Arduino-Based 2WD Sumo Tankbot with Scraper

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***Abstract*—In recent years, the field of robotics has witnessed significant advancements, enabling the development of autonomous systems that can tackle various challenges. This paper presents an Arduino-based 2WD Sumo Tankbot equipped with a scraper, designed to compete in Sumo robotics competitions. The robot incorporates an HC-05 Bluetooth module and an Android mobile application for seamless wireless control. Its key components include two high-torque 6V DC motors, a sturdy aluminum tank chassis, a precision-cut galvanized steel scraper, an Arduino UNO R3 microcontroller, and an L298N motor driver. The integration of these components forms a robust and agile robotic platform capable of executing precise movements and strategies in Sumo battles. This paper outlines the design, construction, and implementation of the Arduino-based 2WD Sumo Tankbot, highlighting its mechanical, electrical, and software aspects, as well as discussing the potential applications and future developments of such a versatile robotic system.**

***Keywords*—Arduino, Bluetooth, Wireless, Sumobot, Tankbot**

I. DESIGN BACKGROUND AND INTROCUTION

In today's rapidly advancing field of robotics, there is a growing need for robust systems that can tackle various challenges. This research aims to address the challenges in design Sumo robotics competitions by developing an Arduino-based 2WD Sumo Tankbot. This study asserts that through the utilization of this robot, equipped with a scraper and controlled wirelessly via an Android mobile application, an agile and robust robotic platform can be achieved, capable of executing precise movements and strategies in Sumo battles.

A. Target Customers

The Arduino-based 2WD Sumo Tankbot with Scraper presented in this paper caters to a diverse range of target customers within the robotics industry. Aspiring electronics and mechanical engineering students, as well as prototyping enthusiasts, will find this research valuable in enhancing their knowledge and practical skills. The robot serves as a platform for hands-on learning, enabling students to delve into the intricacies of robotics, motor control, and autonomous systems. Moreover, professionals in the robotics field can benefit from the innovative features and technology employed in this solution to tackle real-world challenges.

B. Need

Customers in the robotics industry, engineering students, and prototyping enthusiasts often face the challenge of finding an affordable and versatile robotic platform that combines ease of control, robust construction, and adaptability to various applications. Additionally, there is a need for a robot capable of participating in Sumo robotics competitions, demonstrating superior mobility and autonomous decision-making capabilities. Addressing these requirements prompts the need for an efficient and accessible solution that integrates modern technology and features into a compact and capable system.

C. Solution

This research proposes an Arduino-based 2WD Sumo Tankbot with Scraper as a solution to the aforementioned problem. The objective of this research is to design and construct a versatile robotic system capable of competing in Sumo battles while providing an educational platform for learning and experimentation. The main objectives of this research are as follows:

1. Develop a robust mechanical design incorporating an aluminum tank chassis and a galvanized steel-machine cut scraper for optimal performance and durability.
2. Integrate an Arduino UNO R3 microcontroller and an L298N motor driver to control the two 6V DC motors, ensuring precise movements and agility.
3. Utilize an HC-05 Bluetooth module and an Android mobile application to enable wireless control, enhancing user experience and accessibility.
4. Use an Android-based Bluetooth app to control the prototype’s movements wirelessly

D. Scope and Delimitation

This research focuses on the design, construction, and implementation of the Arduino-based 2WD Sumo Tankbot with Scraper. The scope of this research encompasses the mechanical, electrical, and software aspects of the robot. It explores the integration of key components, such as the tank chassis, scraper, microcontroller, motor driver, Bluetooth module, and mobile application. The research also covers the development of algorithms for controlling the Sumo Tankbot wirelessly. The research does not delve into advanced computer vision or complex AI algorithms. The goal is to create a reliable and accessible solution that balances functionality, affordability, and educational value.

E. Differentiation

Compared to existing robotics solutions, the Arduino-based 2WD Sumo Tankbot with Scraper stands out in terms of technology, functionality, and features. The integration of an Arduino UNO R3 microcontroller and an L298N motor driver provides precise control and motor management, allowing for superior maneuverability and agility during Sumo battles. The inclusion of an HC-05 Bluetooth module and an Android mobile application enables seamless wireless control, offering convenience and flexibility to users. Additionally, the tank chassis, galvanized steel-machine cut scraper, and other carefully selected components ensure durability and robustness, making the robot suitable for various challenging terrains and competitions.

	Differentiation Table	
	Design Solution	***Nearest Similarity***
Technology	Bluetooth Control	GSM and Wi-Fi adapter-based control
Functionality	Short range communiaction	Long range communication
Features	Consistent low-power device communication	High-power, high frequency data transmission

Table 1. *Design differentiation table*

F. Benefits

The beneficiaries will have access to the advantages offered by the features and capabilities of the Arduino-based 2WD Sumo Tankbot with Scraper in several ways. Aspiring electronics and mechanical engineering students can enhance their understanding of robotics, motor control, and autonomous systems through hands-on experimentation with a reliable and accessible platform. Prototyping enthusiasts can utilize the robot for rapid development and testing of Sumo battle strategies. The robot's robust construction and advanced technology allow it to withstand rigorous competitions while showcasing exceptional mobility and decision-making capabilities. The integration of the HC-05 Bluetooth module and the Android mobile application simplifies control and enhances user experience, providing convenience and flexibility. Furthermore, the affordability and versatility of this solution make it an attractive choice for customers in the robotics industry seeking an accessible platform for various applications.

