AQTR 2004 (THETA 14)
2004 IEEE-TTTC - International Conference on Automation, Quality and Testing, Robotics
May 13 – 15, 2004, Cluj-Napoca, Romania

HUMAN PROSTHESES

Virgil ISPAS

Technical University of Cluj-Napoca

virgil_ispas@personal.ro

The abstract

The robot hand is a tool that allows the robot to interact with the environment. It is expected to accomplish tasks like human hand does. Because it is considered as being a tool for creating an effect upon the environment and it is located, generally, at the end of the robot arm, it is usually called end-effector. One of the best ways to make a good end-effector is to develop a mechanical hand like the human hand, which has five fingers that can easily move and perform complex tasks. Anyway, such a hand requires complex mechanisms and control algorithms, causing design difficulties and high costs.

1. Introduction

The industrial robots from applications have, usually, requirements in limited shape objects manipulation and they have to perform limited tasks. For these requirements the human-hand-like end-effector is not economic. A device designed to manipulate limited-shape objects is also called gripper. In other applications where the manipulation of different shapes, weights and materials objects is required, an end-effector which has complex functions is appropriate. This type of end-effector is called universal hand. There were made many researches in designing and manipulating the universal hands but in practice there are only few prototypes.

2.The objects gripping by human hand and by mechanical hand

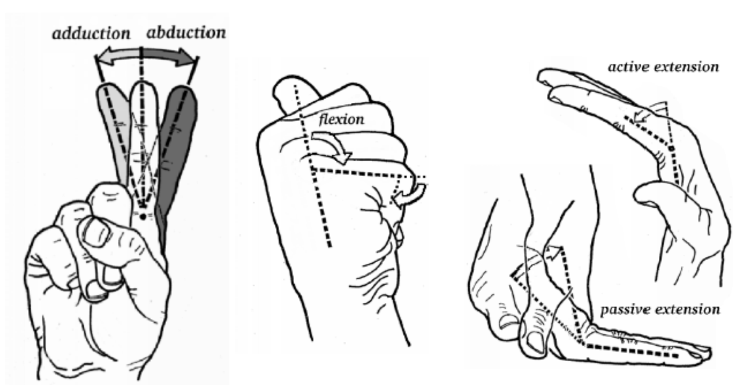

Fig. 1.

The motions performed by human hand are of: adduction, flexion and extension. In prosthesis design we need to take into account the anthropomorphism characteristic, which had an important role in designing the walking, flying, swimming and humanoid robots. Also, the gripping possibilities of the human hand are various and complex. In the Fig. 1. below there are presented few gripping possibilities function of the manipulated object.

In the case of designed mechanical hands, the gripping is not very complex, each finger having only one degree-of-freedom.

For example, in the first variant, if we want to have a rotation motion of the element 1 around the element 2 with an angle of a = 60°, we would need a translation motion along a distance "x".

$$\cos(30) = \frac{x}{10}, \text{ results } x = 10 \cdot \cos(30) = 8.66 \text{ [mm]}$$

