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Proposal of Anthropomorphic Robotic Hand

Marek Sukop*, Peter Marcinko, Ján Semjon, Marek Vagaš, Ondrej Juruš, Peter Tuleja, Rudolf Jánoš

Department of Robotics, Technical university of Kosice, Kosice, Slovakia
*Corresponding author: marek.sukop@tuke.sk

Abstract This article deals with the design and construction of a gripping anthropomorphic unit based on the principle of biomechanism. The new requirements for such grip units, particularly in the part of their mechanical design, require to find new principles of biomechanism applications or looking for new solutions in principle. A multi-unit biomechanical unit for gripping objects and upgrading the gripper unit has been developed. The solution is a whole unit of gripper and a 3D model with simulations.

Keywords: *anthropomorphic unit, gripper, 3D model*

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1. Introduction

Robotic devices represent fully developed systems in the present time. These systems work effective and efficiently with manufacturing systems. Gradually, they have a wide range of applications in industrial and non-industrial areas [1]. The current production of robotic equipment has reached a high level. There is increasing demand for subsystems, but also features and elements that share the morphology of these devices. A detailed analysis of the workspace application of the robotic devices can be from the scope of the application is virtually unlimited. This is the base of the fact that new roles in designing a robotic device will always be extraordinary. Taking into account the recent trends, it is necessary to take into account the fact that professional readiness for their solution. In these contexts, a particular position has the issue of end effectors of robotic devices, in which there are many publications. At the current time, the robotic based on experience and knowledge for such cases applies the principles of biomechanics and biomechanisms [2]. Thus gripping effectors solved are included in the group of biomechanical gripping effectors (grippers), or so-called anthropomorphic effectors. In order to solve this group of grippers, a broader application of knowledge about the properties and abilities of the human hand is needed and their presenting in the biomechanical principles of the proposed gripper. Gripping systems are complex mechatronic system that are used by industrial robots. They are also used in constructions of automated devices and systems in the function of fixators, feeders, manipulators etc.

2. Analysis of End Effectors and Classification

The end effector is a functional part of a robotic device that is directly related to the application and determines the effectiveness of the application. The end effector is practically always the original and prototype for any new application of the robotic device. These effectors are proposed for example by robot makers or robot application designers as well by user of the robotic device.

The principles of end effector mechanisms are utilized in the construction of various devices and systems. End effectors are devices specifically designed for mechanical connection to the end member of the robot actuator mechanism, which allows the task to be performed. Follow to the wide application of the robots and the variety of tasks that these devices perform in industrial and non-industrial processes as well as in service activities, end effectors can be systematically classified into the category defining their specifying – the main function, this classification is shown on Figure 1.

The end effectors have become one of the most diverse components of industrial robots, mainly because of the high number of manipulation objects, their shape, size, weight and physical diversity. Technical practice bring a lot of structurally and technically solutions of end effector.

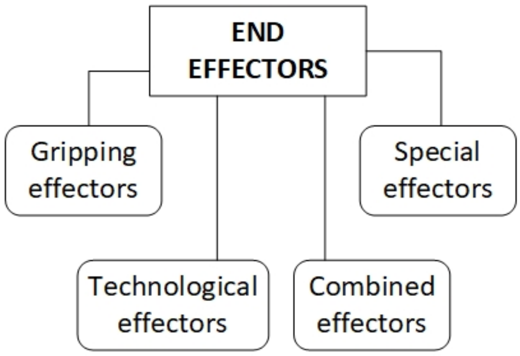

Figure 1. Classification of end effectors

- **Gripping effectors** – grippers – the end effectors designed for gripping and holding. Performs the gripping function, grasping the object of manipulation and its fixation for the time it is moved or for the time of active handling of the object manipulation. Together with the robot perform positioning of the handling object at the place of delivery.

- **Technological effectors –** working heads – are end effectors of the type of the tool, which work effectively on their own. Movement and orientation in the workspace is realized by the sub-movement of the robots arm. Perform the function of the technology tool carrier for the implementation of the specified technology. Positioning and orientation of the effector toward the workpiece being machined by the robot.
- **Combined effectors –** by its concept of solution and construction, it perform the role of multifunctional effectors, realized a combination of gripping effectors or a combination of various technological functions or a combination of gripping and technological functions.
- **Special effectors** – perform functions that, from the point of view of system access, do not fall within the scope of the functions mentioned in previous categories, especially those used in special applications, for example in service robotics [1].

Figure 2 shows examples of various effectors that are used in practice for simple manipulation of objects or welding [3,4].

Figure 2. Examples of various effectors

The current dynamic development of robotization and its penetration into demanding application areas associated with a wide assortment of various operations with motion, including intellectual functions and the ability to respond to changed and unplanned situations in the operating area, brings more demanding requirements to robot and effectors as tools to perform the main function of the robot – manipulative, technological or special task [5]. The theory of robot technology meets these requirements in the category of end effectors by the theory and construction of multi-element effectors, Figure 3.