II. Related Literature and Studies

A. Concept of Mobile Robot

Mobile robots are robots that can move and change their position in a physical environment [3]; Mobile robotics is one of the rapidly advancing sub-field in the field of robotics and can greatly aid humans in various fields [4] like logistics and exploration. Mobile robots are capable of performing locomotion in space. Aside from mobile robots, there are other types of robots as well like articulated robots (a.k.a *robotic arm*), and specialized robots such as medical robots. In this paper, the researchers will only focus on developing a 2WD remote controlled mobile sumo Tankbot.

B. Remote Controlled Mobile Robot

WiFi and Bluetooth communications are some of the common methods to communicate with a mobile robot wirelessly, and control it using a mobile device (e.g., android device) [5]. The main objective of a mobile robot is to aid humans in dangerous tas ks [6]. Aside from WiFi and Bluetooth technologies, there are other methods to control the mobile robot like GSM (Global System for Mobile Communications) control.

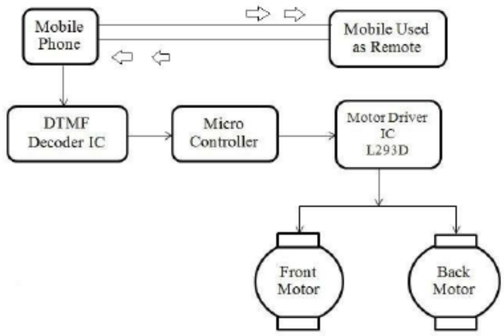

Figure 1. *Simple block diagram of mobile RC robot using mobile phone controller*

A mobile robot can be controlled wirelessly using our mobile phone via Bluetooth communication. We can use our phone to send wireless signal commands to the Arduino microcontroller attached to the mobile robot and process the signal to move the DC motors in forward, backward, left, and right depending on the desired xyz position.

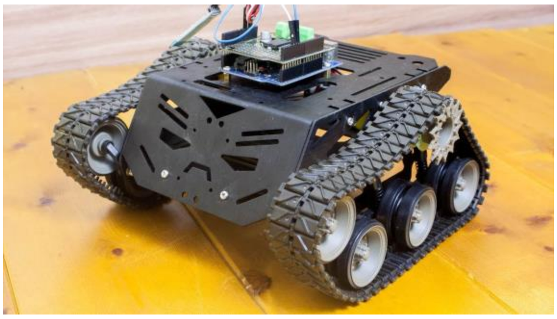

Figure 2. *Black devastator tracked tank mobile robot*

One of the suitable tank sumobot is the devastator tracked tank mobile robot because of its metal chassis, and its mass. It can be equipped with many simple weapons such as flamethrower, scraper, hammer, high-speed retractable linear actuator, and many more which makes it suitable as a mobile RC battle robot.

C. Types of Robot Control

Robot control is an important concept in robotics that allows the robot to move with high precision in space and adapt to its surrounding environment [9]. It is possible to control a robot using various methods such as vision control, and manual control (e.g., haptics and Bluetooth control). Some examples of types from other studies are shown below.

1) Vision based: Smart Scorbot-E9 Pro for Industrial Applications

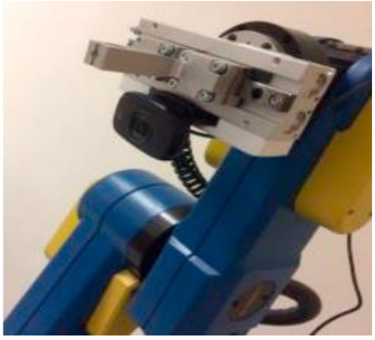

Figure 3. *Scorbot-E9 Pro gripper with attached camera*

Researchers at [10] modified a manually controlled robotic arm Scorbot to become an automated and smart robot by attaching a camera (vision source) near its gripper, so it can pick up objects autonomously and place it to desired location. Image processing for object identification was implemented to make the Scorbot robotic arm automated for autonomous pick and place operation of objects.

2) Bluetooth based: Android-Bluetooth controlled mobile robot

Figure 4. *Bluetooth controlled mobile robot*

An Android app for RC robots can wirelessly control/manipulate the robot's motion from long distance, and can interface the connection between controller and android using bluetooth communication [11]. Controlling mobile robots using android phone as controller and Bluetooth for communication is one the most common method for mobile robot control since it is easy to set up and simple components are only needed.

D. Differential Drive Principle

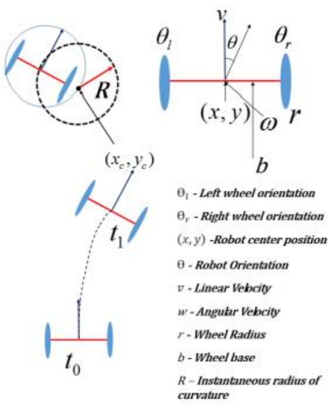

Figure 5. *Kinematics model of differential drive*

Differential drive is one of the common drive system configurations for 2WD (two-wheeled) mobile robot design. In this drive system principle, two DC motors are utilized (as wheels) for the mobile robot's motion and one free wheel (caster wheel) to balance the robot's whole chassis. For forward or backward motion, similar speeds are applied to the two DC motors. For rotational motion, different speeds are applied in each of the two DC motors (wheels). In actuality, the differential drive method is the best design for implementing 2WD mobile robots that deals with defined trajectories [12]. Differential drive method is the most used drive system configuration along for two-wheeled mobile robot design.

