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IoT based Self Driving Car

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Abstract

This project shows an affordable self-driving car prototype that uses Raspberry Pi 4, motor driver, DC motors, USB webcam. The system combines software-control algorithms with hardware elements like DC motors, a motor driver (L298N), and a power supply. Using methods like grayscale conversion, Gaussian blur, etc. OpenCV processes a real-time video frame from the webcam to detect road boundaries, objects, signs, etc. The prototype uses either rule-based logic or a trained convolutional neural network (CNN) model to establish driving direction based on the data obtained from raspberry pi processor. PWM signals are transmitted from the Raspberry Pi to the motor driver in order to control the dc motor speed, direction, etc. Additionally, a VNC - based wireless communication system is included in the setup, enabling Wi-Fi monitoring and remote access. Performance was assessed using lane-following accuracy, and overall driving stability during testing. The system is a good example of how to create a flexible, reasonably priced self-driving platform for testing and teaching.

Introduction

This paper introduces research and a project on self-driving car, the project focuses on building a prototype of autonomous vehicle. This concept of self-driving car is not new, it has been in research since 1920 and experiments had been conducted since 1950 in the form of Advanced Driver Assistance System (ADAS) which includes features like adaptive cruise-control system, lane departure warning system, self-parking systems. The first semi-autonomous car was launched in 1980 by Japan's Tsukuba Mechanical Engineering Laboratory.

The advantage of this concept is it prevents or minimizes accidents issues which are caused due to today's traffic conditions, reduction in fuel consumption, ease in transporting elderly people or disabled without any human intervention. All this is possible with technological advancements with the help of sensors or cameras which collect data and provide it to control systems, the system makes relevant decisions on navigation, obstacle detection and sign/traffic light interpretation.

In this project raspberry pi 4 acts as the main processor which exchanges data with the sensors and work accordingly. The wheels will be controlled by servo motor driver which is also controlled by raspberry pi. Web camera is used to detect objects and the real time data is processed by the main processor. This concept of autonomous car is booming automobile industry making it more advanced, efficient and reliable.

Literature Survey

i. The paper "Design and Implementation of Self-Driving Car" by **Mahmoud Fathy et al.**, published by Elsevier in *Procedia Computer Science* (2020), presents a prototype using Raspberry Pi and Arduino for autonomous navigation. It uses SVM for road irregularity detection, stereo vision for depth estimation, and computer vision for lane detection. Effective decision-making and obstacle avoidance are ensured by the combination of hardware and intelligent algorithms. Additionally, it discusses implementation hurdles, including high costs, legal liabilities, and the necessity for comprehensive regulatory frameworks. The authors conclude that while autonomous vehicles offer substantial advantages, their successful deployment requires addressing these multifaceted challenges.

ii. The paper titled *"Autonomous Vehicles: A Study of Implementation and Security"* by **Firoz Khan et al**., published in the *International Journal of Electrical and Computer Engineering (IJECE)*, Volume 11, Issue 4, August 2021, explores the integration of autonomous vehicles into modern transportation systems. While addressing important issues, especially in the area of security, it also emphasizes the advantages of autonomous vehicles, such as increased efficiency and safety. The study looks at possible cyberthreats to car sensors and communication systems, highlighting the necessity of strong security measures to protect against manipulation and guarantee passenger safety. It also covers implementation challenges, such as excessive expenses, potential legal consequences and the requirement for deep regulatory frameworks. Even though autonomous cars have many benefits, these complex issues must be resolved for them to be successfully implemented.

iii. The paper *"Autonomous Vehicle Implementation Predictions: Implications for Transport Planning"* by **Todd Litman**, published by the **Victoria Transport Policy Institute** in January 2015, explores the possible effects of autonomous vehicles on urban planning and transportation systems. Adoption schedules, societal advantages, hazards, and financial effects are covered. The study highlights that although autonomous cars offer greater mobility and safety, they also bring up issues with equity, traffic, and land use that planners need to take preventive steps to resolve.

iv. The report "Autonomous Vehicle Technology: A Guide for Policymakers", published by the **RAND Corporation** in 2014 offers a thorough analysis of autonomous car technologies and implications for policy. It looks at cybersecurity issues, privacy, legal liability, safety, and technical capabilities. In addition to highlighting the significance of balanced regulations to promote innovation, public trust, and safe integration into current transportation systems, the guide aims to support policymakers in understanding the transformative potential of autonomous vehicles.

v. The paper *"Simultaneous Localization and Mapping: A Survey of Current Trends in Autonomous Driving"* **by G. Bresson, Z. Alsayed, L. Yu, and S. Glaser**, published by the **IEEE** in the *IEEE Transactions on Intelligent Vehicles*, Vol. 2, No. 3, September 2017, reviews SLAM techniques used in autonomous vehicles. In order to achieve reliable vehicle localization and mapping, it examines visual, LiDAR-based, and hybrid approaches, highlighting difficulties like dynamic environments, computational complexity and real-time performance.

