Design and Development of Compliant Robotic Gripper By 3D Printing Technology

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Abstract :

Microgripper is an essential device in the micro-operation system. It can convert other types of energy into mechanical energy and produce clamp movement with the required chucking force, which gives it a broad application prospect in tiny components' processing and assembly, biomedicine and optics, etc. A microgripper's performance depends on its power supply, type of drive, mechanism structure, etc.

In this project, we use 3D printing technology to develop a compliant gripper for micro-object manipulation. We studied different types of 3D printing materials. We also studied Pro-series software for mathematical and structural designing and simulation for redesigning. The resulting design of the gripper can be done by using ABS plastic

Keynote :

Robotic Micro Gripper, 3D Printing, Additive Manufacturing, Complaint Technology.

Introduction :

Microgripper plays an important role in micromanipulation and micro-assembly tasks. Microgrippers with various actuation principles have been reported in the literature, such as electrostatic [1], electrothermal [2], and piezoelectric microgrippers [3]. In particular, the piezoelectric actuator [4], [5], is attractive owing to its merits of sub-nano-meter positioning resolution and rapid response speed.

In the article "SOME ASPECTS OF MULTI-FINGERED GRIPPERS" the author discussed some aspects of multi-finger grippers. In addition, they have also discussed some limitations of this type of gripper. As this gripper is joint, so this type of Gripper could drop parts with loss in air pressure as this type of gripper is air pressure control. This type of gripper can only be for a singular purpose. In another paper "Magnetic Gripper Using Magnetic Switchable Device" where authors worked on magnetic grippers. The attraction gripper is fundamentally simple. There are two primary problems with this type of end

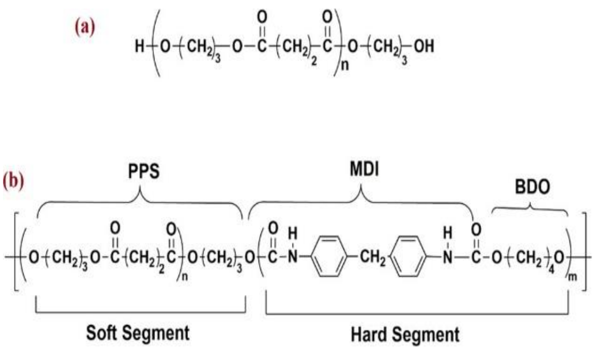
effector. For a magnetic attraction gripper to work, the object it grasps must contain a ferromagnetic material such as iron or steel. The magnetic field produced by the end effector can permanently magnetize the objects it handles. In some cases, this is not a concern, but it can cause trouble in other instances.
Among the fundamental design parameters of a robotic arm, the ratio between the structure weight and the strength that can be held by it are especially relevant, and both of them are intrinsically related to the usual building materials, namely, aluminium and steel. Our aim was to improve these two key parameters by using ABS plastic in the design and construction of a robotic arm structure with six degrees of freedom. ABS plastic is a relatively light material and the most suitable one.

Material Selection :

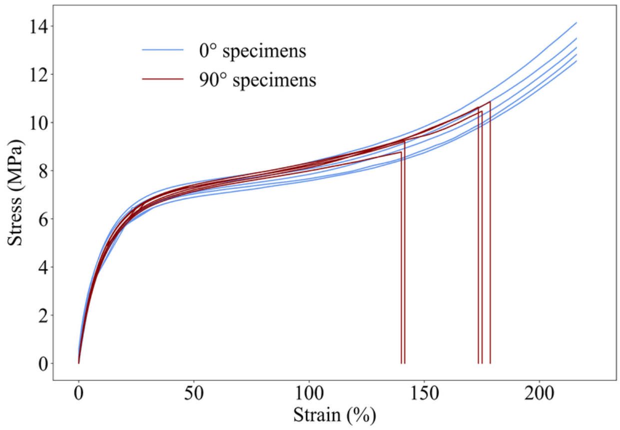
Low elastic module materials and smart structures that are inspired by nature empower soft robots to perform tasks by mechanically adapting their bodies to dynamic environments by undergoing extremely large deformations without any sign of material or structural failures due to their inherent softness. In this project, we have selected TPU for gripper design and for arm we use PLA.

