EMBEDDED 3D PRINTING OF STRAIN SENSORS WITHIN STREACHABLE ELOSTOMERS

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Abstract

Sabancı University is established at 1999 in Turkey by Sabancı Foundation. The internship was done in Soft Robotics and Control Lab under Faculty of Engineering and Natural Science of Sabancı University. Soft robotics is a subfield of robotics that concerns the design, control, and fabrication of robots composed of compliant materials, instead of rigid links. Recently, curiosity about wearable electronics, human/machine interfaces, and soft robotics has opened a new class of electronics. It is known as stretchable electronics. One example of these electronic devices is a strain sensor. Soft sensors are typically composed of a deformable conducting material patterned onto, attached to, or encapsulated within an inactive stretchable material. There are several production methods for creating these sensors. One of the newest techniques is embedded 3D printing. Viscoelastic ink is extruded through a deposition nozzle directly into an elastomeric reservoir in this e-3D printing technique. The ink is a resistive sensing element, while the reservoir serves as a matrix element. The sensor will be ready when the reservoir material is cured. As a result, when the soft material stretch, the ink material will also stretch. Then due to strain, the resistance of the ink material will be changed. This is called a soft strain sensor. The project included the control and calibration of the 3D printing. Some background about g-code, python will be good for understandability of the report.

Company Information

The seeds of Sabancı University, the Sabancı Group's most comprehensive social responsibility project in the field of education, were sown in the summer of 1995, at a search conference in which 50 academics from 22 countries as well as students and representatives from the private sector participated. The conference, however, was just the beginning, as it marked the start of an extensive process during which the leading educational institutions in Turkey and across the world were examined to find out how they work and identify the fundamentals that made them successful. In the end, instead of choosing one university as a template or replicating existing examples and institutions, a new and unique university was designed. Since 1999, when students began enrolling, Sabancı University itself has set an example for many universities.

Introduction

Soft sensors are typically composed of a deformable conducting material patterned onto, attached to, or encapsulated within an inactive stretchable material. There are several production methods for creating these sensors. One of the newest techniques is embedded 3D printing. Viscoelastic ink is extruded through a deposition nozzle directly into an elastomeric reservoir in this e-3D printing technique. The ink is a resistive sensing element, while the reservoir serves as a matrix element. The sensor will be ready when the reservoir material is cured. As a result, when the soft material stretch, the ink material will also stretch. Then due to strain, the resistance of the ink material will be changed. This is called a soft strain sensor. This report explains the control and calibration process of the 3D embedded printer and dispenser in the Soft Robotics and Control Lab under the Faculty of Engineering and Natural Science of Sabancı University. During the internship, the control and calibration of the 3D printer, connection, and control of the dispenser were done.

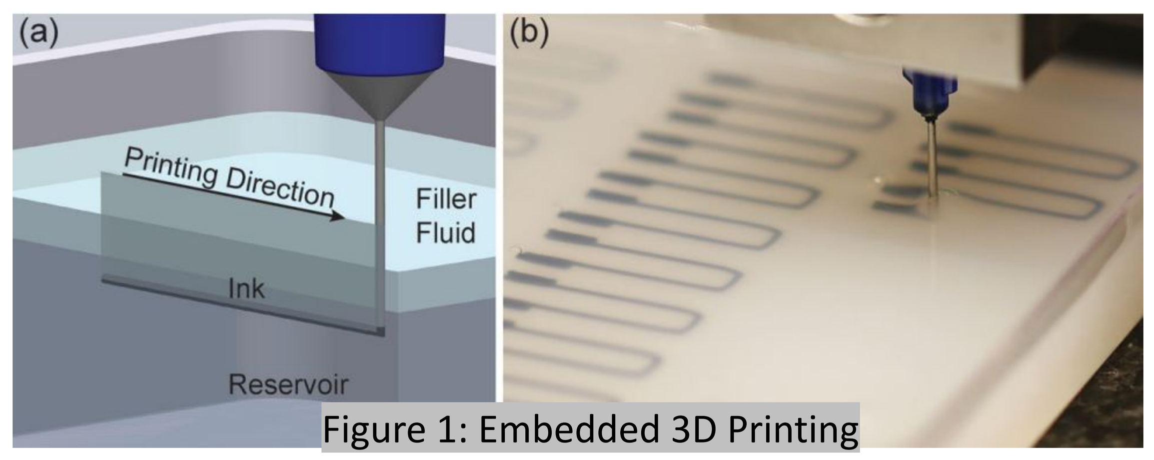

Figure 1: Embedded 3D Printing

Steps of Project

I. Literature review and some of tutorials were done about Strain Sensors, Embedded 3D Printing, g-code, Raspberry Pi, usage of the dispenser.
II. Writing simple python functions about motion of the printer.
III. Learn dispenser usage and connecting it to the printer.
IV. Design a syringe holder for printer, then print and assemble it to the printer.
V. Update the code based on printerbed boundary limitations.
VI. Optimize and calibrate the printer by using ink material as toothpaste.