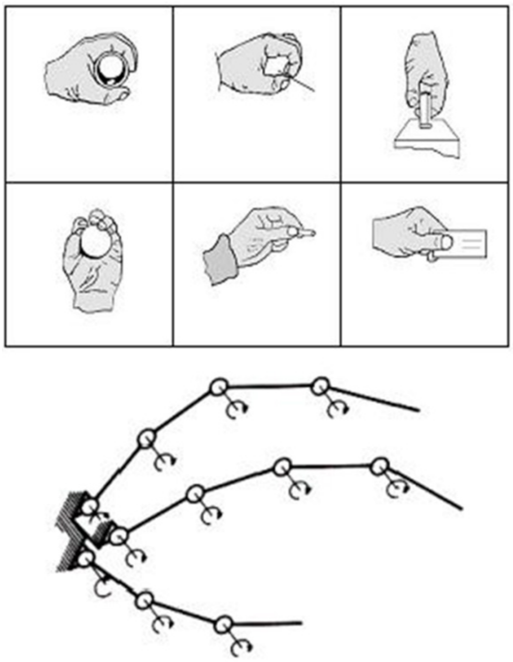

Figure 3. Functional – kinematic principle of multi-element effector

The functional principle of multi-element effectors – gripping heads – multi-element gripper is based on the principle of biomechanics of gripping objects (O_M) by a human hand securing so-shape and force closure with a closure in which the positon of the O_M is defined by the arrangement (configuration) of the gripping fingers and their force acting [10].

This concept and multi-element effector design bring a number of advantages and prerequisites to handle the most challenging handling tasks the most challenging technical details such as the gripping process and the handling of any O_M.

2.1. Overview of Different Solutions

Figure 4 shows different view of multi-element effector solutions.

Figure 4. Different solutions

- **Schunk SDH-2** – the highly universal gripper SDH-2 has three identical two-joints fingers, by Schunk (Figure 4 on left) [6]. One finger is solid and two are movably connected inside the base and indirectly can rotate by 90 degrees. SDH-2 is therefore suitable for gripping almost all shapes of industrial components. The force of the fingers corresponds to the average power of the human hand. This gripper is equipped with six contact sensors. Using them, they can identify different objects to ensure sensitive and reliable grip.

• **Shadow hand** – is the world´s most advanced robotic hand with the same degree of freedom as the human hand (Shadow robot Company, London, UK). The robot is powered by 40 pneumatic muscles that are placed in the forearm and are connected to the finder elements by means of the strands. The hand is equipped with touch sensors and is capable of handling even very small objects (Figure 4, in center of picture).

• **DLR Hand II** – biomechanical gripper was developed at the DLR Institut fur Robotik und Mechatronik, Wessling, 2003. It is a universal gripper head with 13 degrees of freedom of movement, it is equipped with 84 sensors and its own weight 1.8 kg. It can develop a gripping of 30 N. The drives are placed directly in the element of finger and thumb (at the right side of Figurer 4) [6].

2.2. Drive

When choosing a drive, many options and solutions are available, electric, pneumatic and hydraulic. Hydraulic and pneumatic drives have a great deal of disadvantage, the need to connect auxiliary systems, valves for dosing. Hydraulic drive is not suitable for this proposal. These drives are used for massive structures. Also a disadvantage is often maintenance. Pneumatic systems are the same complication as the hydraulic system, but there is no need for often maintenance, less running costs. Decision to use electric drive. The use of electric drives is a low price, low operating costs and almost maintenance-free operation. For this proposal of the anthropomorphic robotic hand, servomotors were used [12].

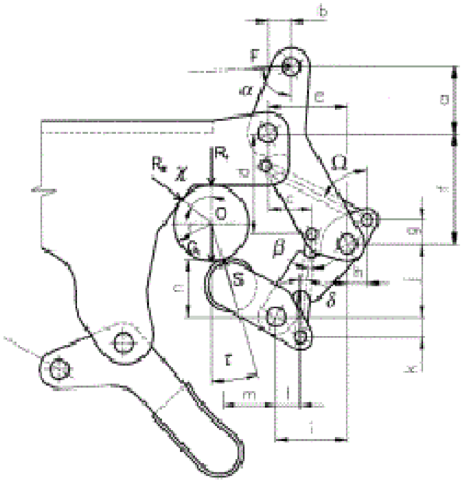

Figure 5. Forces for gripping

In Figure 5 are depicted forces acting the robotic hand mechanism. After the calculation it was found that the servomotor to be used should have a torque of 0.15 Nm. For use on this design, it was decided between two servomotors. The first type was the servomotor Emax es3351 digital servo or the second servomotor Tower pro microservo 9g [7]. Both types of these servomotors are small and light, with high output power [8].

