FIRST APPROACH OF PNEUMATIC ANTHROPOMORPHIC HAND

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Abstract- **This work is a first approach of an articulated hand with the purpose of solving the basic needs of a hand-amputated person. The anthropomorphic hand has two active degrees of freedom and 6 passive, actuated by a pneumatic system. The main objectives are simplicity, low weight and minimum consumption, minimum control and natural appearance.**
Keywords- Anthropomorphic, hand, Pneumatic system, Prosthesis

1. Introduction

For some time articulate hands that attempt to replace some of the functions of the human hand have been developed. One of the main difficulties from prosthesis design is the great complexity of Human hand which has 20 degrees of freedom that allows it to have greater grasping capacity for a wide variety of objects in different ways and configurations. It has also a sophisticated sensor system where the fibers are allowed to detect heat, pressure, slip, pain, etc. On the other hand success of developing a functional hand prosthesis resides in having a system that responds to patient's necessities but even more it is required that the prosthesis fulfills the specifications of weight and minimum consumption, of cosmetic appearance and simple operation.

Many works have been focusing on the description of mathematical modeling or even to the simulation of the processes of human grasping, with the goal of understanding the process of manipulation of an object.

The most important works try on diverse configurations of mechanical structures and controls that are compared with the tasks that Human hand can carry out. Each project determines the diverse possibilities of manipulation and stability in function of the number of fingers and its degrees of freedom.

For the moment, the idea of designing artificial hands have gathered the results of this investigations and allows us to find relatively simple structures, able to take and manipulate certain objects with a relative dexterous.

The projects have been guided through an specific line of development. The project MARCUS[1] includes easiness as the most important aspect what increases the possibilities of acceptance of prosthesis by the user. Multiple degrees of freedom of the prosthesis are difficult to control independently and require a high concentration level.

In the MARCUS project, the control was arranged in a hierarchical manner to ensure the control of multiple degrees of freedom with a little direct intervention by the user. This hand of two degrees of freedom has been developed to demonstrate this concept and a sufficiently compact object has been manufactured that allows user to winning experience with it.

The University of Reading has developed a dexterous hand of 4 fingers with an anthropomorphic design. Each finger has three degrees of freedom for a total of 12 DOF. Each degree of freedom in each finger is commanded by a single actuator a couple of tendons and are required for operation 12 actuators to operate it. Each finger has three sections. The two distal unions and the thumb are able move between -90º and 90º degrees. The hand also includes 36 pulleys of low friction to manage each tendon.

The project U.B. Hand II refers to an artificial hand of 3 fingers with 11 degrees of freedom. Four degrees for each finger and 3 degrees for the thumb. This hand is integrated to an artificial arm of two degrees of freedom.

The project U.B. has an effective integration between hand, wrist and arm considering both a mechanical aspect and functional integration of the design.

There are projects like that of Utah/MIT, or Stanford/JPL which anthropomorphic considerations but with different design objectives for the rehabilitation.

This is a proposal for the development of an articulated hand with the purpose of solving the basic needs of a hand-amputated person. This prosthesis has two active degrees of freedom and 6 passive, actuated by a pneumatic system.

The main objectives of this project are:

1) Design, to achieve the characteristics of

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mechanical design like simplicity, low weight and minimum consumption, as well as compatibility of materials which allow the user to adapt it self as quickly as possible

2) Minimum control: which allows the user to have a minimum of attention in the handling of the prosthesis

3) Natural appearance

II. Methodology

The design of the anthropomorphic hand is divided in three parts: Mechanical design, control, sensors and pneumatic system.

1) *Mechanical design*: The design of the anthropomorphic hand is based on three active articulate fingers. Index and, half fingers which act as virtual finger and the thumb. The index and half has three degrees of freedom (passives) and the thumb only two. The fingers are actuated by pneumatic cylinders and three kevlar filaments, which act like contractor tendon. Each finger has three springs that act like an extensor tendon.

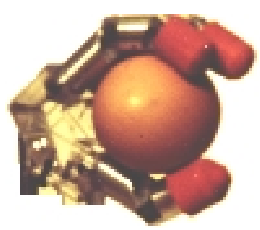

Fig. 1. Mechanical Structure of the Anthropomorphic Hand

The system is a open-end tendon drive. Where the number of tendons is less than the number of degrees of freedom, therefore the motion of the manipulator cannot be controlled at will [6]. This type of manipulation is called an insufficiently actuated manipulator

Although the joints cannot be controlled independently, the fingers can conform to an object of random shape with to uniform grasping forced. The tendon is routed along the finger and it is connected to the top of it.

