SDM5002 Final Report

Operational Amplifier and Electronic Scale

Chen KeZhou
Robotic Engineering
11911917@mail.sustech.edu.cn

***Abstract*—This report is written as a summary to conclude my missions and process in this SDM5002 lesson.**

***Index Terms*—End effector and its control**

I. Introduction

I have done a lot of researches and physical attempts to build an appropriate end effector with control. In order to accomplish the task of AED gripper, many methods must be tried. It is necessary to calculate and make corresponding physical objects to test. This makes the end-effector selection very important and lengthy due to some hardware and design limitations.

The design of the end-effector tried soft gripper (pneumatic and wire driven), suction cup and hard gripper. Finally, the hard mechanical gripper was selected as the final version

At the same time of VR detection depth, we hope to detect an obstacle at the end, so we try to use ultrasonic ranging and laser ranging to obtain the information of obstacle distance

In addition, the AED electrode slice is a soft piece, which is a fragile thing and easy to bend. To protect its function and extend its life span, the slice should not be over-bend.

II. Attempts Iteration

A. End effectors with soft materials

The myCobot arm is a lightweight collaborative arm with a load of only 250 grams, so the claws need to be designed to be as lightweight as possible, so soft materials are a good choice. The soft material on the market is mainly AB silica gel with a density of 0.8/g to 1.2/g. It is estimated that the final weight should be about 50g. The remaining 200g load is used to clamp heavy objects, which is more than enough for this mission.

- Common suction cup: The ordinary suction cup made of rubber has the characteristics of light weight and durability, and has good adsorption capacity for flaky objects. The use of large area of the sucker can ensure that the AED pole plate always coincide with the end surface, reducing the control trouble.
  Reasons not to use: However, due to the surface of the AED pole sheet has non-woven fabric, so it can not ensure the continuous vacuum when absorbing, and will gradually leak. When tested with a mask, it only holds steady for six seconds, which is not enough.

Fig. 1. Common suction cup

- Soft pneumatic gripper: There are 2 pneumatic gripper candidates: gripper1 and gripper2. A is an integral gripper, with air chambers on both sides and confined in the middle, so that the two claws can rotate to the middle when inflating, so as to grasp objects. B is a kind of split gripper, each finger runs independently, which can improve the freedom of grasping, and the posture of the target can be changed with the air volume of controlling different grippers.
  Reasons not to use: After surfing the Internet, its hard to find a precise(easy to control the input and output of the air) tiny pump. Which leads to designing an air valve to control. This complicate the control process. Moreover, the noise of the pump violates the requirement of the product.

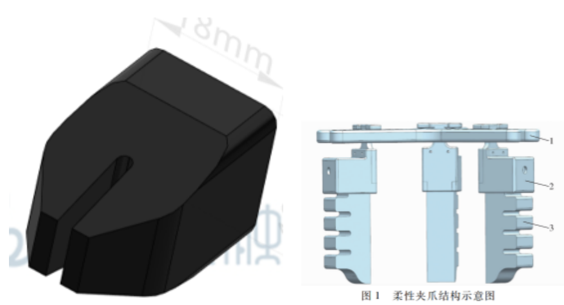

Fig. 2. Soft pneumatic gripper

- Plastic wire drive gripper: The topologically optimized segmentation bar is able to bend along the segmentation, and then change the attitude and force (including Angle and size), which can capture relatively smooth objects. At the same time, it is self-adaptive, and the damage to the gripper is lighter than that of the rubber gripper. [1] Reasons not to use: This kind of gripper is suit for some extremely light objects like berries or grapes, which has fragile shell since the maximum force is only 0.3N for a ball with diameter of 9.5mm according to the paper[1]. Besides, the material it made in paper is hard to get.

