MEAM 5100 Group 1 Lab 4 Report

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This project report presents the successful implementation of our web-controlled car featuring a steering mechanism integrated with a simplified feedback control system.

Mobile base approach

After conducting extensive research on various types of mobile bases, our team opted for the Ackerman steering mechanism. Due to resource constraints, we decided to simplify the Ackerman mechanism, so that the front wheels are parallel and have the same rotation angle. Utilizing an HS-422 servo motor, we controlled the front wheels, connecting them through an axle crafted from lasercut MDF board and 3D-printed connectors, as depicted in the images.

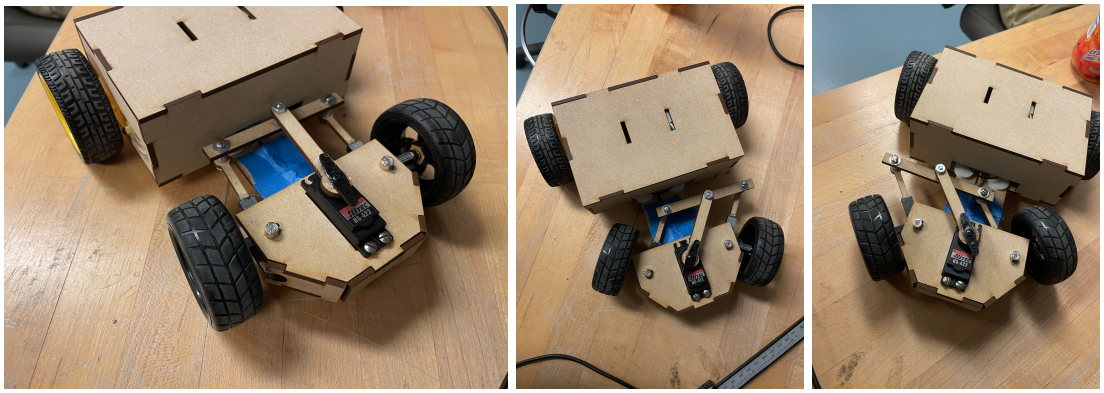


Figure 1. Steering design in different views

Videos demonstrating the operation of the steering mechanism and the servo that controls it:

1. https://youtube.com/shorts/_e_zdFxwGgY?si=4TwgdxkAf4daelOv
2. https://youtu.be/zpVyDnp4c_A?si=zqYmYNsai5EaQCTe

To allow easy modifications to the car's design and circuit, we employed the press-fit method during the assembly of the car body, which offers a flexible solution.. The wheel connectors, represented by the black components in the image, were 3D printed using PLA.

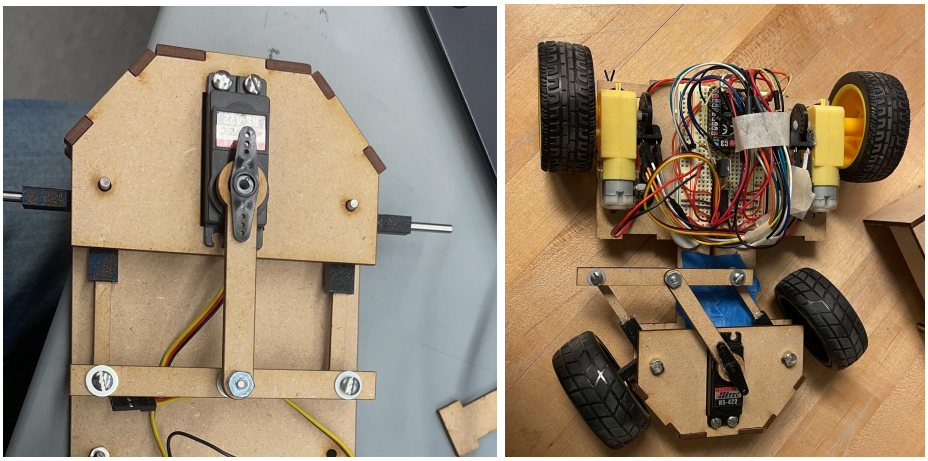


Figure 2. Assembly of the car body, with the press-fit feature highlighted in the left image
In this design, each connector features two dowels. The first dowel is vertically installed, enabling vertical rotation and steering of the wheels. The other dowel is horizontal and connects to the wheel, allowing the wheels to rotate freely. The axle comprises four MDF strips, with the side ones connected to the wheel connectors, the middle one linked to the servo motor, and the horizontal one interconnecting all strips for the Ackerman mechanism. Screws and nuts secure the connections for the front wheels, axles, and dowels, while glue is applied to firmly affix the axle to the wheel connectors.

