Tip-Grasp Experiences with Three-Finger Anthropomorphic LARM Hand

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Abstract: *This paper presents tip-grasp experiences with a robotic hand with three 1 dof anthropomorphic fingers of human sizes. The last prototype of LARM Hand built at LARM in Cassino is illustrated as a low-cost easy-operation design. Cylindrical-grasp experiences have been previously carried out in order to compare the force measure results with the force results that are measured during the tip-grasp experiences. Tip-grasp experiences have been developed by using specific grasping strategies and they have been carried out successfully for a suitable easy-operation of the LARM Hand.*

Keywords: *Robotic hand, anthropomorphic design, finger, tip-grasp*

I INTRODUCTION

Since the beginning of Robotics, several researchers have investigated different types of devices for achieving grasping and handling of objects. Mechanical grippers having two fingers are widely used in industrial applications and mostly in industrial robots, as illustrated for example in [1-2]. However, multi-fingered robotic devices and hands have been also widely investigated. This type of devices tries to mimic the performances of human hands. Significant examples can be identified in the hands proposed in [3-4]. Most of the available multi-fingered prototypes have a high number of degrees of freedom, a complex control and a high cost.

Since a recent past, design and research activities have been carried out at LARM in Cassino in order to design a low-cost and easy-operation anthropomorphic hand. A last prototype of robotic hand has been built at LARM in the year 2005. Experimental tests have been carried out in order to validate the function of the hand prototype, as illustrated in [5].

In general, human hand has the capacity of performing six main kinds of grasp, [2]: cylindrical grasp, tip grasp, snap of hook grasp, palmar grasp, spherical grasp and lateral grasp. The tip grasp is a grip where the palmar surface of the pad of the thumb presses against the surface of the first phalange of the index, [6], as shown in Fig. 1.

This paper reports tip-grasp experiences with the LARM Hand prototype. Cylindrical and tip grasp experiences have been carried out in order to measure the grasp force during different hand grasps and to check on efficiency of LARM Hand. Successful results of the experiences have validated the grasps of the LARM Hand and they have characterized its operation.

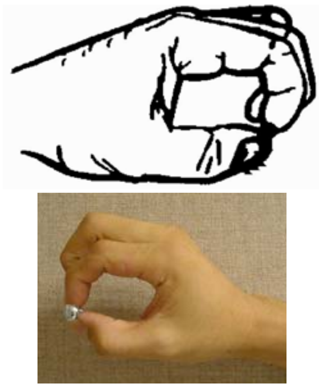
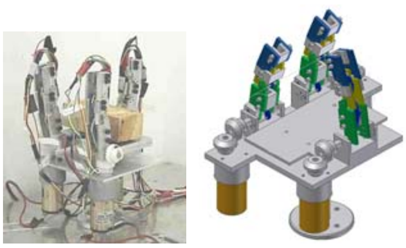


Figure 1
Tip-grasp of human being, as defined in [6]

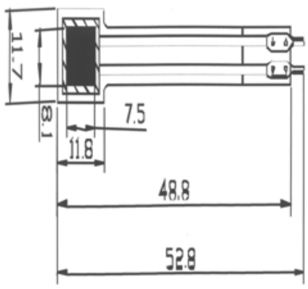
II THE THREE-FINGERED ANTHROPOMORPHIC ROBOTIC HAND

Figure 2 shows the sensored prototype of the three-fingered LARM Hand. Particularly, Fig. 2(a) shows a whole assembly of the sensored hand prorotype and Fig 2(b) shows a 3D-CAD model that has been developed in Autodesk Inventor environment.

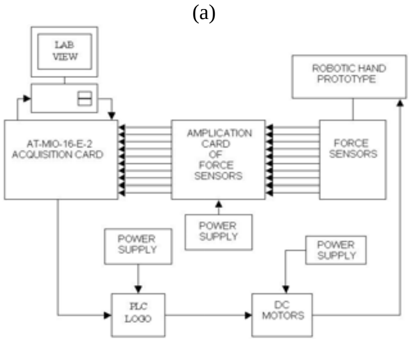


(a) (b)
Figure 2
A prototype of three-fingered LARM Hand with 1-D.O.F. anthropomorphic fingers of human sizes: (a) the sensored prototype; (b) a 3D-CAD model

Each mechanical component of the hand has been designed also by using Autodesk Inventor for the analysis of mechanical interference and to simulate the grasping, as outlined in [5]. A low-cost and light weight prototype has been obtained by manufacturing it with commercial alluminium alloy. The fingers are actuated by DC motors with 24 V and 1 A. The operation of the DC motors has been managed by using a PLC LOGO!, that is a low-cost commercial PLC. The LOGO! has been programmed to achieve the opening and closing of the hand for automatic operations. In addition, six force sensors have been installed on the phalanxes in order to measure the grasp forces during experimental experiences.



