# Fuel Efficient Self-Driven Vehicle using CNN with V2V Communication

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In today's Artificial Intelligence (AI) -driven era, transportation is being revolutionized through AI and computer vision technologies, utilizing cameras, ultrasonic sensors for detecting obstacles, GPS for pinpointing locations, and ADXL345 for directional guidance. The objective is to improve vehicle safety and fuel economy by applying Machine Learning (ML) techniques, using resources like the Carla Driving Simulator's Lane Detection data and Vehicle-to-Vehicle (V2V) communication. Raspberry Pi and Arduino are employed for computational tasks, allowing for AI-based forecasts using models such as Convolutional Neural Network (CNN), You Only Look Once (YOLO), and OpenCV. The conversion to grayscale and the application of Canny edge detection minimizes data channels, while YOLO and CNN are tasked with image segmentation. ML algorithms autonomously steer the vehicle to the most efficient and secure route, merging navigation, obstacle deterrence, collision avoidance systems, GPS, and fuel optimization. Conforming to official traffic regulations secures passenger safety and facilitates vehicle communication for maintenance alerts and troubleshooting. Vehicle performance is further refined with location-tailored enhancements.

**Keywords:** Computer Vision, CNN, Obstacle Avoidance, Anti-Collision, GPS, Fuel-Efficient.

2025. In Mukesh Saraswat & Rajani Kumari (eds.), *Applied Intelligence and Computing*, 223–236. Computing & Intelligent Systems, SCRS, India. DOI: https://doi.org/10.56155/978-81-955020-9-7-22

# 1 Introduction

The An innovative answer to the urgent problems of transportation safety and energy efficiency is the deployment of AI-driven autonomous cars [1] in emerging countries. Unquestionably, new methods are required with over 1.4 billion motor vehicles traveling great distances every day. The Raspberry Pi 4 acts as the main processing unit in your concept, while the Arduino simplifies sensor integration and motor control by way of the LM298 driver. A strong and effective autonomous vehicle platform is expected to be produced by this well-considered hardware choice. Specifically for the setting of electric cars, the incorporation of battery voltage monitoring and power control by linear regression is a praiseworthy approach. It makes certain that these cars run as efficiently as possible, expanding their range and lowering their need for fuel [2]. These vehicles take on a new dimension with the addition of computer vision, made possible by cameras and supported by OpenCV and YOLOv8. By developing perception and interpretation skills, they are able to perform critical tasks including lane detection, traffic signal recognition, obstacle avoidance, and distance estimate. This gives the vehicles the ability to maneuver across difficult terrain, greatly enhancing overall safety and efficiency. The potential advantages are extensive, including not just increased transportation safety but also significant energy savings and economic effectiveness. The road ahead, meanwhile, is not without its difficulties [3]. It is crucial to address legislative issues, provide infrastructure, and increase public confidence in autonomous technology. Further integrating this project with sustainability objectives may be done by investigating renewable energy sources for these cars. the plan has the potential to alter transportation while also igniting economic growth and job creation in sectors connected to technology by developing collaboration with regional stakeholders and fostering research and development initiatives. It is a bold initiative that might provide communities in need with safer, more energy-efficient, and accessible transportation options

# 2 Methods

## 2.1 Hardware components

### 2.1.1 Raspberry Pi 4b

A credit card-sized computer board called the Raspberry Pi is renowned for its small, cost-effective design. As a result, it relies on external devices for input (keyboard and mouse), output (display), and data storage (SD card) due to the lack of internal peripherals and storage. The SD card contains the operating system, which needs a power source and several wires to function. You can utilize hard drives or SD Flash memory to increase storage. For connectivity, the gadget supports Bluetooth and wireless LAN, and it offers a huge selection of programming languages, including Python. It supports the Linux operating system and has 8GB RAM and a Quad-core Cortex-A72 processor.Four USB 2 ports, two HDMI connectors, a C-Type charger port, and a four-pole stereo output are all features of the Raspberry Pi.Additionally, a Micro SD slot for installing the operating system and a 2.5A Micro USB power supply are included as shown in"Figure 1".