III. Design Procedures

A. Conceptual Framework

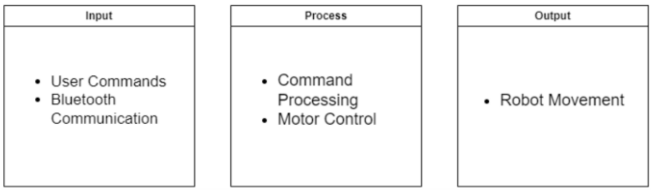

Figure 6. *Project conceptual framework*

For the input aspect, the Android-based mobile app allows the user to input commands through a graphical user interface (GUI). The user can specify the desired movement direction (forward, backward, left, right, forward-left, forward-right, backward-left, and backward-right). Then, the Android mobile app communicates wirelessly with the HC-05 Bluetooth module connected to the Arduino Uno R3. The app sends the user commands to the robot via Bluetooth.

The Arduino Uno R3 then receives the user commands from the HC-05 Bluetooth module. It processes the commands and determines the appropriate actions to be taken by the robot. Next, the Arduino Uno R3 generates the necessary motor control to utilize the L298N 2-wheel motor driver to control the speed and direction of the motors. The microcontroller continuously updates the speed and direction signals depending on the user input.

Finally, the motor control signals generated by the Arduino Uno R3 are sent to the L298N motor driver, which then controls the speed and direction of the 2x 6V motors. This movement allows the tank robot to navigate in the specified (octal) direction.

B. Hardware Development

1) Hardware Specifications and Functionality

Figure 7. *Arduino UNO R3*

Based on the Arduino website, the Arduino Uno R3 is a microcontroller board that features the ATmega328P, an 8-bit AVR architecture microcontroller. It operates at a clock speed of 16 MHz and has 32 KB of flash memory (with 0.5 KB used for the bootloader), 2 KB of SRAM, and 1 KB of EEPROM. The board runs on a 5V operating voltage and accepts an input voltage range of 7-12V (with limits from 6V to 20V).

With 14 digital I/O pins (6 of which provide PWM output) and 6 analog input pins, it offers flexibility for various applications. The Arduino Uno R3 includes communication interfaces such as USB (ATmega16U2 for USB-to-serial conversion), UART, SPI, and I2C. It has 2 external interrupt pins and features a 10-bit ADC with 6 channels. The board also supports 6 PWM outputs and utilizes 3 timers. Power can be supplied through USB or an external DC power source (7-12V), with a built-in 5V voltage regulator.

The Arduino Uno R3 has a compact form factor, measuring 68.6mm in length and 53.4mm in width. It weighs around 25g and includes a reset button, LED indicators for power and communication, and an ICSP header for in-circuit serial programming. The board can be programmed using the Arduino programming language and the Arduino IDE, which is a free and open-source integrated development environment.

Figure 8. *L298N h-bridge motor driver*

The L298N is a dual H-bridge motor driver module commonly used for controlling DC motors or stepper motors in various applications. This module can handle a wide range of motor voltages, allowing compatibility with different motor types. With its built-in high-voltage and high-current capability, the L298N can handle motor voltages up to 46V and peak currents up to 2A per channel (3A with proper heat sinking), as stated in components101. Its dual H-bridge configuration enables independent control of two motors, providing options for forward, reverse, and brake operations. The module features 4 input pins for controlling motor speed and direction, allowing for easy integration with microcontrollers or other control systems. Additionally, the L298N includes protection features such as built-in flyback diodes for protecting the circuit from voltage spikes generated by motor operation.

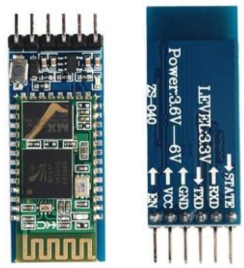

Figure 9. *HC-05 Bluetooth module*

The HC-05 is a Bluetooth module that enables wireless communication in electronic projects. It operates on Bluetooth 2.0 + EDR (Enhanced Data Rate), allowing for faster data transmission rates compared to standard Bluetooth 2.0, as shown in circuits101. The module supports commonly used Bluetooth profiles such as the Serial Port Profile (SPP) and Bluetooth Basic Rate (BR). With a communication range of up to 10 meters, the HC-05 provides reliable wireless connectivity for short-range applications. It features a compact form factor and is widely compatible with various microcontrollers and devices.

Figure 10. *6V DC motor*

With a physical size of around 27.7mm in length and 24mm in diameter, the RF-370CA-22170 motor weighs approximately 40 to 50 grams, making it easy to integrate into space-constrained projects. The motor's brushed design ensures straightforward control and simple commutation using brushes and a commutator. In terms of power consumption, the motor typically draws a current ranging from a few hundred milliamperes (mA) to around 1 ampere (A) at its rated voltage, making it energy-efficient for a variety of applications. Overall, the RF-370CA-22170 6V motor strikes a balance between performance, size, and power consumption, making it a popular choice for various electronic and mechanical projects where compactness and moderate power are required.

