Hand Gesture Controlled Robot for Assisted Living Applications

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ABSTRACT

In the US alone, 1 in 4 adults have some form of disability[1], and as of 2020, 1 in 6 adults is 65 years old or over[2]. We believe it is our responsibility as engineers to create assistive devices for these vulnerable sectors of the population.

For this project, it was necessary to gain a better understanding of general robotics, the application of engineering standards in design projects, as well as design evaluation methods.

The objective of this project was the construction of a hand gesture controlled robot for assisted living purposes that could be easily operated using a glove controller.

DESIGN REQUIREMENTS

Constraints: Structural integrity is needed for loads of at least 100lb for the device wooden base. Compliance with safety standards must be ensured in all aspects of our design. A limited budget of $350. An ergonomic design for a user-friendly glove controller.

Standards: Some of the standards incorporated into this design include ISO 12100, as it details relevant safety parameters such as a 250mm/s speed limit, ISO 13842, which explains safety evaluation processes, and ISO 9241, to ensure ergonomic and inclusive designs. Other applied standards include IEC 61000, ISO 10218, NEC Standards, and Zigbee.

DESIGN ALTERNATIVES

Fig 1. Alternative designs for driving system

Wheels
- Omnidirectional wheels
- Mecanum wheels

Material Selection
- Plywood
- Aluminum
- Steel

Motor Mounts
- Single shaft
- Straight shaft with spokes
- Tapered shaft with spokes

BUDGET

ITEM	PRICE
nRF24L01+ Transceivers (x2)	$13.99
MPU 6050 IMU	$10.62
L298N Motor Controllers (x2)	$10.62
Arduino MEGA 2560 Rev3	$48.40
REV Robotics Omni Wheels (x8)	$129.07
Greartisan 24V DC Motors (x4)	$63.76
Chassis Metal	$60.17
6mm M3 Mounting Screws	$12.72
Total Budget Spent:	Budget Remaining:
$349.35	$0.65

FINAL DESIGN IMPLEMENTATION

HARDWARE

Our project can be broken down into five subsystems:
Structure: Our system is built using a plywood base (with dimensions of 15"x15") and 4 aluminum angles that not only serve as motor mounts but also protect the user from any splintering injuries.
Intelligence: The robot's operations are controlled using an Arduino Mega 2560 Rev3 microcontroller, while the glove controller uses an Arduino Nano, in addition to an inertial measurement unit (IMU), to understand the hand movements.
Transmission: Two nRF24L01+ transceivers enable communication between the robot and the glove controller. Transmission can be started and stopped via a pushbutton on the index finger of the glove controller.
Locomotion: Two L298N dual H-bridge motor controllers drive four 24V motors, each with a set of double stacked omnidirectional wheels. Double stacking ensures contact between at least one perpendicular roller and the floor at all times.
Power: On the robot, two 9.6V batteries wired in series power the motors, while the Arduino Mega is independently powered by a 9V battery. The Arduino Nano on the glove controller is also powered by a 9V battery.

