A BIOLOGICAL GRIPPING MECHANISM EQUIVALENT WITH THE BIOMECANISM OF THE HUMAN

Professor Liliana LUCA, PhD, University Constantin Brancusi of Targu-Jiu
Professor Emeritus Iulian POPESCU, PhD, University of Craiova
Assist. Prof. dr. Ruxandra LUCA, University of Medicine and Pharmacy "Victor Babes" Timisoara

Abstract: *Studying the biomechanisms makes possible the discovery of interesting equivalent mechanisms. These mechanisms can be used to industrial robots in many branches. The gripping biomechanisms have different parts in the living world (gripping and pressing the prey, gripping of the branch for supporting, the conveyance of some objects, etc.). By technical point of view, the constructive solutions are interesting, the kinematic and kinetostatic performances, and acting systems. In this paper it is presented the biological gripping mechanism equivalent with the biomechanism of the human hand. There are presented the experimental results regarding the equivalent mechanisms.*

Keywords: biomechanism, human, hand, gripping mechanisms

1.Introduction

The living world offers many gripping biomecanisms which may be models for the gripping mechanisms of the industrial, medical, household, cosmic, etc. robots.

In this work are shown many aspects in connection to a variant of the mechanism equivalent to the gripping biomechanism of human hand.

Until the present time, the most studied gripping biomechanism was proved to be the one of the human hand. The previous researches in this field lead to the determination of an impressive number of mechanical hands for robots and of a high number of medical prosthesis. Several studies have been done about gripping biomechanisms of living world, biomechanisms that meet at humans, birds, insects, etc. [1, 2, 3, 4, 5, 6]. They state, as regard to the biomechanism of the human hand and the possible equivalent mechanisms, many matters are to be tackled.

This paper proposes two structural schemes for the biological gripping mechanism of the hand.

2. The biomechanism of the human hand

The complex structure of the hand skeleton represented by the 27 bones and 36 joints determined to obtain an equivalent mechanism with a rather complicated kinematic scheme. The 27 bones that make up the skeleton of the neck and hand are represented by three groups: Carpian bones: (8 in number), Metacarpian bones (5 in number), Fingers bones (phalanxes) continue in the direction of the metacarpines. The thumb (police) has only two phalanxes, the other four fingers (index, middle, ring, and little finger) have three phalanxes.

The movements are flexion-extension, abduction-adduction and low amplitude circumduction, in the neck of the hand and flexion-extension, lateral inclination and circumduction at fingers II, III, IV, V.

At the level of the thumb, the movements are: flexion, extension, abduction, adduction, opposition (the tabs look at his palm face, palm face of the 2-5 fingers) and circumduction. The thumb overlaps over the other 4 fingers, turning your hand into a real tweezer that allows prehension.

Figure 1 shows a hand biomechanism image.