2) Wiring Diagram

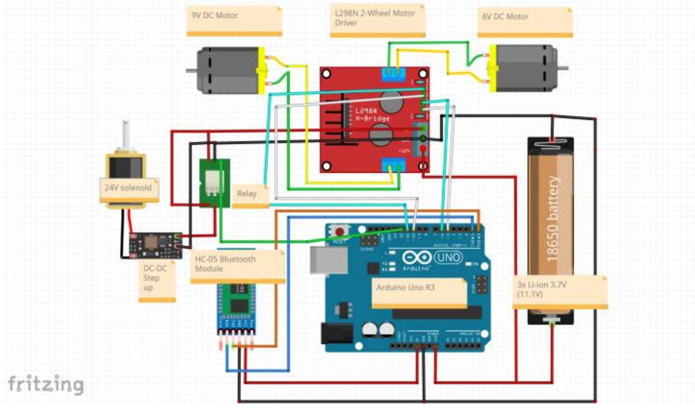

Figure 11. *Robot wiring diagram*

The wiring diagram for the Arduino-based tank sumobot with scraper and L298N motor driver is illustrated in the figure above. The sumobot is equipped with two 6V DC motors that are connected to the L298N motor driver module. The first motor's positive terminal is linked to the M+ terminal on the L298N, while its negative terminal is connected to the M- terminal. Similarly, the second motor's positive terminal is connected to the other M+ terminal, and its negative terminal is connected to the M- terminal on the L298N. The Li-ion batteries (3.7V each), providing 11.1V in series, are connected to the L298N's "+12V" and "GND" terminals, respectively. The HC-05 Bluetooth module is integrated into the Arduino board, with its TX pin connected to digital pin 0 (RX) and RX pin connected to digital pin 1 (TX) on the Arduino board. IN1 and IN2 of the motor driver are connected to the Arduino pins 5 and 6, respectively, whereas IN3 and IN4 are connected to 10 and 11, respectively. Additionally, the positive terminal of DC-DC step up voltage is connected directly to 5V relay and its GND in connected directly to the GND of L298N and GND of 5V relay. The 24V solenoid valve is then connected to the DC-DC step up voltage, as shown in figure 11.

3) 3D Printing for Solenoid Valve Weapon

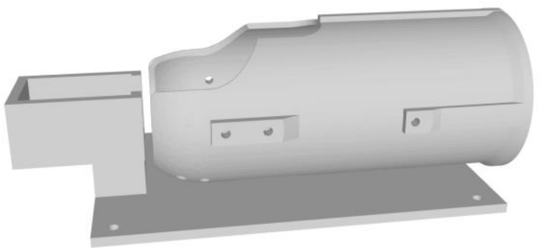

Figure 11.1 Body frame for Solenoid Turret Weapon

Figure 11.1 shows the 3D model design of the solenoid-based turret gun weapon that will shoot ping-pong balls that will hit the aimed target. The solenoid-based turret gun will be places atop the Sumo Tankbot considering its spacious area at the top.

C. Software Development

1) Arduino IDE

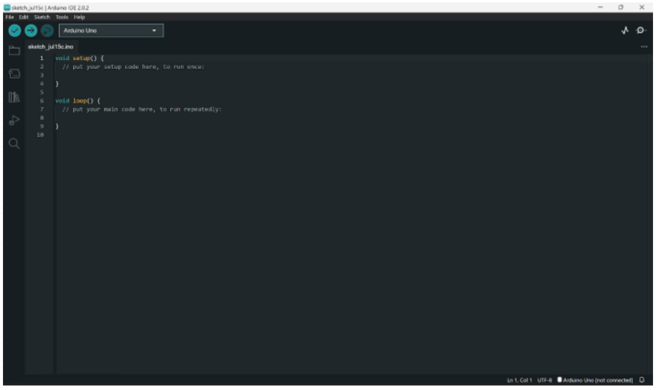

Figure 12. *Arduino integrated development environment*

The Arduino IDE is an open-source software application designed to facilitate the development and programming of Arduino-based projects. It serves as a central platform for researchers and hobbyists to create code that controls and interacts with Arduino microcontrollers effectively. For the development of code for the Bluetooth tank sumo robot, the researchers utilized the Arduino IDE due to its user-friendly interface and extensive community support. The IDE offers a text editor with features like syntax highlighting, auto-completion, and indentation, aiding in code readability and minimizing errors. Researchers can easily import libraries to extend the functionality of the robot's code, and the IDE handles the compilation process, translating the human-readable code into machine language specific to the Arduino board. Additionally, the IDE's serial monitor helps to debug and monitor the robot's output during runtime. Its integration with the Arduino board allows straightforward code uploading and execution. The Arduino IDE played a pivotal role in the successful development of the Bluetooth tank sumo robot's code, providing a seamless environment for coding, testing, and iterating on the project.

2) Bluetooth RC Controller

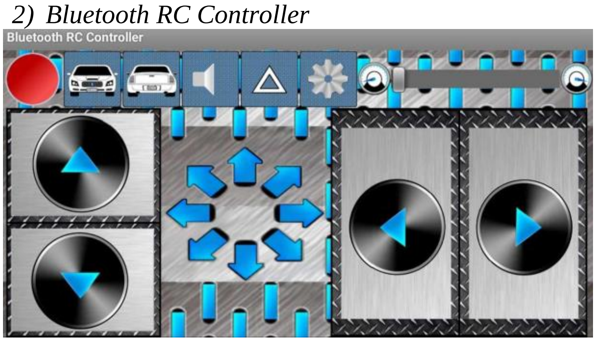

Figure 13. *Bluetooth controller app*

To control the robot via Bluetooth wireless communication, an android application Bluetooth RC Controller developed by Andi.Co was utilized. It is an android application that allows the user to control a microcontroller and Bluetooth fitted RC car with a smartphone. With the right interfacing and configuration of Arduino UNO with HC-05 module and Bluetooth RC Controller application, it allows the user to control the robot’s motion by Bluetooth communication. A user can send forward, backward, forward-left, forward-right, backward-left, backward-right, left, and right commands wirelessly to the mobile robot.