(a)



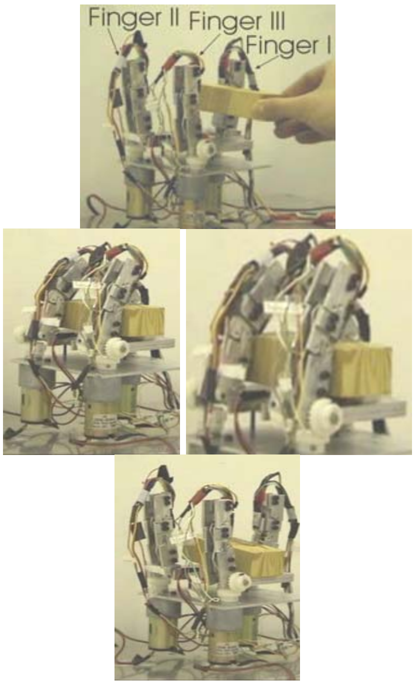
(b)
Figure 3
Control system of the three-fingered prototype of Fig. 2: (a) the used FSR150CP12 force sensor with dimensions in mm; (b) a control scheme

FSR150CP12 force sensors have been used since they are low-weight, low-cost and easy-operation, as reported in [5]. They have also suitable dimensions as shown in Fig. 3(a) so that they can be installed on the surface of the finger phalanxes.

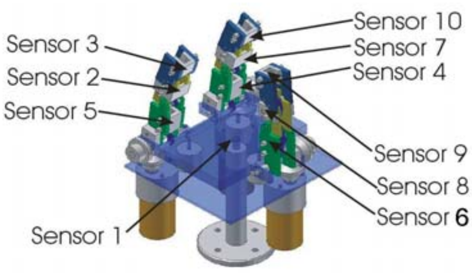
The overall experimental system has been settled up according to the scheme of Fig. 3(b). The operation of the sensors has been managed by using an acquisition card AT-MIO-16E-2 and a suitable virtual instrument has been developed in LabView environment.

III CYLINDRICAL-GRASP EXPERIENCES

Previous cylindrical-grasp experiences have been carried out by using LARM hand prototype in order to check its practical feasibility and operation. Figure 4(a) shows a photo sequence of a cylindrical-grasp experiment. Figure 4(b) shows a 3D-CAD scheme of the hand with the location of force sensors. In general, a cylindrical grasp is a grip where the fingers press the object against the palm surface in a cylindrical configuration, [2;6]. The experimental tests have been carried out through four phases. The first phase consists in opening the hand to a suitable configuration. During the second phase the LARM Hand approaches the object. In the third phase a static firm grasp of the object is achieved by closing the finger against the object. Finally, in the fourth phase the object is released. The cylindrical-grasp experiences have been carried out for comparing test results with force results that are measured during tip-grasp experiences. Figure 5 shows the plot of force that has been measured by the force sensor 1 of the palm during the static grasping of an object of 0.1 Kg made of compliant plastic. In Fig. 5 is possible to observe the general evolution of the measured force. In particular, in Fig. 5 the gasp starts at about 5.5 sec. and the force is increased until a stable value at about 6.5 sec. From at about 6.5 sec. until 7.3 sec. the force has been kept almost constant.



