Design of a Robot Gripping System: Theoretical Considerations and a New Solution

José Zárate, Stefan Lutherdt, Hartmut Witte
Biomechatronics Group, Technische Universität Ilmenau
jose-luis.zarate-moya@tu-ilmenau.de, stefan.lutherdt@tu-ilmenau.de, hartmut.witte@tu-ilmenau.de

1 Introduction

Adaptive grippers can grasp a broader range of objects. They offer an additional way to solve problems that a rigid gripper cannot. The grasping joints are formed by an elastic transmission based on a flexible gripper. A grasping and movement mechanism is a fundamental requirement for robots to hold objects the same way humans do, considering that the shape, size, weight, material, and surface condition of the part to be gripped are different. The project took place in the Biomechatronics group, whose goal was to design an elastic and lightweight grasping structure. This type of robot has the advantages of simple construction, low cost, and easy maintenance.

1.1 Overview

The following are the current development trends in this type of robotic systems:

1 Improve the speed and accuracy of movement and reduce weight and space.

2 Development of new structures for different types of situation, such as micro-mechanisms to achieve accuracy, multi-jointed limbs and fingers with several degrees of freedom.

3 Sensors and monitoring devices, such as tactile, visual, acoustic, and distance sensors, are used to gather information about the surroundings, the location, and the status of the manipulable element [1].

2 Design Principles

This research focuses on the OpenBionics [2] open source project, which aims to develop low-cost, lightweight, scalable, and adaptable robotic and bionic systems easily replicated using readily available materials.

2.1 Functional Synthesis

The gripping of the robot gripper system is broken down into more manageable and systematically variable and combinable subtasks. Transfer and conversion of energy, information, and materials between different functional elements are revealed.

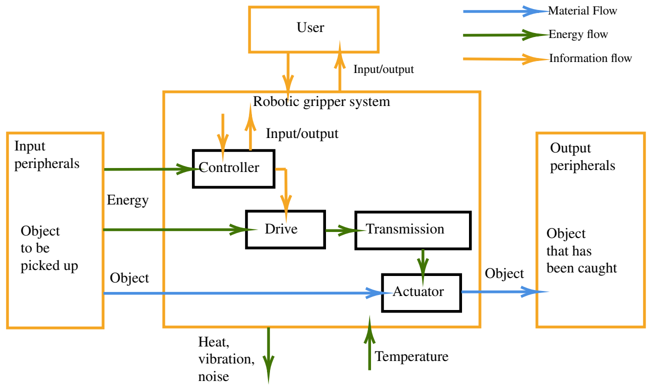

Figure 1: General functional structure

The system can meet the user's different requirements, the shape, the surface roughness of the object, or other materials. The driver manages the movement of the actuator through the gearbox after receiving the signal from the controller.

The controller is used to regulate the closing and opening of the robot gripper, as shown in Figure 1.

2.2 Design phase

The length and width of the fingertip in relation to a human paragon were increased to maximize the contact area with the target. The sizes of the second and third phalanges for humans as paragon were selected with averaged lengths of 30 mm and 40 mm as bases for scaling (cp. [3]).

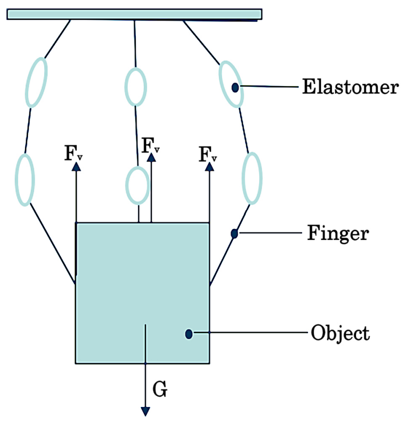

Figure 2: Analysis of the forces acting vertically on the object

Since in human walking the vertical forces in the moving system may be the 1.2 fold of gravitational forces [4], the hand held mass of 0.2 kg maximally underlies a vertical force of

$$F_v = 1.2 \cdot G = 1.2 \cdot m \cdot g = 2.4 \text{ N} \tag{1}$$

In humans, the upper extremity damps the motions actively, and thus decrease dynamic forces.