3) Project Code

```
#define LED 13
int command; //Int to store app command state.
int Speed = 204; // 0 - 255.
int Speedsec;
int buttonState = 0;
int lastButtonState = 0;
int Turnradius = 120; //Set the radius of a turn, 0 - 255 Note:the robot will
malfunction if this is higher than int Speed.
int brakeTime = 45;
int brkonoff = 1; //1 for the electronic braking system, 0 for normal.

void setup() {
  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);
  pinMode(in3, OUTPUT);
  pinMode(in4, OUTPUT);
  pinMode(LED, OUTPUT); //Set the LED pin.
  Serial.begin(9600);  //Set the baud rate to your Bluetooth module.
}

void loop() {
  if (Serial.available() > 0) {
    command = Serial.read();
    Stop(); //Initialize with motors stopped.
    switch (command) {
      case 'F':
        forward();
        break;
      case 'B':
        back();
        break;
      case 'L':
        left();
        break;
      case 'R':
        right();
        break;
      case 'G':
        forwardleft();
        break;
      case 'I':
        forwardright();
        break;
      case 'H':
        backleft();
        break;
      case 'J':
        backright();
        break;
      case '0':
        Speed = 100;
        break;
      case '1':
        Speed = 140;
        break;
      case '2':
        Speed = 153;
        break;
      case '3':
        Speed = 165;
        break;
      case '4':
        Speed = 178;
        break;
      case '5':
        Speed = 191;
        break;
      case '6':
        Speed = 204;
        break;
      case '7':
        Speed = 216;
        break;
      case '8':
        Speed = 229;
        break;
      case '9':
        Speed = 242;
        break;
      case 'q':
        Speed = 255;
        break;
    }
    Speedsec = Turnradius;
    if (brkonoff == 1) {
      brakeOn();
    } else {
      brakeOff();
    }
  }
}

void forward() {
  analogWrite(in1, Speed);
  analogWrite(in3, Speed);
}

void back() {
  analogWrite(in2, Speed);
  analogWrite(in4, Speed);
}

void left() {
  analogWrite(in3, Speed);
  analogWrite(in2, Speed);
}

void right() {
  analogWrite(in4, Speed);
  analogWrite(in1, Speed);
}

void forwardleft() {
  analogWrite(in1, Speedsec);
  analogWrite(in3, Speed);
}

void forwardright() {
  analogWrite(in1, Speed);
  analogWrite(in3, Speedsec);
}

void backright() {
  analogWrite(in2, Speed);
  analogWrite(in4, Speedsec);
}

void backleft() {
  analogWrite(in2, Speedsec);
  analogWrite(in4, Speed);
}

void Stop() {
  analogWrite(in1, 0);
  analogWrite(in2, 0);
  analogWrite(in3, 0);
  analogWrite(in4, 0);
}

void brakeOn() {

  // read the pushbutton input pin:
  buttonState = command;
  // compare the buttonState to its previous state
  if (buttonState != lastButtonState) {
    // if the state has changed, increment the counter
    if (buttonState == 'S') {
      if (lastButtonState != buttonState) {
        digitalWrite(in1, HIGH);
        digitalWrite(in2, HIGH);
        digitalWrite(in3, HIGH);
        digitalWrite(in4, HIGH);
```

```
        delay(brakeTime);
        Stop();
      }
    }
    // save the current state as the last state,
    //for next time through the loop
    lastButtonState = buttonState;
  }
}

void brakeOff() {
  // Implementation for turning off the electronic braking system
}
```

D. Prototype Development

Figure 14. *Designing and cutting of metal scraper*

Figure 15. *Assembly of robot body*

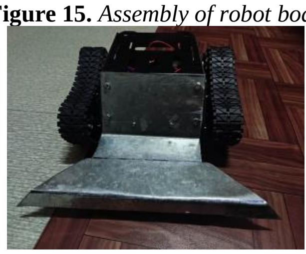

Figure 16. *Attachment of scraper to main robot*

1) Design Constraints

The tank robot initially was supposed to be equipped with servo motors attached to the scraper. Unfortunately, the available servo motors were either not strong enough to lift the heavy metal scraper or would draw too much power from the mobility motors, which in both cases, lowered the robot's fighting offensive and defensive capabilities.

2) Impact of Design Solution

Instead, the metal scraper was bolted to the front panel of the robot to function as a bumper shield and scraper to push other robots. This not only gives more free power to the mobility motors and increases the robot's movement speed, but also gives the robot a versatile tool for offense and defense.

3) Engineering Principle and Modern Engineering Tools

The design and development of the Bluetooth tank sumo robot were guided by a combination of fundamental engineering principles and modern engineering tools. The device's successful implementation relied on the application of electrical and mechanical principles, as well as an understanding of wireless communication protocols and control systems.

a) Electrical Circuits and Motor Control

The robot's movement and functionality were achieved through the principles of electrical circuits and motor control. The L298N motor driver, a crucial component in the robot's architecture, allowed for precise control of the two 6V DC motors that powered the tank's wheels. Kirchhoff's current law (1) and Ohm's law (2) were applied to ensure efficient power distribution and optimal motor performance. By utilizing these principles, the robot demonstrated reliable maneuverability and responsiveness during the sumo competition.

$$\sum I(in) = \sum I(out) \tag{1}$$

$$V = IR \tag{2}$$

b) Wireless Communication and Bluetooth Technology

The incorporation of the HC-05 Bluetooth module introduced wireless communication capabilities to the robot. The understanding of Bluetooth technology, its data transmission protocols, and the Serial Communication protocol in the Arduino IDE played a pivotal role in enabling remote control of the robot via a paired smartphone or computer. This wireless communication feature elevated the robot's operability and allowed for seamless user interaction, making it ideal for sumo robot contests.

