MECHANICAL SIMULATION OF FINGERS OF HAND PROSTHESIS

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Abstract: Geometrical design of the fingers was done using anti-quadrangle linkages, the dynamic modeling being achieved using GLScene soft for Delphi programming language. This program can be used not only for hand prosthesis, which use anti-parallelogram linkages but also for anthropomorphic robot hands. This simulation offers the possibility that, at the end of the animation, obtaining the graphical representation of speed and force to the last element of the index.

Keywords: hand prosthesis, linkages, Delphi program

1. INTRODUCTION

Hand prostheses are very complex mechanical devices and their design has to satisfy a large numbers of constrains. Among these constrains stand the gripping force at the tip of the fingers, the movement of the fingers, the shape of the gripped objects and so on [1]. The fingers design begins considering the numbers of joints desired for each finger, the mechanisms chosen to model the finger and the lengths of each element. The control, in the case when there is no prototype, implies either to conceive a program similarly with an interface for electronic part of the system or all the control as an abstract thing, starting from a data base there is obtained the output and this is compared with the desired one.

The present paper presents the program designed to simulate the movement of the fingers, based on kinematical equations that define the fingers.

2. FINGERS DESIGN

As it was underlined above, the mechanisms that can be used to design the structural part of the fingers are multiple. In this paper, it is presented one of the most complex types of design: the fingers, except the thumb, have three joints modeled using anti-quadrangle [3] linkages. The thumb is designed using only one anti-quadrangle mechanism and that means that it has only two joints. Next, the fingers are actuated, each of them by a direct current motor. This type of mechanisms

allows the prosthesis to grasp also cylindrical or spherical objects. The actuators are not drawn but this paper briefly presents the control of the prosthesis.

The fingers dimensions were chosen thus the prosthesis would be used by an adult. The fingers are made from aluminum and, with the above dimensions there were done the strength calculus. The structural and kinematical analysis bases on a database composed from geometrical adopted data. The analysis is based on solving the equations that result from the vectorial outline for each anti-quadrangle mechanism.

The movements of the fingertip of the fingers depend on the variation of input angle, α (figure 1). As input date, angle α, varies between 0^o and 90^o. This value is adopted considering movements as close as possible of human hand's movements.

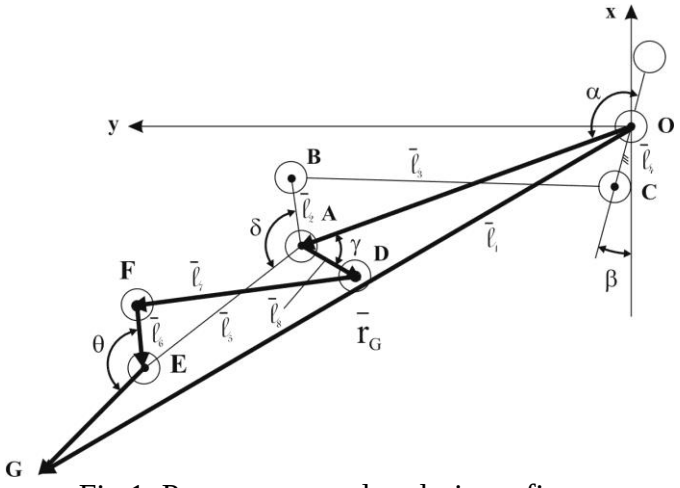

Fig.1. Parameters used to design a finger

After the calculus was done there were obtained the diagrams that gives the position, speed of the tip of the fingers and desired force needed to actuate the fingers [2].

3. FINGERS SIMULATION

The design of a prototype for the prosthesis implies high quality of mechanical parts otherwise the functionality of it is not an appropriate one.

This is the reason why it was chosen to create a program that simulates the drawing of a prosthesis with five fingers actuate individually by 5 DC motors (the motors were not drawn). The program simulates also the movement of the fingers based on the kinematical equations. It was also included, as part of the program, the fuzzy controller used to control the movement of the fingers. This controller is not detailed in this paper.

The program was created in Delphi program and the drawing part was done using the GLScene toolbox of Delphi [4, 5].

A program that simulates hand prosthesis should be adapted also for an anthropomorphic robotic hand. This is why the program allows the user to chose the number and type of the fingers

desired (figure 2)and also the dimensions needed for each element of the fingers (figure 3). In figure 3 are presented besides the parameters shown in figure 1 those for width of the fingers (Gb_M and Gb_m), the dimensions for the bolts used to connect the linkages and also the position of the finger in space (all the parameters in figure 4 are given for the forefinger).

Fig.2 Finger selection window

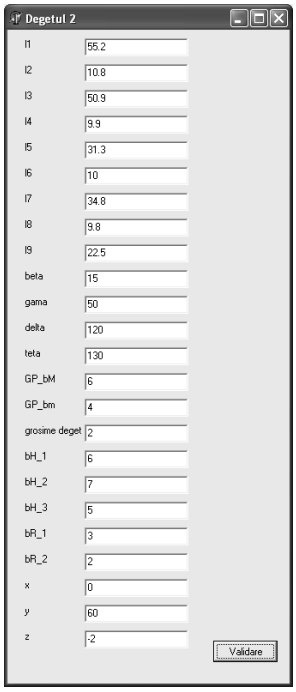

Fig. 3 The forefinger design parameters

a) b)

Fig.4 The main window: a) the front view of the simulated fingers; b) lateral view

The main window of the simulation program is shown in figure 4. It should be mentioned that the shown position of the fingers it is obtained after the fingers were drawn and there were given the parameters for the fuzzy control.

Considering that the mass of the mobile system is 100g, the representation interval is 2s, an adjacent force of 2N appears after 1s it was obtained the time-diagram of the fuzzy controller. It can be observed that the position is damped after 0.5s (there is an oscillation with one step left-one step right). When the adjacent force appears the system is disturbed but it is quickly damped. Thus for the parameters given above during the simulation interval, the controller is able to damp the system.

4. CONCLUSIONS

The program presented in this paper simulates the movement of the fingers.

The advantage of this program is that it can be used not only for hand prosthesis with only one set of dimensions but also for any set of dimensions that satisfy the strength equations and motion conditions required by the appropriate function of the mechanisms.

It also can be used to design and simulate any anthropomorphic robot hand. The program can be modified as that it can be used for any type of mechanisms not only for anti-parallelogram ones, the only condition being that the mechanism should be a linkage one.

In the future it is desired that the palm of the hand to be also dynamically simulated. The palm can be designed either considering some mechanisms with linkages and plates, or with springs, or with a differential mechanism. To be able to say that one reproduces the human hand that means that the fingers, palm but also the wrist of the hand is simulated. These are some aspects that the future work will deal.

REFERENCES

[1] Cutkosky, M., Howe, R.(1990) - Human grasp choice and robotic grasp analysis. Dextrous Robot Hands, pp.5-31, Springer Verlag
[2] Visser, H., Herder, J.(2000) - Force-directed design of a voluntary closing hand prosthesis. In: Journal of Rehabilitation Research and Development Vol. 37 No. 3.
[3] Design manufacturing. Linkage – MIT Course, 2002
[4] Delphi 5.0 – Help pages
[5] GLScene tutorials