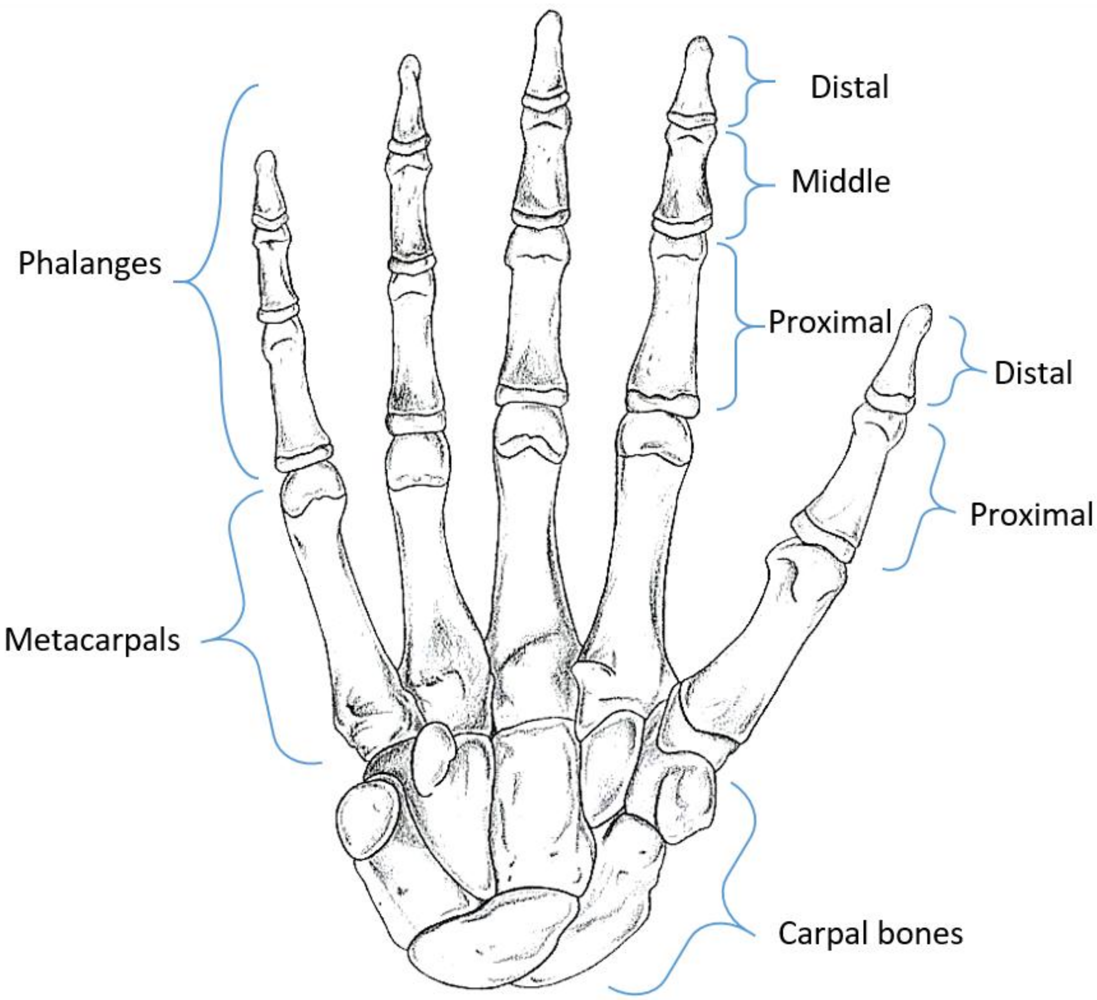

Figure 1. The skeleton of the human hand

3. **The biological gripping mechanisms**

In this study of biomechanism of the human hand we are interested in the prehension function of some objects. Thus, some simplifications can be made to the equivalent gripping mechanism. Of the 27 mobile elements, only 14 mobile elements corresponding to the 14 phalanxes are stored.

The elements are linked by 14 kinematic couplings corresponding to the 9 inter-phalangian joints and 5 meta-carpho-falangian joints. The other mobile elements together with the couplers that link them can be eliminated because they have an insignificant contribution to the prehensive process. The proposed kinematic scheme is shown in Figure 2.