c) Microcontroller Programming and Arduino IDE

The Arduino microcontroller served as the brain of the Bluetooth tank sumo robot. Its programming was facilitated by the Arduino Integrated Development Environment (IDE). Researchers leveraged the user-friendly IDE to write and upload code, ensuring the efficient control of motors, sensors, and Bluetooth communication. The IDE's built-in libraries simplified the coding process, while its serial monitor aided in real-time debugging, contributing to the successful development and calibration of the robot's functionality.

d) Mechanical Design and Chassis Construction

The robot's mechanical design played a crucial role in its overall performance. The selection of appropriate materials and the design of the tank sumo robot's chassis were crucial in achieving a sturdy and well-balanced structure. For this project, DFRobot's CNC-cut aluminum frame and a custom galvanized steel scraper were sourced for the creation of the prototype. The incorporation of a scraper further enhanced the robot's sumo performance by providing strategic pushing capabilities during matches.

e) Modern Engineering Tools

Various modern engineering tools were employed throughout the project to facilitate the prototype's development and construction. These tools included soldering irons, multimeters, and desoldering pumps, which were instrumental in assembling the electronic components, ensuring proper connections, and diagnosing any technical issues. allowing for accurate measurements and efficient prototyping

IV. Testing, Presentation, and Interpretation of Data

A. Pairing Android Phone to Bluetooth Module

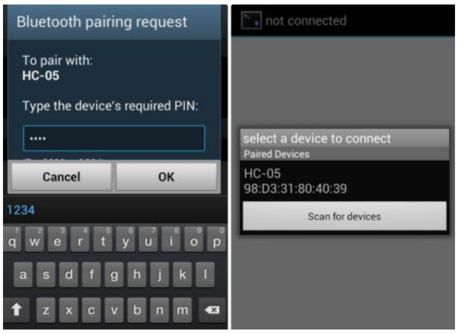

Figure 17. *Pairing with HC-05 using Android phone*

To connect an Android phone with the Bluetooth module, the user must enable Bluetooth services on the phone and search for the “HC-05” device name in the available Bluetooth device list. Selecting the module will require a password to pair, which is usually “1234” or “0000”, which in this case is the former. Once paired, communication between the phone and the HC-05 is possible and will now receive commands as a slave device. Furthermore, to determine whether the devices are connected, the module must change from blinking rapidly to still lighting. This step is the fastest as it only took one attempt to pair the Android phone (Poco F3) to the HC-05 Bluetooth module.

B. Bluetooth Controller Application Testing

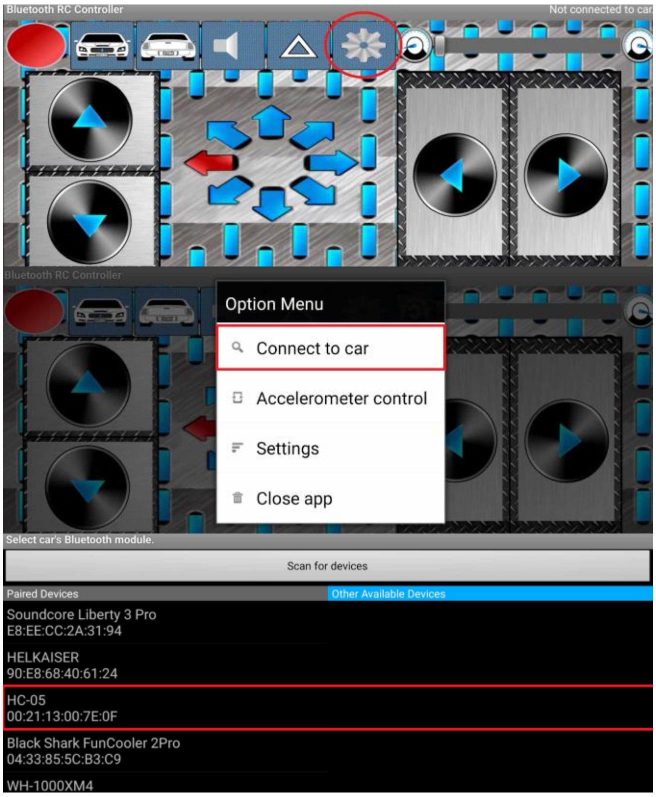

Figure 18. *Connecting to the tank robot*

In this step, an Android phone was set up as a wireless (Bluetooth) controller of the tank robot to control its movements. To do this, the app “Bluetooth RC Controller” was launched. To configure its connection to a Bluetooth device, the gear icon was pressed to open the settings menu. Then, the option “Connect to car” was selected. After which, a list of paired devices to the smartphone will be shown. By selecting the “HC-05” name of the device, the app will attempt to connect to the Bluetooth module. After around the 5th attempt, the app successfully connected with the tank robot, turning the red circle indicator in the app to green. Further and future tests of this connection require only one attempt to connect the app to the robot if the setup was done beforehand.

C. Wireless Motor Control Test

In testing the Bluetooth control, the following test cases were considered to evaluate the mobility functionality of the robot: forward, backward, left, right, forward-left, forward-right, backward-left, and backward-right. To perform the forward, backward, left, and right movement control, the corresponding arrow buttons were pressed, while pressing combinations of either left or right with either down or up buttons would enable differential drive movement control.