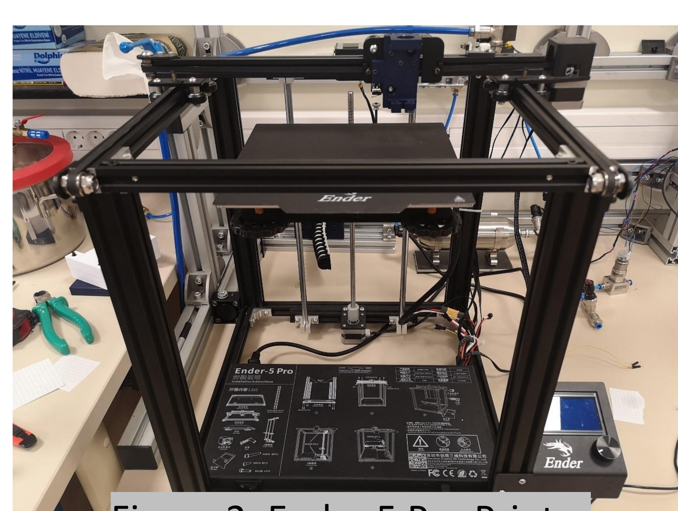

Figure 2: Ender 5 Pro Printer

Figure 3: Fisnar DC100 Dispenser

Project Details

The holder design is done, then it was printed and assembled to the Ender 5 Pro.

After the control code is finished, as you can see from the sample output code figure, the program shows each motion and printing mode on the screen. Also it plots a graph that show the expected printerhead motions and printed shape.

