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Design and fabrication of soft gripper using 3D printer

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Abstract. Soft robotics is the most emerging subject in the present world. This paper focuses on the grippers (end effectors) that are attached with robots to interact with the environment. We proposed soft robot gripper with a modular design of cad model, which can hold multiple types of objects. This soft gripper consists of four fingers which are attached commonly and a holder which is used to attach the gripper to robot. All components were 3D printed and the soft finger structure is made molding technique using platinum cure silicon rubber. The fingers analysis is done in using finite element (FE) analysis by applying different loads. The bending of finger is obtained by providing pressurized air. A curvature sensor is integrated inside each finger to measure the curvature or bending angle during grasping. The proposed gripper could grasp and lift objects with different shapes and weights.

Keywords. soft gripper, soft finger, finite element (FE) analysis.

1. Introduction

In last few years, soft electrometric robot grippers brought great attention to the world in many applications, because of its excellent characteristic and compliance factors. Developing of soft grippers are started in late 90s. Suzumori proposed the first flexible micro actuator which works by electro pneumatic system. Its cylindrical structure will show us the yaw, pitch, and stretch motions. In this he integrated four micro actuators which can do several grasping tasks, like screw a bolt, fitting a bulb etc., Marchessat presented a work on the soft fluidic type elastomer robots and its design is proposed, these soft fluidic elastomeric robots are divided into three types, according to its working: namely 1) pleated 2) robbed and 3) cylindrical type. The soft robot gripper is mainly used in pick and place experiments and also for other several tasks Example; a star-fish type robot gripper can hold soft materials like egg, fruits, paper containing nuts, etc., This soft gripper manufacturing takes several process like CAD modeling, analyzing, fabricating, assembling and gluing. In this we proposed a CAD model design of the soft gripper which can be able to grip or hold a delicate object like egg, fruit etc., and the design is made by using pro-e cad software. The



fingers are made by soft material like platinum cure silicon rubber, and the mold is made by hard material like ABS (Acrylonitrile Butadiene Styrene). [1] proposed a 3-d printed soft gripper for studying soft grasping forces between a soft gripper and a deformable object such as a paper contained peanuts. They introduced the model of the finger and the gripper followed by the explanation of the fabrication process. Calibration of the finger integrated with curvature sensor was also presented. [2] presented soft grippers for grasping and lifting a cup container filled with food materials. Three finger design is explained in this it also explained the FE analysis of all three fingers. [3] explained the stiffness damping and friction properties of soft gripper. The property of this parameters are such that their values are not fixed rather they different due to different viscoelastic materials. The main thing is model of soft fingertips gripper used for gripping and manipulation under these parametric variations. [4] developed a design of soft grasping system with both adaption ability and robust grasping security. A novel tri-finger robot gripper is proposed, comprising of three dual chambered ellipse profiled soft pneumatic fingers and a novel palm design with a compliant chamber. Finally, fabrication and analysis of soft gripper is presented. [5] designed a soft gripper, modeling, fabrication and experimental tests. They already done worked on 3-d printed soft gripper for packing a Japanese lunch box. Due to the angle of the initial configuration, the contact area grasping was limited and effected the grasping stability.to overcome that a parallel configuration is used. [6] focused on the curved shape memory alloys based soft actuators and its application for soft gripper. It states the difference between the curved actuator and a straight actuator. Curved actuators have the maximum bending for the same cross section than straight actuation. And finally explained the advantage of curved actuator. [7] designed a 3-d printed soft gripper and assembled the three fingers into a holder using snap-lock mechanism. A dynamic model to predict the FEA deformation and grasping force is presented. They have done an optimization-based approach to identify the unknown model parameters. [8] designed a soft touch gripper for grasping delicate objects like fruits and vegetables. This gripper requires less than 60 W of power during grasping or release of objects. They made a simplified analysis model, which can be used to estimate the griping strength of soft touch gripper and validated through a experimental analysis. [9] developed a hybrid tele-manipulator system, comprised of a soft robot gripper and a soft fabric based haptic glove. They designed a gripper of four pneumatic finger and an adjustable base which can be integrated to a robot arm. Tao-Gang [10] presented a simple and compact universal two-fingered hand with soft finger-tips with jamming effect. To grasp several kinds of object, high-DoF fingered hand, multi-gripper device etc. has been developed. We adopt jamming effect device for a finger-tip to fit various object shape. [11] designed and Fabricated a Pneumatic Soft Robotic Grippers made for surgical application. This new soft robotic gripper consists of a 3D-printed hook retractor shell, a soft inflatable actuator and two small rods... Two small rods are used to separate the inflatable actuator into three-fingers-like bloats which can firmly grip the soft tissues by multi-contacts between the tissues and the gripper when the air pressure is applied to the pneumatic channel. [12] developed a soft gripper having three pneumatic actuated fingers and a rigid base. They also conducted experiments on all fingers. They analyzed finger bending curves and analyzed using FEA (finite element analysis).

