Namal University

Mianwali

Department of Electrical Engineering

EE-252L: Introduction to Embedded Systems

Sumo War Robort

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Abstract[2]

This report presents a comprehensive analysis of the Arduino Uno Based Sumo Robot, developed as a course-end project for the Introduction to Embedded Systems course. The project encompasses the conceptualization, construction, and functional assessment of a sumo robot, with a primary focus on the utilization of the Arduino Uno microcontroller and a 14V power supply composed of four 3.5V cells, each with a capacity of 6500mAh. The development process explored key controlling factors such as torque and speed, which were critical in both the construction and testing phases. Using the L298N motor driver and four yellow gear motors, the robot achieved a maximum speed of approximately 1.19 meters per second. Additionally, the calculated torque at 14V was approximately 3.5 kg.cm. The robot's performance was rigorously evaluated, leading to insights that informed the optimization of its operational capabilities. The findings highlight the significance of embedded systems in robotics, demonstrating practical applications of theoretical principles learned during the course.

Acknowledgments

We would like to thank our course instructor Engineer Misbah Batool, Dr. Naureen Shaukat, for their guidance and support throughout this project. Special thanks to Namal University for providing the resources and facilities necessary for the successful completion of this project.

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I. Introduction[1]

The field of embedded systems offers a vast array of applications, particularly in robotics, where the integration of hardware and software is pivotal. This report details the development of an Arduino Uno Based Sumo Robot, a course-end project for the Introduction to Embedded Systems course. The project aimed to provide hands-on experience in designing, constructing, and optimizing a functional robot, emphasizing the practical application of theoretical concepts covered during the course.

The sumo robot, inspired by traditional sumo wrestling, is designed to push its opponent out of a circular ring. The foundation of this robot is the Arduino Uno microcontroller, chosen for its versatility, ease of use, and extensive community support. Powering the robot is a 14V power supply, configured using four 3.5V cells each with a capacity of 6500mAh, ensuring sufficient power for operation.

Key aspects of the project include exploring and balancing critical factors such as torque and speed. These factors are crucial for the robot's performance, as higher torque provides better pushing power, while higher speed enables quicker movements and reactions. The L298N motor driver was selected to control the four yellow gear motors, a choice driven by its compatibility with the Arduino platform and its ability to handle the required voltage and current.

During the construction phase, various challenges were encountered, including the selection of appropriate components, mechanical assembly, and ensuring reliable electrical connections. In the testing phase, the robot's performance was evaluated based on its speed and torque. The robot achieved a maximum speed of approximately 1.19 meters per second, and the calculated torque at 14V was approximately 3.5 kg.cm, demonstrating its capability to perform the intended tasks effectively.

This report provides a detailed analysis of the idea, construction, working, and results of the robot, offering insights into the practical applications of embedded systems in robotics. The findings and experiences from this project underline the importance of a systematic approach to embedded system design and highlight the potential for future developments in this field.

II. System Design and Architecture

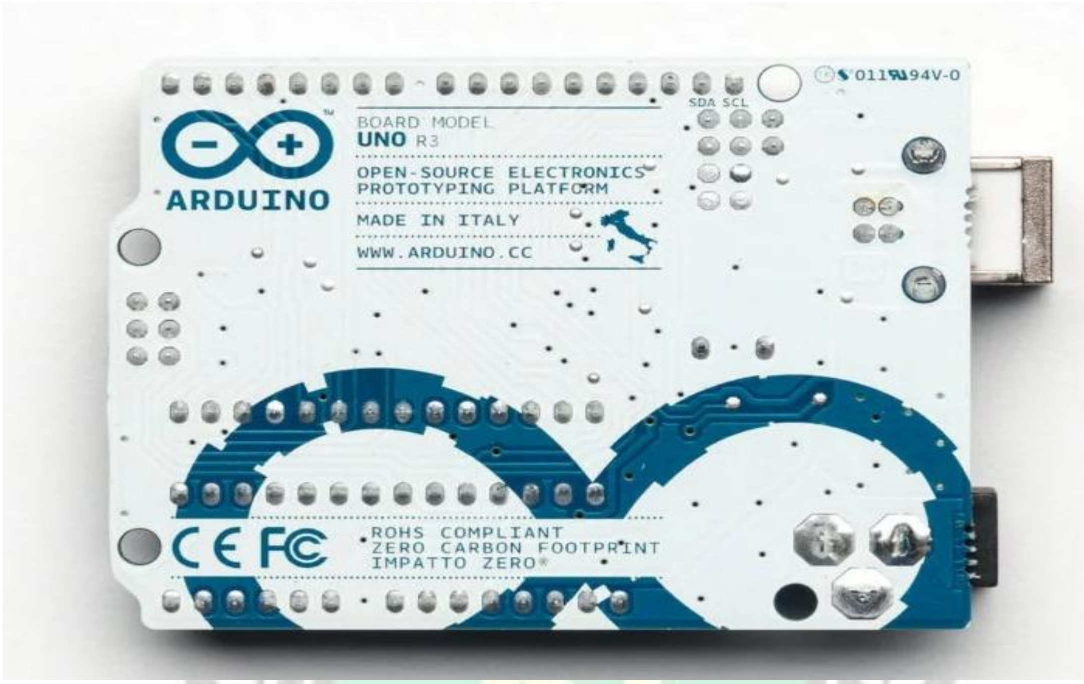
A. Overview:

The system architecture of the sumo robot is centered around the Arduino Uno microcontroller, which serves as the brain of the robot, coordinating various components and processing sensor inputs to control the motors effectively.

B. Components:

1. Arduino Uno: The microcontroller platform used for its simplicity and support.

Component Picture:

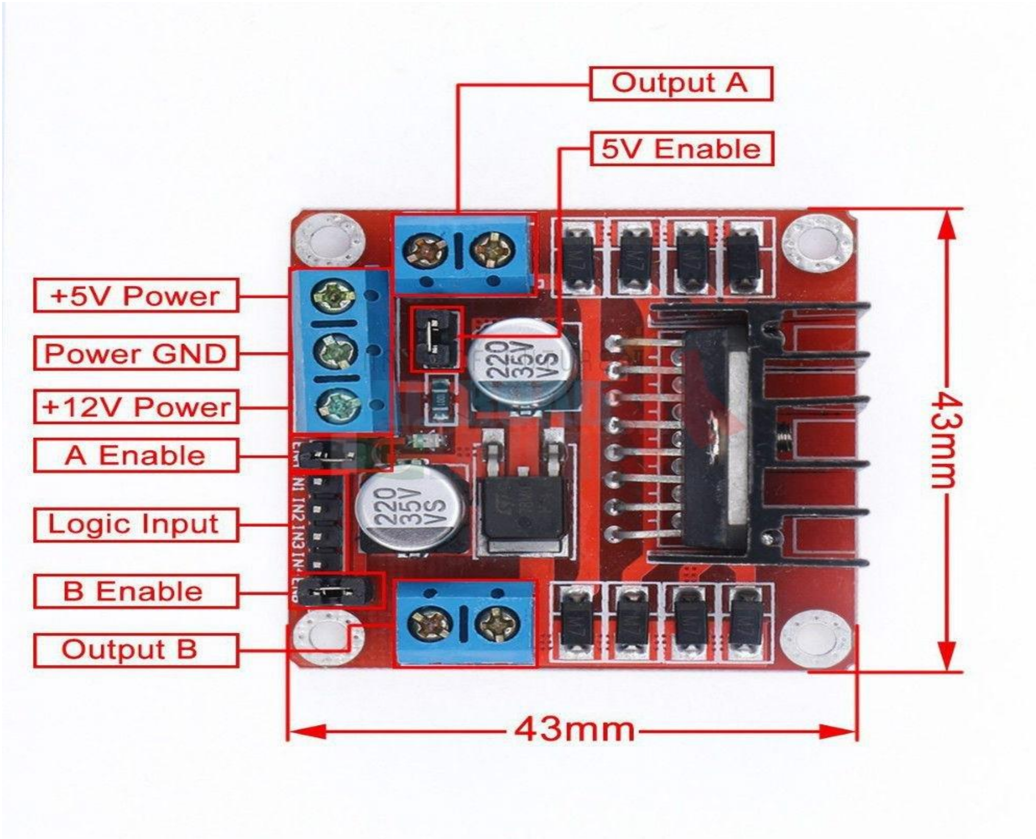


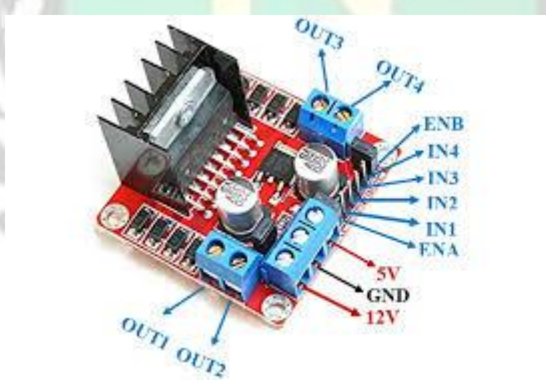
2. Power Supply: Four 3.5V cells, each with 6500mAh capacity, providing a total of 14V.

