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Solar-Powered Obstacle Avoiding Car: Design and Implementation

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ABSTRACT

The constant increase in world population has led to a rise in demand for transportation, mainly automobiles. However, this has led to an increase in pollution, which is harmful to the environment. To cater to society's needs while protecting the environment, researchers have been seeking alternative sources of energy to power transportation. Solar energy is a sustainable option that can power automobiles through the use of photovoltaic cells, producing no harmful waste. To develop solar cars, advancements have been made in capturing, converting, and storing solar energy to make it competitive with conventional fossil fuel vehicles. This article provides a review of the current state of research on solar cars, highlighting advancements and gaps in the literature.

Index Terms— Solar energy, Photovoltaic cells, Electric vehicles, Sustainable transportation, Renewable energy, Charging infrastructure, Carbon emissions, Vehicle efficiency.

1. INTRODUCTION

The project is a solar-powered car that is designed to navigate its environment and avoid obstacles. It utilizes multiple solar panels to charge battery, and an Arduino Uno microcontroller to control its movements. The car is equipped with a sonar sensor that enables it to detect objects in its path and adjust its course accordingly.

This project is an excellent example of how renewable energy sources such as solar power can be utilized in everyday applications. With the increasing concern over the depletion of non-renewable resources and their impact on the environment, renewable energy sources have become a popular alternative. Solar power is one such source that has gained widespread recognition due to its numerous benefits, such as its ability to reduce energy costs and its low impact on the environment.

By integrating solar power into the design of the car, the project demonstrates how it is possible to harness this energy source to power everyday devices. Additionally, by incorporating a sonar sensor, the car is able to navigate its surroundings and avoid obstacles, which could have numerous practical applications in fields such as robotics and autonomous vehicles.

2. HISTORY OF SOLAR VEHICLES

Solar vehicles have a long history that dates back to the 19th century. In 1839, French physicist Alexandre Edmond Becquerel discovered the photovoltaic effect, which is the conversion of light into electricity. However, it was not until the 1950s that practical solar cells were developed. In the 1960s, solar-powered devices such as calculators and watches became popular, and the use of solar cells in space applications began. In 1977, the first solar-powered car, called the "Bluebird," was built by Dr. Paul MacCready's AeroVironment team. Since then, there have been many advancements in solar vehicle technology, including the development of solar-powered boats, airplanes, and even a solar-powered plane that flew around the world. Today, solar vehicles are becoming more popular as people look for ways to reduce their carbon footprint and rely on renewable energy sources. However, they still face challenges such as limited energy storage capacity and the need for more efficient solar cells.

3. RELATED WORK

There has been a significant amount of research and development in the field of solar-powered vehicles in recent years. Many universities and companies have undertaken projects to design and build solar cars, with the goal of promoting sustainable transportation and reducing dependence on fossil fuels.

In addition to solar cars, there have also been developments in other types of solar-powered vehicles, such as bicycles and boats. These vehicles typically use lightweight materials and highly efficient solar panels to maximize performance and reduce energy consumption.

Overall, the continued development of solar-powered vehicles represents a promising direction for sustainable transportation and renewable energy research.

4. METHODOLOGY

4.1. Component Selection:

The selected components included solar panels, a battery charger (TP4056), batteries, a boost converter, an Arduino Uno, and a sonar sensor.

4.2. Assembly and Wiring:

Once the necessary components were identified, we assembled the car chassis. We then wired the components together following diagrams, ensuring that all connections were properly made.

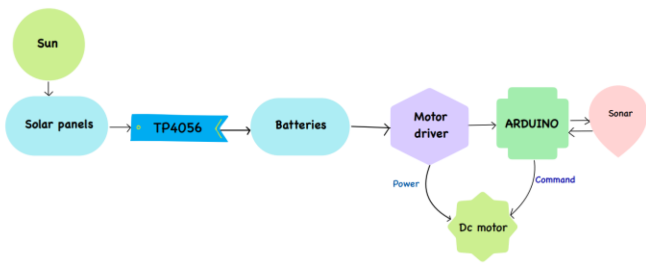

Figure 1: Block Diagram

4.3. Power Requirements:

To ensure that the solar-powered car would function properly, we conducted a series of tests to determine the power requirements of both the components and the solar panels. In order to measure the voltage and current of the solar panels and battery, we used a multi-meter, which allowed us to accurately assess their performance. This process was crucial to ensure that the car would have the necessary power to run on solar energy, and to identify any potential issues that might have arisen during testing. By measuring and monitoring the performance of the solar panels and battery, we were able to ensure that the car would operate efficiently and reliably.