D. Movement Test Cases

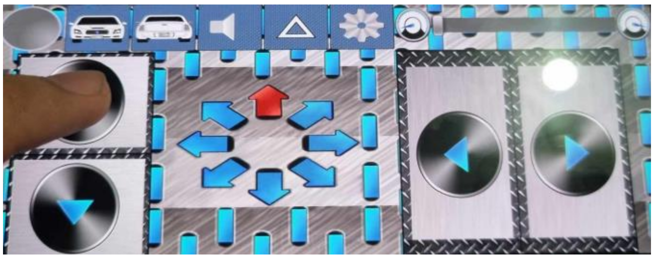

Figure 19. *Forward drive*

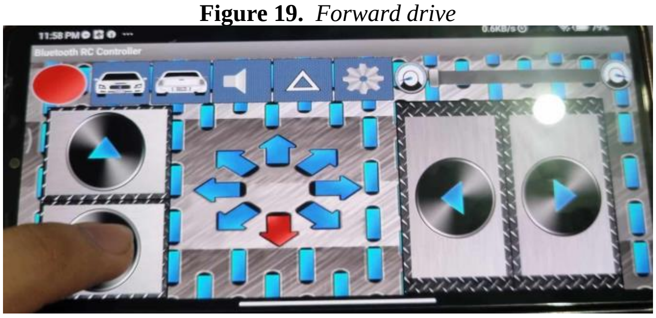

Figure 20. *Backward drive*

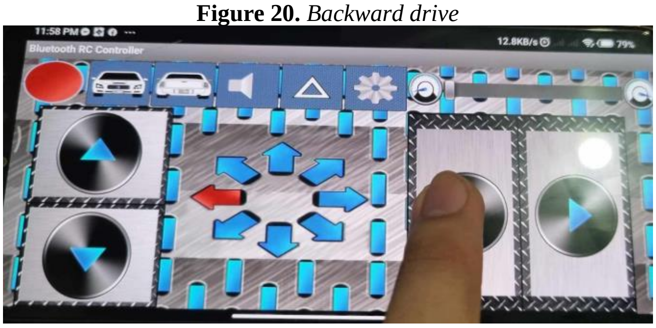

Figure 21. *Stationary left turn*

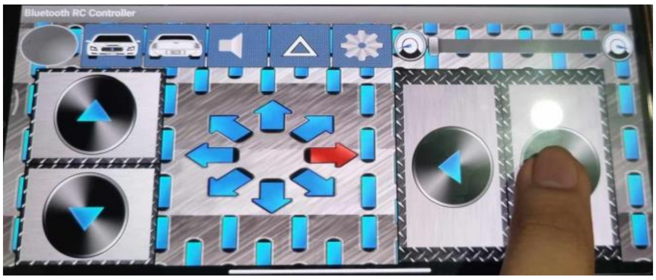

Figure 22. *Stationary right turn*

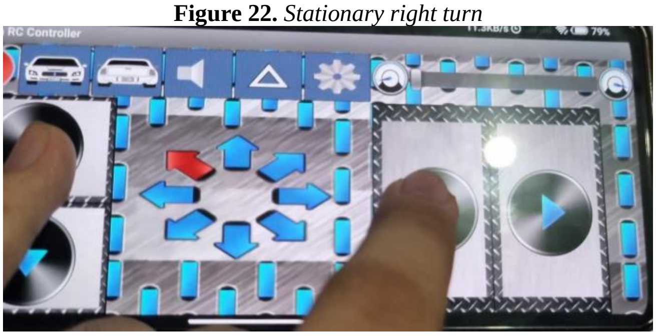

Figure 23. *Differential drive forward-left*

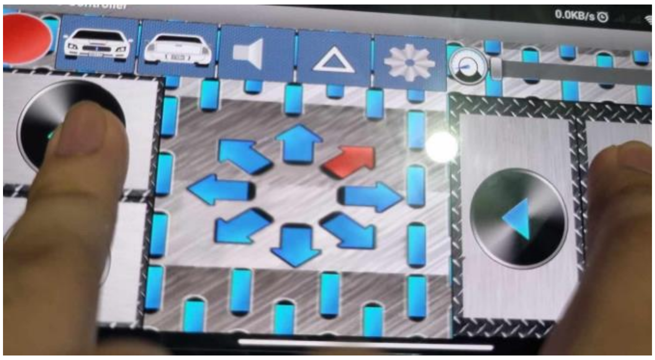

Figure 24. *Differential drive forward-right*

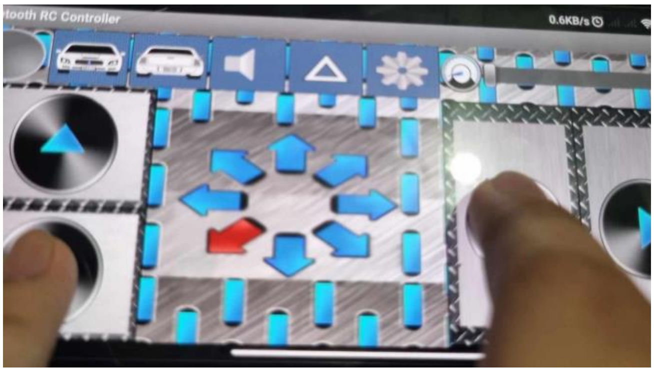

Figure 25. *Differential drive backward-left*

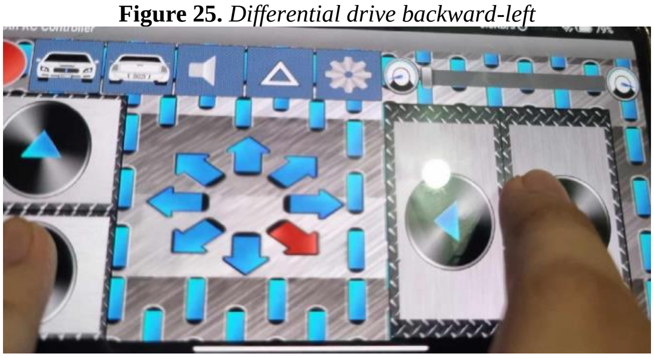

Figure 26. *Differential drive backward-right*

E. Tables of Collected Data

Trial #	**Movement Test**			
	Forward	*Backward*	*Left*	*Right*
1	Fail	Fail	Fail	Fail
2	Success	Success	Success	Fail
3	Success	Success	Fail	Success
4	Success	Fail	Success	Success
5	Success	Success	Success	Success

