Prismatic Robotic Arm Optimized for Torque

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Introduction

Robot dogs and their impact on society are becoming more and more investigated by scientific research facilities because they can do tasks that are deemed unsafe for humans to do. Some examples of these tasks include search and rescue in hazardous environments, surveillance and security in high-risk areas, and handling hazardous materials. To ensure that these robotic systems are as effective as possible, Professor Nguyen and his lab decided to conduct research and experiments regarding a robotic arm that would sit and extend from the robot dog's back.

Although it may seem simple and intuitive, multiple considerations need to be taken account for such as the strength of the gripper of the robotic arm as well as the potential length and weight of the arm. These potential issues were addressed in the research we conducted over the summer in Professor Nguyen's lab. Specifically, we focused on how gear ratio affects the torque and force of the robotic gripper and designed potential ideas for the most optimal way of balancing strength and speed.

Objective & Impact of Professor's Research

Professor Nguyen's lab is dedicated to advancing knowledge and innovation in achieving extremely agile and robust locomotion on dynamic robotic systems. The primary goal of our summer research was to optimize the strength and torque of the robotic arm gripper, bring about ideas regarding a passive prismatic joint for maximum arm extension, and to engineer the robotic arm onto the Aliengo robot dog.

Acknowledgements

My journey through SHINE wouldn't have been possible without the support and guidance of several individuals. I extend my deepest gratitude towards Professor Nguyen for giving me the opportunity to conduct this research amongst other contenders and to my mentor, Junchao, for his mentorship and invaluable insights throughout the projects. I'd also like to thank my fellow lab members for their collaboration and camaraderie.

Research & Methodology

Because of the laboratory's goal of engineering a robotic arm to be mounted on the back of the Aliengo robot dog, I first learned about machining and different techniques such as tapping and the construction of physical mechanisms.

Our research also investigated the rotation of the gripper of the robotic arm, so I was tasked with learning about Arduino program and produce a way of rotating the upper gripper using a servo motor.

Figure 1: Robot Dog with Arm

Most of the the laboratory's research over the summer was spent researching the best gear ratio possible for the gripper to optimize strength and rotational force without the expense of strength in a heavy way. Because of this, I researched about different mechanisms that could have been possible to gain the 3:1 gear ratio that we desired. Between a mechanism with pulleys and timing belts, and a planetary gear box, we decided to go with the planetary gear box as it provides a better design aesthetically. When producing the design of the planetary gear box through SOLIDWORKS, I learned about multiple different necessary components such as the module, clearance, and teeth of the gears.

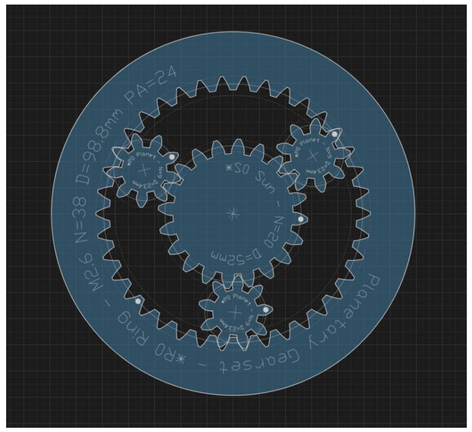

Figure 2: Planetary Gear System

Skills Learned

Throughout SHINE, I had the opportunity to engage in intensive research and develop a large range of skills that have significantly contributed to my academic growth.

- Electrical Wiring
- Arduino

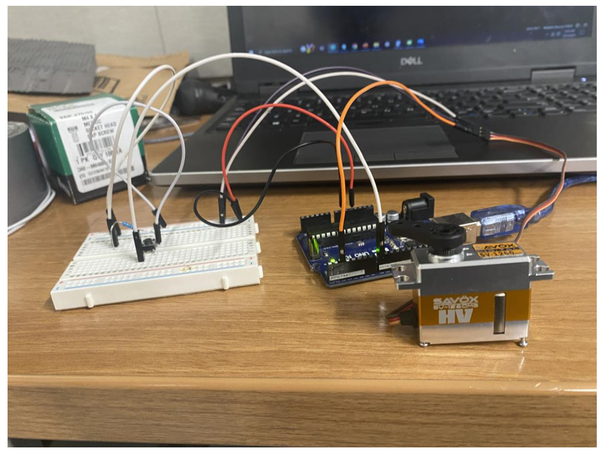

Figure 3: Electrical Wiring

- SOLIDWORKS (CAD)

Figure 4: Robot Arm CAD

- Machining
- FEA (Finite Element Analysis) using ANSYS
- Topology Optimization

How This Relates to Your STEM Coursework

My STEM coursework included AP Physics C and AP Computer Science which greatly helped my understanding in my SHINE lab.

AP Physics C gave me knowledge when it comes to rotational motion, forces, and torque, which were necessary things to know for the gear ratio optimization of the gripper to maximize grip strength.

Although AP Computer Science focused mainly on Java, a lot of the fundamental concepts about programming and syntax were very similar and gave me a solid foundation to work upon.

Next Steps for You & Advice to Future SHINE Participants

After SHINE, I hope to dive deeper into mechanical engineering and engage in continuous self-improvement to advance my knowledge academically. I am also encouraged to perform more research in university and assemble a strong portfolio showcasing my projects
and interests.

My advice for future SHINE students to make the most out of your time in the program are to take initiative and actively participate in all aspects of the program, connect with your fellow participants, instructors, and mentors, and to not fear failure.

Figure 5: Robot Dog with Arm CAD