Human Interrupted Task Compliance Robot

April 2024

Western Engineering

Introduction

The outcome of this project is a platform for Western University's robotics club, WEBots. The platform allows the club's members to test their subsystems in a safe way, without requiring a full robot. The robot is designed to offer a safe way to quickly iterate design ideas.

Problem Definition

WEBots has had difficulty working on Project TITAN due to steep learning curves and sub team interdependencies. The club requires a platform that allows their members to safely test, demonstrate, and communicate their ideas.

Project Scope

TITAN is a 6ft humanoid robot, but the project focuses on supporting members with the design of TITAN's arms. The platform needs to be modular and flexible for testing. The platform's focus is on motion planning for task completion with interchangeable hardware. A key safety requirement is handling physical collisions arising due to student error.

The input of the system is the student's planned trajectory with the platform handling cases of collision.

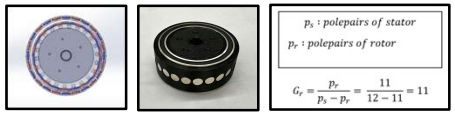
Design Objectives	
Property	Objective
Size	Low weight for portability
Hardware	Allow for swapable hardware components
Lifespan	Low wear components to avoid replacement
Waste	Use recyclable materials where possible
Repeatability	Repeated usage does not impact performance

Design Constraints	
Property	Constraint
Cost	Remain within WEBots budget
Sensor Type	Only use TITAN competition allowable sensors
User Safety	No hazardous materials
System Safety	Damage from student misuse is prevented
Camera Input	Must allow camera input for TITAN compatibility

Design Subsystems

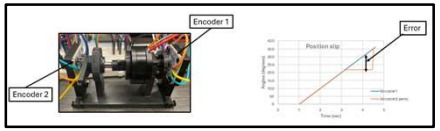
Joints

•Allows slippage without damaging the gears
•Resilient to Student misuse and over torquing of joints
•If linkage torque exceeds magnet strength, slippage occurs [1]



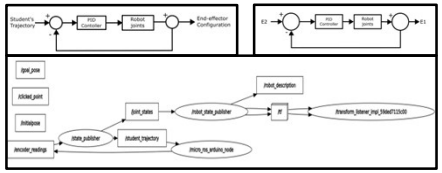
Collision Detection

•Dual encoder system one tracks rotation of motor second tracks rotation of linkage
•If these values differ, slippage is detected



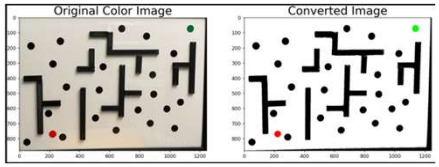
ROS2 Integration

•Path planning & simulation done in ROS2
•ROS2 features easy hardware agnostic and testing
•Allows WEBot members to gain experience on an increasingly popular robotics tool



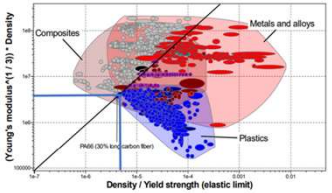
Digital Image Processing

- Manipulator features a camera to capture the environment
- Images of the workspace size and task are processed to determine path planning



Mechanical Linkages

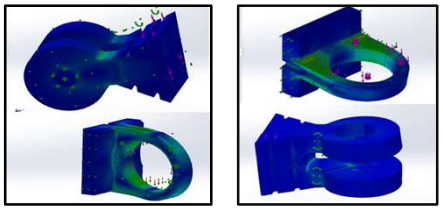
- Linkages were chosen using Ansys Granta and 2 performance equations optimizing mass, with required stiffness and strength
- Analysis yielded 30% long carbon fiber as the best linkage material selection



Analysis

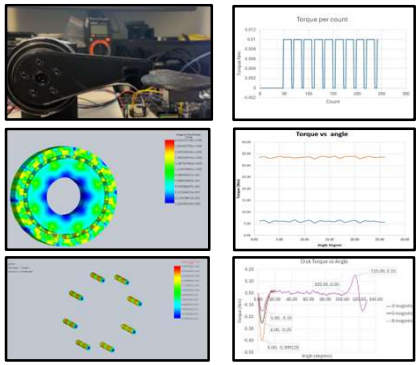
Finite Element Analysis of Joints

- Horizontal and vertical loading



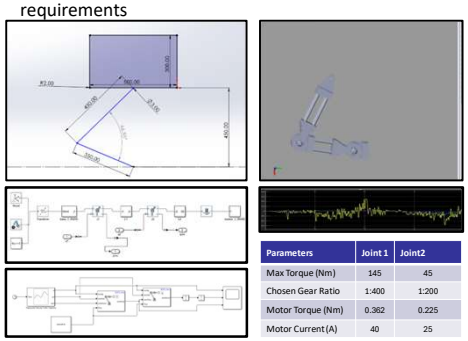
Analysis of Magnetic Gearing

- Utilized EMS to for different configurations and torque analysis.



Torque Analysis of Arm

- Simscape Multibody analysis of torque on joints to get requirements

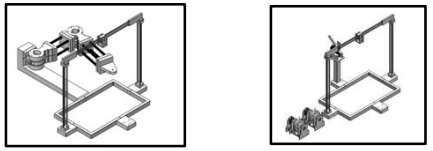


Parameters	Joint 1	Joint2
Max Torque (Nm)	145	45
Chosen Gear Ratio	1:400	1:200
Motor Torque (Nm)	0.362	0.225
Motor Current (A)	40	25

Final Design

Design & Prototype

- The final design is the robot arm in earlier portions of this poster.
- The prototype handles the joints separately; however, the ROS simulation would show in real time the end-effectors position due to the motors.



•The prototype also utilizes a laser that points where the end-effector of the robot would be due to the revolution of the motors.

Conclusion & Future Directions

This project has been a great learning experience for the group and future iterations will be added to allow more types of tests (torque testing, computer vision, etc) for WEBots members.

References

[1] Axial Flux Cycloidal magnetic gears | IEEE Journals & Magazine | IEEE ..., https://ieeexplore.ieee.org/document/6646317/ (accessed Nov. 27, 2023)