For the back wheels, which were specifically chosen to match the motors, we connected the motors to the board through holes in the MDF board. Metal wires and glue were employed to secure the motors in place, with a dedicated space created to ensure free rotation of the encoders. The breadboard was fastened to the base using Velcro tapes, allowing for easy removal for adjustments.

Discussion of performance (list your race time) and list of improvements

Race times: 40s; 37s; 32s; (first, second, and third trials)
Final race time: 28.52 s, checked off by Jonathan

Performance of the design:
The overall performance of our mobile base design can be fully demonstrated by the race time and videos. The successful incorporation of Ackerman steering, driven by a servo motor, along with the rear-wheel driving mechanism, attests to the proficiency of our design.

Performance of the feedback control:
The encoder-interrupter pairs on both sides of the rear motors were able to record interrupt counts per second precisely and simultaneously. The implemented proportional control function systematically processes the received values, dynamically adjusting the real-time speed on a per-second basis to ensure precise synchronization of rotation for both rear wheels. The efficacy of this control mechanism was substantiated through rigorous testing, wherein the adjusted interrupts per second consistently aligned with the desired values for both wheels. Subsequent ground experiments further validated its effectiveness, as the vehicle exhibited divergent speeds in the absence of the control function, contrasting with the straight-line trajectory achieved upon its incorporation.

Performance of the circuit stability:
The circuit exhibited optimal performance on the breadboard, with almost no instances of poor contact issues observed. With an original intention to enhance circuit stability and connectivity, we attempted to solder the finished circuit onto a prototype board. Unfortunately, the soldered esp32 board exhibited corruption, likely due to heat generated during resoldering.

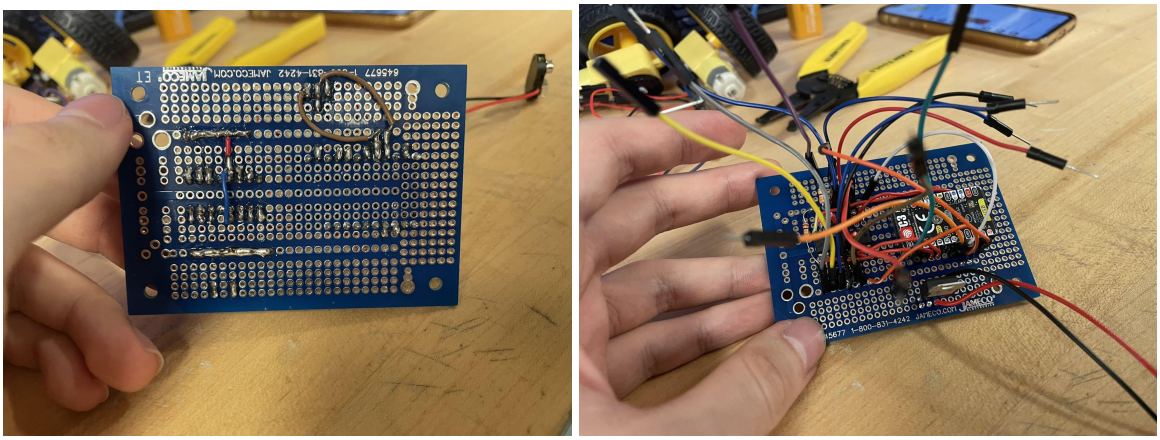


Figure 3. The soldered circuit on a prototype board

Performance of the web control:
The webpage can promptly and accurately control both the speed of the rear motors and the angle of the servo motor with minimal delay. During peak operational hours in the GM lab, we encountered occasional delays in communication between the control board and the associated webpage. To account for that, we used personal hotspots for connection. In the future, we also look forward to perfecting the user interface by adopting user-friendly equipment for better control.

