# On Control Interfaces for the Robotic Sixth Finger 

Irfan Hussain<br>Università degli Studi di Siena,<br>Dipartimento di Ingegneria<br>dell'Informazione<br>Via Roma 56, 53100<br>Siena, Italy<br>hussain@dii.unisi.it

Gionata Salvietti<br>Università degli Studi di Siena,<br>Dipartimento di Ingegneria dell'Informazione<br>Via Roma 56, 53100<br>Siena, Italy<br>salviettigio@dii.unisi.it

Domenico Prattichizzo<br>Department of Advanced<br>Robotics, Istituto Italiano di<br>Tecnologia<br>Via Morego 30, 16163<br>Genoa, Italy<br>prattichizzo@dii.unisi.it


#### Abstract

In this demo, we present two possible control interfaces for a robotic extra-finger called the Robotic Sixth Finger. One interface is an instrumented glove able to measure the human hand posture. The aim is the integration of the motion of robotic finger with that of the human hand so to achieve complex manipulation skills. The second interface is a ring with a push button embedded so to implement a simple and intuitive control. The presence of an extra robotic finger in human hand enlarges the workspace, increases the grasping capabilities and the manipulation dexterity. We will propose a series of grasping and manipulation tasks to be performed with the help of the robotic sixth finger and the relative interface so to prove their effectiveness in augmenting the human hand capabilities.


## 1. BACKGROUND

The Robotic Sixth Finger is way of augmenting human hand grasping capabilities using a robotic extra-finger. The human five fingers and the device coordinately move and shares the workload to perform tasks that are impossible to do with a single hand. Over last years, despite of the significant technological and scientific advancements achieved in the field of wearable powered robotic technologies, we can only find very few examples of augmenting the humans existing abilities by wearable robotics [1]. This is a newly emerging research direction towards augmenting human capabilities through wearable robotics, different from traditional human oriented robotic technologies like prosthetics to substitute lost limbs or exoskeletons to assist human limbs. In our opinion, the integration with the human body should be of primary importance in developing wearable devices. Even though the human hand is an extremely versatile tool, suited for a huge range of manipulation tasks, exhibiting flexible and efficient solutions to the features and constraints presented by different tasks, our objective is to integrate it with an additional robotic finger to explore the improvement in grasping and manipulation capabilities.

We believe, at this preliminary stage of research in this domain, different design of devices and control interfaces need to be explored to better understand the effective and intuitive means of interactions with these devices. This is also due to the fact that these devices could have numerous applications ranging from healthy

[^0]

Figure 1: The Robotic Sixth Finger and the two possible control interface. On the left, an instrumented glove is used as interface. On the right, the ring interface.
people to clinical needs. Some of them are more complex manipulation demanding, means complex control algorithms while, on the other hand, the clinical oriented may need simple devices but more intuitive and easy control. This is the prime motivation for proposing portable and wearable design with different control interfaces which could be suitable for this kind of devices.

## 2. THE ROBOTIC SIXTH FINGER

### 2.1 The prototype

In this demo, we will present a new prototype of the Robotic Sixth Finger based on the preliminary version presented in [2]. Moreover we will present two possible control interfaces based on a sensorized glove and on a ring embedding a push-button.

The finger is based on the principle of modularity. Each module contains an actuator, 3D printed ABS (acrylonitrile butadiene styrene, ABSPlus, Stratasys, USA) plastic part and a soft rubber part used to increase the friction at the contact area. The actuator used is the HS53 MicroLite servo motor. The modules are connected so that one extremity of each module is rigidly coupled with the shaft of the motor through screws, while the other has a pin joint acting as revolute joint. Modules are connected in a pitch-pitch configuration for the flexion/extension motion of the finger. The flexion/extension modules are attached to a base revolute joint, realized by spur gears. The joint at the base increases the workspace and dexterity of finger around the whole palm of hand. One of the spur gear is mounted on the shaft of the servo motor while the other is placed on the base of the finger. We used bearings to decrease the friction during rotation. The finger can be easily worn by the user by means of an elastic band. The technical details of the finger are listed in Table 1.

