Multi-Nozzle 3D Printer for Printing Soft Materials

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ABSTRACT – Additive manufacturing/3D printing is widely used for rapid prototyping and fabrication. In this project, our aim is to implement a 3D printer with multi-nozzles to print soft materials to print complex soft actuators. The printer should be like any other 3D printer in design; however, it should be able to print structures using soft materials. We are preferring to have two to three nozzles that can print the main material (i.e., soft material), a support material (i.e., a soluble material), and a hard material (i.e., PLA; ABS). The printer is expected to be used in fabricating soft actuators with minimum internal feature sizes range from 20 to 30 microns. The final prototype is expected to be validated by printing a functional soft structure at the end of MECH458X.

Introduction

Soft robots are getting popular as they are being applied in many applications such as healthcare, manufacturing, surveillance, etc... These robots are made from compliance materials in which internal chambers are arranged in a networked fashion to expand upon pressurization. The deformation caused by pressure variation is used to realize different movements. The morphological changes in the exterior are designed based on the requirement of the application. These robots have better functionality, adaptability, and flexibility than traditional electromechanical robots. However, one of the main challenges in these robots is the requirement of complex steps in the fabrication process. Soft lithography is one of the most popular techniques that is used to fabricate soft actuators. However, this technique has many steps, tedious, time-consuming, expensive, and not modest in mass production. Therefore, our main goal is to use additive manufacturing to rapidly prototype and fabricate these actuators efficiently and cost-effectively. The state-of-the-art extrusion type 3D printers can go up to 20 microns in the resolution (e.g., Raiser3D N2 = 10 microns, Ultimaker 3 = 20 microns, MakerGear M2 = 50 microns ... etc.). This project expects to produce a similar printer but prints soft structures.

Brief Project Description

This project aims to develop a 3D printing platform to print soft materials that are compatible with soft robots. The main platform should be a well-designed computer-controlled printing bed to generate required extruder movements in a very smooth manner (the expected resolution is between 20 to 30 microns). The hardware and electronics are expected to be supported by an open-source slicing software (we prefer to have both SD card support and direct computer connection to the printer to transfer G-code) available for free download. The preferred design should have multi nozzles (minimum of two; three is preferable) in which one nozzle will print the elastic material and the other one will print the supporting material. The design team is free to decide the best strategy to implement internal features (e.g., a soluble material can be used to build the supporting structure, and later it can be washed away). The team is free to select one of the open source low-cost 3D printing platform available online and can be modified according to the objectives of this project. The team can work from home and we suggest distributing the workload equally among all team members. However, each member can be individually responsible of design, fabrication, assembly, documentation, and procurement as appropriate.

Expected Outcomes

This project aims to implement a fully functional multi-nozzle additive manufacturing platform to print soft structures with complex internal features. The expected outcomes are as follows:

1. A fully functional desktop 3D printing system supported by an open-source slicing software.
2. A multi-nozzle printing head that can print several materials in a single print.

3. Capability of making internal features with a resolution of 20 to 30 microns.
4. A final print of an example functional soft structure as the validation of the prototype.

Resources Available

We will provide weekly (or bi-weekly) consultation on zoom to give you feedback (by Dr. Mu Chiao and Hiroshan Gunawardane). The design team can work-from-home and finally hand over their product to the MEMS Lab after the successful completion of MECH458-X.

Customer Requirements

The customer would like to have a fully functional 3D printing platform along with a technical manual. The main features mentioned in the above sections are expected to integrate into the prototype and a simple functional 3D structure is expected to be printed as prototype validation.

Some Useful References

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