Table 2. *F-B-L-R consistency test*

The first trial failed such that the robot moved in the opposite direction. This was found to be due to a reverse in polarity when sending current to the motors. This was fixed by interchanging both the M+ and M- wires of both motors that were connected to the motor driver. As for the 2nd and 3rd trials, the right and left turns failed, respectively due to a misfit of the gear teeth to the tank treads. A simple realignment of the components solved this. The 4th trial saw a failure in backward turn proceeding a forward movement due to dislocation of the motor from previous realignment of the treads. By the 5th trial, the motors were screwed tighter to the chassis and the gear teeth synchronized with the tread gaps as the robot moved- ensuring success in all basic movement tests.

Trial #	**Movement Test**			
	Forward-Left	*Forward-Right*	*Backward-Left*	*Backward-Right*
1	Success	Success	Success	Success
2	Success	Success	Success	Success
3	Success	Success	Success	Success
4	Success	Success	Success	Success
5	Success	Success	Success	Success

Table 3. *FL-FR-BL-BR consistency test*

The differential drive tests were conducted after perfecting the basic movement controls. Incidentally, each of the movement tests using the combinatorial commands were a success. There were times that rapid change of instruction from a previous differential drive instruction led to desynchronization of the gear teeth to the tank treads that resulted into derailing. There were times that the treads would get stuck when the motor suddenly reverses its operation.

F. Specification Table of Robot

Design Specifications	
Max Range (m) (from transmitter to smartphone)	25 m
Max Distance (km)	1 km
Weight (Kg) (assembled body + scraper)	2 kg
Operating Voltage (V)	2-7.5 V
Max speed (m/s)	0.3 m/s
Dimensions LxWxH (in) (Frame)	8.86 x 8.66 x 4.25 inches/ 225 x 220 x 108 mm
Dimensions LxWxH (in) (With Scraper)	12 x 12 x 4.25 inches/ 304.8 x 304.8 x 107.95 mm

Table 4. *Robot design specifications*

Max Distance Calculation:
Battery Capacity: 2400 mAh (3x in series)
Arduino Avg. Consumption: 98 mA (9V reference)
Bluetooth Module Avg. Consumption: 20 mA
2x 6V Motor Avg. Consumption (max speed): 2 x 1300mA = 2600mA
Battery Depletion Time to 0: 2400mAh / (98mA + 20mA + 2600mA) = 0.88 hrs = 52.8 mins
Max Distance = Max Speed (0.3 m/s) x 0.88 hrs x 3600s/1hr = 950m

V. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

In conclusion, this paper introduced a contribution to the field of robotics by presenting the development of an Arduino-based 2WD Sumo Tankbot. Equipped with a scraper and designed for Sumo robotics competitions, the robot showcases the potential of autonomous systems to tackle complex challenges. Its seamless wireless control through the HC-05 Bluetooth module and Android mobile application highlights the growing capabilities of robotic platforms to integrate advanced communication technologies.

The key components of the Sumo Tankbot, including the high-torque 6V DC motors, sturdy aluminum tank chassis, precision-cut galvanized steel scraper, Arduino UNO R3 microcontroller, and L298N motor driver, synergistically form a robust and agile robotic platform. This integration enables the execution of precise movements and strategic maneuvers during Sumo battles, making it a competitive contender in the competitions.

Throughout this paper, comprehensive insights into the design, construction, and implementation of the Arduino-based 2WD Sumo Tankbot were provided. The mechanical, electrical, and software aspects of the robot were meticulously detailed, offering valuable knowledge for researchers and enthusiasts seeking to explore similar projects or delve into the realm of robotics.

B. Recommendations

To further enhance the Sumo Tankbot's performance and competitiveness, several recommendations are put forth. Firstly, it is essential to improve the DC motor's mounting by fastening them more tightly to the chassis. Additionally, precise alignment of the tank tread belts to the DC gear teeth should be ensured to prevent derailment issues and optimize traction during high-speed maneuvers.

To achieve even greater speeds and higher torque, upgrading to stronger motors is recommended. High-torque motors will bolster the robot's pushing force and responsiveness, elevating its potential for success in Sumo battles.

Moreover, to support the stronger motors effectively, it is advisable to consider increasing the number of batteries beyond the current 3x 3.7V Li-ion batteries. The addition of more batteries will maximize the motor power, prolong the robot's endurance, and enable it to perform at its peak during competitions.

Implementing these recommendations will elevate the Sumo Tankbot's capabilities, further solidifying its position as a formidable contender in Sumo robotics competitions. The continuous exploration of advancements in robotics technology and thoughtful improvements to the Sumo Tankbot's design will undoubtedly contribute to the ongoing evolution of autonomous systems, enabling them to tackle even more complex challenges in the future.

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