Thermoplastic polyurethane (TPU):

Thermoplastic polyurethane (TPU) is a melt-processable thermoplastic elastomer with high durability and flexibility. It provides several physical and chemical property combinations for demanding applications. It has properties between the characteristics of plastic and rubber. In terms of practical use, TPU offers desirable material properties like flexibility, good tensile strength, and



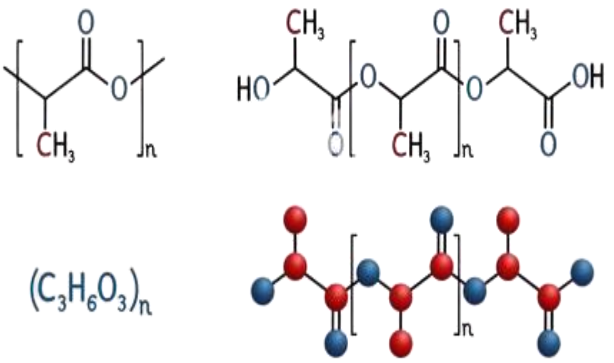
resistance to tears and abrasions.

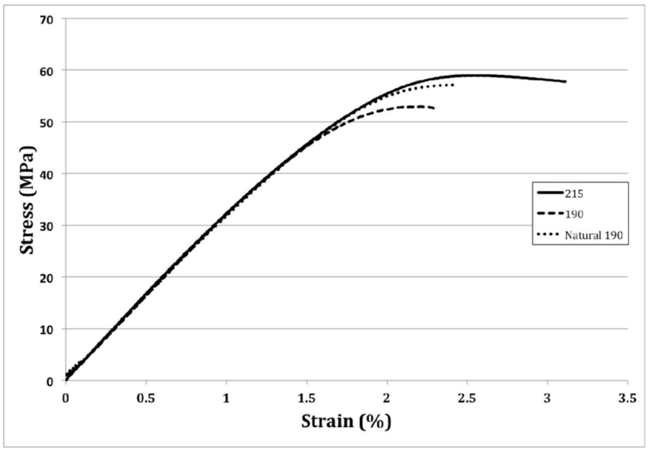


Polylactic acid (PLA) :

PLA is a user-friendly thermoplastic with higher strength and stiffness than both ABS and nylon. With a low melting temperature and minimal warping, PLA is one of the easiest materials to 3D print successfully. Unfortunately, its low melting point also causes it to lose virtually all stiffness and strength at

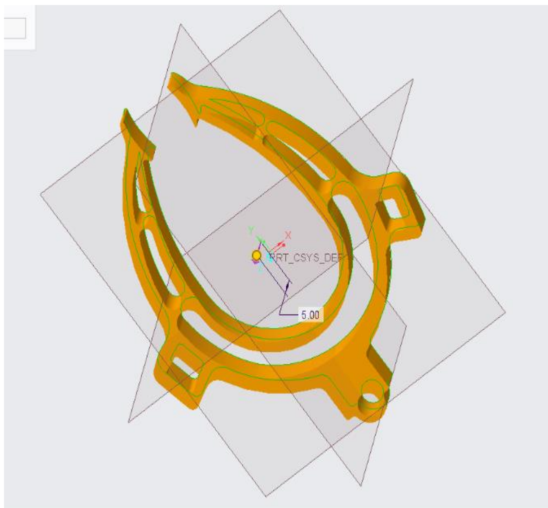
temperatures above 50 degrees Celsius. In addition, PLA is brittle, leading to parts with poor durability and impact resistance.
Although PLA is the strongest of these three plastics, its poor chemical and heat resistance force it into almost exclusively hobbyist applications.



