

Smart Solar Vehicle Using AI and Ultrasonic Sensors

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ABSTRACT

The growing demand for sustainable and intelligent transportation solutions has led to the integration of renewable energy and advanced sensor technologies in modern vehicle design. This project presents the development of an AI-based solar-powered vehicle equipped with ultrasonic sensors, aiming to reduce carbon emissions and enhance autonomous navigation capabilities. The vehicle harnesses solar energy through photovoltaic panels to power an electric motor, offering an eco-friendly alternative to conventional fossil fuel-based systems. Artificial Intelligence algorithms are employed to manage energy consumption efficiently and support semi-autonomous decision-making, such as obstacle avoidance and path optimization. Ultrasonic sensors provide real-time distance measurements, enabling the vehicle to detect and respond to obstacles in its environment, improving safety and navigation accuracy. The fusion of solar energy, AI, and sensor-based technologies demonstrates a promising approach for next-generation smart transportation systems.

Keyword: Solar Plate, Battery, Wheels, Ultrasonic Sensors, Motor Driver, Microcontroller Unit (MCU)

1. INTRODUCTION

An AI-based solar-powered vehicle equipped with ultrasonic sensors represents a promising advancement in autonomous mobility and sustainable transportation. This system leverages renewable energy sources, incorporates intelligent decision-making through AI, and utilizes ultrasonic sensors for real-time obstacle detection and navigation, creating a safer and more efficient vehicle.

Simultaneously, artificial intelligence (AI) has emerged as a transformative technology capable of revolutionizing automation, decision-making, and real-time control systems. Integrating AI into solar vehicles enhances their capabilities, enabling autonomous navigation and intelligent obstacle detection without human intervention. One of the key technologies facilitating this autonomy is the use of ultrasonic sensors, which allow the vehicle to perceive its surroundings and avoid collisions in dynamic environments.

2. LITERATURE REVIEW

S. R. Boselin Prabhu [1] developed a solar-powered electric vehicle system, highlighting solar charging efficiency and battery management. Though it addressed energy sustainability, it lacked advanced control mechanisms for autonomous driving or navigation

Tiwari and Sodha (2012) [2] highlighted the role of Maximum Power Point Tracking (MPPT) algorithms in optimizing solar energy extraction under varying conditions.

Singh and Verma [3] (2019) demonstrated the effectiveness of combining ultrasonic data with AI algorithms (like fuzzy logic) for real-time path planning in crowded environments.

Kritayakirana and Gerdes (2012) [4] showed that AI controllers can significantly enhance the path-following accuracy of autonomous vehicles.

3. MAJOR COMPONENT USED

3.1 MCU Controller :

The Microcontroller Unit (MCU) is the central element of the proposed AI-based solar-powered vehicle, acting as the brain of the entire system. It handles input from multiple sensors, performs AI computations, manages energy utilization, and outputs control signals to actuators such as motors. The selection of the MCU is crucial due to the need for low power consumption, adequate computational capability, and support for sensor interfacing and communication.



Fig : 3.1 MCU Controller

3.2 Ultrasonic Sensor :

Ultrasonic sensors are non-contact proximity sensors that utilize sound waves above the range of human hearing (typically 40 kHz) to detect objects and measure distances. In autonomous systems, these sensors provide essential data for real-time obstacle detection, collision avoidance, and environmental mapping. Ultrasonic sensors play a critical role in enabling obstacle detection and collision avoidance in autonomous vehicles. In this project, HC-SR04 ultrasonic sensors are employed due to their affordability, reliability, and compatibility with microcontrollers like the ESP32.



Fig : 3.2 Ultrasonic Sensor

3.3 Geared DC Motors

Geared DC Motors are electric motors that incorporate a gear reduction system to adjust their speed and torque characteristics. They're widely used in systems that require more torque at lower speeds than what a standard DC motor can provide.



Fig : 3.3 Geared DC Motors

3.4 Solar Panel :

A solar panel is a device that transforms sunlight into electrical energy through the photovoltaic effect. It consists of numerous solar cells, typically made of silicon, which capture sunlight and produce direct current (DC) electricity. This generated energy can be utilized right away, stored in batteries, or converted into alternating current (AC) with the help of an inverter for use in homes, businesses, or to contribute to the electrical grid. Solar panels are

commonly adopted as they provide that helps to decrease greenhouse fossil fuels.

a clean, renewable energy source gas emissions and reliance on



Fig : 3.4 Solar Panel

3.5 Motor Driver IC :

A Motor Driver IC (Integrated Circuit) is an electronic component that controls and drives the operation of motors, especially DC and stepper motors, in electronic circuits. It acts as an interface between low-power control signals (from a microcontroller or microprocessor) and the higher power needed to drive motors. Since microcontrollers typically cannot supply enough current or voltage to power a motor directly, the motor driver IC boosts the signal and controls the direction and speed of the motor. Most motor driver ICs, like the popular L293D or L298N, can control two motors independently and support functions like forward, reverse, stop, and speed control using pulse-width modulation (PWM). These ICs are essential in robotics, automation systems, and DIY electronics, where precise and safe motor control is required.



