HUMAN ARM

Abstract

This report details the design, analysis, simulation, and automation of a robotic arm using ROS2 and Gazebo. The robotic arm was first modeled in SolidWorks, analyzed in Ansys, and then built as a physical prototype. Finally, the project was simulated in ROS2 and Gazebo, where servo motors were used to automate the movements of the fingers and elbow. The primary goal was to evaluate the arm's motion in a simulated environment before real-world implementation.

Introduction

With advancements in robotics, simulation and analysis have become crucial steps before hardware implementation. In this project, a robotic arm was designed in SolidWorks, analyzed in Ansys, and then built physically. The objective was to automate its finger and elbow movements using servo motors, ensuring smooth articulation and precise motion control in a ROS2 and Gazebo simulation environment.

Methodology

<u>1. CAD Model Development</u>

- The robotic arm was first designed in SolidWorks.
- The design included a segmented structure for fingers and an elbow joint.
- The CAD model was exported as a URDF file for ROS2 compatibility.

<u>2. Structural Analysis in Ansys</u>

- The SolidWorks model was imported into Ansys for stress, strain, and deformation analysis.
- Load conditions and material properties were applied to ensure structural integrity.
- The results helped in optimizing the design for better performance.

<u>3. Physical Implementation</u>

- The robotic arm was built using selected materials based on the analysis results.
- Components were assembled to replicate the virtual design.
- Servo motors were installed to control finger and elbow movements.

4. ROS2 and Gazebo Simulation

- The URDF model was loaded into Gazebo for physics-based simulation.
- The simulation environment provided realistic conditions, including gravity, friction, and collisions.
- The arm's movement was tested by applying forces to joints and automating control using ROS2 nodes.

5. Motor Control and Automation

- Servo motors were used to control finger and elbow movements.
- ROS2 nodes were created to send motor commands based on predefined sequences.
- A control algorithm was implemented to automate movements and test performance.

Results

- The robotic arm was successfully modeled in SolidWorks, analyzed in Ansys, and built physically.
- Structural analysis confirmed the feasibility of the design.
- The physical prototype functioned as expected, with servo motors enabling smooth motion.
- The ROS2 and Gazebo simulation validated the automation and control system.

Discussion

- The design and analysis phases helped in refining the structural strength and motion precision.
- Servo motors provided better control but required proper tuning for optimal performance.
- Future improvements include integrating sensor feedback for real-time adjustments and implementing PID control for smoother motion.

Conclusion

This project successfully demonstrated the feasibility of designing, analyzing, building, simulating, and automating a robotic arm using ROS2 and Gazebo. The use of servo motors for automation proved effective, and future iterations can further refine movement accuracy and real-world applicability.