Servomotors, Parameters	Emax	TowerPro
Weight:	10,6 g	9 g
Dimension:	23x9x24	22x11x31
Stall torque:	2,0 kg/cm – 4,8 V 2,2 kg/cm – 6 V	1,8 kg/cm – 4,8 V
Other:	plastic, digital	plastic, digital

Figure 6. Parameters of servomotors

The basic parameters of the servomotors are described in Figure 6, both types are suitable, but for this proposal of design anthropomorphic robotic hand, Emax servomotors have been used for a larger torque.

The importance of designing an anthropomorphic robotic hand comes for using in prosthetics. For replacing the member with using servomotors for restore the capabilities of positioning and gripping objects. Although, there is still no common definition characterizing human hand skills, biological variants have been found in the length of the bones, the tenderness off the tendons and muscles. All these things suggest that the human hand´s skills do not differ from person to person by its ability to control the muscles of the hand, but also by being bound to the unique biomechanical characteristics of the owner, so they cannot be generalized due to biological differences [11]. The conventional approach to designing an anthropomorphic robotic hand often involves biomechanical parts with joints, rods and ball pins to simplify the complexity of the human hand. This approach is very helpful in approximating human kinematics in general but inevitably brings unwanted differences between human and robotic hands. Unique biomechanics of any human, including complicated bone shapes, different rotational axes and other biomechanical benefits, can be seen as a physical system as a whole, but most of these remarkable features are eliminated in process mechanization.

2.3. Fingers

For gripping of cylindrical and spherical objects, a multi-element effector has been selected [9]. The gripping principle is based on the biomechanics of gripping objects of the object of manipulation by the human hand, providing a shape and force closure with a closure, in which the position of the object of the manipulation is defined by the arrangement of the grip fingers and their force acting. Drives for robotic hands can be placed in the hand or wrist where they are joined by a tendon system in which the loop of the fibrous cable is wrapped around the socket and attached to the base of the finger. In this case, the system of rods was used.

3. Model in 3D Representation

The next Figure 7 shows the thumb model. The thumb is made up of a few parts, which are connected. Every part of this hand is made by a 3D printer. At the center of the picture is a model of the entire anthropomorphic robotic hand that is attached to the flange. Each of thumbs is coupled with the servomotor by the rods. The entire system of rods and servomotors ensure move, which allow gripping the objects of manipulation. The bottom of the picture is a complete robotic hand. To control this entire mechanism, the control board by Arduino was selected. All five servomotors must be powered from an external power source.

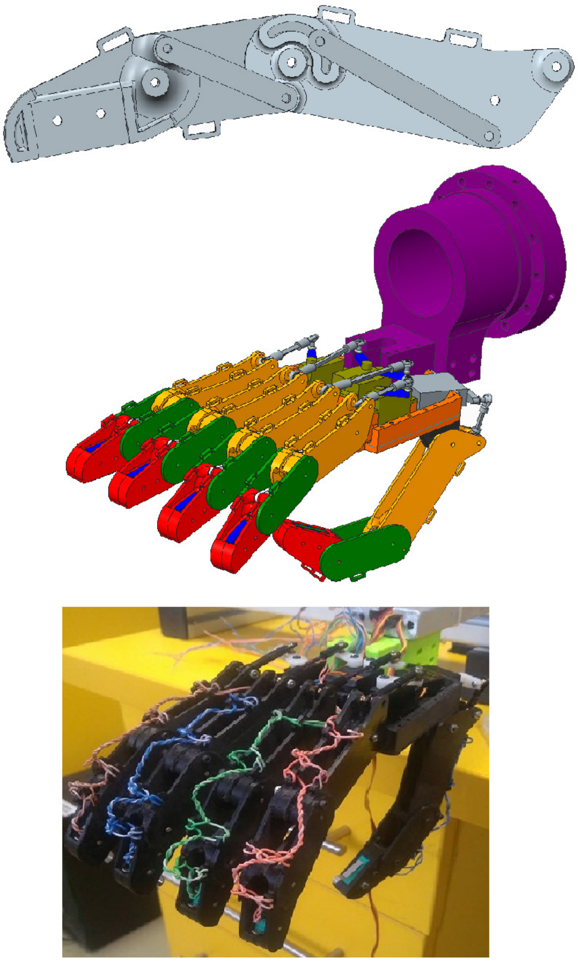

Figure 7. 3D model of finger and robotic hand

4. Conclusion

The main aim was to design an anthropomorphic robotic hand. In this case, the end effector was designed to gripping objects of spherical or cylindrical shape. When the robotic hand is mounted on a standard flange, it could also be used in industrial robotics.

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