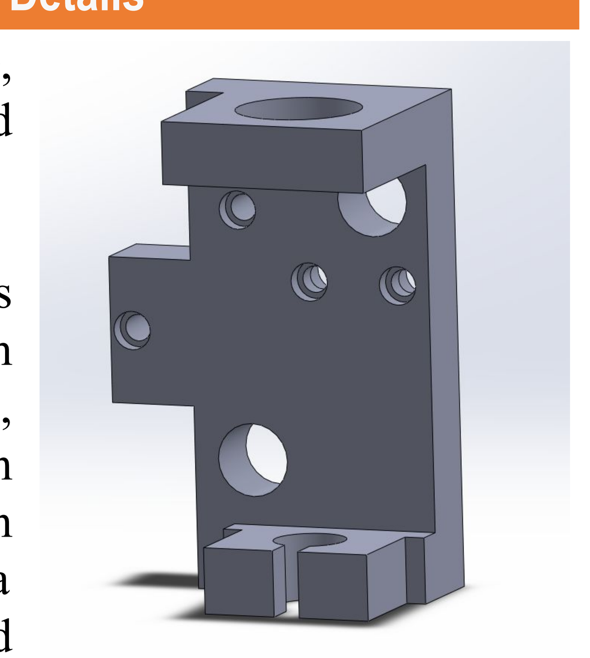

Figure 4: Syringe Holder Cad Design

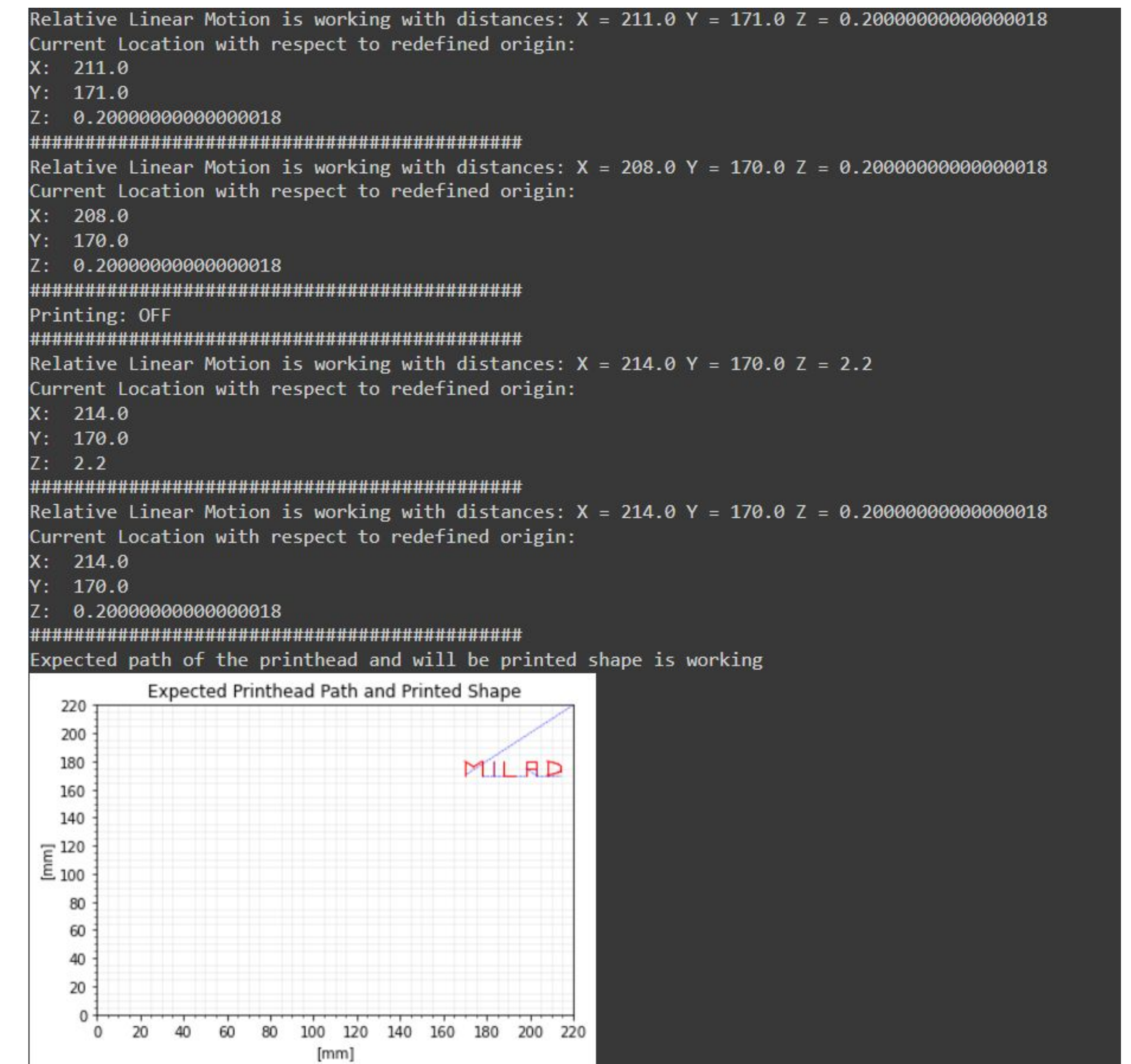

Figure 5: Successful Working Code

If the user enter a position that is out of boundary, the code giving an error and suggestion about how to solve the problem by giving error axis.

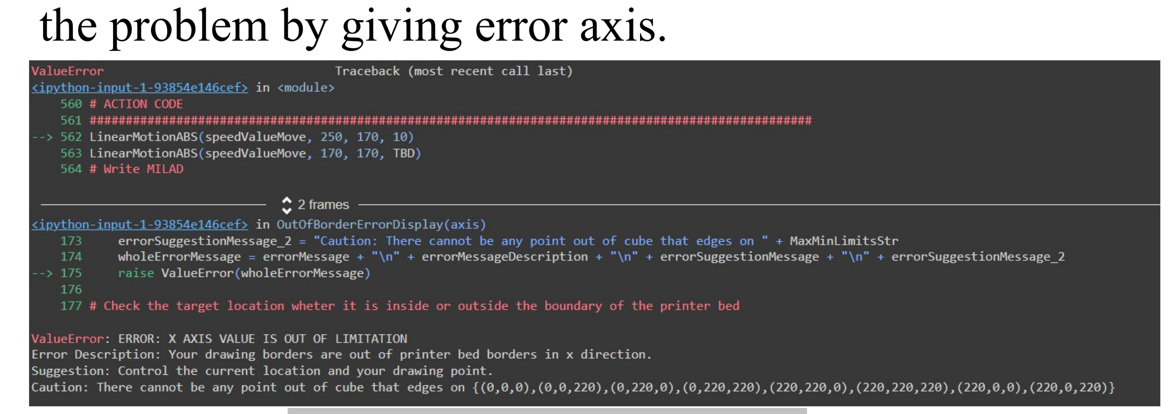

Figure 6: Limitation Error Code

After the coding process was done, the next part was calibrating the printer. There were 3 important parameters to consider:

- Tip Bed Distance (TBD): Z-axis distance between the end of the syringe tip and printer bed.
- Feed Rate: The speed of the printhead motion.
- Pressure: The output pressure which is given to the syringe on the printer.