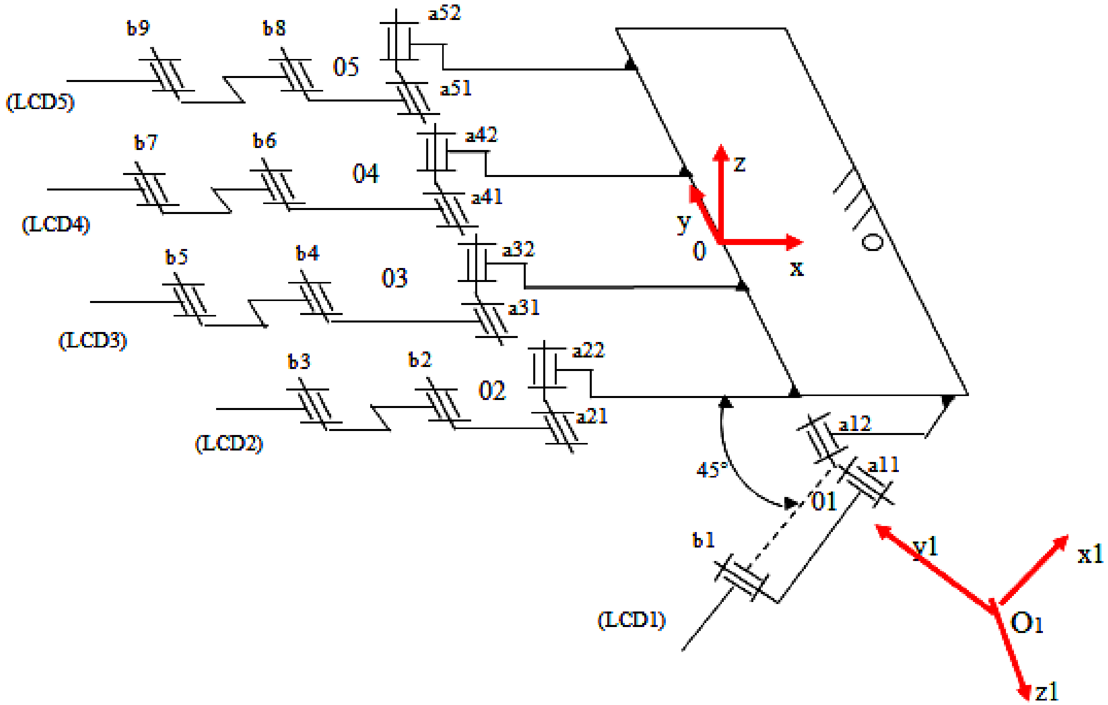

Figure 2. Equivalent mechanism- version 1, [1, 7, 8]

In the figure 2 is given the equivalent mechanism with the hand biomechanism. The biological mechanism has 5 kinematic open chains, equivalent with gripper fingers. The kinematic chains (LCD1, LCD2, LCD3, LCD4, LCD5) are guided in the same way like the biomechanism and it has 14 mobile elements.

The kinematic couplings b1, b2, ..., b9 are equivalent to the 9 monomobile interphalangeal joints. The kinematic couple pairs (a11, a12), (a21, a22), (a31, a32), (a41, a42) and (a51, a52) are equivalent to the five meta-carpho-falangian bimobile joints.

The kinematic couplings a11, b1, a21, b2, b3, a31, b4, b5, a41, b6, b7, a51, b8 and b9 provide the flexion movement of the fingers. The kinematic couplers a12, a22, a32, a42 and a52 provide the abduction-adduction motion which is rotation about the OY axis for the finger 1 and rotation about the OZ axis for fingers 2, 3, 4 and 5.

A second variant for the equivalent biological mechanism is also proposed. This is given in Figure 3. The mechanism was obtained by replacing the coupling pairs (a11, a12), ... (a51, a52) by the spherical kinematic couplings a1, a2, a3, a4 and a5.

So movements in the mechanism are equivalent to movements in hand biomechanism, plus the rotation movement around the OX axis. This movement favors a much greater number of prehensive positions.

The structural model of Figure 3 consists of five open cinematic chains (LCD 1; LCD 2; LCD 3; LCD 4; LCD 5) consisting of elementary, monomobile and trimobile kinematic chains. The biological mechanism has 14 mobile elements linked to 14 kinematic couples. All 14 couplings are leading couplings and the mechanism has the degree of mobility M = 14.