2.Methodology

The making of the proposed soft gripper has been constructed and discussed in this chapter. The steps are from designing, calculation. the following fig.1 depicts every step till the end.

First, we should find the best optimized design of soft gripper by several designs by creating in cad software. Then select suitable components for the actuation like control unit, compressor, and soft material

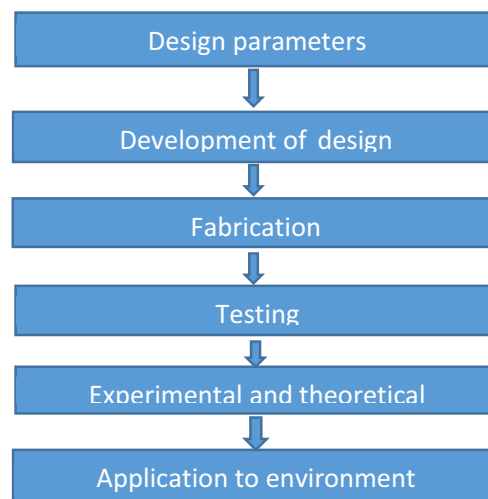


Figure 1. Flowchart showing methodology

Method

The method of fabrication of soft gripper is involved several stages. The process of fabrication of soft gripper is as below

Design and material parameters

Various designs are needed to find the best design parameters for the soft gripper which can be adopted to the requirement environment. The materials used for fabrication of soft gripper is to be analyzed.

Optimize the parameters

After the design parameters are determined, then from the obtained parameters and specifications, optimize the best parameters and the best design is done.

Develop of design

Developing of design is made using CAD software's like pro E, Creo, Ansys etc. In this we used ProE cad software for the design. Many designed were created and tested. The best design is used for the fabrication of soft gripper.

Fabrication

The designed CAD model is fabricated by using 3-D printer of ABS material. The soft gripper contains four fingers and a holder are fabricated. The platinum cure silicon rubber is used for the fabrication of gripper. It takes 6 to 8 hours to solidify the liquid silicon at room temperature.

FEA analysis

The analysis of the fabricated design should do by using Ansys software. The analysis of fluid flow and thermal analysis is done by giving desired input parameters.

Experimental and Ansys analysis

The fabricated model is tested by experimental analysis and Ansys. The calculations are done. The required graphs are obtained by output obtained by analysis. The testing is done on different types objects of different shapes.

Minimization of errors

The errors or problems obtained in the experimental analysis is to be minimized and corrected. After minimizing the errors adopt it to the environment.

Application to environment

The soft gripper is to be tested by fixing it to the end effector of the industrial robots. And it used in pick and place operations of soft objects like egg. Ball, fruits.

3. Design and Fabrication of Soft Gripper Mold

The soft gripper mold is designed by using pro-E cad software. This design is fabricated in 3-D printer.