**Figure 1.** Raspberry Pi 4b.

### 2.1.2 Arduino NANO

An open-source electrical gadget called an Arduino can receive analog or digital inputs from things like sensors and create outputs like starting motors. It contains a software program called Arduino IDE and a microcontroller circuit board that can be programmed. With this software, the code can be created and uploaded to the circuit board. The in extension should be used for saving programs created using the Arduino IDE, which uses the C programming language to send instructions to the microcontroller and control board operations. On the ATmega329P, the Arduino microcontroller is built.There are 6 PWM output pins out of the 14 digital I/O pins that make up this device. It includes 6 PWM digital I/O pins and 6 analog input pins. It's got memoryas shown in"Figure 2".


**Figure 2.** Arduino NANO.

### 2.1.3 LM298 Motor Driver

The L298N is a twin H-Bridge motor driver that enables simultaneous speed and direction control of two DC motors. The module can operate DC motors with peak currents of up to 2A and voltages ranging from 5 to 35Vas shown in"Figure 3".

**Figure 3.** LM298 motor driver

### 2.1.4 Pi Ccamera

A Raspberry Pi with a serial interface is attached to the lightweight portable module known as the "Pi camera" by an elastic connection. Both photos and videos captured by this camera module are of the highest caliber. The autonomous vehicle's top is covered with a Pi camera, which collects photos and transmits them to a Raspberry Pi for preliminary processing. The Raspberry Pi camera module is a 5MP color camera without a microphoneas shown in“Figure 4”.

**Figure 4.** Pi Camera

### 2.1.5 GPS Module

A GPS (Global Positional System) module is a small electronic gadget that uses signals from a network of satellites to detect its precise location and transmit positional data in real-time. These modules are increasingly common and are utilized in a variety of applications, such as vehicle tracking, location-based services, navigation systems, and more. High precision, real-time tracking, small size, a variety of interface choices, and interoperability with several satellite systems are key elements that increase positioning accuracyas shown in“Figure 5”.

**Figure 5.** GPS Module

### 2.1.6 ADXL345

It is used to measure the three-axis acceleration with accurately record motion data because of its high resolution and sensitivity, which enable it to detect both static and dynamic acceleration. The ADXL345 is a popular option for jobs like tilt sensing, vibration analysis, and orientation detection since it is simple to incorporate into different electrical systems and has communication interfaces including I2C and SPIas shown in“Figure 6”.

**Figure 6.** ADXL345 Accelerometer

### 2.1.7 IR Encoder

A sensing tool frequently used in autonomous vehicle systems to record exact rotational or linear motion data is the infrared (IR) encoder. It typically consists of an IR light source and a photodetector that are positioned so that they can detect interruptions in the IR beam brought on by a spinning or linearly moving encoder disc or strip. These disruptions provide electrical signals that may be counted to calculate position and speed, usually in the form of pulses. IR encoders are valuable components for activities like tracking wheel or motor movement because of their advantages like high resolution, dependability, and resilience to environmental conditions like dust and moisture. This enables precise control and feedback in a variety of autonomous vehicle applicationsas shown in“Figure 7”.


**Figure 7.** IR Encoder

## 2.2 Software Requirements

Python is a well-liked high-level programming language that is simple and easy to read, making it suited for both inexperienced and seasoned workers. It supports a variety of programming paradigms and has a sizable standard library that makes many routine jobs easier. Python's versatility makes it useful in a variety of industries, including web development, data analysis, scientific computing, and artificial intelligence.