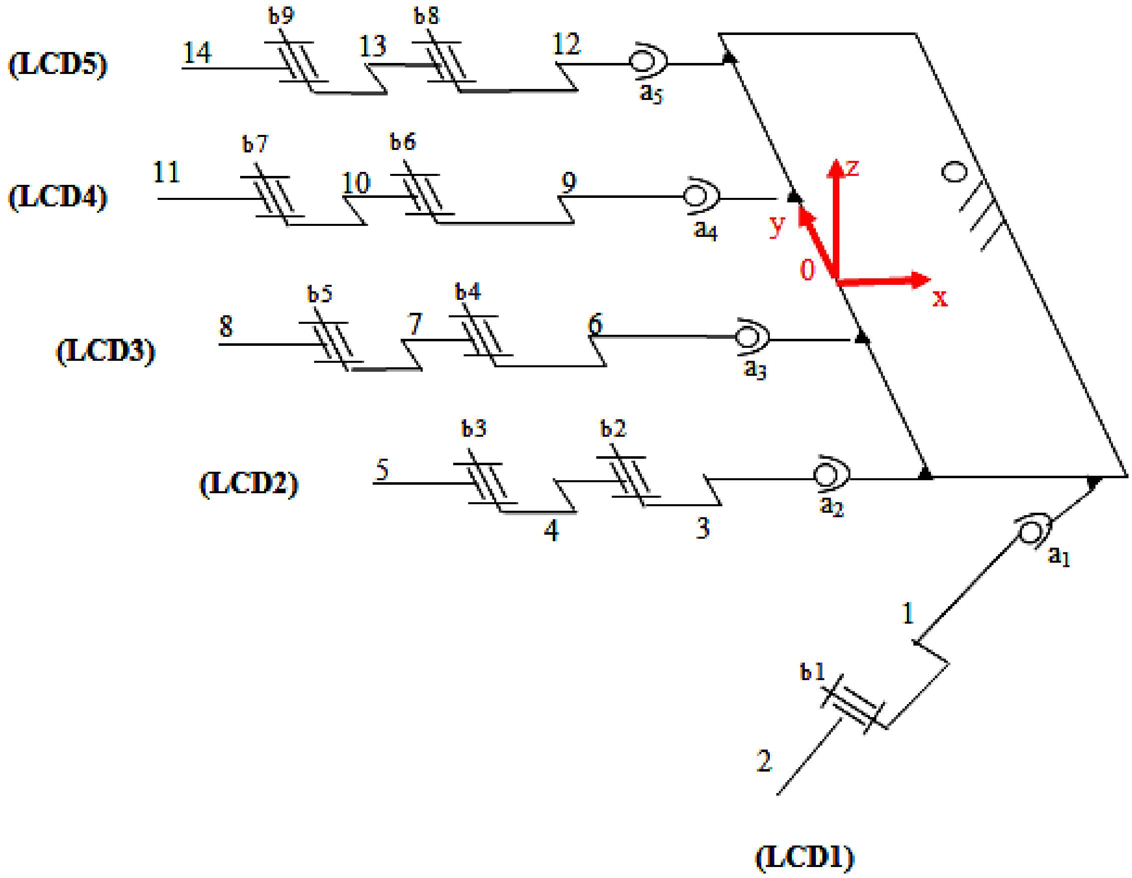

Figure. 3. Equivalent mechanism- version 2, [1, 7]

The biological mechanism in the figure 3 (a mechanism made up of five general kinematics chains) can be transformed according to Artobolevski's theory into a mechanism with fundamental kinematic chains. Replace kinematic couplings of any kind in the elemental kinematic couplers (V-class rotary or translational couplings).

From the study of biomechanism of gripping movements of the human hand, it was determined that some positions of prehension are favored by the position of the thumb over the other 4 fingers.

Figure 4 shows several positions of prehension of objects having different shapes. (Prehension at the top, Palm Prehension, Lateral Prehension, Cylindrical Prehension, Spherical Prehension, Grapnel Prehension). It is considered that each phalanx of the biomechanism corresponds in the biological equivalent mechanism to one linear rigid cinematic element. The number of contact possibilities of an object with a finger depends on the number of finger phalanxes. After the experimental investigations they are determined some movements of the biomechanism witch are not interesting for technical field.

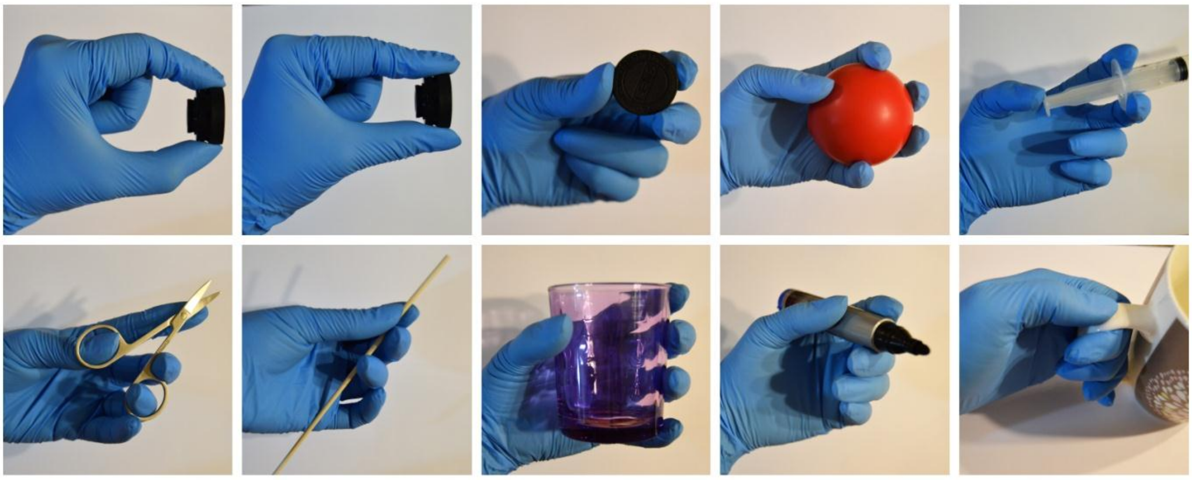

Figure 4. Variations of prehension

4. Conclusions

The researches concluded on the gripping biomechanism of the human hand and also on the equivalent biologic mechanism that they are important for designing some new prehensors for robots.

The mechanisms which are proposed in this paper can be used for building some gripping devices utilized for industrial robots.

Determining multiple variants of biological mechanisms helps constructing various robotic hands. This is very important, since in practice there is a need to grab objects with very varied geometries.

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