MODELING AND SOFTWARE DEVELOPMENT OF SOFT GRIPPER FOR AUTOMATED ROBOTS

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Abstract

Of late, people have started using automated robots for many applications in wide range of industries. The automated machines are very costly due to their increasing demand and the manufacturing cost. Due to this, there are many small industries who want to increase their production and expand but cannot afford to spend on an automated robot in their industry. In food industry there will be subdivisions such as cooking, quality check, packing and dispatch etc. There is a need for low cost, highly reliable, automated robots in order to satisfy the small scale industry needs. In order to approach the market of low priced robots for small scale industries, the following research and development of prototype was carried out to produce a soft gripper. This development of soft gripper was carried out in a sequential manner starting from studying the industrial needs, rough design of the gripper, working on material properties, then optimizing the design which is good enough to build a compact prototype. The proposed gripper has a capacity up to 1000cm$^3$ in its wrist. By operating the lever and button, the operator can hold, lift and place the object. The design exhibits good grip and has good stability. This gripper is more economical compared to the gripper which is in use. The present work will have wide range of application in packing division of the industries.

Key Words: Mechanically Actuated 3D Printed Soft Gripper, Modelling, Assembly, Arduino Programming, Compact Prototype, Dynamic Environment Interaction

1. INTRODUCTION

In order to survive in the environment almost all life forms have developed some form of manipulators to interact with nature and carry out daily tasks such as hunting, building nest and feeding etc. The development of these manipulators is based on the environment which they interact with and varies according to their habitat. The softness and adaptability of these manipulators enable them to interact with the environment dynamically; however, this softness varies in different ways for different animals. For instance, the octopus survives in water by utilizing its soft and long tentacles which can extend, compress, and bend in various
directions simultaneously allowing it to carry out complex tasks. Another example is the human hand which consists of rigid bone phalanges and the soft ligament joints which contribute to the overall strength and also provide the necessary flexibility required. With such a complex design human beings can create objects and construct complex structures, from micro-machinery to huge buildings which is the proof that human beings have the most advanced manipulator system.

Due to the task definitions, the manipulator designs were required to achieve high precision, large force exertion, and low mechanical flexibility which was compensated with adaptive control strategies. Based on the knowledge and the expertise on rigid body dynamics and inverse kinematics, the earlier examples of human inspired robotic hands also utilized rigid body links, fixed degree of freedom (DOF) joints, and low mechanical flexibility.

The key underlying principle of soft robotics is compliance which allows us to exploit the interaction of the robot with the environment. This “softness” provides adaptability and robustness which is seen in natural organisms, enabling tasks such as grasping and manipulation to be achieved with ease. Using such techniques and methods, soft materials may enable automation of tasks which are currently not possible using existing robotic technologies and solutions. Such systems have the potential to interact more safely within a human unstructured environment and deal with uncertain and dynamic tasks. This may enable the grasping and manipulation of unknown objects in unstructured environments.

3D printing is one of the various processes in which material is joined or solidified under computer control to create a three-dimensional object. It’s an old technology but has come into picture in the recent years with vast development and people are creating everything with this technology. Soft compliant grasping is essential in delicate manipulation tasks typically required in manufacturing and/or medical applications to prevent stress concentration at the point of contact. In comparison with their rigid counterparts, the intrinsic compliance of soft grippers offers simpler control and planning of the grasping action, especially where robots are faced with a number of objects varying in shape and size. However, quantitative analysis is rarely utilized in the design and fabrication of soft grippers, due to the fact that significant and complex deformation occurs once the soft gripper is in contact with external objects.

Most of the soft-grippers presently in use are actuated using either a hydraulic or pneumatic actuation system. These systems are complex and expensive compared to string and stepper motor actuation which we have applied for our work. Thus after considering the entire above factor the present scope of this work is to minimize the cost and time of the manufacture of these grippers and to make it simple and easy to manufacture in large scale.

The present work primarily focuses on the use of simple mechanically actuated 3D printed soft grippers in place of the regular soft grippers presently used in the food processing industries. The present technology or process used for manufacturing of soft grippers is the basic molding and casting method. This method is a tedious process and takes a lot of time to manufacture in large scale and even the cost is high.
2. Material Properties

We have selected the suitable material with appropriate properties and liable for 3D printing of soft gripper. Various materials used for the soft grippers are Poly flex, Semi flex, Flex solid, sTrue flex, Ninja flex, Fila flex. Ninja Flex being selected because of its superior flexibility and longevity compared to non-polyurethane materials. Its consistency in diameter and ovality (roundness) will have preference over other polyurethane materials. This makes it uniquely flexible, strong prints ideal for direct-drive extruders.