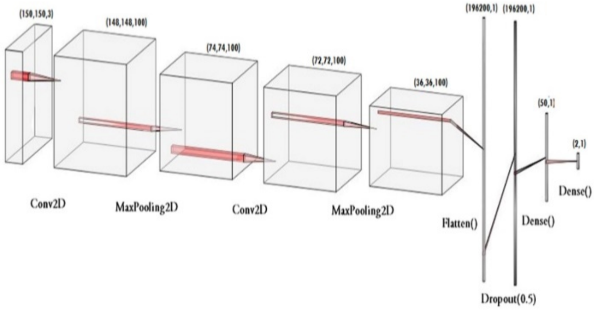


**Figure 8.** CNN Architecture

Convolutional Neural Networks (CNNs) [4]for image processingas shown in"Figure 8", YOLOv8 for real-time object recognition, OpenCV for a variety of computer vision applications, and the PySerial package for fluid communication with hardware components are all crucial tools in the field of autonomous cars and computer vision. The Arduino IDE makes it easier to program microcontrollers for precise control, while Flask makes it easier to create nifty web interfaces for data interaction and remote vehicle monitoring. The open-source simulation software CARLA, which provides a realistic testing environment, also supports research and development for autonomous driving systems.

## 2.3 Hardware Integration and Functionality

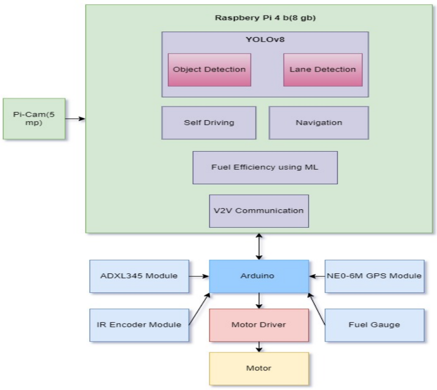


**Figure 9.** Block Diagram

In our methodas shown in“Figure 9”, we seamlessly combine Raspberry Pi and Arduino to build a powerful autonomous vehicle system. By interacting with several sensors and actuators, the versatile microcontroller platform Arduino, which is used in this project, plays a crucial part. To guarantee the best possible power management, it gathers information from sensors such as the ADXL345, which provides compass direction data and continuously checks battery voltage. Additionally, for precise control of the vehicle's electric motors, Arduino communicates with the LM298 motor driver. This control also includes monitoring battery voltage for effective linear regression-based energy management of energy usage. An IR encoder is used to gather information for a linear regression analysis, which will further improve energy efficiency. The Raspberry Pi controls the entire system as its central processing unit [5]. To make judgments about real-time vehicle navigation, obstacle avoidance, and energy efficiency, it analyses data from Arduino, including motor control commands and data from the IR encoder. The Raspberry Pi uses the YOLOv8 library and OpenCV's computer vision capabilities to process data from the Pi Camera. By enabling the system to carry out tasks like lane detection, traffic signal recognition, and object detection, this functionality improves the vehicle's capacity to react to its surroundings. Additionally, the Raspberry Pi uses machine learning techniques, such as convolutional neural networks (CNNs), to analyze camera and sensor data, enabling the car to choose the most reliable and effective route. In addition to performing these tasks, the Raspberry Pi enables GPS module connectivity for location data and offers a channel for communication with vehicle owners, providing prompt servicing notifications and problem detection. Our autonomous vehicle system's core is built by the tight integration of Arduino and Raspberry Pi, which enables it to make knowledgeable judgments in real time to improve safety, energy efficiency, and overall transportation efficacy.

## 2.4 Lane Detection and Object Detection

We use the Canny edge detection method and Gaussian blur to greatly increase lane detection [6] accuracy in our live video streaming setupas shown in“Figure 10”. To improve lane marking clarity, reduce image noise, and smooth pixel transitions, gaussian blur is used.

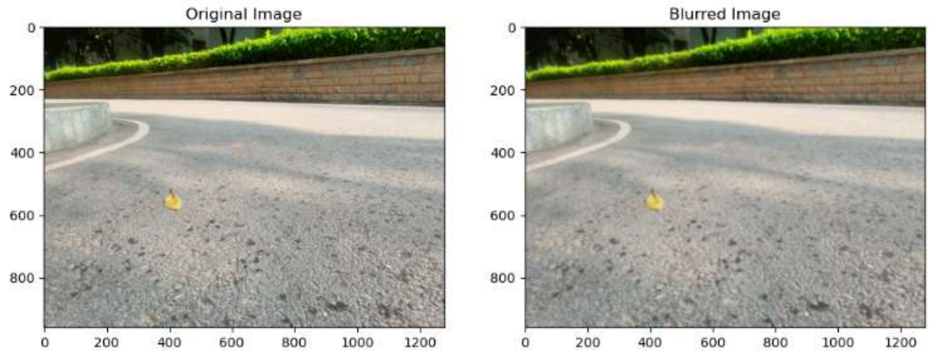


**Figure 10.** Gaussian Blur

We can precisely extract lane borders by using the Canny edge detection technique, which locates edges in the image. This combination improves our car's capacity to precisely track lanes [7], which is essential for autonomous navigation[8]as shown in“Figure 11”.