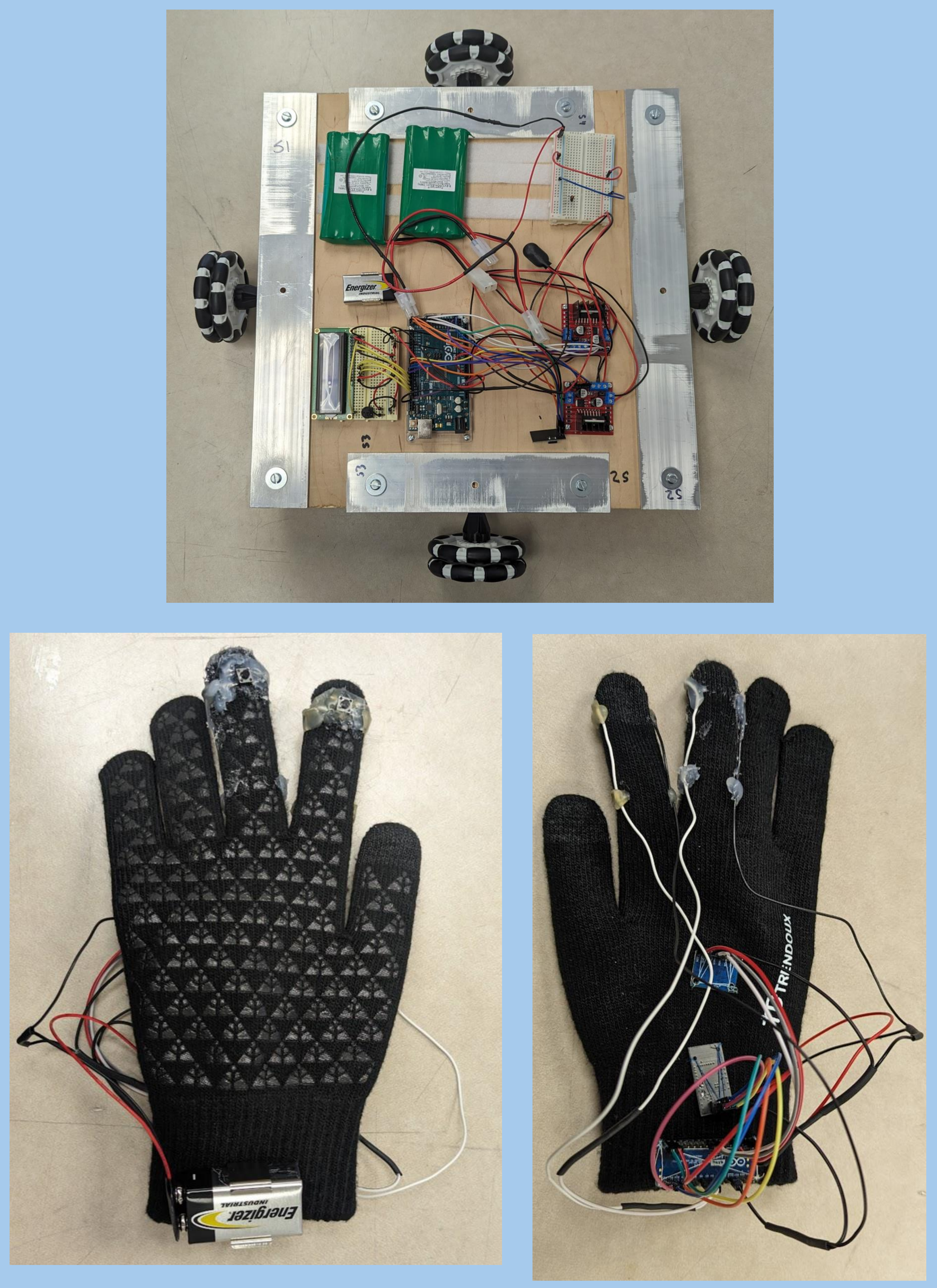

Fig 2. Final robot design (above) and glove controller (below)

SOFTWARE

- The Arduino Mega on the robot is programmed to receive incoming IMU data from the glove controller and determine the speed and direction to move based on said data.
- For debugging purposes, an LCD display is used on the robot to see what data it is receiving.
- Whether to move or not is determined using a dead zone of ±10000 units or about 45° in any direction on the XY plane.
- Individual PWM signals are sent to each motor to control the speed at which they spin.
- A value called transmitData is toggled in the controller code to determine whether to transmit the IMU data from the controller to the robot or not, which starts and stops the robot from moving. This is done with the button on the index finger.
- The IMU can be recalibrated using the button on the middle finger, which adds or subtracts the current IMU values when the button is pressed to effectively zero out the system.

