A Wearable Robotic Glove based on Optical FMG Driven Controller

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Abstract— **This work presents the development of an underactuated glove-like orthosis to be used by people with disability in hand and difficulty to perform firm grasps. The wearable glove uses a tendon-driven system to perform fingers flexion/extension, triggered by optical fiber force myography sensors placed on an opposites muscle pairs with the aim to activate the glove actuators. The steps involving the physical construction of the sensor and the underactuated glove-like orthosis are explained, as well as the architecture and the control strategy of the system. Experiments conducted using the glove indicated satisfactory results related to the type of grasp and confirm that the optical FMG sensor can be used as a control input for trigger the tendon-driven system.**

I. INTRODUCTION

In 2011, the World Health Organization estimated that more than one billion people in the world lived with some form of disability [1]. Amongst the several disabilities, those that affect the upper limb movements, as stroke and spinal cord injury (SCI), can generated great frustrations because these people need the assistance of other people to perform their activities of daily living (ADLs). Moreover, most of them are residents of low- and middle-income countries, whom cannot afford health care.

As a means of helping people with these disabilities, several hand exoskeletons have been developed in the last two decades, aimed to be used as orthoses [2]–[6]. In the work proposed by [2], a pneumatic system is used to perform the opening and closing actions of the hand, whereas in other works such as described in [3]–[6], a tendon-driven system is employed in order to perform the same actions. Both of these devices, regards the user intent detection as the main control input. Usually, the user intent detection applied in orthoses chiefly encompasses control input from surface electromyography (sEMG) [2,4,6], key/button press mechanisms [5] and detecting the flexion of the wrist [3,7].

The most common way used to trigger orthoses and prostheses, is by detecting signals registered from muscles activity through the traditional approach based on sEMG. Despite this technique it is based on a noninvasive procedure to detect the muscle activity, the sEMG signals must be filtered and rectified to compute its power envelope what makes them more difficult to treat [8]. Moreover, sEMG can be affected by electromagnetic noise, sweat, among other drawbacks [9].

Another way to detect muscles activity and overcome the leading drawbacks presented by the use of sEMG is using force myography (FMG). In the FMG approach the muscle activities are assessed in terms of mechanical stimuli generated by the volumetric changes of the muscles, producing results comparable to the electrical approach using sEMG [10]. Some relevant works considering FMG applied on the forearm, highlighted that the FMG technique provides a high classification accuracy when regarding cases as estimation of grip force, grasp detection, hand gestures classification, and prediction of finger movements [10]–[14], encouraging the use of FMG as an alternative technique to supersede the conventional sEMG. However, the aforementioned researches made use of a flexible forearm bracelet containing force-sensitive resistors (FSRs) for collecting pressure signature from muscles. Envisioning new applications for FMG, differently from the previous achievements, in this work, we report the development of a glove-like orthosis, using a tendon-driven actuator, and we make use of optical fiber force myography (FMG) for assessing the muscle activities and trigger the tendon-driven system. We will use a device consisting of a noninvasive optical fiber FMG sensor similar to that proposed in [15,16]. However, there is not enough evidence in the literature of projects using this type of control input.

In order to present this work, this paper is divided into four sections. This first section presented a brief introduction to the problem of hand disability and exposed our contribution to solve this problem. Information concerned with the glove design, system architecture, the optical fiber force sensor and integration of sensors in the control strategy are described in Section II. Experimental results using the FMG sensor and the designed soft glove are reported in Section III, followed by Section IV related to conclusions and future works.

II. METHODS AND MATERIALS

In this work, we propose an assistive device for patients who have any degenerative illness that prevent them from provide force in upper limbs for accomplishing of activities of daily life (ADLs), e.g. weak grasp. This device makes use of two channels of a FMG transducer that is based on optical

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