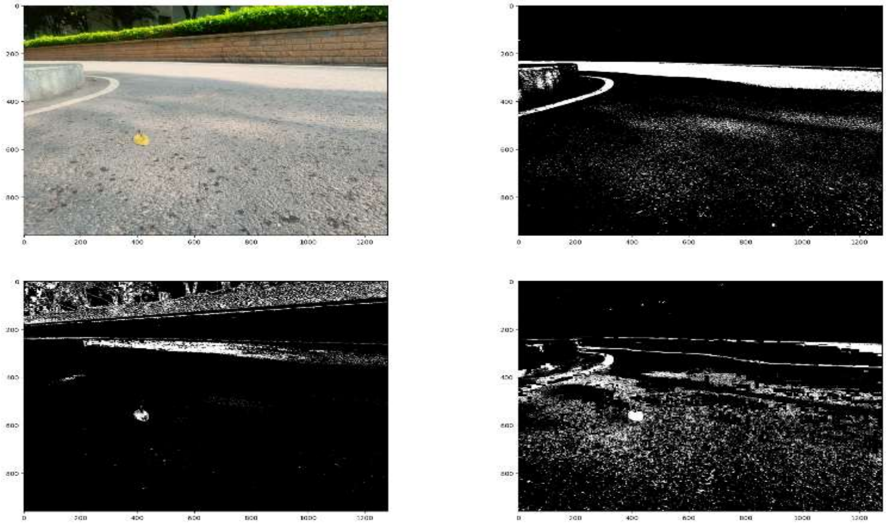

**Figure 11.** Lane Detection Process

Furthermore, because of its excellent speed and accuracy, we chose YOLOv8 (You Only Look Once version 8) for object detection [9]. The real-time processing capabilities of YOLOv8's architecture make it the perfect fit for our autonomous driving system, where the importance of quick judgments is crucial [10]. Furthermore, YOLOv8 provides reliable object detection across a variety of classes, such as traffic lights and road signs. Because of its adaptability and effectiveness, it is a good option for comprehensive environmental perception because it enables our vehicle to recognize and react to numerous things in real time, ensuring safe and effective autonomous navigation. Although there are other YOLO versions available, YOLOv8 is the version we recommend for object detectionas a process shown in“Fig. 12”, “Fig. 13” and “Fig. 14” in our live video streaming setup because of its great balance of speed and accuracy.

**Figure 12.** Original Image


**Figure 13.** Object Detection


**Figure 14.** Image Segmentation

## 2.5 Process of Self-Driving and Navigation

The NEO-6M GPS module and the ADXL345 accelerometer, both of which are crucial for boosting the capabilities of our autonomous car system, are acquired from the Arduino in the next step of our process. The NEO-6M GPS module works by gathering signals from various Earth-orbiting satellites and triangulating its location using the difference in time between these signals. It determines the location of the vehicle's latitude, longitude, altitude, and accurate timestamp. This information allows our car to pinpoint its precise worldwide position on the surface of the Earth, making it essential for self-driving and navigation. The system may make decisions about route planning and adherence to navigational instructions in real time by continuously updating this information, resulting in effective and precise autonomous driving. The ADXL345 accelerometer also serves as an inertial sensor, measuring acceleration in the x, y, and z axes. The fundamental workings of this sensor rely on the monitoring of changes in capacitance caused by the movement of tiny accelerometers inside the gadget. The ADXL345 gathers vital data regarding the vehicle's orientation, tilt, and acceleration in real time by sensing these accelerations. For preserving stability and providing secure autonomous navigation, this information is vital. For instance, the system can identify sudden changes in the vehicle's speed, sudden turns, or veering off the intended course by evaluating acceleration data. This data enables the car to make the required modifications, guaranteeing a safe and comfortable drive.

