A 3D Printed Soft Gripper and Its Application for Lunch Box Packing

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***Abstract*— In this paper, we proposed a 3D printed soft robot gripper with modular design for lunch box packing. The gripper consists of a rigid base and three soft fingers. All components were 3D printed and the soft finger structure is based on the principle of fluidic elastomer actuator. The finger design and the gripper grasping and lifting deformable objects were investigated through finite element (FE) analysis and experiments. Results suggested that the proposed gripper could grasp and lift objects with variable shapes and softnesses.**

I. Introduction

In Japan, eating box lunch (obento) is very popular due to its convenience and great variety. Every day, several million box lunches are produced and consumed in Japan. However, packing these lunch boxes is still performed by humans due tothe fragility, variety, and high deformability of the food materials [1]. To reduce the labor costs, automation systems of lunch box packing are highly demanded by food industry.

In recent years, soft elastomer robot grippers have drawn great attention in many applications due to its characteristic of high compliance and resilience. Soft robots provide an opportunity to bridge the gap between machines and people [2]. The soft finger design proposed in this poster is based on the pleated type morphology of fluidic elastomer robot [3]. Three such fingers were connected to a rigid base to construct a soft gripper, which was experimental tested for grasping and lifting a paper cup container filled with different food materials.

II. Single Finger Design

As shown in Fig. 1, the finger consists of eleven smaller chambers and one bigger chamber at the end. The smaller chambers have a wall thickness of 1 mm and the larger chamber has a wall thickness of 3 mm. This makes the finger end stiffer than the rest part of the finger to mimic the function of thehuman nail. The finger has a size of 82 mm (length) $\times$ 16 mm (width)$\times$ 15 mm (height). A hole with a diameter of 6 mm was designed on the connector to insert air hose. A snap-lock mechanism with male (on the connector) and female (on the base) interfaces was designed for connecting the connector to the base without using screws.

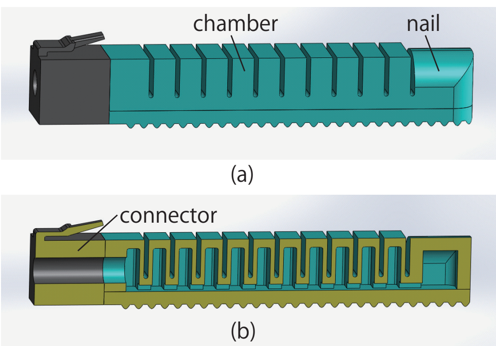

Fig. 1. The finger design in (a) an isometric view and (b) a section view.

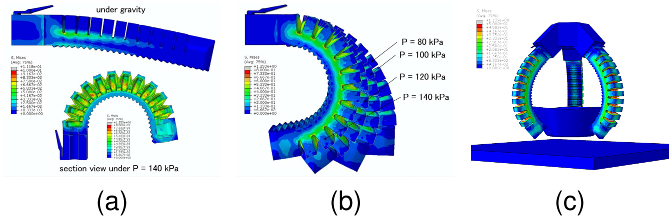

Fig. 2. Simulation results of deformation (a) under gravity, (b) under different air pressures, and (c) grasping a deformable cup container.

III. Simulation Results

Finite element (FE) simulation results were shown in Fig. 2. Different air pressures (80 kPa$\sim$140 kPa) were used to evaluate the bending motions. The material elasticity (Young's modulus) is set as 2.25 MPa according to the material data-sheet of the 3D printer. Since the finger was largely deformed, geometry nonlinearity was included in the simulations. The finger mesh consists of 87,014 nodes and 204,174 tetrahedra elements. We found that the finger bended over 90° with a pressure input of 140 kPa. The gripper with three soft fingers can successfully grasp and lift up a deformable cup container.

IV. Fabrication and Experiments

All gripper components were printed using a state-of-the-art 3D printer (Objet260Connex^{TM} system). A single finger was printed as two separate parts: (1) the chambers together with the connector, and (2) the bottom cover to seal the chambers from leaking. After removing the support materials, the cover was glued onto the chambers to complete the finger construction. The chambers were printed with a rubber-like soft material (TangoBlack+). It takes approximately 2 hours to print the two separate parts of the finger. Multiple fingers can be printed simultaneously as long as the parts can fit in the printer workspace (255 mm$\times$252 mm$\times$200 mm). It takes approximately 10 minutes to remove the support material, and 10 minutes to glue the two parts together. This significantly reduced the fabrication time comparing with the conventional molding process.

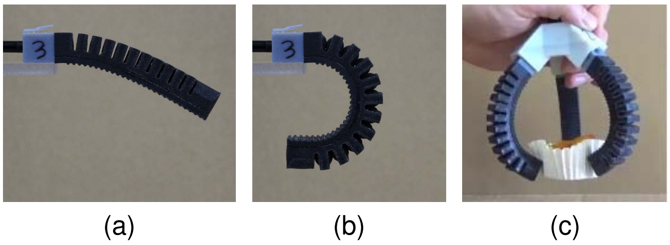

Fig. 3. Experimental results of deformation (a) under gravity, (b) under pressure 50 kPa, and (c) grasping a fried chicken in a cup container.

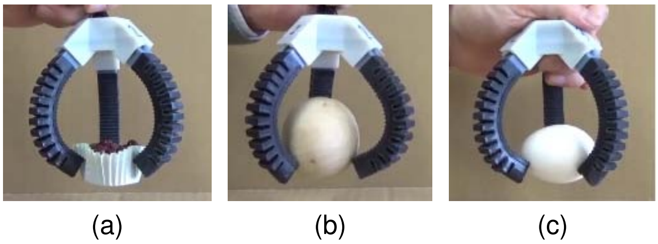

Fig. 4. Grasping experiments on (a) a paper container filled with red beans, (b) a 64 g wooden ball, and a 48 g raw egg.

In experiments, we employed an air compressor (JUN-AIR 3-4) and an electro-pneumatic regulator (SMC® ITV2030) to generate constant air pressures. Experiments of single finger under different pressure loadings and gripper grasping the paper container filled with different objects were performed. As examples shown in Fig. 3, the finger could bend over 90° with a suitable pressure input and the gripper with three fingers could successfully grasp and lift up deformable container filled with different food materials, such as a 36 g fried chicken (Fig. 3c) and 50 g red beans (Fig. 4a). Experiments on grasping rigid objects were also performed and two examples were shown in Figs. 4b, and 4c.

References

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