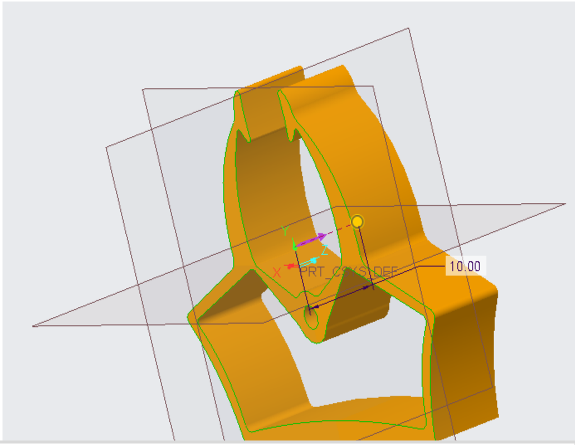


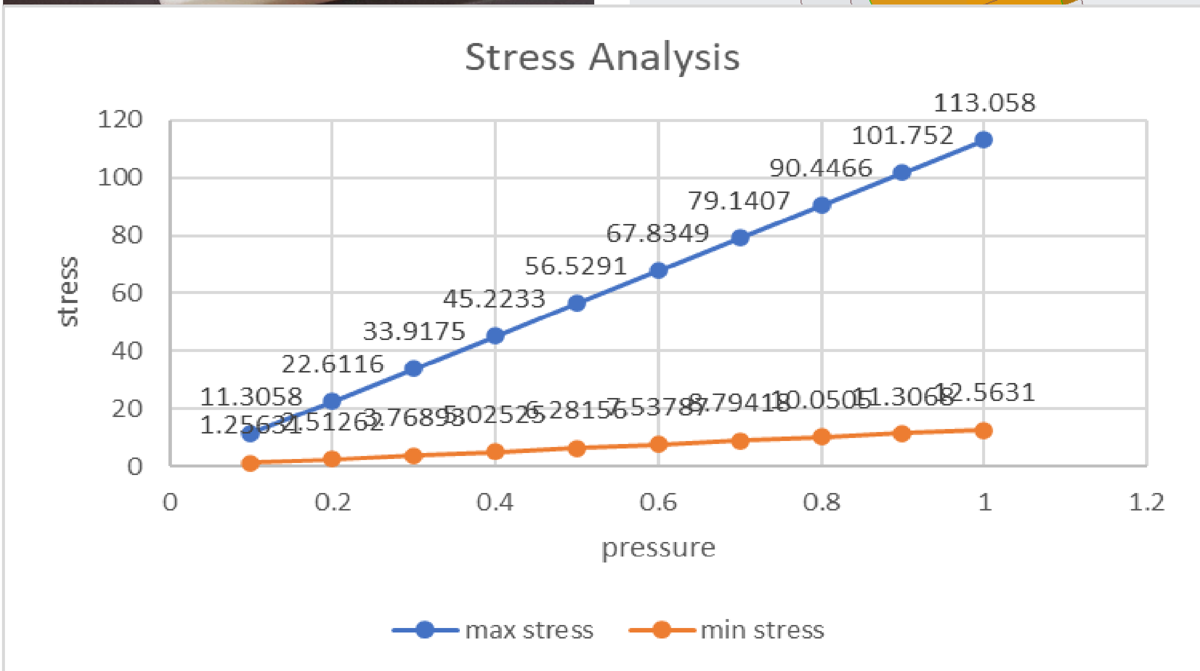
Mechanical Design and Analysis :

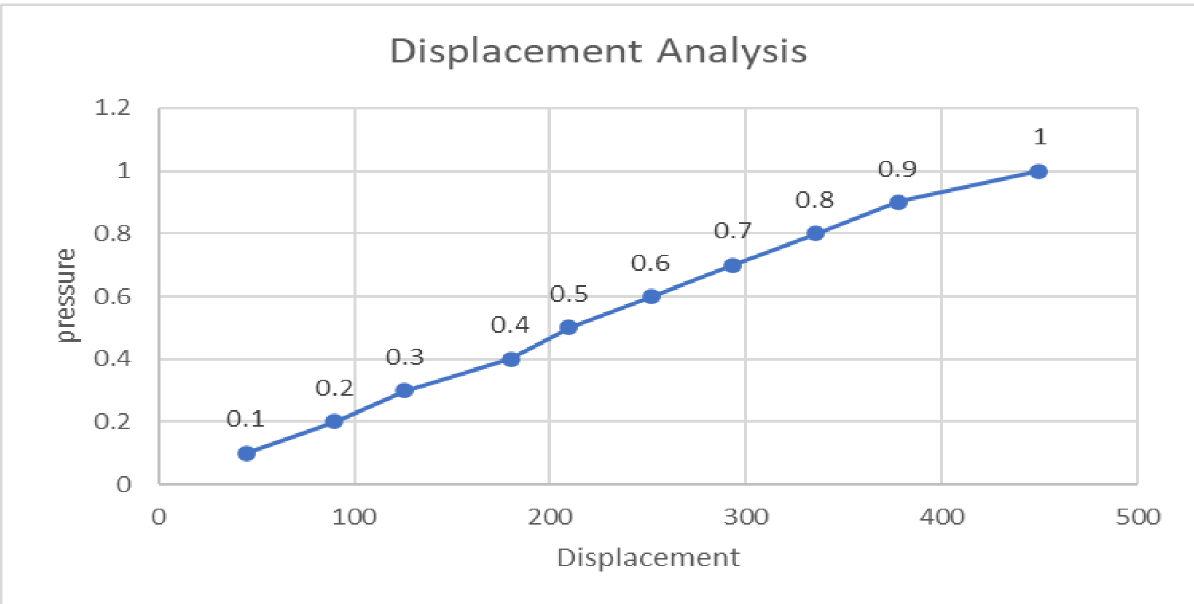
The first iteration of the robotic microgripper consisted of two parallel arms connected by a flexure mechanism. The flexure mechanism was designed to allow the arms to move to each other, enabling the gripper to open and close. The prototype was 3D printed using ABS material. The gripping force was measured using a force sensor. Due to its small size and high material density, the gripper doesn't work