## 2.6 Fuel Efficiency using ML

Using a fuel gauge system at the start and end of the vehicle's journey, we concentrate on optimizing fuel economy in the next step of our process. We harness the power of linear regression analysis to produce a best-fit graph using past data from the car. By considering past vehicle performance data, such as speed, acceleration, and topography, this graph is an essential tool for estimating the minimal fuel consumption. Given that it allows us to model the relationship between these variables and fuel usage, linear regression is particularly important in this situation. We may plan routes and develop driving techniques in an informed manner by utilizing this data-driven method, therebyreducing fuel usage. This not only increases the autonomous vehicle system's commercialviability but also promotes resource efficiency and environmental sustainability by lowering carbon emissions.

## 2.7 V2V Communication

In the following step of our process, we create a cloud network where all vehicles within the autonomous fleet connect and share essential data to construct a thorough V2V (Vehicle-to-Vehicle) communication system[11]. This network of interconnected systems creates a real-time data exchange platform that is essential to avoiding collisions and maximizing fuel efficiency. Vehicles exchange data about fuel consumption patterns in addition to information about their positions, speeds, trajectories, and potential risks. Using a comprehensive strategy, cars can avoid crashes, assure safe navigation, and cooperate to reduce fuel consumption. We improve safety and environmental sustainability by integrating collision avoidance and fuel efficiency concerns in this V2V communication system, leading to a more responsible and effective fleet of autonomous vehicles.

## 2.8 Traffic Signal and Sign Board Detection

An essential component of autonomous cars is the classification and recognition of traffic signals and signage. The frequency of accidents globally can be decreased by utilizing intelligent technology to automatically recognize these traffic signals [12]. To ensure traffic flow is safe, the government has set several regulations. Roadside traffic signs must be observed to prevent accidents, and an autonomous vehicle must recognize and understand them while operating. In this study, traffic signals and signs are classified using an artificial neural network that was trained using real-time information. Traffic sign recognition is accomplished in two steps: detection and categorization. While detection locates or detects traffic signs inside a bounding box of a certain category, classification categorizes them by assigning a class label to an image that indicates the type of sign that is present. As seen in "Fig.15," the pictures of the road signs are transformed into grayscale, and then these grayscale images are filtered using streamlined gabour wavelets. The maximum stable External regions approach is used to extract the region of interest and support vector machines are then used to classify it. Convolution neural networks are then used to identify the signs, and a color-based segmentation model is used to remove or clip the specific signs from the boardsas a process shown in“Figure 15”and“Figure 16“.


**Figure 15.** Image before pre-processing

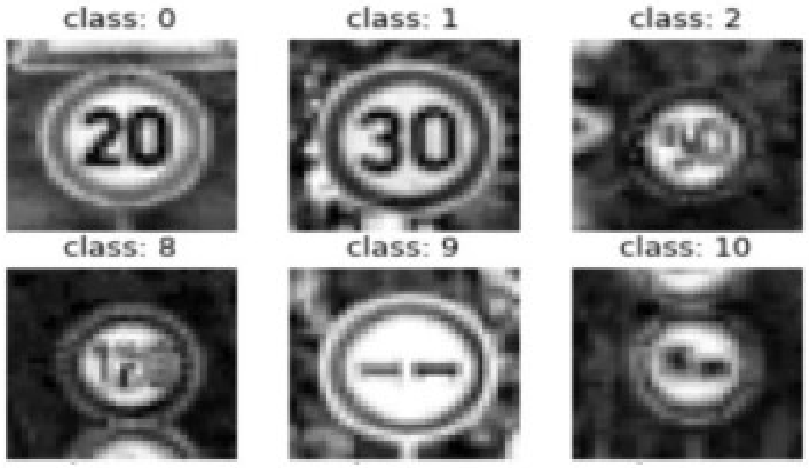


**Figure 16.** Grey Scaled image.

Faster RCNN (Region-based convolution neural network) InceptionV2 model with transfer learning is employed for reliable recognition and detection of traffic lights. Transfer learning is a method in machine learning where a learning model that has already been trained and its information are applied to a separate but related learning problem. For instance, a model that has been pre-trained to anticipate a picture of vehicles may be used for the task of identifying trucks.

