Virtual Reality Integrated Humanoid (CNTR)

TEXAS A&M UNIVERSITY Engineering

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TEXAS A&M UNIVERSITY
ROBOTICS TEAM & LEADERSHIP EXPERIENCE

Intro & Problem Definition

Machines have been proven to operate safely and effectively in environments that are too dangerous or inaccessible for humans. From the vacuum of space to deep-ocean depths, robotic systems can perform inspections, maintenance, and repair tasks without exposing humans to extreme conditions. These machines offer improved safety while also increasing efficiency, as they can work continuously and withstand harsh environments. Because of these advantages, robotics has become an essential tool for modern hazardous environment operations.

Mission Statement

CNTR's mission is to develop a modular humanoid robotic system capable of operating in hazardous or inaccessible environments through precise VR-based control. By integrating a rotating sensor head, a mobile base, and interchangeable task-specific arms, we aim to replicate essential human capabilities while protecting operators from dangerous conditions. Through iterative prototyping, hands-on mechanical and electrical testing, and continuous refinement of our control systems, we seek to demonstrate CNTR's adaptability across a wide range of challenging tasks. Ultimately, our goal is to validate CNTR as a reliable, flexible platform while expanding our team's experience in practical robotic design, development, and real-world deployment.

Mechanical

To create a functional arm assembly, this semester was spent designing each arm joint [***Figure 1,2,3***]. To meet the design requirements, we chose to:

- Use 4 separate servos to control each arm movement at the shoulder (1), elbow (2), and wrist (3)
- Use ball bearings to create smooth rotational movement of each arm piece to remove load bearing forces on servos
- Use heat set inserts to reduce the space required to link each joint together to create a compact design
- Prototype each joint using 3D printing and PLA to test the size and fit of each part

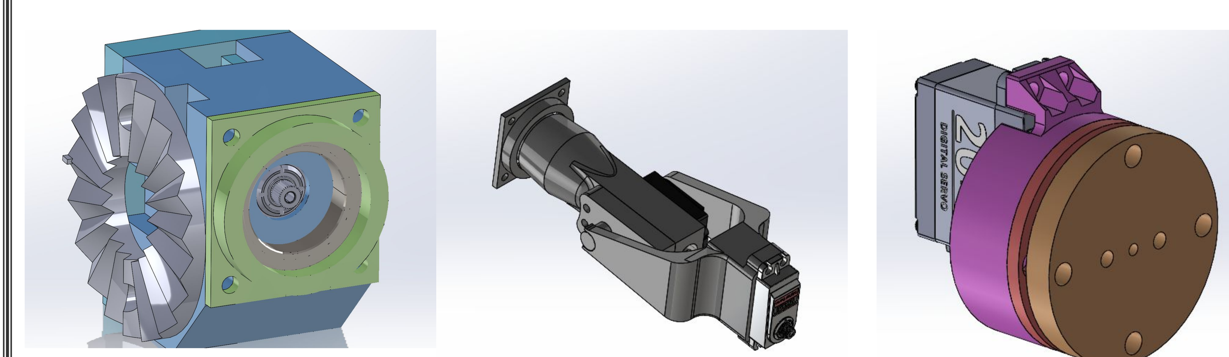

Figure 1: *(left) Shoulder,* ***Figure 2:*** *(center) Elbow,* ***Figure 3:*** *(right) Wrist*

For the base of the robot we focused on keeping the design simple and easy to assemble [***Figure 4,5***]. The key design requirements consist of the following:

- Large enough to hold main components:
  - Driving motors for the wheels
  - Motor for the torso gear and the gear itself
  - Motor controllers
- Have accessibility wire flow accessibility through the base so that the wiring can be connected to the body
- Easy to 3D print and fit within the bounds (10in x 10in x10in)
- Use bearing on the torso gear to reduce the moment forces and allow for ease of rotation
- Turreting Base to allow torso to have left/right motion