These were tried and noted. The proper values are:
TBD = 0.2 mm, Feed Rate = 500 mm/sec, Pressure = 15 psi

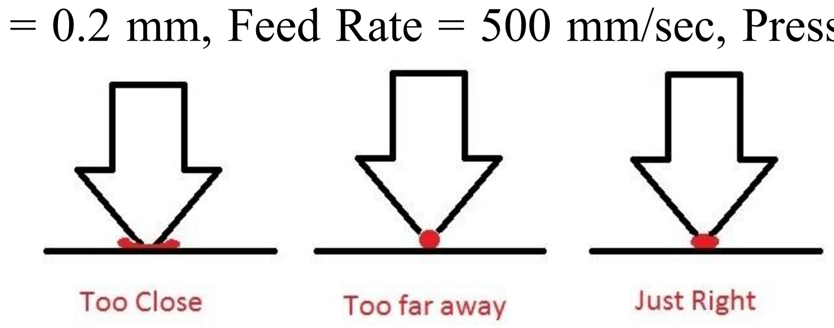

Figure 7: Calibration Tips for Z axis

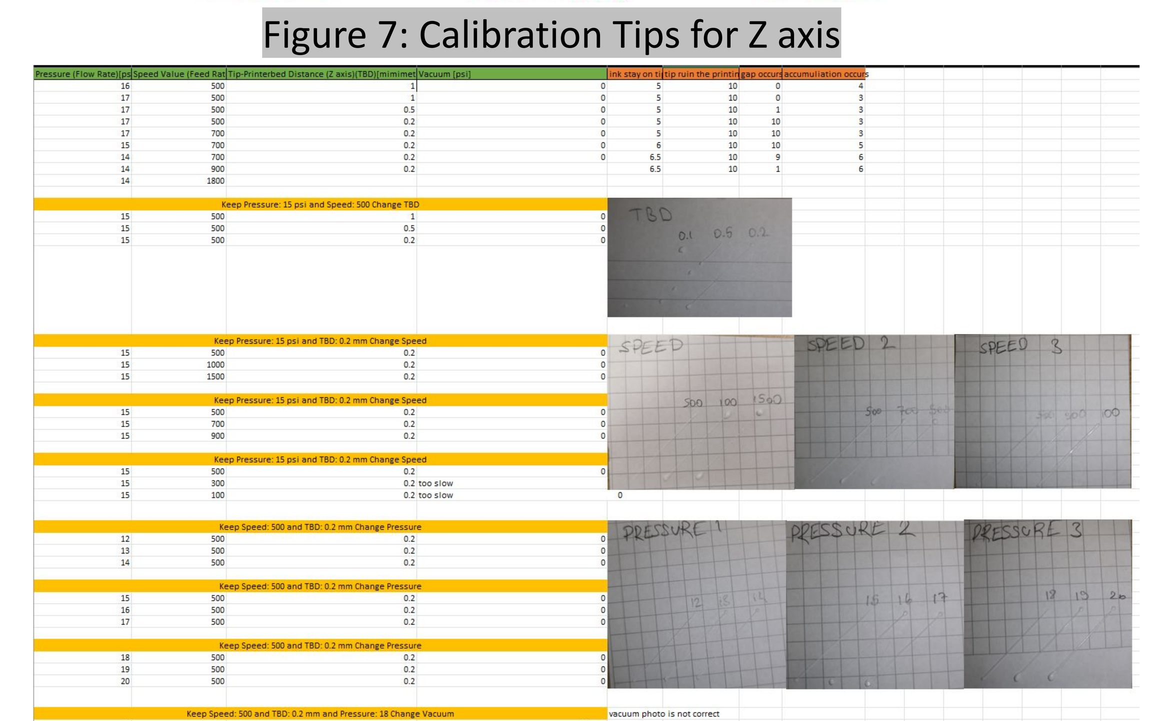

Figure 8: Calibration Excel File

Below figure shows successful printing with toothpaste.