In the second iteration, the flexure mechanism was modified to provide more flexibility, allowing the arms to move more freely. The gripper was also equipped with two fingers with serrated tips to improve the gripping force. The prototype was 3D printed using TPU material. We are planning to work the gripper using a servo motor, and the gripping force was measured using a force sensor. The results showed a significant improvement in gripping force compared to the first prototype.

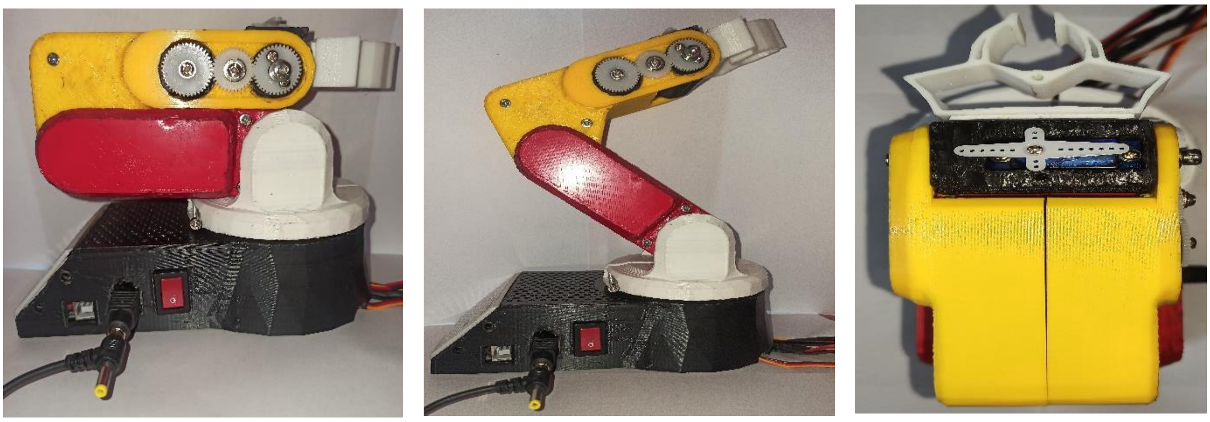


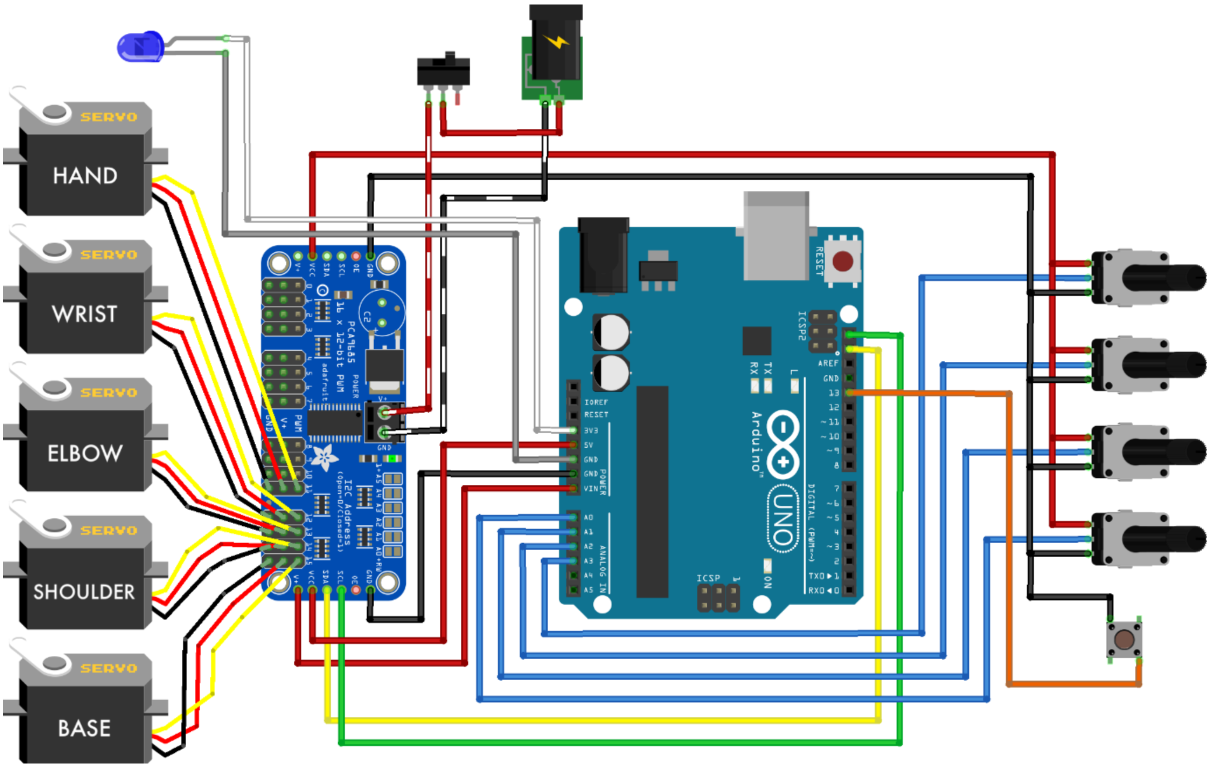




Arm Designing and Electrical Circuit :

A 4-degree-of-freedom (DOF) robotic arm, as its name suggests, boasts four independent axes of movement, enabling a range of complex manipulations. Compared to simpler 3-DOF arms, these dexterous machines unlock new possibilities in various fields. The robotic arm is constructed with lightweight yet durable materials to ensure efficient movement and reduce inertia. The 4-DOF configuration providing flexibility in reaching targets from various orientations. The joint mechanisms utilize high-torque actuators and advanced gear systems to enhance payload capacity while maintaining accuracy.





This circuit is used to control the 4-DOF robotic arm controlled by an Arduino Uno. It uses a PCA9685 16-channel I2C PWM driver to control five servos. The PCA9685 is a popular choice for controlling multiple servos with an Arduino because it frees up the Arduino's PWM pins for other tasks.The circuit is powered by a 12V power supply that is connected to the Arduino's Vin pin. The servos are

also powered by the 12V power supply, but they are regulated to 5V using a voltage regulator. The voltage regulator is necessary because servos typically operate at 5V.
The five servos are connected to the PCA9685 driver on the I2C bus. The I2C bus is a two-wire serial bus that is used to communicate between devices. The Arduino Uno communicates with the PCA9685 driver over the I2C bus to send PWM signals to the servos.