Performance of the battery:
To achieve a lightweight design and adequate power supply, we used 9V batteries for the race and it did work well as we expected. But considering the short lifetime of 9V batteries, we would rather use LiPo batteries in the future to curtail spending on frequent replacement of batteries.

Major concerns of the design:
One major concern of our design emerged when a crash occurred, where the dowels connecting the front wheels to the server could become unstable after a violent impact. In addition, when the car encountered obstacles, the front wheels were stuck in place due to the low stall torque of the servo, which could block the car from continuous motion. We believe that the above problems can be resolved with better car body design and the adoption of more sturdy materials like acrylic in the future.

Final version of code used on mobile base and input ESP32. (include code for race and 4.2.2.1 if different)

Final version code on Github (no difference between code for race and for 4.2.2.1):
https://github.com/guiyanahaha/Lab4.2-Remote-control-car

Bill of materials

Part:	Amount:	Cost:	Website:
Front wheels (pack of 4)	1	$8.99	Link
Rear wheels and motors (pack of 2)	1	$8.99	Link
9V Batteries (pack of 8)	1	$12.99	Link
Total	$30.97		

The MDF board that was used for laser cutting was provided by the MEAM lab. Servo motor HS-422 was provided by the BE lab.

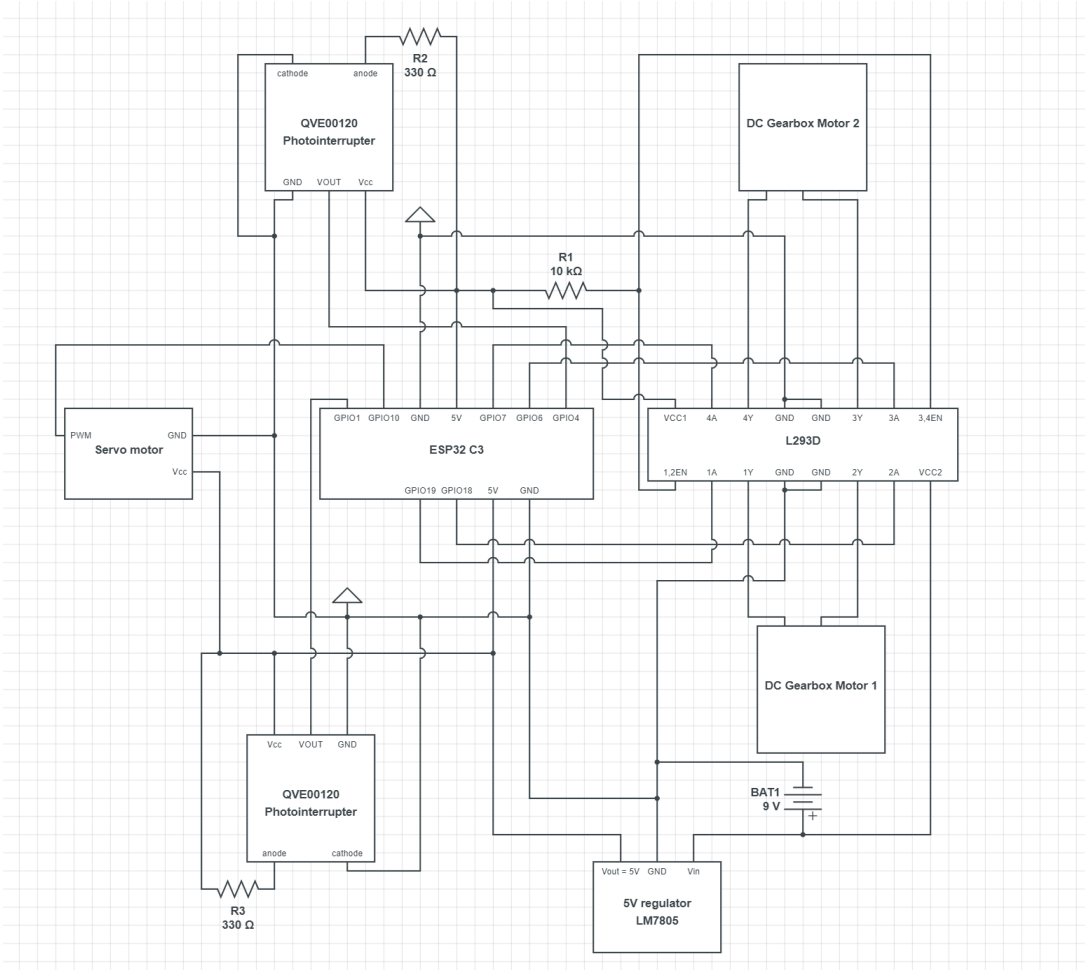