Fig : 3.4 Motor Driver IC

3.6 Battery

A six 2-volt battery system refers to a setup where six individual 2V cells are connected in series to produce a total voltage of 12 volts ($6 \times 2V = 12V$). Each of these 2V cells is typically a lead-acid type, most commonly used in industrial applications like solar power systems, forklifts, and backup power systems. These cells are larger and heavier than the individual cells found in a standard 12V car battery, but they offer higher durability, deeper discharge capability, and longer cycle life. Using six 2V batteries instead of a single 12V unit allows for better maintenance and flexibility in large-scale energy storage systems. Users can replace or maintain individual cells more easily and often benefit from increased energy efficiency. This setup is especially popular in off-grid solar setups and telecom power backup systems, where reliability and long-term performance are critical.



Fig : 3.6 Battery

4. SAMPLE ARDUINO CODE SNIPPET:

```
#define ENA 5
#define ENB 6
#define IN1 7
#define IN2 8
#define IN3 9
#define IN4 10
#define IR_RIGHT 2
#define IR_LEFT 3
#define IR_FRONT 4
#define LED1 12
#define LED2 13
#include <SoftwareSerial.h>
SoftwareSerial BT(0, 1); // RX, TX for HC-05
unsigned long previousMillisLED1 = 0;
unsigned long previousMillisLED2 = 0;
const long blinkInterval = 500;
void setup() {
  pinMode(ENA, OUTPUT);
  pinMode(ENB, OUTPUT);
  pinMode(IN1, OUTPUT);
  pinMode(IN2, OUTPUT);
  pinMode(IN3, OUTPUT);
  pinMode(IN4, OUTPUT);
  pinMode(IR_RIGHT, INPUT);
  pinMode(IR_LEFT, INPUT);
  pinMode(IR_FRONT, INPUT);
  pinMode(LED1, OUTPUT);
  pinMode(LED2, OUTPUT);
  BT.begin(9600);
}
void loop() {
  if (BT.available()) {
    char command = BT.read();
    executeCommand(command);
  }
}
```

```
if (digitalRead(IR_RIGHT) == LOW) {
    blinkLED(LED2, &previousMillisLED2);
}
if (digitalRead(IR_LEFT) == LOW) {
    blinkLED(LED1, &previousMillisLED1);
}
if (digitalRead(IR_FRONT) == LOW) {
    handleObstacle();
}
}
void executeCommand(char command) {
    switch (command) {
        case 'F': moveForward(); break;
        case 'B': moveBackward(); break;
        case 'L': turnLeft(); break;
        case 'R': turnRight(); break;
        case 'S': stopCar(); break;
    }
}
void moveForward() {
    digitalWrite(IN1, HIGH);
    digitalWrite(IN2, LOW);
    digitalWrite(IN3, HIGH);
    digitalWrite(IN4, LOW);
    analogWrite(ENA, 150);
    analogWrite(ENB, 150);
}
void moveBackward() {
    digitalWrite(IN1, LOW);
    digitalWrite(IN2, HIGH);
    digitalWrite(IN3, LOW);
    digitalWrite(IN4, HIGH);
    analogWrite(ENA, 150);
    analogWrite(ENB, 150);
}
void turnLeft() {
    digitalWrite(IN1, LOW);
    digitalWrite(IN2, HIGH);
    digitalWrite(IN3, HIGH);
    digitalWrite(IN4, LOW);
    delay(500);
    stopCar();
}
void turnRight() {
    digitalWrite(IN1, HIGH);
    digitalWrite(IN2, LOW);
    digitalWrite(IN3, LOW);
    digitalWrite(IN4, HIGH);
    delay(500);
    stopCar();
}
void stopCar() {
    digitalWrite(IN1, LOW);
    digitalWrite(IN2, LOW);
    digitalWrite(IN3, LOW);
    digitalWrite(IN4, LOW);
}
```

```
}  
void blinkLED(int ledPin, unsigned long *previousMillis) {  
    unsigned long currentMillis = millis();  
    if (currentMillis - *previousMillis >= blinkInterval) {  
        *previousMillis = currentMillis;  
        digitalWrite(ledPin, !digitalRead(ledPin));  
    }  
}  
  
void handleObstacle() {  
    stopCar();  
    delay(500);  
    turnRight();  
    delay(500);  
    moveForward();  
    delay(500);  
    if (digitalRead(IR_FRONT) == HIGH) {  
        turnLeft();  
        delay(5000);  
        moveForward();  
        delay(5000);  
        turnLeft();  
        delay(5000);  
        moveForward();  
        delay(5000);  
        turnRight();  
        delay(5000);  
        moveForward();  
        delay(5000);  
    }  
    stopCar();  
}
```

5. CONCLUSIONS

The development of an AI-based solar-powered vehicle integrated with ultrasonic sensors showcases the fusion of renewable energy, intelligent control, and advanced sensing technologies to create a smart and sustainable mobility solution. The use of solar panels enables clean, self-sustaining power generation, reducing reliance on fossil fuels and minimizing environmental impact. Meanwhile, the inclusion of ultrasonic sensors allows the vehicle to detect and avoid obstacles, contributing to autonomous navigation and enhanced safety.

The solar-powered system not only ensures energy efficiency but also offers a renewable and cost-effective solution to traditional fuel-based vehicles. Artificial intelligence, implemented through microcontrollers and smart algorithms, enables real-time decision-making, path planning, and adaptability to various operating conditions. Meanwhile, the use of ultrasonic sensors provides a reliable method for detecting obstacles and preventing collisions, making the vehicle safer for autonomous navigation.

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6. REFERENCES

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