The servo motors are pulse width modulation (PWM) controlled. The PWM signals are generated by a microcontroller At-mega 328

Table 1: The Robotic Sixth Finger technical details

| Module dimension | $42 \times 33 \times 20 \mathrm{~mm}$ |
| :--- | ---: |
| Module weight | 16 g |
| Support base dimension | $78 \times 24 \times 5 \mathrm{~mm}$ |
| Support base weight | 28 g |
| Max torque per motor | 0.15 Nm |
| Velocity of one module | $0.5 \mathrm{rad} / \mathrm{s}$ |
| Max payload | 610 g |
| Total device weight (4 modules) | 160 g |
| External battery pack | 5 V |

installed on an Arduino Nano board. The portability and wearability of the device is improved by enclosing all the electronics circuitry in a 3D printed housing which is attached to the finger base support. An external battery pack is used to provide power to the actuators.

### 2.2 Control Interfaces

The Robotic Sixth Finger coordinates with the human hand by means of two types of control interfaces, i.e., a data glove and a push-button ring. The former approach is an extension of the object-based mapping algorithm proposed in [3] and is more suitable for complex manipulation tasks. The mapping algorithm is based on the definition of a set of reference points on the so called augmented hand which includes the human hand and the robotic extra-fingers. A virtual object is defined as a function of the reference points. When the human hand fingers are moved, the virtual object is moved and deformed. The robotic extra-finger is then actuated so that the reference points on it follow the same transformation. The mapping algorithm can be applied considering the whole human hand in the definition and in the transformation of the virtual sphere, but it is possible to adopt only a part of it, for example three fingers. In this case, the remaining fingers which are not involved in the mapping process, can be used to perform another task, see Fig.2-b. The Cyberglove III System is used to track the human hand. The grasp type is selected by recognizing the gesture of human hand. The base revolute joint is used to set the orientation of the finger according to the selected grasp type.

The ring interface is based on a trigger signal to control the motion of the finger. The switch is used to start the robotic finger flexion procedure and to move the finger back to an initial predefined position. The ring has been designed to be worn on the index finger of the hand. In this way, the user can press the push button on the ring using his thumb. We introduce a new control strategy that enables the finger to autonomously adapt to the shape of the grasped object. When the switch is activated, the finger starts to flex with a fixed joint angle increment, equal for each module, from a predefined position. As soon as one module is in contact with the object, that module stops its motion, while the others keep moving toward the object. When the grasp is complete, the finger starts to autonomously keep the grasp stable. This grasp stabilization is obtained by controlling the compliance of each module.

## 3. DEMO DETAILS

Examples of the use of the Robotic Sixth Finger are reported in Fig. 1 and Fig. 2. The user will test both kinds of control approaches, i.e., sensorized datagloves and push-button ring interface.


Figure 2: Possible examples of tasks performed with the help of the Robotic Sixth Finger.

## 4. ACKNOWLEDGMENT

The research leading to these results has received funding from the European Union Seventh Framework Programme FP7/20072013 under grant agreement n. 601165 of the project "WEARHAP - WEARable HAPtics for humans and robots".

## 5. REFERENCES

[1] F. Wu and H. Asada, "Bio-artificial synergies for grasp posture control of supernumerary robotic fingers," in Proceedings of Robotics: Science and Systems, (Berkeley, USA), July 2014.
[2] D. Prattichizzo, M. Malvezzi, I. Hussain, and G. Salvietti, "The sixth-finger: a modular extra-finger to enhance human hand capabilities," in Proc. IEEE Int. Symp. in Robot and Human Interactive Communication, (Edinburgh, United Kingdom), 2014.
[3] D. Prattichizzo, G. Salvietti, F. Chinello, and M. Malvezzi, "An object-based mapping algorithm to control wearable robotic extra-fingers," in Proc. IEEE/ASME Int. Conf. on Advanced Intelligent Mechatronics, (Besançon, France), 2014.


[^0]:    Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).
    AH '16 February 25-27, 2016, Geneva, Switzerland
    (c) 2016 Copyright held by the owner/author(s).

    ACM ISBN 978-1-4503-3680-2/16/02.
    DOI: http://dx.doi.org/10.1145/2875194.2875243