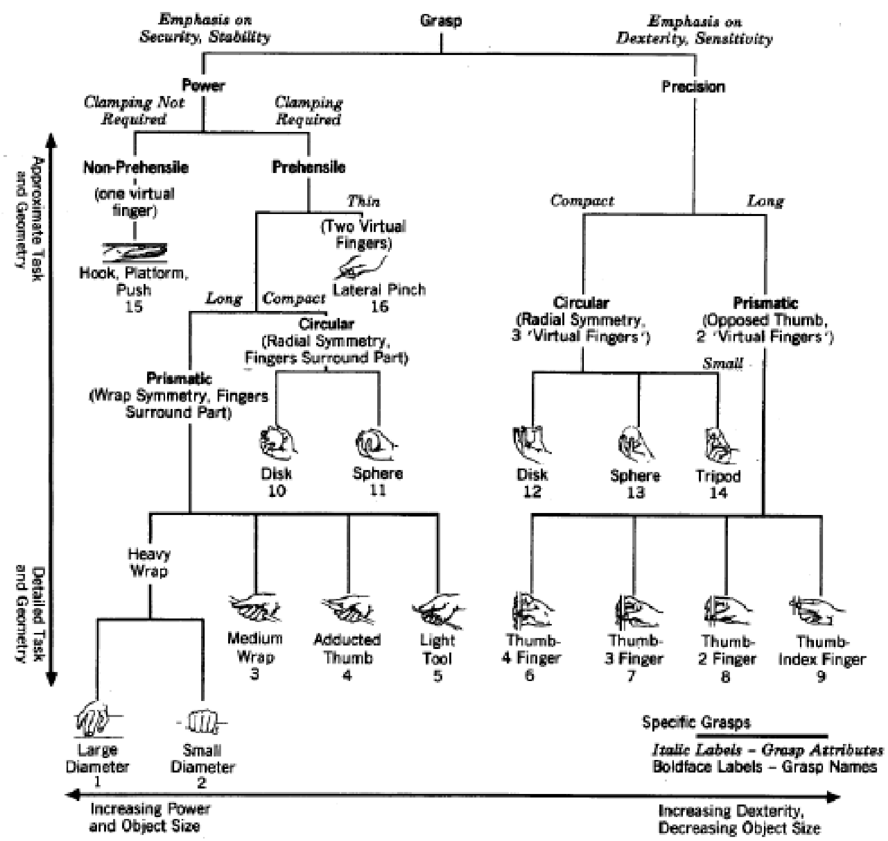

Fig. 2.

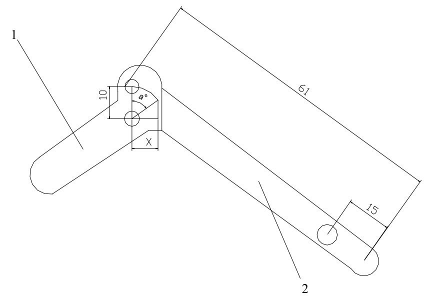

Fig. 3

But we know that if we pull the element 2, it will rotate around its rotation center with an angle "i".

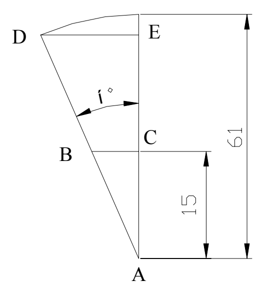

Figure 16.

In the ABC and ADE triangles, we can write

$$\frac{BC}{DE} = \frac{AC}{AE},$$

that is:

$$\frac{8.66}{DE} = \frac{15}{61} \text{ and DE = 35.21 [mm]}$$

Then the total opening angle for a displacement of 8.66 [mm] will be:

$$\alpha = a + i = 60 + 33.07 = 93.07\,^{o}$$

If we want to know how many rotations must perform the ball screw for opening the hand with the angle above resulted then we need to calculate:

1 rot …………4 [mm]

y rot …………. 8.66 [mm]

$$y = \frac{8.66}{4},\ y = 2.165\ \text{[rotations]}.$$

In the case of second and third variants, with simultaneously actuation of all pistons, the parts gripping is made by performing a rotation motion of the shaft on which are connected all the belts bands or, like in second case, by performing a linear motion of the piston.
To rotate (Fig. 4.)a finger part with an angle of 25° we need a rotation of the shaft with the same angle because the wrapping and rotation rods have the same diameter.
Thus, at a rotation with 25° the shortening of the belt band will be:

$$2\pi r \ldots\ldots\ldots\ldots 360^{\circ}$$

$$x \ldots\ldots\ldots\ldots\ldots 25^{\circ}$$

$$x = \frac{2 \cdot \pi \cdot r \cdot 25}{360} = 3.49\ \text{[mm]}$$

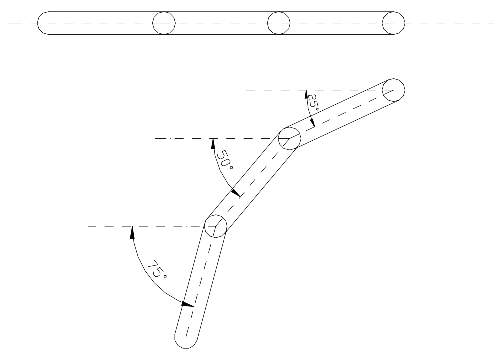

Fig. 4.

where r is wrapping radius [mm].
The final angle at the end of the finger will be 75°.

Taking into account that the rotation motion is transmitted simultaneously to each of the five fingers, it results that the gripping is performed especially for the cylindrical objects or objects with a regular shape. For the third variant the gripping is much effective because the rotation in each joint can be controlled.