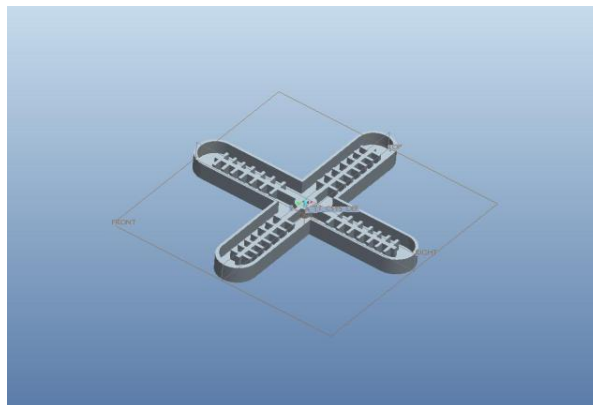


Figure 2. Design of soft gripper mold

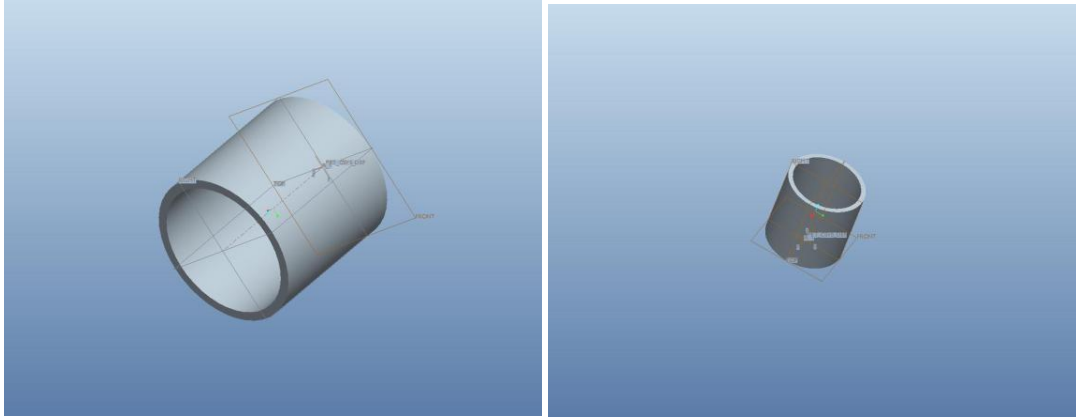


Figure 3. Holder design for soft gripper

4. Fabrication of soft gripper

The gripper mold is printed using 3D printer. Platinum cure silicon rubber is used to fabricate soft gripper. Silicon rubber is of two parts (part A and part B). both should be mixed in equal amounts in a cup and mixed gently without having any air bubbles. The mixture is poured in the mold. it will be cured in oven at 150° for 15 minutes or cure it for 4-6 hours at room temperature. Holder is attached to soft gripper using glue. The other side of fabricated part is sealed with fabric by applying some silicon rubber.



Figure 4. a) soft gripper mold and b) Fabricated soft gripper attached with holder and pneumatic pipe

5. Experiment and results

The fabricated soft gripper is actuated using pneumatic pressure. It is capable of holding components like mouse, duster, egg, ball, etc...

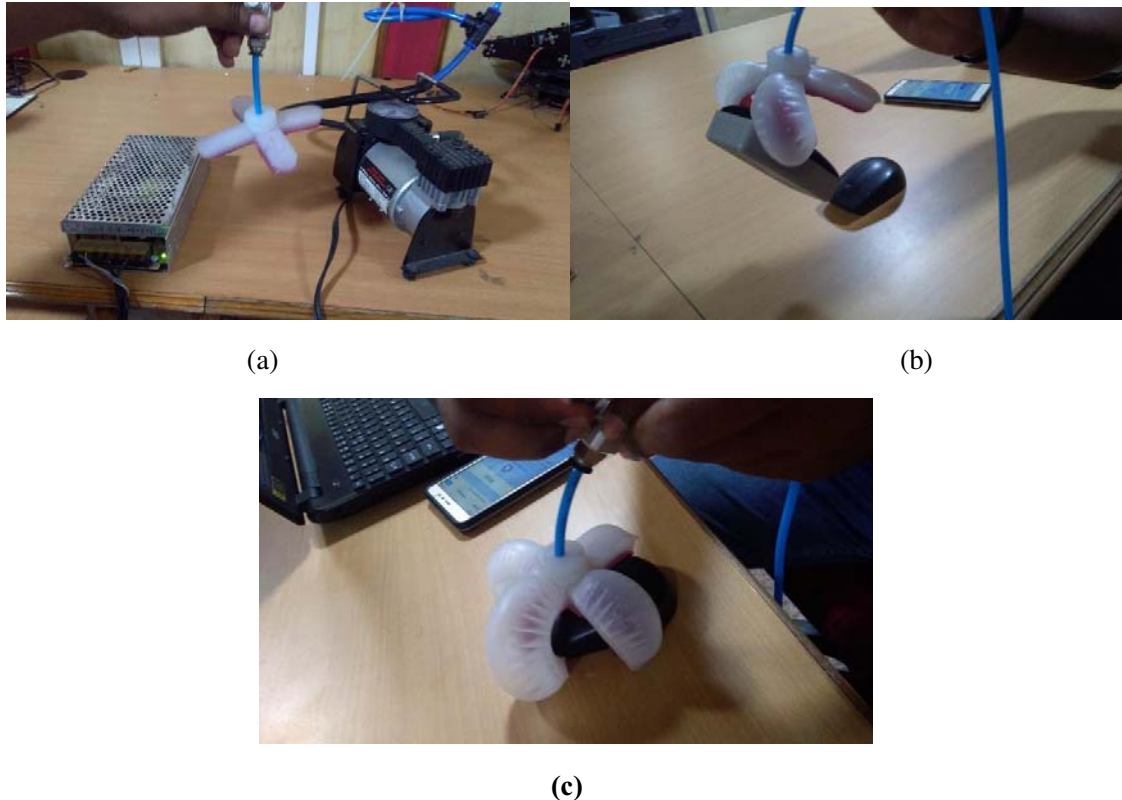


Figure 5. a) Control unit for gripper b) Soft gripper holding duster and c) Soft gripper holding mouse

6. Conclusion

Various design parameters and models are observed, based on the limitations and different challenges the best design is made for fabricating the soft gripper which is capable to grasp delicate objects like egg, fruits. The base of the soft gripper is fabricated using 3-D printer.

Gripper is fabricated using silicon rubber material. The experimental and FEA analysis is conducted on the fabricated model. By rectifying the errors and problems the soft gripper is adopted to IRB 1410 robot which is capable to grasp soft material like egg, fruits for pick and place.

7. Future scope

Various designs are created for maximum the efficiency of gripping ability. A curvature sensor is integrated inside each finger to measure the curvature or bending angle during grasping. The FEA analysis is done by using Ansys.

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