(a)



(b)

Figure 4
Cylindrical-gasp experience by using the three-finger LARM Hand prototype: (a) a photo sequence; (b) location of force sensors

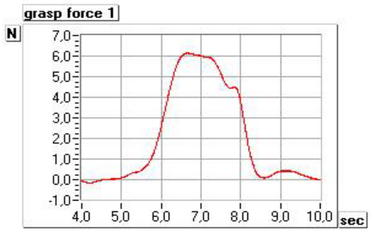


Figure 5
Plots of the force measured by sensor 1 during a cylindrical grasping of an object made of compliant plastic with LARM Hand of Fig. 2

The time history of grasp force is not constant and there are small changes of magnitudes, as consequence of the unstable contact between the grasp object and corresponding force sensor, as reported in [5]. Finally, at about 7.3 sec. to 8.5 sec. the force is decreased until the final release. Similar results of measured force have been obatined for the othres nine force sensors, as illustrated in [5]. In addition, few sensors have measured a non-zero force, since the grasp has not given contacts with all sensors. This is a consequence of the rigid structure of the fingers. A compliant plastic object adapts its geometry to the surface of the phalanxes. Therefore, it is possible to have almost all sensors measuring. The maximum measured force during the cylindrical experiments has reached 12 N approximately, as measured by sensor 4.

IV TIP-GRASP EXPERIENCES

Figure 6 shows a photo sequence of the LARM Hand carrying out a tip-grasp of a compliant plastic object. During tip-grasp experiences sensors have been installed on the finger tips in order to monitor the forces during experiments. Thus, only finger tip sensors have been activated by the grasped object. The phase operations during tip-grasp experiences and the position of the sensors have been the same during cylindrical-grasp experiences of Fig. 4. Figure 7 shows the forces that are measured by the force sensors during a static tip-grasp of an object of 0.1 Kg made of compliant plastic as in Fig. 6. The maximum grasping force has been about 7 N as measured by sensor 9 of the finger I tip, as shown in Fig. 7(a). In the result plots of tip-grasp experiences, time evolution of the grasp forces does not show a constant magnitudes since the contact between grasped object and sensors has not been completely firm. Nevertheless, the plots of forces have shown suitable results for the tip-grasp of LARM Hand since the grasp has shown firm configuration with proper level of forces and phase durations.

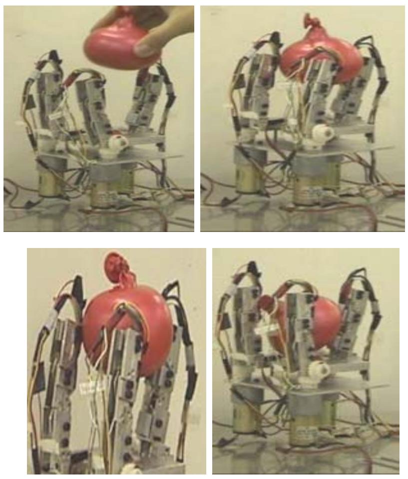
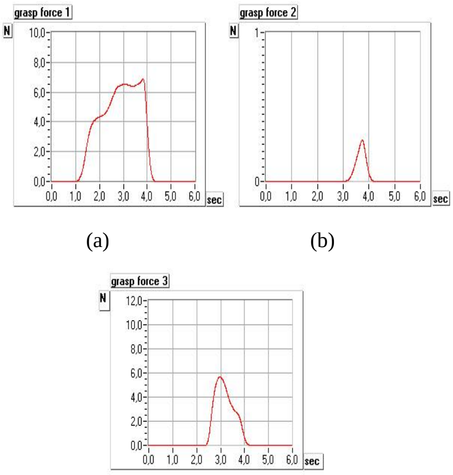


Figure 6
A sequence of the tip-grasp experience with the three-finger LARM Hand prototype

Both in the results of cylindrical-gasp and tip-grasp tests, the plots show proper magnitudes of measured forces and time evolution. The time evolution of the grasp forces has presented a similar evolution of increase, remaining and decrease in both grasp types.



(a) (b)

(c)

Figure 7
Plots of the measured forces during a tip grasping of an object made of compliant plastic with LARM Hand of Fig. 6: (a) by sensor 9; (b) by sensor 3; (c) by sensor 10

Summarizing, tip-grasp has proved the practical efficiency and versatility of the LARM Hand for an additional grasp type by still using easy-operation application.

Conclusions

Tip-grasp experiences with LARM Hand prototype has been illustrated to validate and characterize its operation. Successful results are obtained during cylindrical-grasp and tip-grasp tests. In both cases plot results show time evolution of the grasping with suitable smooth behaviour and values. By carrying out cylindrical and tip grasp experiences, the grasping of the LARM Hand has been checked experimentally with the designed characteristics for easy-operation efficient operation.

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