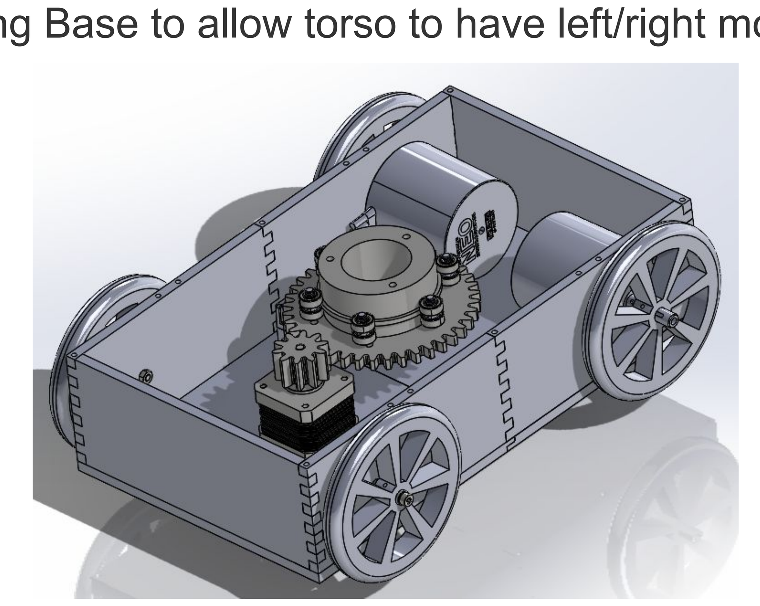

Figure 4: *Base Assembly*

The Torso subsystem is the main upper body of the robot. This subsystem holds the electronics and houses one of four of the arm servos in the shoulder

- Large enough to hold main components:
  - Easy access electronic plates that hold most of the electrical components
  - Arm servo that provides the pitch motion to the 4 DoF arm
  - Attaches to the turreting base
- Holds the hirth gear clocking mechanism

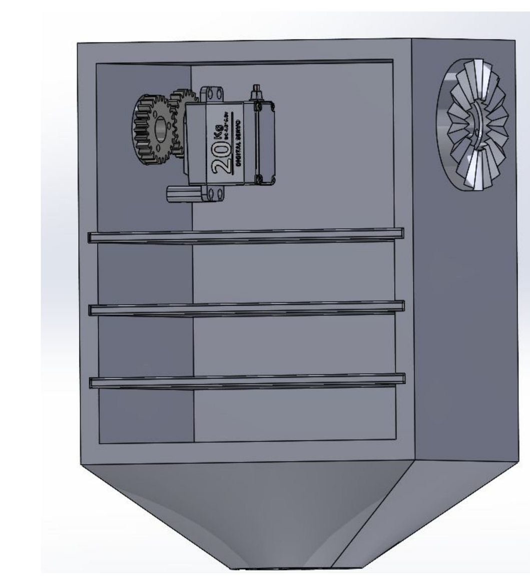

Figure 7 Torso Assembly

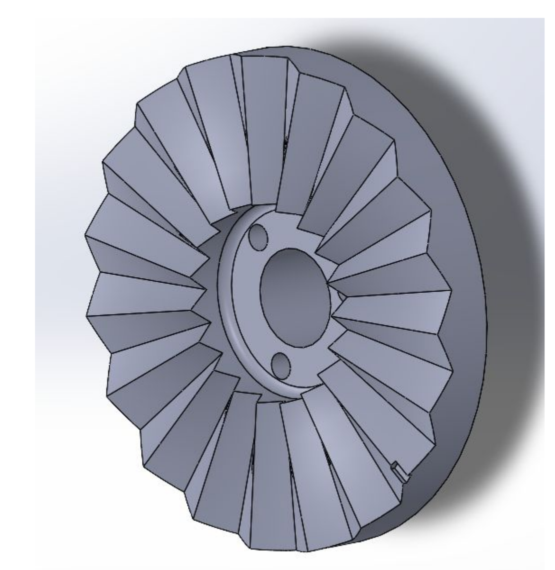

Figure 8 Hirth Gear

Electrical

A 12V 10Ah LiPo battery with 10A peak current output was chosen for the electrical test bed. Functionality tests of the motors and servos gauged performance and current draw to model the needs of the circuit under operation.