Figure 4. Circuit diagram for the car assembly, including resistors, ESP board, H-bridge (L293D), Gearbox TT motors, Servo motor, Photointerrupters (QVE00120), 9V battery, and 5V voltage regulator.

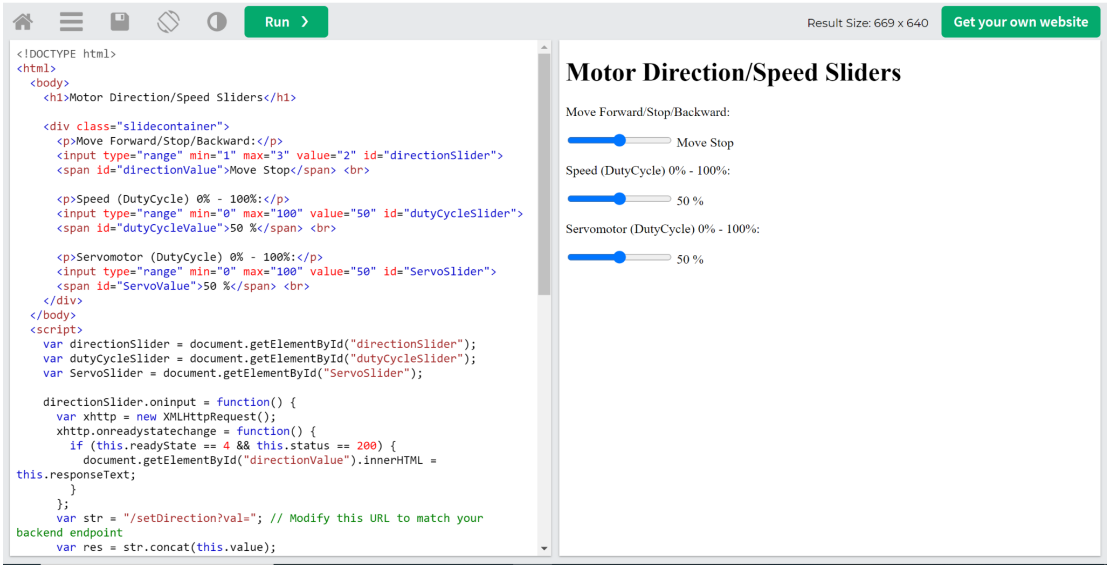


Figure 5. Web page with sliders to control the car's movement: The initial slider dictates the car's mode (forward, stop, backward), the second slider regulates the speed of the gearbox motors, and the third slider manages the angle of the servo

Contributors to the project:

Team member Yining Guo: designed and implemented code used on car mobile base and ESP32, including web interface, motor actuation, and proportional feedback control. Conducted circuit design and testing for feedback control.

Team member Yuetong Hao: helped design and tune the code for the mobile base car. Tried to solder with prototype board, conducted circuit connection, and recorded testing and races.

Team member Hanyu Gong: designed the car’s body, the pressfit, and the steering mechanism using CAD, fabricated all parts of the car using lasercut and 3D print, and assembled it. Assisted with the codes and circuit connection, and controlled the car during the race.

Video links:

Race 3 times around the center obstacles:
https://youtube.com/shorts/asALb82T338?si=HaWf0lD14aQO0TzC

Video shows control without disturbance:
https://youtube.com/shorts/5L57vNa6YOA?si=3mkCemGfJRrMQGs_

Video shows disturbance of a midway push:
https://youtube.com/shorts/MW29y-59zcE?si=iCOPbMUlJztDk-Qw