Three fingers compensate this force:

$$F_{v,f} = F_y/3 = 0.8 \text{ N} \tag{2}$$

The necessary frictional forces are each $F_n = F_{v,f}/\mu_s$.

A list of material pairings maximizing gripping forces was available by preliminary own work [5].

3 Test Protocol

The finger grip was measured using a simple test stand, as shown in Figure 3. First, the fingertip in contact with a glass surface sample is attached to a force sensor to analyze the higher the compliant robot gripper's stiffness, the greater the grip force it generates. The fingers are then mounted on a frame with the motors and electronic components. The advantages of compliant robot gripping systems are also fully demonstrated by gripping fragile glasses. It can even hold objects with a weight of up to 300 g and grip them from any direction.

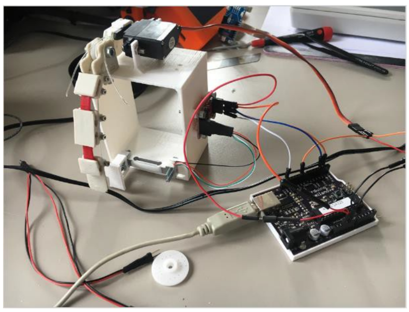

Figure 3: Finger test bench

4 Summary and Outlook

With different shapes, textures, and consistencies, the gripping robot device can be applied to various objects. The versatility of this robot gripping system will be evident, especially when gripping irregularly shaped objects. For this purpose, the automation of several previously considered too fragile tasks for robot use can be increased by this robot gripper. Hence, particularly a robot that requires less load can be used in combination with this light-weight compliant robot gripper.

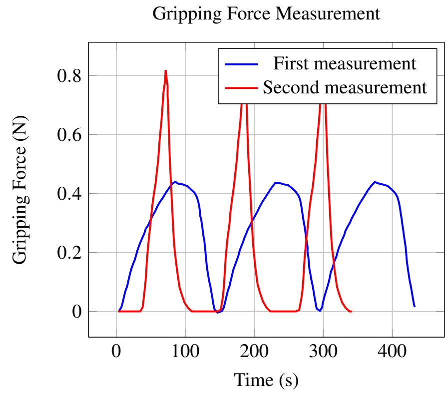

Figure 4: Measurement of finger grip force

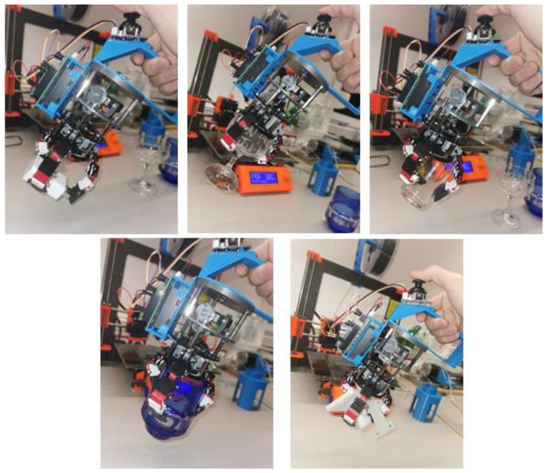

Figure 5: Experiment with the robot gripping system

The compliant robot's gripper is lower in rigidity due to the existing cable transmission and the elastic joint. Therefore, the preload force varies as the number of movements of the elastic joint increases. If the user wants to restore a cable transmission or an elastic finger joint, the robot's entire grip device can be dismounted. In developing the compliant robot gripping system, changing the rope's arrangement to decrease friction and improving transmission efficiency should be considered. By adjusting the rope drive and the elastic joint material, an attempt is made to achieve the appropriate stiffness.

References

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