SCHEMATICS

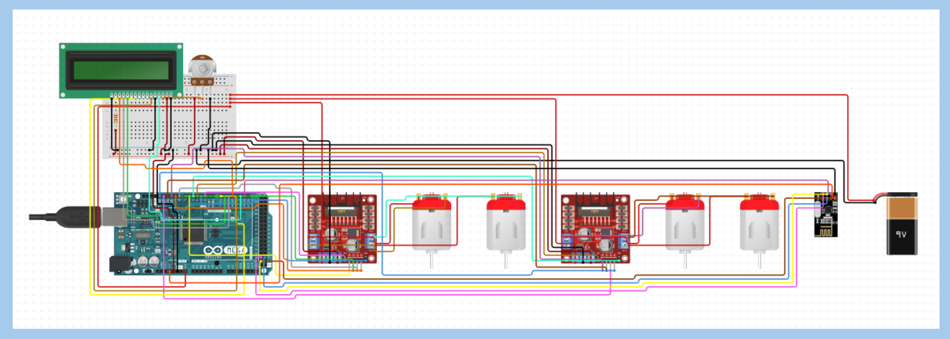

Fig 3. Schematic for logistic robot

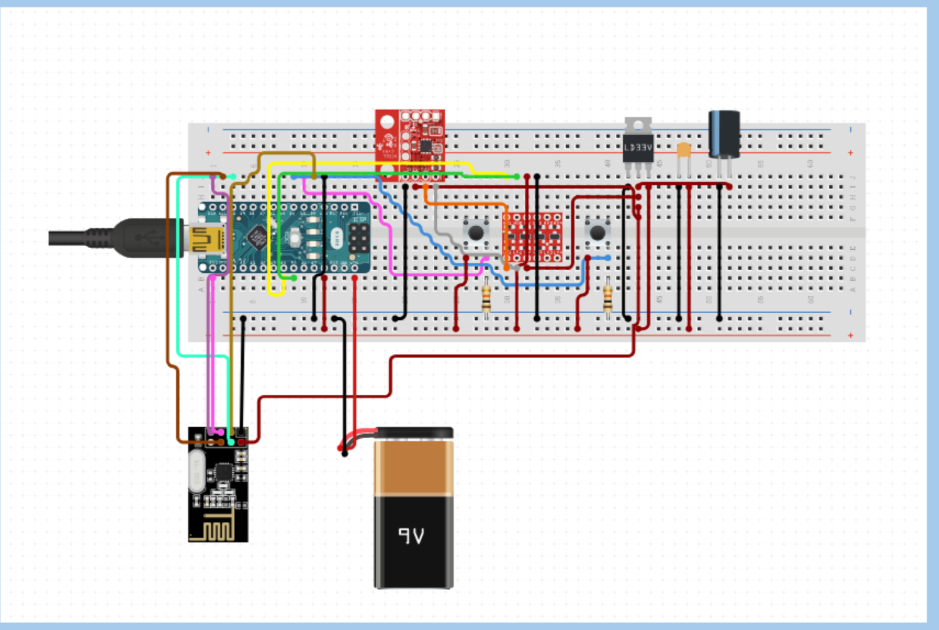

Fig 3. Schematic for glove controller

DESIGN EVALUATION

- The structural integrity of the system has been tested as the project was iterated and developed. Our device can tolerate approximately 30lbs of added weight.
- The transmission system was tested in different environments to ensure reliable communication regardless of obstacles.
- Items attached to the glove were sewn on to avoid risk of falling off during operation.
- Design changed from initial all-wood chassis to a combined wood and aluminum chassis.