vi. The paper *"Sensor Fusion Using Fuzzy Logic Enhanced Kalman Filter for Autonomous Vehicle Guidance in Citrus Groves"* by **V. Subramanian, T. F. Burks, and W. E. Dixon**, published in **Transactions of the ASABE** (American Society of Agricultural and Biological Engineers), Vol. 52, No. 5, 2009, presents a sensor fusion method for autonomous off-road driving. The system increases the accuracy of vehicle guidance in challenging agricultural environments by combining GPS and inertial sensors with an uncertain logic-enhanced Kalman filter.

vii. The Intel® RealSense™ LiDAR Camera L515, developed and published by **Intel Corporation.** Is a small, solid-state depth sensor intended for applications requiring high-precision 3D scanning. It provides precise depth readings between 0.25 and 9 meters by using a MEMS mirror-based scanning system that can record up to 23 million depth points per second. The L515 uses less than 3.5W of power and is equipped with a 2MP RGB camera and an inertial measurement unit. It is perfect for robotics, logistics, and indoor mapping applications because of its lightweight design and high-resolution capabilities.

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Methodology

This project uses a Raspberry Pi and a USB webcam to create a simple self-driving car prototype. The approach uses a combination of hardware and software elements to sense the surroundings, make choices, and manage the motion of the vehicle.
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1. Overview of the System Architecture

These are the main parts of the self-driving car system:
Raspberry Pi 4 serves as the central processing unit.
Real-time video from the front of the vehicle are captured by the USB webcam.
Motor Driver (L298N or comparable): Regulates the DC motors for steering and driving by controlling the speed, direction, torque.
DC Motors and Chassis: DC motor allows the wheels of vehicle to move. Chassis serves as support system for structural appearance, weight management, mounting essentials.
The power source is usually a power bank or rechargeable battery pack.

2. Data Gathering

Continuous video frames are captured using a webcam attached to the Raspberry Pi Processor. Computer vision techniques i.e. artificial intelligence that enables machine to see and understand the surrounding is used to process these frames in real time.

3. Feature detection and image processing

The OpenCV library is used to process captured frames in order to identify road boundaries and lane lines. The actions listed below are carried out:
Grayscale conversion makes image processing simpler.
Gaussian Blur: Smooths edge and lowers noise in images.
Region of Interest (ROI): To concentrate processing solely on the road segment, a polygonal mask is used.
Hough Transform: Determines the road's direction by identifying lines inside the ROI.

4. Algorithms for Decision Making and Control

The Raspberry Pi uses either a machine learning model or basic logic to determine the necessary steering direction based on the road and obstacles it has detected. There are two methods that can be employed:
Rule-Based Control: If-else reasoning to steer left, right, or straight based on lane positions.
Machine Learning Approach: A CNN (Convolutional Neural Networks) model that has been trained to predict steering angles using input from camera frames as the image is broken in layers and scanned
using special filters which detect edge or shapes.

5. Control of Motors

The motor driver acts as an interface between motor and processor (raspberry pi). It receives the controlling commands produced by the raspberry pi according to which the dc motors are operated. The vehicle's direction and speed are managed by PWM (Pulse Width Modulation) signals:
Movement forward, backward, left, right are managed by the L298N's direction pins.
By adjusting the speed of the left and right motors, required driving is fulfilled .

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6. Examining and Adjusting

Clear Lane markings and a controlled environment are used for system testing. The performance is assessed using the following criteria:
Accuracy of road-following
Road curve reaction time
Consistency at varying speeds
To increase performance, control logic and image processing parameters are iteratively adjusted.

7. Making Wireless with VNC

Turn on the VNC and SSH from Raspberry pi and find the IP address of Raspberry pi. Also find IP address of laptop. Now download Real VNC Viewer Application and copy raspberry pi's IP in the application. The network connected to both laptop and raspberry pi should be same.

Component specification

I. A **webcam** is a compact digital camera used to capture real-time video and images, typically connected to a computer via USB. It is commonly used for video conferencing, streaming, surveillance, and computer vision tasks. Most webcams feature HD or Full HD resolution, built-in microphones, and support 30–60 fps video capture. Due to their portability and ease of use, webcams are ideal for projects like robotics and self-driving car prototypes using platforms like Raspberry Pi.

II. Raspberry pi 4: The raspberry pi is the main processor here. Popularly known as low cost single board computer. We are using raspberry pi 3B+ version for image processing. With the help of Open CV software, a machine learning algorithm is implemented and the images are trained in various lighting conditions using neural network technology. Further the decisions taken by the raspberry pi are sent as commands to Arduino.

