya Maruyama & Seiya Maeda presented Autoware on Board, a new profile of Autoware, especially designed to enable autonomous vehicles with embedded systems. Autoware is a popular open-source software project that provides a complete set of self-driving modules, including localization, detection, prediction, planning and control. They used DRIVE PX2 as a reference computing platform, which is manufactured by NVIDIA Corporation for development of autonomous vehicles and evaluate the performance of Autoware on ARM-based embedded processing cores and Tegra-based embedded graphics processing units (GPUs). They believe that this observed computing performance is even acceptable for real-world production of autonomous vehicles in certain scenarios.

In Study [2], the authors S. Kato, E. Takeuchi, Y. Ishiguro & Y. Ninomiya aimed to develop a new upgrading method of digital map content for automated driving on nationwide public roads. In general, a dense waypoint map based on a digital map is necessary to realize precise motion controls of intelligent automobiles. However, current preparation methods for digital maps have two problems for practical use on public roads in wide areas: the size of the map data for onboard storage and the monetary and human resources for manual mapping processes.

In Study [3], the authors Morgan Quigley, Brian Gerkey, Ken Conley & Josh Faust took the overview of ROS, an open-source robot operating system. ROS is not an operating system in the traditional sense of process management and scheduling; rather, it provides a structured communications layer above the host operating systems of a heterogenous compute cluster. In this paper, they discussed how ROS relates to existing robot software frameworks, and briefly overviewed some of the available application software which uses ROS. ROS, the framework described in this paper, is also the product of tradeoffs and prioritizations made during its de-sign cycle. They believe its emphasis on large-scale integrative robotics research will be useful in a wide variety of situations as robotic systems grow ever more complex.

In study [4] M R Chaitra, Monika P, Sanjana M, Shibha Sindhe S R and Manjula G had suggested an innovative robotic solution for borewell rescue operations, integrating features like real-time tracking, emergency alerts, and live video streaming to enhance effectiveness and safety. Critical challenges were addressed in the research which aligns with most with the current objectives of this research. In contest there's a need for further research in mapping, teleoperation, and manipulation systems to improve rescue capabil In Study [4], the authors D. Dolgov, S. Thrun, M. Montemerlo & J. Diebel described a practical path-planning algorithm for an autonomous vehicle operating in an unknown semi-structured (or unstructured) environment, where obstacles are detected online by the robot's sensors.

In Study [5], the authors B.Nagy & A. Kelly described Curvature polynomials of cubic order which are ideal primitive trajectories for car-like robots. Their study said that unlike the clothoids, which are linear curvature polynomials, cubic curves can be used to determine a unique trajectory to an arbitrary target posture using a single continuous primitive. Such curves are also the lowest order curves which are continuous in the torque applied to steering mechanisms, so they generate trajectories which are relatively easily tracked by a real vehicle. Like the clothoids, cubic curvature polynomials are relatively difficult to compute but are easy to execute. A real-time numerical method to compute them is described by them

METHODS & MATERIALS

Component Review:

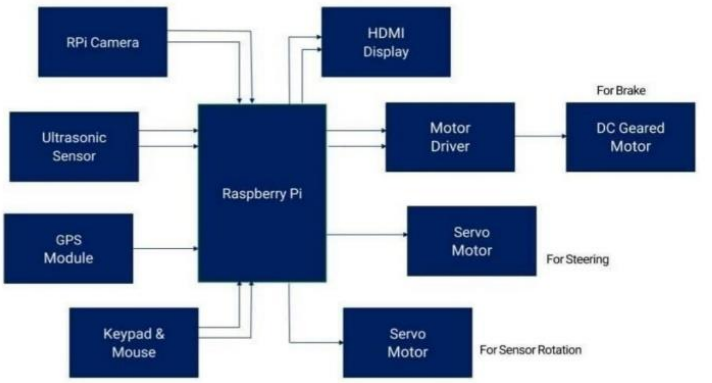


Fig 2. Block Diagram of model.

Raspberry Pi camera module features a Sony IMX 219 PQ CMOS image sensor, offering an 8-megapixel resolution within a compact and lightweight design. Primarily utilized for object detection, it captures real-time images for processing through machine learning algorithms, identifying pedestrians, vehicles, and road obstacles.

Raspberry Pi model 3B+ employs a Broadcom BCM2837B0 processor, Cortex-A53 64-bit SoC @ 1.4GHz, with 1GB LPDDR2 SDRAM. Its 40-pin GPIO header enhances versatility, providing a cost-effective platform for autonomous vehicle development.

Ultrasonic sensors function by emitting high-frequency sound waves (typically above 20 kHz), measuring the time it takes for these waves to return after encountering objects. This time delay enables distance calculation.

GY-GPS6MV2 Ceramic GPS module, utilizing ceramic technology, offers enhanced environmental resistance and high accuracy in location determination, typically within a few meters. Its fast signal acquisition ensures quick fixes, even in challenging environments.

L293D motor driver is tailored for driving small DC motors bidirectionally, controlling speed via pulse-width modulation (PWM). Employing an H-bridge configuration, it can drive two motors independently or one stepper motor, featuring High-Noise-Immunity inputs.

Servo motors MG90S, are vital for controlling camera or sensor movements, crucial for perception tasks such as object detection and obstacle avoidance. Compact and torque-efficient, the MG90S typically operates at speeds ranging from 0.08 to 0.12 seconds per 60 degrees.

DC geared motors offer variable speed control and high torque at low speeds, suitable for steering and propulsion tasks. Commonly used in wheel drives and steering mechanisms, these motors feature metal gears and a circular 6mm diameter shaft with a 23mm shaft length.