**Figure 17.** Traffic Light Images before classification


Figure 18.Image after classification

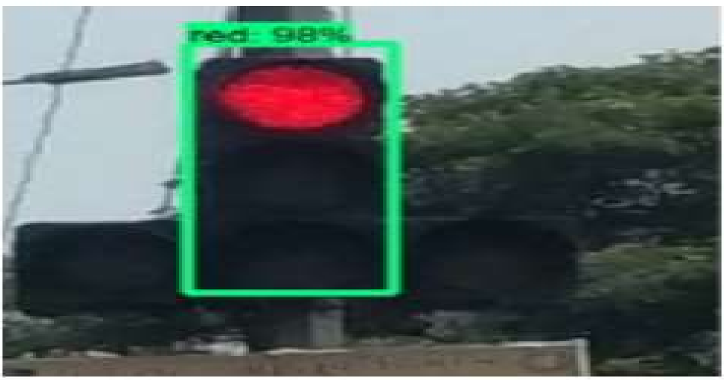


**Figure** 19.Image classified as red light

Images of Indian traffic lights are gathered and pre-processed to create an accurate dataset for training the CNN model. The CNN model is trained for a long period of time after gathering the training datasets. The model is verified with testing datasets after a short period of training, at which point it robustly identifies traffic lights and classifies them according to their kind by assigning a class label as illustrated in “Figure 17”,"Figure 18" and "Figure 19".

# 3 Results

## 3.1 Equations

It is essential for the proper functioning of autonomous cars to comprehend and make use of basic equations like Ohm's law (V = I * R) and power calculation (P = V * I). To perform functions like motor control and power management, it is crucial to understand the connections between voltage (V), current (I), and resistance (R) in various electrical components. Encoder feedback is also essential for properly tracking the movement of the vehicle in the context of autonomous vehicle systems. The angular displacement of wheels or motors in degrees may be calculated using the encoder angle formula (Angle = 360 / Number of Signals), where the number of signals in our example is 10. For navigation and control, this information is crucial. Additionally, we use the distance calculation formula (Distance = (Angle in degrees / 360)* 2* * r), where 'r' stands for the wheel's radius, to determine how far the vehicle has moved. Collectively, these equations support autonomous vehicles' fundamental abilities to navigate, reason, and assure exact movement, eventually boosting their safety and effectiveness.

# 4 Result and Future Work

YOLOv8 has proven to perform better than its predecessors in our comprehensive testing, obtaining an astounding FPS rate of 60, an exceptional mAP score of 0.75, and an amazing inference time of just 15 ms. Due to its excellent performance and smooth integration with Arduino's energy-efficient control and data-gathering features, our system is now a very competitive option for a variety of applications, particularly in the field of autonomous cars. Looking ahead, our efforts will be concentrated on improving item detection accuracy, further tailoring the system for resource-restricted settings, and investigating cutting-edge machine learning methods as well as sensor fusion strategies. By improving the accuracy and security of autonomous cars, these initiatives hope to pave the door for increasingly safer and more effective transportation systems.

# 5 Conclusion

This article introduces a reliable and effective autonomous car system that smoothly combines Raspberry Pi and Arduino, utilizing each platform's advantages to provide intelligent real-time judgments. With the help of an IR encoder for accurate data gathering, we have developed cutting-edge power management techniques using Arduino, such as voltage monitoring and linear regression-based energy management. With the Raspberry Pi acting as the main processing unit, computer vision functions including object detection, lane detection, and traffic signal recognition are performed using YOLOv8 and OpenCV. The system includes GPS connectivity for position data and contact with car owners for timely repair and issue identification, in addition to ensuring safety and energy economy. Our approach illustrates the successful fusion of hardware and software elements, producing a potent autonomous vehicle system capable of successfully traversing its environment.

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