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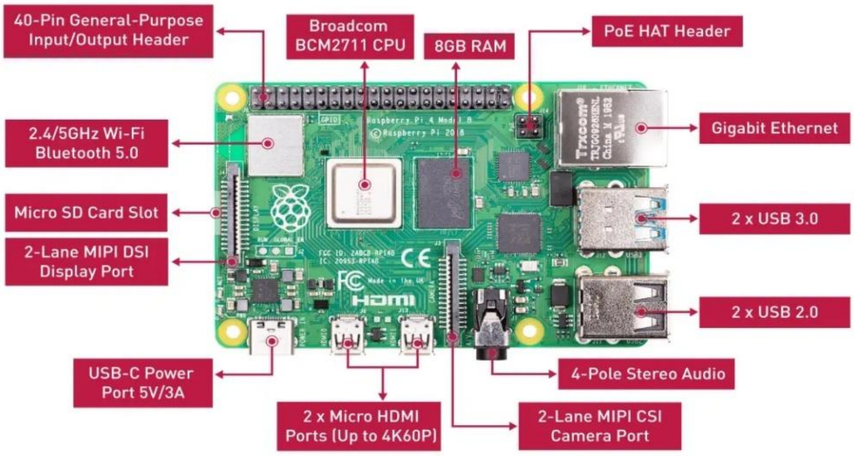

III. L298N Motor Driver: It is a basic motor driver module used to drive dc motors as well as stepper motors too. H bridge is used along with L298 IC to drive motors. H bridge is a circuit that can drive current in polarity and will be controlled by pulse width modulation (PWM)