4.4. Battery Charging:

Despite our initial attempts to power the car directly from the solar panels, we discovered that the installed solar panels were not able to meet the power demands of the car. Therefore, we made the decision to charge the batteries using the solar panels, and then use the charged batteries to power the car. This approach allowed us to effectively harness the power of the sun to keep the car running without experiencing any power-related issues. As the solar panels did not meet the power requirements to directly power the car, the batteries were charged using the TP4056 battery charger from solar panel, which supplies a constant-current/constant-voltage principle. The TP4056 has several advantages, including a small package size, low external component count, no blocking diode required, and thermal feedback regulation.

5. HARDWARE & SOFTWARE DETAILS

ATmega328P microcontroller:

The ATmega microcontroller is a family of microcontrollers developed by Atmel Corporation (now a part of Microchip Technology). The ATmega microcontrollers are widely used in embedded systems and are particularly popular in the Arduino platform.

Figure 2: Arduino Uno Board

Arduino Uno is a popular microcontroller board based on the ATmega328P chip. It was introduced in 2010 and is designed to make it easy for hobbyists, artists, and designers to create interactive projects that incorporate sensors, motors, and other electronic components. The board features digital input/output pins, analog input pins, a USB connection for programming and power, and other features that make it easy to interface with a wide range of devices and components.

LC293D motor shield:

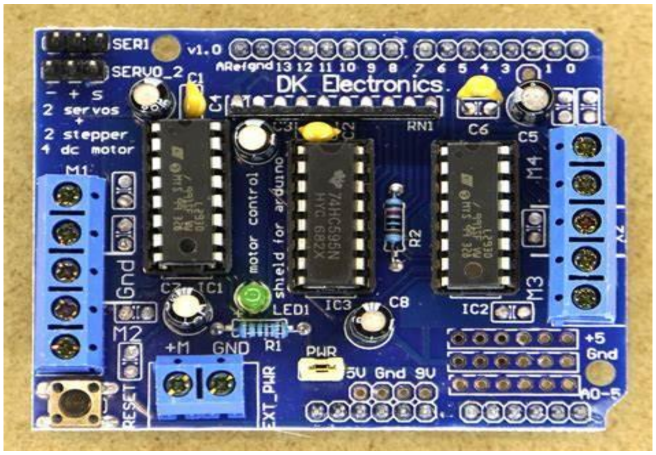

Figure 3: LC293D Motor shield

The L293D is a popular integrated circuit that can control up to two DC motors at the same time, or one stepper motor. It has two H-bridge channels, each capable of delivering up to 1A of current, and a total voltage supply range of 4.5-36V. The IC contains diodes to protect the circuit from inductive voltage spikes that occur when driving inductive loads, such as DC motors. The L293D is often used with an Arduino board to control the speed and direction of motors used in robotics and other projects. It can also be used to control other high current devices such as solenoids or relays. The L293D motor shield is a popular add-on board for the Arduino that includes the L293D IC, making it easy to interface with motors and other high current devices.

Sonar sensor:

Figure 4: Sonar Sensor

A sonar sensor is an electronic device that uses sound waves to detect objects and measure distances. It works by emitting a high-frequency sound wave and then measuring the time it takes for the wave to bounce back after hitting an object. The sensor then calculates the distance to the object based on the time it took for the sound wave to return. Sonar sensors are commonly used in robotics, autonomous vehicles, and underwater navigation systems. They are particularly useful for detecting objects in environments where other sensors, such as cameras, may not be effective, such as in low light or underwater conditions. Sonar sensors can also be used to create maps of environments by measuring the distances to multiple objects in different directions.

Servo motor:

Figure 5: Servo Motor

A sonar sensor is an electronic device that uses sound waves to detect objects and measure distances. It works by emitting a high-frequency sound wave and then measuring the time it takes for the wave to bounce back after hitting an object. The sensor then calculates the distance to the object based on the time it took for the sound wave to return. Sonar sensors are commonly used in robotics, autonomous vehicles, and underwater navigation systems. They are particularly useful for detecting objects in environments where other sensors, such as cameras, may not be effective, such as in low light or underwater conditions. Sonar sensors can also be used to create maps of environments by measuring the distances to multiple objects in different directions.