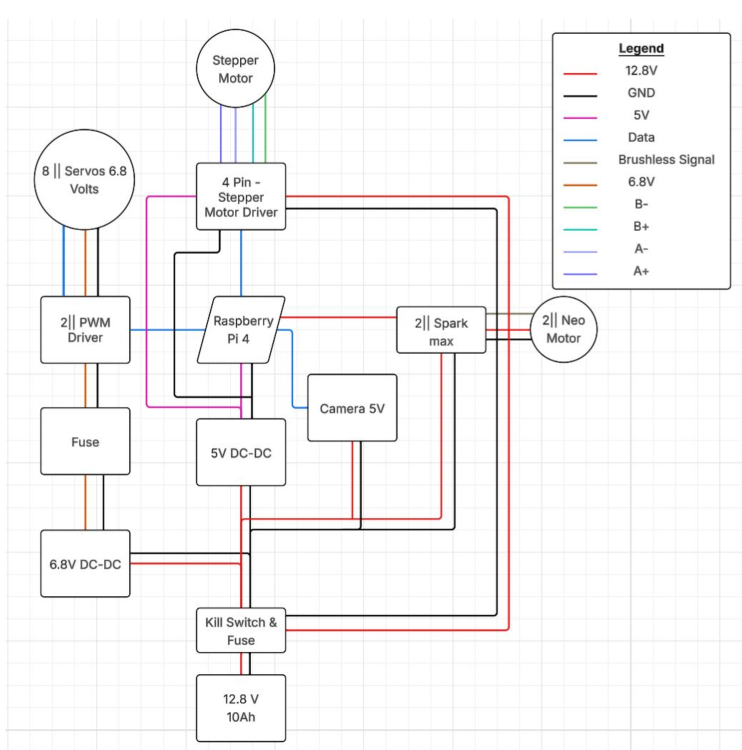

Figure 6 Circuit design

- Made wire harnesses and mounts for servos, motors, power electronics, and Raspberry Pi.
- Ensured components scale for future CNTR upgrades.
- 12V LiPo couldn't power full robot; tested motor torque at 5A and it was sufficient.
- Researched stronger batteries, including custom 18650 pack.
- Worked with software team on serial comms and inverse kinematics.
- Set up 12V, 5V, and 6.8V power zones with buck converters.

Software

ITo stream Oculus input to the Raspberry Pi and send sensor data back, we use Unity and ROS2. The final setup runs ROS2 in a Docker container on the RPi, with port forwarding from a PC running Unity, which handles all Oculus controls.

To setup the RPi (3B) we have:

- established communications with the RPi and a PC through WiFi
  a. We plan to use the IoT WiFi on campus
- Installed Docker on RPi
  a. This allows Ubuntu on a Debian machine like an RPi while also maintaining its OS capabilities.

To setup Unity we have:

- Researched necessary imports to have the process working as smooth as possible
- Send UDP data between Python and Unity for future communication

Next Steps

In the coming semester, our team plans to continue improving our project by:

- **Arm:** Design and attach an end effector that connects to the wrist in ***Figure 2***. Reduce size of elbow and wrist servos for a more compact design.
- **Torso:** Finish integrating arm servo and add electronic beds
- **Robot Integration:** Fit check the each fixture, including arm to torso, torso to base, electrical wire flow
- **Electrical:** Develop wire harnesses, power distribution boards, and electrical boxes for the torso and drive base. Develop and test a custom 3S2P 18650 cell battery for higher power and lower weight.
- **Unity:** Finish setting up VR project for Oculus control and setup UDP communication on Unity
- **Controls:** Write scripts to use ROS2 and control the motors through Unity input data