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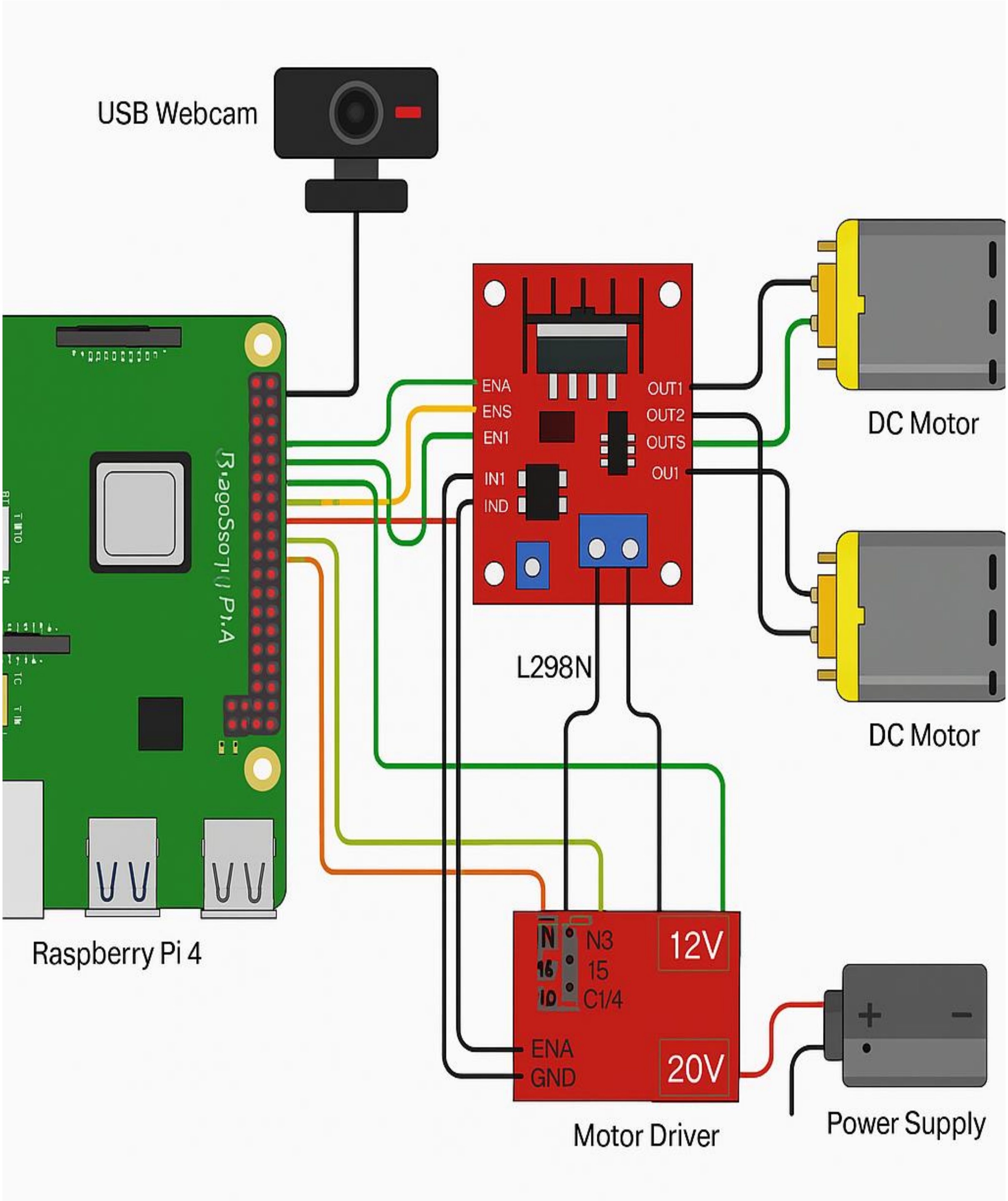
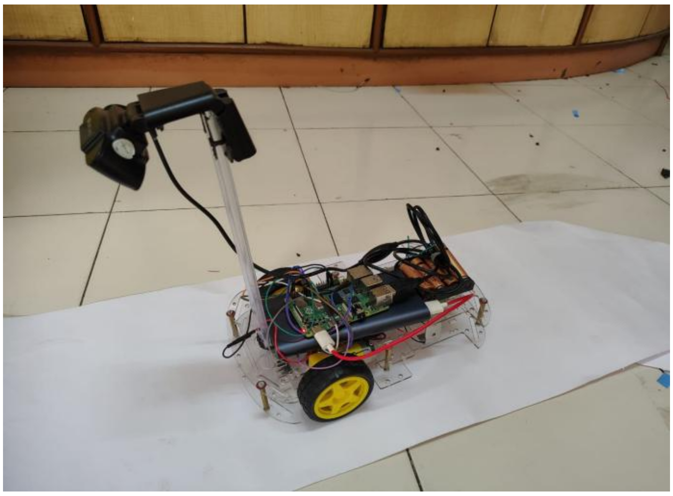
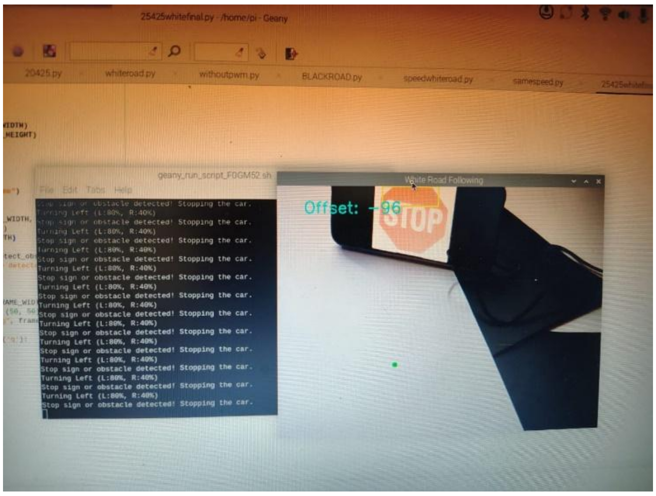
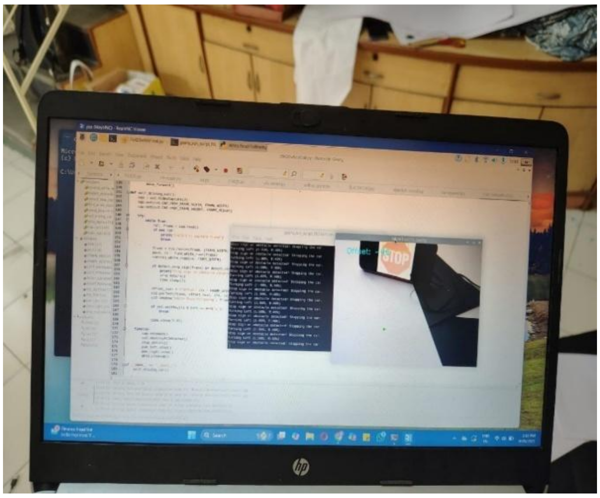
Circuit Diagram



Results:




Offset: -96
STOP
Stop sign or obstacle detected! Stopping the car.
Turning Left (L:80%, R:40%)



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Future Scope

There is a vast area for automobile researchers and companies which can build their self-driving cars with accuracy and safety. Use of advanced cameras, sensors and processors can come up with a completely interactive car which will interact with its passengers, surrounding cars and also the parts within itself which will be reliable, efficient, on road solution for today's traffic issues.

Conclusion

This project effectively combines computer vision and motor control into a small, affordable design by showing a working prototype of a self-driving car using a Raspberry Pi, motor driver, DC motors, webcam. The system can automatically detect roads and adjust navigation by using OpenCV for real-time image processing and basic decision-making algorithms or machine learning models. VNC- enabled wireless access increases accessibility by enabling remote control and monitoring. The project demonstrates the possibilities of combining open-source software and easily available hardware for autonomous vehicle testing and learning.

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