TP4056 battery charger:

The TP4056 is not a Maximum Power Point Tracking (MPPT) charger, it is a Simple Power Path Management (SPPT) charger. It does not actively track the maximum power point of the solar panel. Instead, it uses a constant current/constant voltage charging algorithm to charge the battery at a fixed voltage and adjustable current. The TP4056 can charge a single cell lithium-ion battery from sources such as USB or wall adapters, as well as from solar panels, as long as the input voltage is within its specified range.

Arduino IDE:

The Arduino project offers an integrated development environment (IDE) for programming microcontrollers, which uses the Processing programming language that supports C and C++. The Arduino IDE is open source and provides a simple way to write and upload code to the board.

6. RESULT AND ANALYSIS

The solar-powered obstacle-avoiding car was successfully tested in various environments and situations, demonstrating its ability to detect and avoid obstacles. Calibration tests ensured that the sonar sensor accurately detected obstacles, and the car's movements were smooth and precise. Performance evaluation showed that the car was efficient in terms of power consumption, speed, and distance traveled.

However, we encountered a challenge with the solar panels not fulfilling the power requirements needed to directly power the car. To address this issue, we used the solar panels to charge the batteries and then used the charged batteries to power the car. Total charging time was about 15 hours because the solar panel we used was low rated. We can improve the charging time by higher rated solar panel. Moreover, it may also power the car directly.

Overall, the solar-powered obstacle-avoiding car demonstrated the potential for alternative energy sources in the automobile industry, as well as the importance of proper power management and calibration testing for optimal performance. Further improvements could be made to enhance the car's power generation and storage capabilities, potentially leading to a more sustainable and eco-friendly transportation option.

7. APPLICATION

Solar vehicles have a wide range of potential applications, including transportation, military, and aerospace. In the transportation sector, solar vehicles can be used for personal transportation, public transportation, and even commercial transportation such as trucks and buses. Solar vehicles can also be used for military purposes, such as unmanned aerial vehicles (UAVs) and ground vehicles. In the aerospace industry, solar-powered airplanes and satellites are already in use. Solar vehicles have the potential to reduce dependence on fossil fuels, decrease emissions, and provide sustainable energy solutions. However, there are still technological and economic challenges that need to be addressed before solar vehicles can become mainstream.

8. Pictures of Final Implementation

Figure 6: Final Implementation

can help mitigate the negative impact of transportation on the environment.

Figure 7: Battery Charging by Solar Panel

8. CONSIDERATIONS TO PUBLIC HEALTH AND SAFETY

Considerations to public health and safety are important when designing and operating any form of transportation, including solar vehicles. Some potential safety concerns with solar vehicles include the risk of accidents due to limited visibility and speed, as well as the potential for battery-related fires or explosions. To mitigate these risks, designers and manufacturers of solar vehicles must ensure that the vehicles meet safety standards and regulations, such as those related to crash testing and battery safety. Additionally, solar vehicle operators must follow safe driving practices and be trained in handling the unique features of solar vehicles, such as their regenerative braking systems and battery charging protocols. Overall, ensuring the public health and safety of solar vehicles requires a comprehensive approach that involves collaboration between designers, manufacturers, regulators, and operators.

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9. CONSIDERATIONS TO ENVIRONMENT

The use of solar vehicles is considered environmentally friendly due to their ability to produce zero emissions during operation. Unlike conventional vehicles, solar vehicles do not emit harmful pollutants into the environment such as carbon monoxide, nitrogen oxides, and particulate matter, which contribute to air pollution and climate change. Additionally, the production of solar vehicles is less resource-intensive than that of traditional vehicles because they require fewer raw materials and less energy to manufacture. However, the disposal of solar panels at the end of their life cycle can be a concern as they contain toxic materials. To minimize the impact of solar panel waste on the environment, researchers are exploring ways to recycle and reuse these materials. Overall, the use of solar vehicles

10. FUTURE SCOPE

The future of solar vehicles looks promising as more research and development is being done to improve the efficiency, reliability, and cost-effectiveness of these vehicles. The use of lightweight materials, advanced battery technologies, and innovative design concepts are some areas where progress is being made. In addition, the integration of smart technologies such as artificial intelligence and internet of things (IoT) is expected to enhance the functionality and safety of solar vehicles. Furthermore, the deployment of charging infrastructure and the development of energy storage systems for solar power are expected to address some of the challenges associated with the adoption of solar vehicles. Also, image processing can be used to detect occlusion, which will increase the car's ability to detect and avoid obstacles in various lighting conditions and environments. This technology could be incorporated into future iterations of the solar-powered car to enhance its obstacle-avoidance capabilities. Additionally, improvements could be made to the car's solar panels to increase their power output and make it possible to power the car directly from the solar panels. Overall, the solar-powered obstacle-avoiding car shows promise as a sustainable and efficient mode of transportation, with potential for further development and improvement in the future. Overall, the future scope of solar vehicles is not limited to personal transportation but also includes public transportation, delivery services, and other commercial applications.