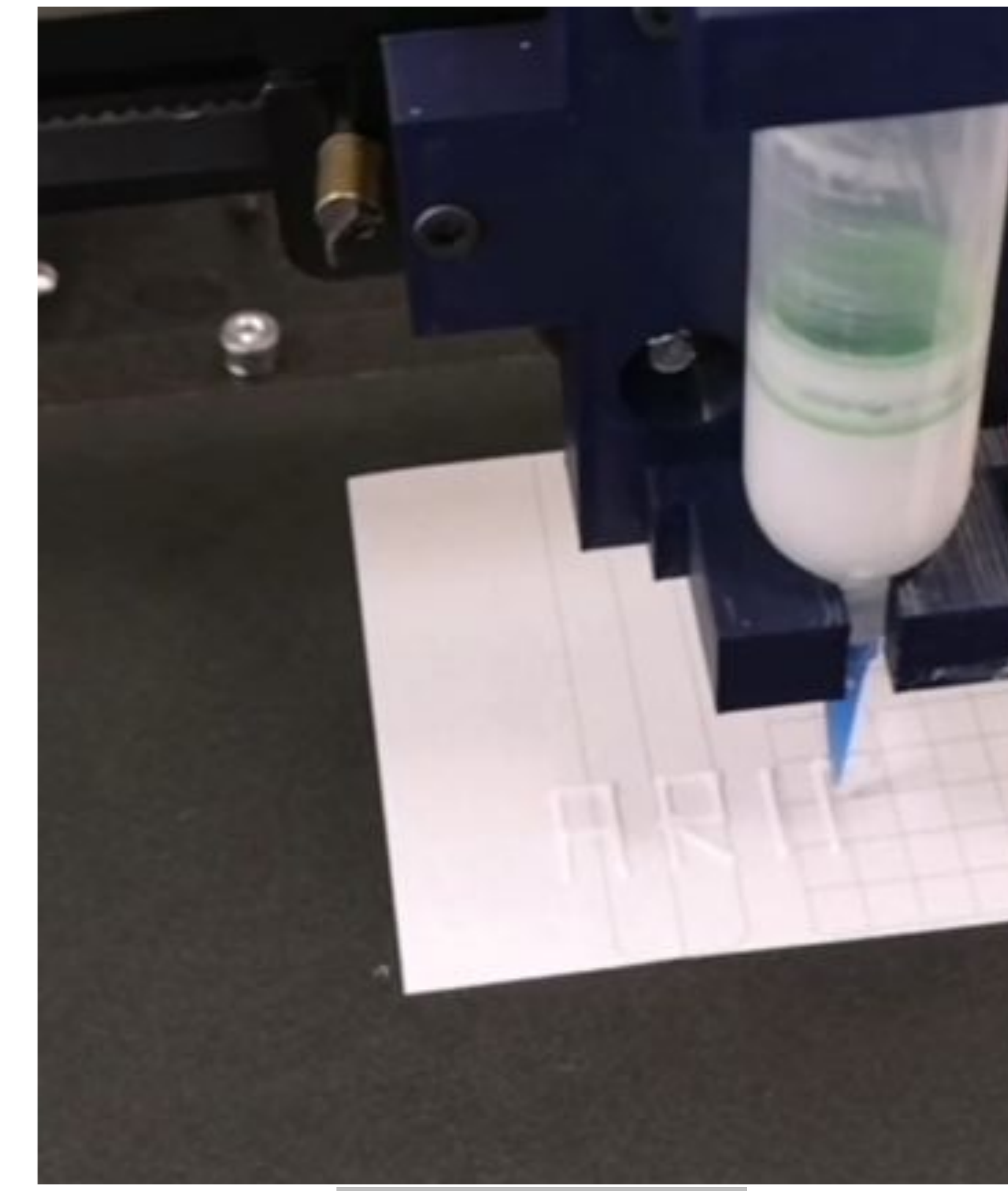

Figure 9: Successful Printing

Conclusion

The internship project was related to the preparing a 3D printer for fabrication of strain sensors via method called embedded 3D printing. I have learned how to use and control CNC and 3D printer type machines by g-code. Additionally, I experienced first time work with dispenser and a pressure system. I used my previous CS course knowledge and code the printer for easy usage of the user.

References

Muth, J. T., Vogt, D. M., Truby, R. L., Mengüç, Y., Kolesky, D. B., Wood, R. J., & Lewis, J. A. (2014). Embedded 3D printing of strain sensors within highly stretchable elastomers. *Advanced materials*, *26*(36), 6307-6312.