Component Picture:

3. L298N Motor Driver: Selected for its ability to handle up to 35V and control two DC motors simultaneously.

Component Picture:



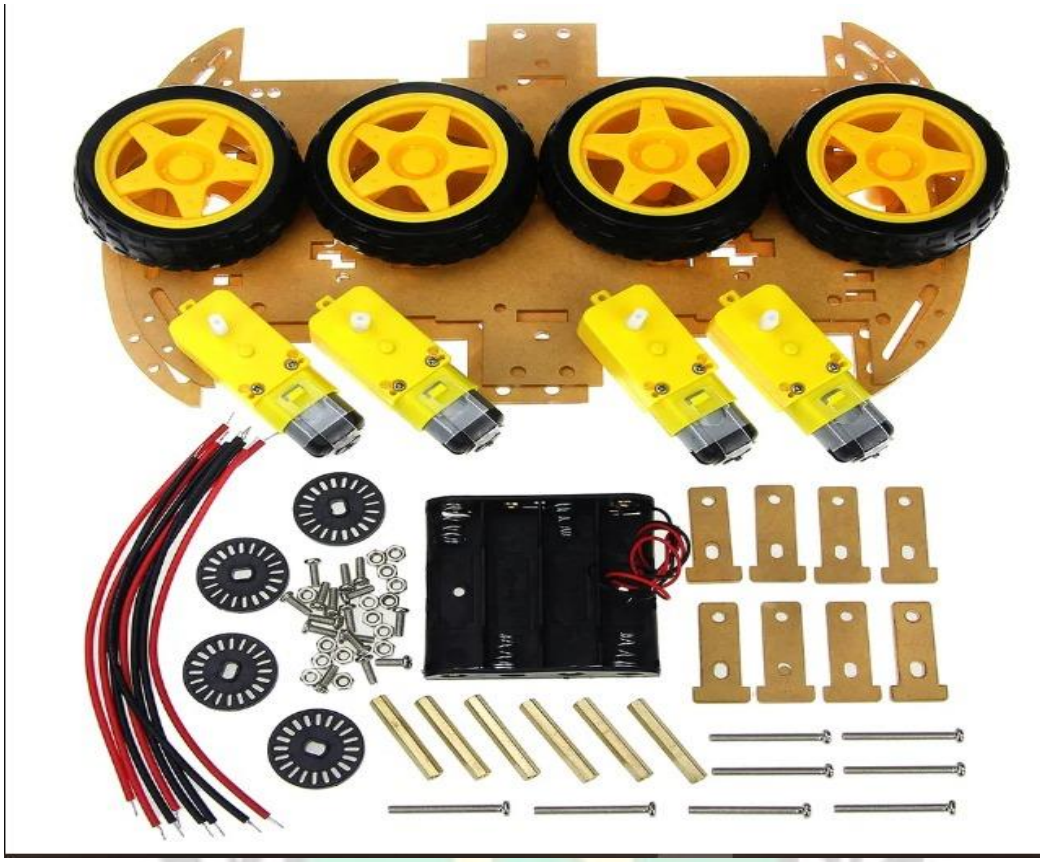


4. Yellow Gear Motors: Four motors, each rated at 6V, capable of achieving up to 200 RPM with a stall torque of 1.5 kg.cm at 6V.

Component Picture:

5. Chassis and Wheels: The physical structure and mobility components of the robot.

Component Picture:



C. Power Management

The power management system ensures that the voltage and current supplied to the motors and the microcontroller are within safe operating limits. The 14V supply is managed to prevent over-voltage conditions that could damage the motors or the driver.

III. Construction and Assembly[3]

A. Mechanical Assembly

The mechanical assembly involved constructing the chassis to house all components securely. The design had to balance stability and agility, crucial for sumo robot competitions.

Description **Specification**

Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz

B. Electrical Connections

The electrical connections included wiring the power supply to the L298N motor driver and connecting the motors to the driver outputs. The Arduino Uno was interfaced with the motor driver and sensors using appropriate jumper wires and connectors.

C. Software Development

The software development involved programming the Arduino Uno to process sensor inputs and control the motors. The primary functions included:

1. **Edge Detection:** Using sensors to detect the edge of the ring and prevent the robot from driving out of bounds.

2. **Opponent Detection:** Identifying the opponent robot and strategizing movements to push it out of the ring.

3. **Motor Control:** Managing motor speed and direction based on sensor inputs and programmed strategies.

Here is the Source Code Which Smoothen our sumo war robot functionality:

Source Code[4]

```
// Motor control pins
int enA = 5; // PWM pin for motor 1 speed control (ENA)
int in1 = 2; // Motor 1 direction control (IN1)
int in2 = 3; // Motor 1 direction control (IN2)
int enB = 6; // PWM pin for motor 2 speed control (ENB)
int in3 = 4; // Motor 2 direction control (IN3)
int in4 = 7; // Motor 2 direction control (IN4)
char command = 0;
void setup() {
  // Set motor control pins as OUTPUT
  pinMode(enA, OUTPUT);
  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);
  pinMode(enB, OUTPUT);
  pinMode(in3, OUTPUT);
  pinMode(in4, OUTPUT);
  // Initialize serial communication
  Serial.begin(9600);
}
void loop() {
  if (Serial.available() > 0) {
    command = Serial.read();
    Serial.print(command);

    // Motor control based on received command
    if (command == 'B') {
      digitalWrite(in1, HIGH);
      digitalWrite(in2, LOW);
      analogWrite(enA, 255); // Full speed (255)
      digitalWrite(in3, HIGH);
      digitalWrite(in4, LOW);
      analogWrite(enB, 255); // Full speed (255)
    } else if (command == 'F') {
      digitalWrite(in1, LOW);
      digitalWrite(in2, HIGH);
      analogWrite(enA, 255); // Full speed (255)
      digitalWrite(in3, LOW);
      digitalWrite(in4, HIGH);
      analogWrite(enB, 255); // Full speed (255)
```

```
    } else if (command == 'L') {
      digitalWrite(in1, LOW);
      digitalWrite(in2, HIGH);
      analogWrite(enA, 255); // Adjust speed as needed
      digitalWrite(in3, HIGH);
      digitalWrite(in4, LOW);
      analogWrite(enB, 255); // Adjust speed as needed
    } else if (command == 'R') {
      digitalWrite(in1, HIGH);
      digitalWrite(in2, LOW);
      analogWrite(enA, 255); // Adjust speed as needed
      digitalWrite(in3, LOW);
      digitalWrite(in4, HIGH);
      analogWrite(enB, 255); // Adjust speed as needed
    } else if (command == 'H') {
      digitalWrite(in1, HIGH);
      digitalWrite(in2, LOW);
      analogWrite(enA, 255); // Full speed (255) forward
      digitalWrite(in3, HIGH);
      digitalWrite(in4, LOW);
      analogWrite(enB, 40); // Adjust speed as needed for diagonal movement
    } else if (command == 'J') {
      digitalWrite(in1, HIGH);
      digitalWrite(in2, LOW);
      analogWrite(enA, 40); // Adjust speed as needed for diagonal movement
      digitalWrite(in3, HIGH);
      digitalWrite(in4, LOW);
      analogWrite(enB, 255); // Full speed (255) forward
    } else if (command == 'I') {
      digitalWrite(in1, LOW);
      digitalWrite(in2, HIGH);
      analogWrite(enA, 40); // Adjust speed as needed for diagonal movement
      digitalWrite(in3, LOW);
      digitalWrite(in4, HIGH);
      analogWrite(enB, 255); // Full speed (255) backward
    } else if (command == 'G') {
      // Move backward-right (one motor backward but slower, one motor
backward)
      digitalWrite(in1, LOW);
      digitalWrite(in2, HIGH);
      analogWrite(enA, 255); // Full speed (255) backward
      digitalWrite(in3, LOW);
      digitalWrite(in4, HIGH);
      analogWrite(enB, 40); // Adjust speed as needed for diagonal movement
    } else if (command == 'S') {
```

```
        // Stop
        digitalWrite(in1, LOW);
        digitalWrite(in2, LOW);
        analogWrite(enA, 0); // Stop motor 1
        digitalWrite(in3, LOW);
        digitalWrite(in4, LOW);
        analogWrite(enB, 0); // Stop motor 2
      }
    }
  }
```

IV. Testing and Results

A. Performance Metrics

The performance of the robot was evaluated based on speed, torque, and operational effectiveness in a sumo match.

B. Speed Testing

The robot achieved a maximum speed of approximately 1.19 meters per second under no-load conditions, verified through experimental trials.

C. Torque Calculation

The torque at 14V was calculated to be approximately 3.5 kg.cm, sufficient for the pushing power required in sumo matches.

D. Operational Testing

Operational testing involved real-world scenarios in a sumo ring, where the robot's ability to detect the edge and opponent, as well as its pushing power, were rigorously evaluated.

V. Discussion

A. Challenges and Solutions[5]

Several challenges were encountered during the project, including power management, motor control, and sensor integration. These were addressed through iterative testing and refinement of both hardware and software components. The major issue faced was the early discharge of batteries and cells. This problem significantly impacted the project's efficiency and reliability, as it limited the operational time and required frequent recharging or replacement of power sources.

B. Insights and Learnings

The project provided valuable insights into embedded systems design, emphasizing the importance of a holistic approach that integrates mechanical, electrical, and software engineering principles.

C. Future Work

Future work could involve enhancing the robot's intelligence with advanced sensors and algorithms, improving its agility and decision-making capabilities in sumo matches.

VI. Conclusion

The Arduino Uno Based Sumo Robot project successfully demonstrated the practical applications of embedded systems in robotics. Through systematic design, construction, and testing, the robot achieved its performance goals, highlighting the importance of integrated system design and optimization. The experiences and findings from this project underscore the potential for further advancements in embedded systems and robotics.

References

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