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<td>Moisture absorption – 24 hours</td>
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<td>Tensile Strength, Ultimate</td>
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<td>Impact Strength</td>
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<tr>
<td>Glass Transition</td>
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<td>Heat Deflection Temperature @ 10.75psi/ 0.07 MPa</td>
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<td>60° C</td>
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<tr>
<td>Heat Deflection Temperature @ 66psi/ 0.45 MPa</td>
<td>ASTM D648</td>
<td>44° C</td>
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3. Modeling of Soft Gripper

The cable is constrained at the extreme end of the gripper and pulled; the arms fold inwards with all the wedges in contact. The complete folding takes place for a pull of approximately 9mm, which requires the motor horn to rotate for about 180 degrees.

➤ Constructional features:-

The entire gripper which includes hub, arms and the seat for motor is built as a single unit. Concentric circles of diameters 23mm and 30mm are drawn as a sketch and extruded for 12mm to create the hub. In a perpendicular plane, at a distance of 15mm from center and a 5mm buffer, a trapezium with 105 degree external angles was drawn with a side 7mm, with 1 mm gap between the trapeziums according to the tapering calculations 7 trapeziums were drawn. This sketch was extruded parallel to the plane to 15mm thick. The same extrusion is again tapered in the perpendicular plane to get the desired arm. The entire arm is selected as a
profile for circular pattern and with hub’s axis as the axis for circular pattern a circular pattern of 4 arms was created. According to the dimensions of the motor a seat shape was drawn with a thickness of 8mm and extruded below the base for 8mm.

The motor hub is designed such that its outer diameter is 30mm and inner diameter is 23mm. Each arm is 65mm long from the edge of the hub. The hub height is 12mm. The arms are such that their height is tapered from 10mm near hub side to 4.05mm at extreme end. The continuous thickness from the base in all arms is 1mm. The wedges on the arm are trapezoidal shape with external angles 105 degrees. The length of the parallel sides are varied over the entire arm’s length as per the taper keeping the external angles constant.

4. Soft Gripper Assembly

The 4 parts that are created were assembled in an inventor assembly file by using mating constraints. The motor was fixed and the rotor gear was assembled on the base created for it, the gripper was made to sit on the motor by using proper constraints on the seat. The horn was later placed on the rotor gear to complete the assembly.
5. **Arduino Programming**

The cable is pulled by means of a servo motor whose rotation is controlled by an Arduino UNO, the constrain is to pull the cable for about 8mm in order to close the gripper’s arms completely. For this we found that approximately 180 degrees rotation is required. Each press of the button should close the gripper (i.e. rotate the motor for 180 degrees) and the next press of the button should open the gripper (i.e. rotate the motor for -180 degrees).

A program booted into Arduino for this operation is given below.

```c
#include <Servo.h>
Servo myservo;
int pos = 0;
int button = 10;
int flag = 1;
boolean last = LOW;
boolean current = LOW;
void setup() {
pinMode(button,INPUT);
myservo.attach(9);
}
void loop() {
boolean state = digitalRead(button);
if (state == HIGH && last == LOW) {
current =! current;
last = HIGH;
}
else
last = state;
if (current == HIGH && flag == 1) {
for (pos = 0; pos<= 180; pos += 1) {
```

![Horn](image1.png) ![Motor](image2.png) ![Gear](image3.png)

**Figure 3: Gripper Assembly**
myservo.write(pos);
delay(15);
flag = 0;
}
}
else if (current == LOW && flag == 0)
{
for (pos = 180; pos>= 0; pos -= 1) {
    myservo.write(pos);
delay(15);
    flag = 1;
}

6. Conclusion

“Soft Gripper” plays a major part in all sectors of industry these days. These grippers are either pneumatic or hydraulic actuated and the system is very complicated and isn’t economical. Our solution to this is a 3D printed soft gripper which has a simple actuation and is also economical. Generally, a whole system of robotic arm used for industrial application would cost more with least features. Thus they prove to be expensive and is not feasible for all industrialists. Based on the results of the analysis, the material used is suitable for the usage in a commercial product as a gripper for small range of loads upto 300gms without failure. Since the mechanism is simple and economical, the above proposed gripper can actually be produced in large quantities for use in multiple fields. The overall expense of this project (only the gripper) proves to be very economical when compared with the one that is in practice. Thus “Soft Gripper” satisfies all the objectives of the work carried out and reduces the cost and manufacturing time as discussed earlier.

7. REFERENCES

[5] Directly printable flexible strain sensors for bending and contact feedback of soft actuators-(Elgeneidy, Khaled Neumann, Gerhard Jackson, Michael R.Lohse, Niels In © 2018 Elgeneidy, Neumann, Jackson and Lohse. Published by Frontiers Media
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