3. **The electrical variant**

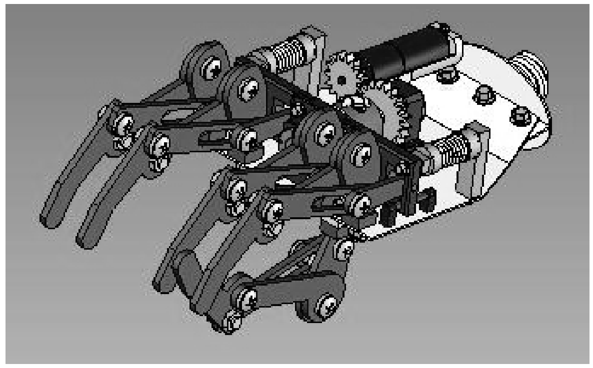

Fig. 5.

The electrical variant (Fig. 5.) represents a human prosthesis or a mechanical hand with five fingers which is actuated by a 6V DC geared motor. The gripping force is given by the two compression springs while the motor performs only the un-gripping/opening motion. The motor transmits the rotation motion to the ball screw with the help of two toothed wheels (spur gear). The screw nut performs a translation motion and being connected to the finger part, it makes the finger to rotate around an axis, performing in this way the opening of the fingers. The ball screw is fixed at both ends by two racks, each of them having a pair of radial-axial bearing to assure the rotation motion of the screw and eliminate the axial displacement of the gear. Each of the fingers is actuated simultaneously with the help of a rod mounted in a bore of a flange with racks. The flange is connected to the screw nut and is performing a translation motion with the nut at once. To avoid the deformation, the flange is equipped with to guiding rods. Between the rods and the flange there are two bushes to decrease/diminish the friction. Each part is mounted on a platform with the help of metric screws and nuts of various sizes and the platform has a threaded part at one end which will assure the connection of the assembly with an arm.

Advantages:

- Constructive simplicity;
- Relatively low production cost/price;
- Low level of noise;
- Ecologic actuation systems.

Disadvantages/drawbacks:

- Components are subjected to blocking;
- Gripping parts with similar shapes;
- The fingers actuation is simultaneous;
- Difficult control;
- Parts are subjected to deterioration.

4. **The pneumatic variant**

This variant (Fig.6) is similar with the one presented above when talking about the fingers type but differs from the actuation point of view. In this case the actuation is

pneumatic and is realized using single acting pneumatic cylinders. This model is equipped with 15 cylinders, one for each belt of each finger.
The un-gripping/opening motion is performed, liken in previous variant, by torsion springs mounted concentrically with each cylinder which represents the rotation center/point of each finger part. At one end of each cylinder is mounted, on a threaded part, a fixing part for each belt band. The cylinders and the other parts are mounted on the platform with the metric screws. The platform also has, like the previous variants, a threaded part for connecting with an arm.

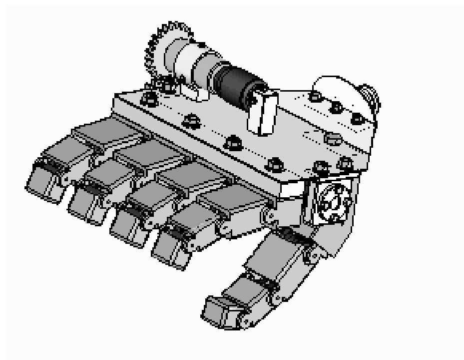

Fig 6.

Advantages:

- Easy/good assembling;
- Good/precise control;
- Fingers can be actuated independently.

Disadvantages/drawbacks:

- Large sizes/dimensions;
- High number of components;
- Higher costs/prices comparing with the other variants.

5. REFERENCE

[ISP 85] Ispas, V., ş.a. Roboţi industriali. Editura Dacia, Cluj-Napoca, 1985.
[ISP 97] Ispas, Vrg., s.a. Studiul singularităţilor la roboţi paraleli cu mecanisme spaţiale cu ghidare in şase puncte de tip II. Buletin Ştiinţific" Acta Universitis Cibiniensis " Sibiu oct. 1997.
[ISP 97] Ispas, Vrg., Roboti pentru aplicatii speciale. Ed. Dacia 1999.