Working:

Research Design:

1] Raspberry Pi Setup:

To begin setting up the Raspberry Pi board, the initial step involves installing the necessary operating system, such as Raspbian, and essential libraries for Python programming.

2]Camera Module :

The Raspberry Pi camera module is connected to the Raspberry Pi board. This camera is pivotal for image processing tasks like object detection and obstacle avoidance. It captures images ahead of the vehicle and interfaces directly with the Raspberry Pi.

3]Ultrasonic Sensor:

Connecting the ultrasonic sensor to the Raspberry Pi enables obstacle detection in the vehicle's path. Utilizing the Echo and Trigger pins of the ultrasonic sensor, it interfaces seamlessly with the Raspberry Pi. Multiple sensors can also be employed for wider coverage.

4]GPS Module:

Integrating the GPS module with the Raspberry Pi provides crucial location data for navigation and mapping purposes. By utilizing the serial transmission pin of the GPS module, the Raspberry Pi effectively interfaces with it, determining both the vehicle's location and the position of obstacles.

5]Servo Motor: Linking the servo motor to the Raspberry Pi allows for controlling the vehicle's direction by manipulating the wheels or steering mechanism. Two servo motors are utilized: one for steering when obstacles are absent, and the other for rotating the ultrasonic sensor.

6]DC Geared Motors and L293D Motor Driver:

The DC geared motors are connected to the L293D motor driver, which in turn interfaces with the Raspberry Pi. The motor driver manages motor speed and direction, facilitating the vehicle's movement, including forward, backward, and turning. Additionally, the DC geared motor applies brakes, with the motor driver responsible for driving it.

7]Integration and Testing

Bringing all components together, the system undergoes rigorous testing in diverse scenarios. Sensor calibration, algorithm refinement, and ensuring appropriate responses to environmental inputs are key aspects of this phase.

This project encompasses hardware integration, software development, and comprehensive testing across various levels. A structured approach, meticulous documentation, and adept debugging skills are indispensable for effectively navigating through the development process and addressing any encountered challenges.

8] Software Development:

Image processing: Integration of Raspberry Pi camera module and openCV libraries enables image processing task like object detection.

Obstacle Avoidance:

Utilizing data from the ultrasonic sensor, algorithms are implemented to detect obstales.

RESULTS

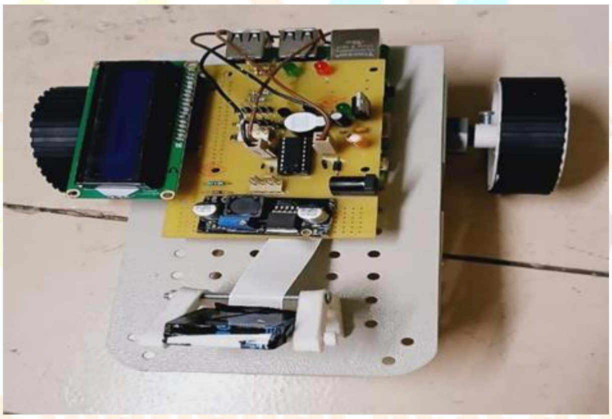
The results of this Paper demonstrate significant advancements in the field of transportation technology. Through the integration of embedded systems, sensors, actuators, and artificial intelligence algorithms, the system has shown promising capabilities in enhancing transportation safety, efficiency, and reliability.

It was tested in extreme conditions and with fail-safe protocols, such as long reuse time. Then, expedited tests were conducted on battery backup and connection interference to ensure reliability over the system.

One key result of the project is the successful development of a functional prototype or simulation of an automated vehicle system. This prototype demonstrates the feasibility of using embedded technology to enable vehicles to perceive their environment, make decisions, and navigate autonomously. By leveraging sensors to gather real-time data about the vehicle's surroundings and AI algorithms to analyze this data and make informed decisions, the system showcases the potential for automation to revolutionize the way we travel.

Additionally, the project results highlight improvements in transportation efficiency and convenience. Automated vehicles equipped with embedded-based systems have the potential to reduce traffic congestion, shorten commute times, and enhance overall mobility. By optimizing route planning, traffic flow, and vehicle coordination, the system can help minimize delays and disruptions in transportation networks.

Furthermore, the project results underscore advancements in transportation safety. Embedded-based automated vehicle systems have the ability to detect and respond to potential hazards more quickly and accurately than human drivers. This can lead to a reduction in traffic accidents, injuries, and fatalities, thereby improving overall road safety for drivers, passengers, pedestrians, and cyclists.



Moreover, the project results contribute to our understanding of the broader implications of automated vehicle technology. By examining the social, economic, and environmental impacts of embedded-based automation, the project sheds light on the potential benefits and challenges associated with widespread adoption. This holistic perspective is essential for informing policy decisions, regulatory frameworks, and public perception surrounding automated vehicles.

CONCLUSION

In conclusion, this Paper represents a significant step forward in the evolution of transportation technology. Through the integration of embedded systems, sensors, actuators, and artificial intelligence algorithms, this project has demonstrated the potential to revolutionize the way we perceive and interact with automated vehicles. By leveraging the power of embedded technology, we have developed a comprehensive solution that enhances transportation safety, efficiency, and reliability.

Throughout the course of this project, we have explored the foundational principles of embedded systems, AI, and autonomous vehicle technology. Drawing upon insights from existing literature and research, we have identified key challenges and opportunities in the field, ranging from technical considerations such as sensor fusion and real-time processing to broader issues such as safety, regulatory compliance, and human factors.

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