A hand control is based on two different routines, precision and power grasping.

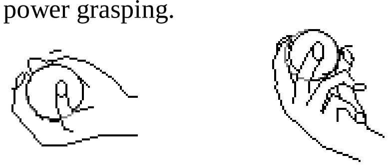

Fig 2. Precision and power grasping

2) *Control*: The control of the hand is divided in two parts:

a) Central system which monitors the signals of the contact sensors, controls grasping strategy and also establishes the communication with the user

b) Subcontrol system which performs the control of the force from each actuator and the position of each finger

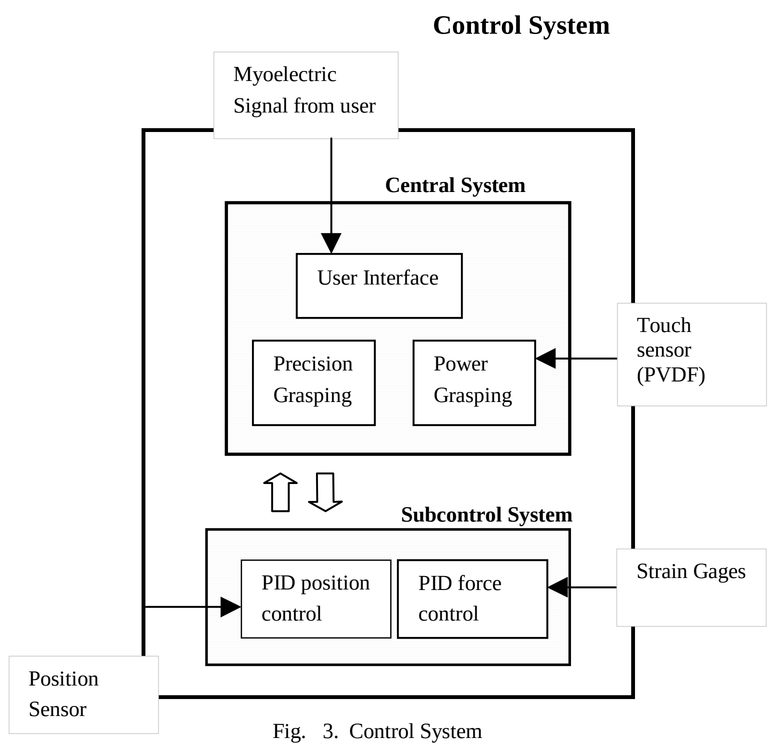

Fig. 3. Control System

The airflow is controlled by a nonliner proportional derivative integrative system (PID).

3) *Sensors:* Each finger has three sensors of pressure integrated (strain gages) and three contact sensors of polyvinylidene fluoride (PVDF). Each sensor is connected with a subcontrol system. The contact sensors indicate in which part of the hand the contact is performed indicating to the central system which strategy of grasping will be activated. The control is implemented in a micro controller.

4) *Pneumatic system:* The pneumatic system will be fed by a micro air pump, which maintain the enough pressure in the system. The pneumatic actuators are two micro cylinders that are controlled by two mini air valves, which has minimum air consumption.

III. RESULTS

At the present time the mechanical part is still being in development. We have the structure of the fingers and partially the assembly of the pneumatic system is already finished. We are working on both, the implementation of the control at the microcontroller and the conditioning sensor signal. The next step is the integration of all the systems with the myoelectric control interface[10].

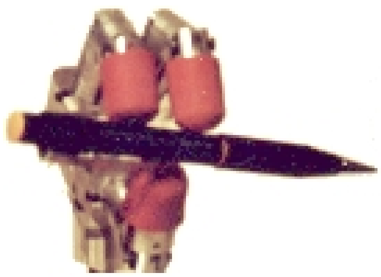

Fig. 4. Partial Structure of the Anthropomorphic Hand

IV. CONCLUSION

The first stage of the project is already conclude in which all systems are integrated. We have to improve the energy consumption and the weight of all system. This project will serve as foundation to obtain useful prosthesis hand with a more sophisticated control, which increases the quality of the amputees.

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