The buttons on the breadboard are connected to the Arduino's digital pins. The buttons can be used to control the movement of the servos. For example, a button could be used to move the servo that controls the shoulder joint of the robotic arm.
The circuit also includes an LCD display. The LCD display can be used to show information about the robotic arm, such as the current position of the servos.

Conclusion :

By the end of this phase I completion of this project we can identify that 3D printed robotic gripper will be the most useful gripper in the near future for its low cost and huge application. The compliant gripper is useful for its high-accuracy grasping of small objects with adaptive control of contact points along with the active surface of the finger.
In conclusion, the development of a robotic microgripper using compliant structures has demonstrated the potential benefits of this approach for the precise and delicate manipulation of small objects. The compliant structure of the gripper provides flexibility and adaptability, allowing it to grasp and manipulate objects without causing damage or deformation.
The project was successfully designed, and fabricated, using compliant structures. The project highlights the importance of considering multiple factors when selecting a gripper for a particular application, including the object size, shape, and material properties, as well as the gripper's linear displacement, gripping force, and adaptability.
Overall, the development of a robotic microgripper using compliant structures has potential applications in various fields, including biomedical research, industrial automation, and micromanipulation. The project provides a foundation for further research and development in this area, with the potential to improve the precision and delicacy of small object manipulation in a variety of applications.

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