11. CONCLUSION

the development of solar cars has the potential to revolutionize the automobile industry by providing a sustainable and eco-friendly alternative to fossil fuel-powered vehicles. While there are still some limitations and challenges that need to be addressed, significant progress has been made in the development of solar cars, particularly in the areas of photovoltaic cell technology, energy storage, and power management systems. By continuing research and development in these areas, it is possible to improve the efficiency, performance, and reliability of solar cars, making them more competitive with conventional vehicles. It is important to note that the adoption of solar cars is not just an individual choice, but a collective responsibility towards the environment and future generations. Governments, industries, and individuals all have a role to play in promoting the use of renewable energy sources for transportation, and the development of solar cars can be a crucial step in achieving a sustainable future.

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Appendices:

```
#include <AFMotor.h>
#include <NewPing.h>
#include <Servo.h>

#define TRIG_PIN A4
#define ECHO_PIN A5
#define MAX_DISTANCE 200
#define MAX_SPEED 190 // sets speed of DC
 motors
#define MAX_SPEED_OFFSET 20

NewPing sonar(TRIG_PIN, ECHO_PIN,
MAX_DISTANCE);

AF_DCMotor motor1(1, MOTOR12_1KHZ);
AF_DCMotor motor2(3, MOTOR12_1KHZ);

Servo myservo;

boolean goesForward=false;
int distance = 100;
int speedSet = 0;

void setup() {

  myservo.attach(9);
  myservo.write(115);
  delay(2000);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
}

void loop() {
 int distanceR = 0;
 int distanceL =  0;
 delay(40);

 if(distance<=30)
 {
  moveStop();
  delay(100);
  moveBackward();
  delay(300);
  moveStop();
  delay(200);
  distanceR = lookRight();
  delay(200);
  distanceL = lookLeft();
  delay(200);

  if(distanceR>=distanceL)
  {
    turnRight();
    moveStop();
  }else
  {
    turnLeft();
    moveStop();
  }
 }else
 {
  moveForward();
 }
 distance = readPing();
}

int lookRight()
{
    myservo.write(50);
    delay(500);
    int distance = readPing();
    delay(100);
    myservo.write(115);
    return distance;
}

int lookLeft()
{
    myservo.write(170);
    delay(500);
    int distance = readPing();
```

```
    delay(100);
    myservo.write(115);
    return distance;
    delay(100);
}

int readPing() {
  delay(70);
  int cm = sonar.ping_cm();
  if(cm==0)
  {
    cm = 250;
  }
  return cm;
}

void moveStop() {
  motor1.run(RELEASE);
  motor2.run(RELEASE);
  }

void moveForward() {

 if(!goesForward)
  {
    goesForward=true;
    motor1.run(FORWARD);
    motor2.run(FORWARD);
   for (speedSet = 0; speedSet <
MAX_SPEED; speedSet +=2) // slowly bring
the speed up to avoid loading down the
batteries too quickly
   {
    motor1.setSpeed(speedSet);

motor2.setSpeed(speedSet+MAX_SPEED_OFFSET)
;
    delay(5);
   }
  }
}

void moveBackward() {
    goesForward=false;
    motor1.run(BACKWARD);
    motor2.run(BACKWARD);
  for (speedSet = 0; speedSet < MAX_SPEED;
speedSet +=2) // slowly bring the speed up
to avoid loading down the batteries too
quickly
  {
    motor1.setSpeed(speedSet);

motor2.setSpeed(speedSet+MAX_SPEED_OFFSET)
;
    delay(5);
  }
}

void turnRight() {
  motor1.run(FORWARD);
  motor2.run(BACKWARD);
  delay(300);
  motor1.run(FORWARD);
  motor2.run(FORWARD);
}

void turnLeft() {
  motor1.run(BACKWARD);
  motor2.run(FORWARD);
  delay(300);
  motor1.run(FORWARD);
  motor2.run(FORWARD);
}
```