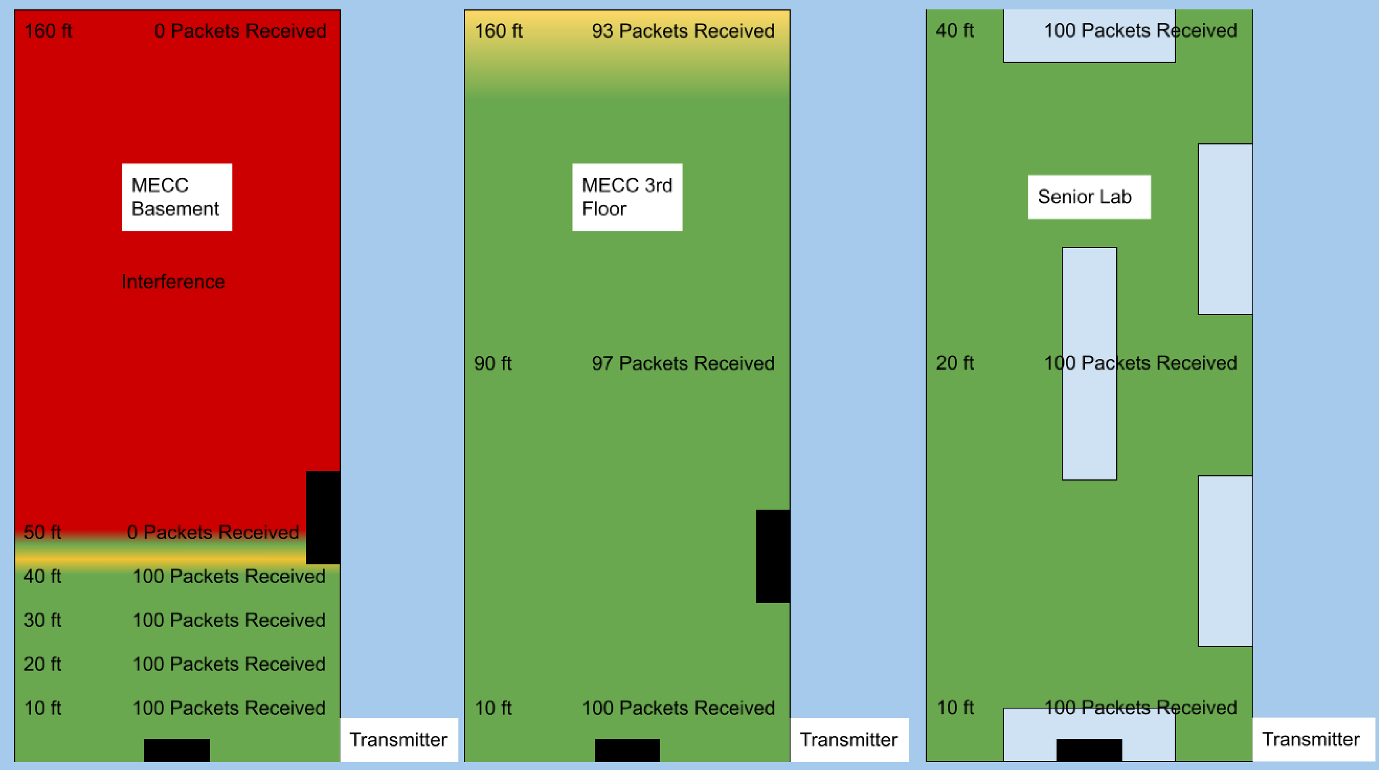

Fig 5. Evaluation of transmission quality for different environments and distances (sample heat map)

CONCLUSION

- The final product of this project is a hand gesture controlled robot that can be driven through a combination of hand positions and angles.
- Reliability of communication, safety features, and appropriate engineering standards are ensured.

FUTURE GOALS

- Our initial project was going to include a tabletop with the ability to adjust its height, but due to budget constraints, we were unable to implement that into our final product. In the future, we would like to implement this addition to our project.
- Additional buttons on the fingertips of the glove controller were planned to be part of our final product, including buttons to raise and lower the aforementioned tabletop lift system. With future development of the lift system, these buttons could also be included.

ACKNOWLEDGMENTS

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CITATIONS

[1] CDCP
[2] United States Census Bureau
[3] Trainum K, Tunis R, Xie B, Hauser E. Robots in Assisted Living Facilities: Scoping Review. JMIR Aging. 2023 Mar 6;6: e42652. doi: 10.2196/42652. PMID: 36877560; PMCID: PMC10028516. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10028516/