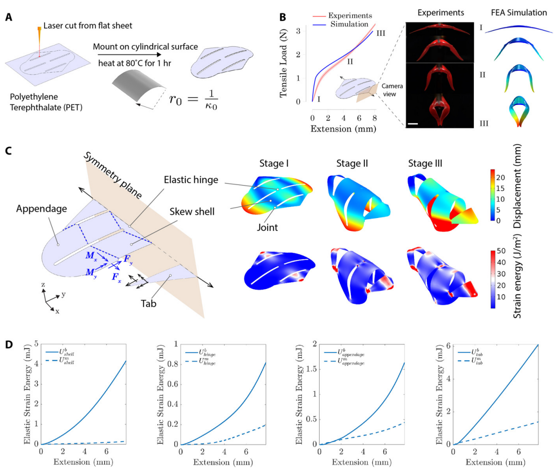

Fig. 3. Plastic wire drive gripper

B. End effectors with hard profile

After excluding all the soft grippers shown above, candidates turn to the hard grippers. The choice of hard one should satisfy the following 2 features: light and small. After searching for information, I found two options: Bernoulli suction cup and rigid mechanical gripper. The former one can buy online, the latter one should design by myself since the official one is big, expensive and full of bugs.

- Bernoulli suction cup: According to the experiment, using the Bernoulli suction cups to produce 0.4 N lift need to more than 8 times air flow comparing to the same suction spiral chuck, low air consumption and reduce the energy loss due to suspension process, at the same time also greatly reduced the noise [2]. This device is designed to grab flat objects without traces, using Bernoulli's principle, to create a pressure difference on the surface of the air flow, and then suck the workpiece. Its advantages are obvious. It can be absorbed without trace and regardless of surface roughness, which is ideal for fragile AED electrodes.
  Reasons not to use: Select proper suction cup for test (30mm x 250g). According to the description of the merchant, the air flow of 12L/min can meet the requirement of picking up objects with the weight of a mask. However, when the goods are delivered, the flow of 20L/min is needed for the test by connecting the miniature air pump in series, which will produce a lot of noise. Therefore, it can be applied to future work[4].

Fig. 4. Bernoulli suction cup

- Mechanical gripper: The advantage of mechanical gripper is that it is easy to control, and can be 3D printed to manufacture, convenient iteration.

III. Mechanical Gripper

A. Mechanical design

This clamping claw adopts four-bar structure, because vertical clamping is required, so it does not use parallel four-bar, the end needs to have a certain angle, to ensure that the clamping object can receive oblique upward support force, rather than just friction.

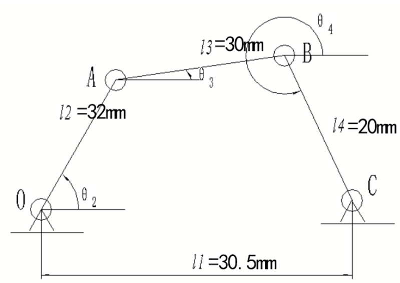

Fig. 5. Four bar model

At the same time, the size of the connecting rod design needs to ensure the following conditions[3]:

- The weight needs to be about 50 grams so that the remaining 200 grams can be used to grip the object.
- The length should be within 10cm to prevent the servo of the mechanical arm from failing to provide sufficient torque. The maximum load provided by the mechanical arm is 250g, which means that the end coordinate system can support the 2.5N times total length of the manipulator
- The end can have a certain area to clamp objects to prevent dislocation

Kinematic simulation of the connecting rod and simulation using MATLAB can obtain the following information:

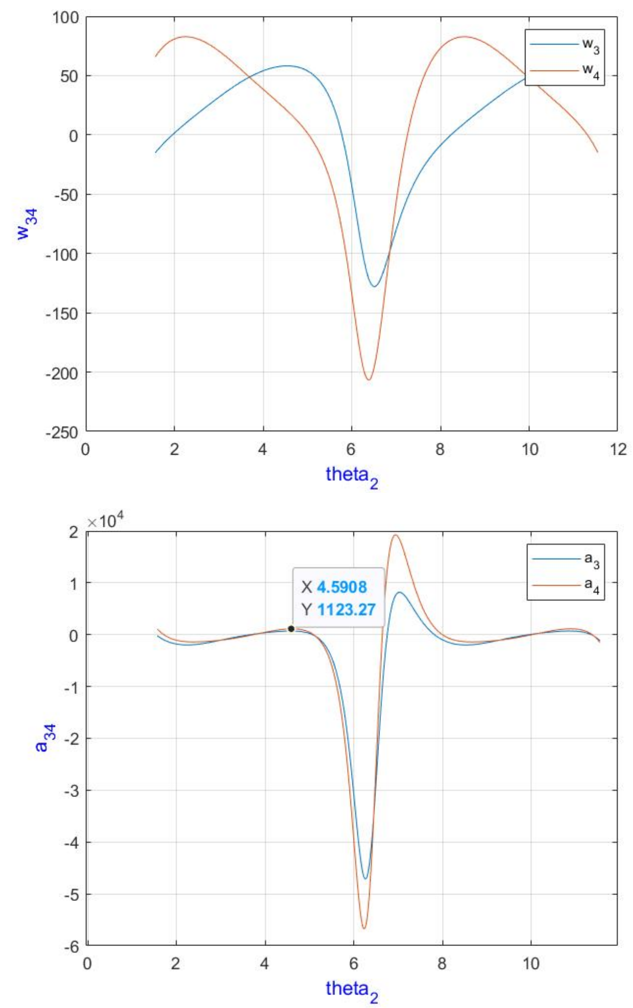

Fig. 6. angular vel and acc figure

As can be seen from the picture, the model of the twin-rocker mechanism can accelerate from 2 to 4.5, and then slows down significantly around 6

When the gripper is closed, a large torque is needed to ensure that the object will not slip due to sufficient friction. Therefore, the 4.5 point with the maximum acceleration is taken as the state when the gripper is closed, that is, the tip of the gripper is on the extension line of L1. That's one of the optimization ideas.

It is observed that the acceleration change between 2 and 4.5 is not obvious, so the feasible solution has a large null space, and the length can be selected according to the specific design and aesthetics.

The second optimization idea is to increase the end of the friction, you can paste sponge, scrap paper, rubber and other objects with greater friction, or make a sawtooth at the end of the clamping place to produce small deformation, so as to obtain a local upward support force. This time, a silicone mold was used to create a soft silicone material embedded in a groove at the end, with enough friction to complete the clamping task.

The theoretical calculation results are as follows:

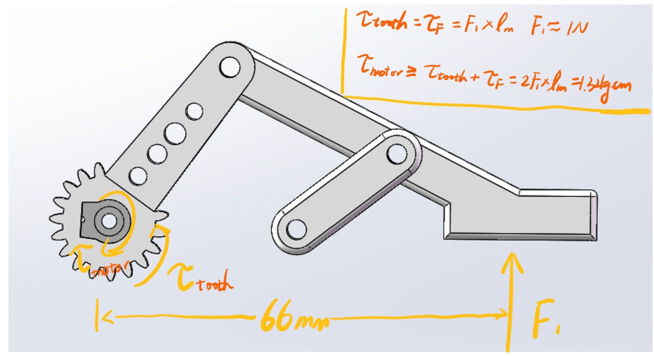

Fig. 7. Mechanical analysis

$$\tau_{tooth} = \tau_{F_2} = F_1 \times l_{max} \tag{1}$$

$$F_1 = 1N(estimated) \tag{2}$$

$$\tau_{servo} = \tau_{F_1} + \tau_{tooth} = 2 \times F_1 \times l_{max} = 1.32kg \cdot cm \tag{3}$$

The third and simplest method is to reduce the friction of the joints, thus converting the torque of the steering gear almost completely into the torque of the grip.

The gear I used is made of the national standard 4.5-module 19-tooth gear, reduced by 5 times. The meshing condition between the two gears is that the indexing circle is tangent, and the diameter of the indexing circle is calculated as follows:

$$d = m \times z = \frac{4.5 \times 19}{5} = 17.1mm \tag{4}$$

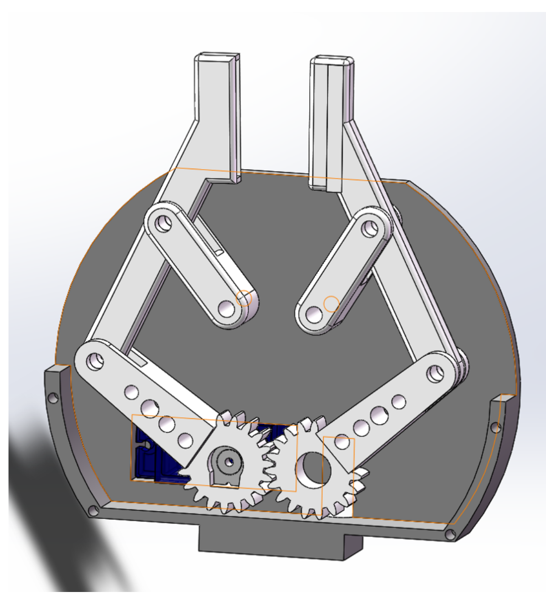

Fig. 8. Mechanical gripper

B. Manufacture

The manufacturing process used 3D printing. After many iterations, including the design of the shell, the steering gear was exposed at the beginning, and then a small warehouse was made to prevent the steering gear from shifting due to the collision between the steering gear and the mechanical arm. The mechanical arm was connected with screws, and the hot melt adhesive was selected for further fixing. 3D printing has the characteristics of lightweight and fast iteration, which is convenient for this design.

C. Control

VR gamepad is used in this project, so VR gamepad needs to be connected. The keys of the handle are mapped to python multithreading to issue instructions, and then the function receiving the instructions transmits parameters to the Arduino to control the steering of the steering gear. In order to make the whole structure lightweight, Servo 9G-180 for Arduino is used to drive the gripper. The parameters of the steering gear are 1.8kg*cm. As calculated in the figure above, the blocking torque of the steering gear is greater than the torque generated by the support force exerted by the end friction, which meets the design requirements.

FUTURE WORKS

The abandoned solution is only because some hardware facilities cannot be achieved, but through the final hardware improvement and development, these solutions can be taken as one of the options, coupled with the tool library Settings, through pneumatic port or magnetic fixation, so as to achieve multi-function through the replacement of the end-effector.

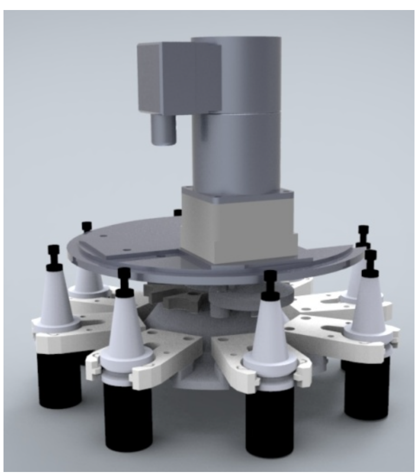

Fig. 9. small tool library

A variety of sensors can also be added to feedback information of the end-effector, including but not limited to distance information obtained by laser sensor and supporting force information obtained by strain gauge.

The data of the laser distance sensor is posted as follows. To reduce the noise in a range, I tried the Kalman filter to deal with the noise. But unfortunately, KF performs well in static data, but it doesn't converge quickly when the distance changes. So this method only can be applied to the time VR showed the end is quite close to the target and need a more precise distance information rather than only judge by eyes.

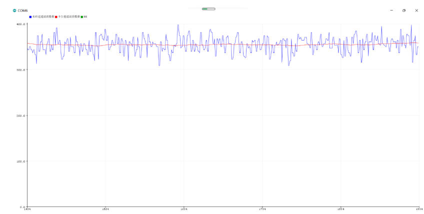

Fig. 10. small tool library

Due to the load, the camera and the robot arm are installed separately. Which means we use ”eye to hand” method to build 3D scenario. The ideal method is ”eye in hand” method, which needs a lighter camera and highly integrated wiring.

ACKNOWLEDGMENT

I am grateful to all the people who have helped me during the semester. I have learnt a lot,and enjoyed the whole process. To finish is project, I made use of my experience and acknowledgements from MEE lessons. Meanwhile, in this project, I also participated in Realsense data access, SolidWorks modeling and physical prototype construction, which will not be described in this report.

Fig. 11. SolidWorks model

References

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