Robotic Arm Based Material Handling

Electrical/Computer Engineering & Mechanical Engineering

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Abstract

The purpose of this project is to design and construct a material handling system to carry out the procedure of fabricating sol-gel piezoelectric material that will be used in the manufacturing of semiconductors. This goal will be achieved via a robotic arm that must be able to handle, transport, and pour beakers containing various solutions that will be combined to create the final product. This is accomplished through building a closed loop control system for the robotic arm that provides feedback on machine movements, ensuring clean and expected execution. aun

Motor Control

The motors were controlled using an Arduino Due, the first complex Arduino board with a 32-bit ARM core microcontroller. Steppers were driven with L298N driver boards.

Figure 1. Pin connections between driver and digital pins on Arduino for single motor

Arm Design

The arm has 6 joints, 3 of which are rotating joints and 3 are revolute joints. It is a 6 DoF arm controlled by 6 stepper motors and a single servo motor at the end effector.

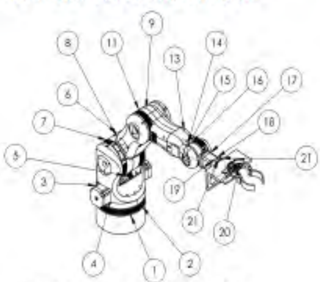

Figure 2. CAD design of arm before print

Finite Element Analysis: Static Simulations

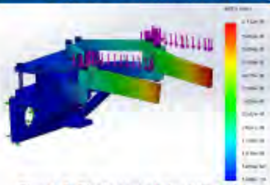

Figure 3. Displacement simulation of the gripper assembly

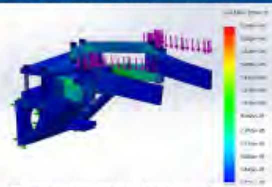

Figure 4: Von Mises stress simulation of the gripper assembly.

Both the displacement of the components and stress that the gripper experiences are important factors to consider in design. Simulations make it is possible to know if a part will fail under a certain load, without having to test the physical part.

Finite Element Analysis: Motion Studies

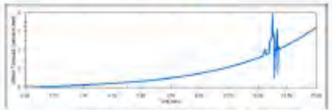

Figure 5. Torque plot for base rotation

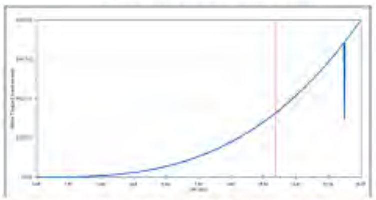

Figure 6. Torque plot for base revolute

Fabrication of Structural Components

- All components printed from PETG (glass transition temp. of 85°C), due to high strength and sustainability
- 1.2 mm wall thickness and 40% infill
- 40 mm/s was optimal print speed for maintaining quality and strength
- Layer orientation is important in consideration to side loads
- Largest print (base clevis) took 56+ hours

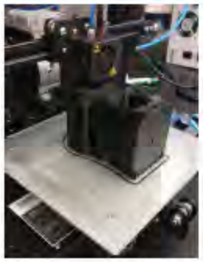

Figure 7. Assembly part during print

Future Work

Future developments of the robotic arm will progress towards automation of the entire system. Algorithms of Artificial Intelligence and Machine Learning need be developed for implementation across the machine which can advance the handling system through analysis of regression models. End effector types can be improved by making use of already built-in vacuum lines. The final steps towards an absolute material handling system must be met by scaling the system to an industrial-sized robotic arm.

Figure 8. Final assembly of arm

Conclusion

Key features of the this project include design and fabrication of a structural arm and basic control via electronic sequencing of motors, encoders, drivers, power supply units, and a microcontroller. Additional features such as a feedback system with encoders and noise reduction using motor dampeners, allow for more accurate and smoother repositioning of the arm. Overall, the foundation of our material handling system has been successfully laid out for future development.

Sponsors

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