Design of a Low Cost Non-actuated Support Arm

○ Gustavo Kato, Diego Onchi, Elsa Cairampoma (Pontificia Universidad Católica del Perú)

1. Introduction

Research regarding arm supports has been done for more than 50 years. The dynamic arm supports can be classified in three major categories [1]: non-actuated devices, passive-actuated devices and actively-actuated devices. The non-actuated devices do not require external energy operation, are low cost but do not offer all the mobility required for activities of daily living (ADL). The passive-actuated devices can store potential energy by the use of counterweights, springs and elastic bands and provide better support than the non-actuated devices but do not offer all the required mobility. On the other hand, the actively-actuated devices require external energy for operation, offer excellent mobility but are expensive. The study presented by Miyawaki [2] demonstrates that low cost exoskeleton type devices are effective to support elderly people with disabilities on the upper arm and forearm. On the other hand, cable-driven mechanisms have demonstrated to be efficient transmission system for robot arms [3], [4] but require advanced control algorithms to properly operate the robot arm. The present study shows the concept of a novel design of a non-actuated support arm for use as third arm. The design is based on the wire system used on the japanese "karakuri" dolls. The proposed system can have multiple applications going from medical or construction to activities of daily living.

2. Low cost non-actuated support arm

The low cost non-actuated support arm, shown in figure 1, consists of an arm composed by a spherical joint at the shoulder, two rotary joints on the elbow and the wrist, and three rotary joints on the hand. The arm parts are made of aluminum and the elbow support for the spherical joint is made of plastic. The hand is composed of four aluminum plates: one plate for the palm, one for the thumb, one for the index finger and middle finger, and one for the ring finger and the little finger. The plates for the fingers have straps that allow the users hand to hold and move the hand plates. The details of the hand are shown in figure 2. Wires connect the tips of the three finger plates through the palm plate to the shoulder part of the support arm. Other three wires go along the whole arm between the wrist, elbow and shoulder joints.

Fig. 1: Low cost non-actuated support arm.

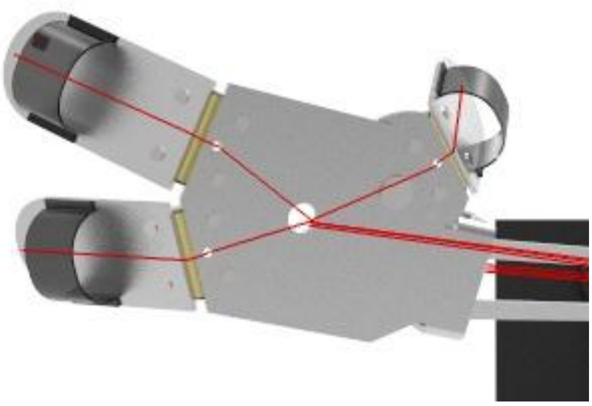

Fig. 2: Low cost non-actuated support arm.

In the shoulder of the support arm there is a locking mechanism actuated by a DC motor. The DC motor rotates a screw that moves forward a pressing mechanism that holds the wires and locks the shoulder spherical joint. The spherical joint is locked by two semispherical pieces as shown in figure 3. A microswitch located on the fingertip of the index finger plate activates the DC motor to lock the position of the support arm or to unlock it.

The shoulder pack of the non-actuated support arm holds the microcontroller and the battery pack that energizes the DC motor and the control system.

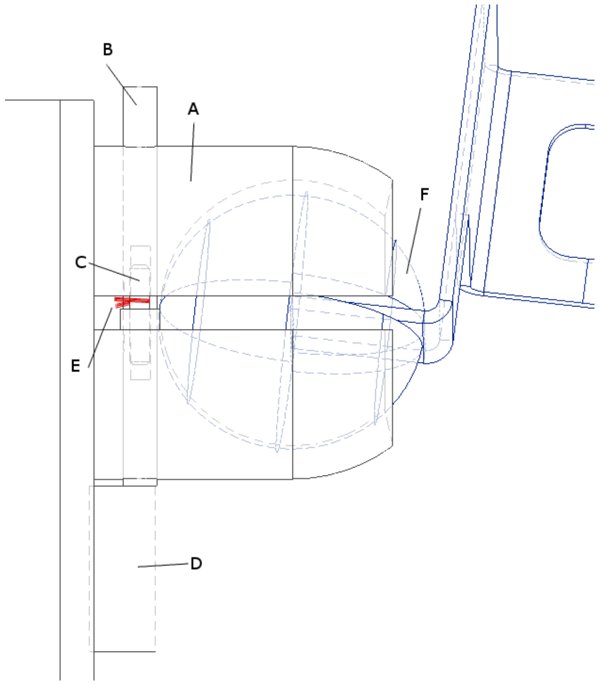

Fig. 3: Detail of the spherical joint and locking mechanism.

The details of the spherical joint and locking mechanism shown in figure 3 are as follows: A: locking semispherical mechanism, B: Screw, C: Wire locking bar, D: DC motor, E: Wires, F: Spherical Joint.

3. Using the non-actuated support arm.

For using the non-actuated support arm, the user straps the system around his chest. Then the user holds the support arm from its outer part and inserts his fingers on the hand straps. The support arm moves with the movement of the user arm and can grasp objects using the three plates for the fingers. The size of the support arm pieces has to be custom made for each user. When the user desires to lock the support arm in position pushes the microswitch next to the finger tip of the index finger. The microswitch sends a signal to the microcontroller and it activates the DC motor locking the arm in position. The user then can remove his arm from the support arm and leave it locked in position.

4. Applications of the support arm.

The support arm can be used in different fields reducing the support personal required to hold items in place. For example: in the construction field, the support arm can help the user in keeping wood boards in place while using both hands for hammering a nail. In the security field, firefighters could use the support arm to hold equipment or tools in place while using both hands for another task. In the medicine field, a paramedic could use the support arm to lock a tourniquet while using the hands to perform another life saving task. The support arm could be used even for activities of daily living like holding a bag, a drink or even a mobile phone. Figure 4 shows another view of the support arm in a locked position.

Fig. 4: Example of a locked position of the support arm

References

[1] Van der Heide, L., Gelderblom, G., Witte, L., “Dynamic arm supports”, IEEE International Conference on Rehabilitation Robotics (ICORR), 2013.

[2] Matsunaga, T., Sato, T., Iwami, T., Matsunaga, T., Chida, S., Shimada, Y., Obinata, G., “Evaluation of the utility of the Arm-Balancer arm support system”, Internacional Symposium on Micro-NanoMechatronics and Human Science (MHS), 2010.

[3] Ma J., Li, Y., Ge, S., “Adaptive Control for a Cable Driven Robot Arm”, Proceedings of 2012 IEEE International Conference on Mechatronics and Automation, pp. 1074-1079, 2012.

[4] Zollo, L., Siciliano, B., Laschi, C., Teti, G., Dario, P., “Compliant control for a cable-actuated anthropomorphic robot arm: an experimental validation of different solutions”, Proceedings of the 2002 International Conference on Robotics & Automation, pp.1836-1841, 2002.