An Exosuit to Assist with Arm Swing in Pathological Gait

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***Abstract*— There is a known connection between arm swing and gait, suggesting that manipulating arm swing with wearable technology can be beneficial for people with gait impairment. Previous research has shown the feasibility of such an approach in principle, but so far all implementations resulted in devices that are too bulky and not suitable for use by patients in daily life. In this paper we present preliminary results on a lightweight, cable-based exosuit that uses cable mounts attached to a shoulder strap and a small DC motor attached to the waist. Preliminary results show the ability of the system to actuate the arm though the range of angles required for arm swing. Ongoing work is focused on generating closed-loop controlled arm trajectories from measured angles of the thigh and on optimizing the system for dynamic arm motions.**

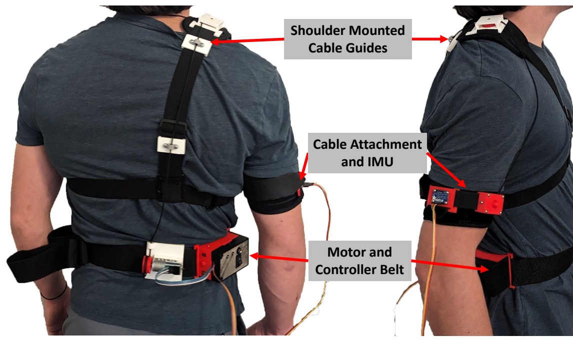
I. Introduction

Gait and arm swing are deeply interconnected, and physical therapy delivered on the arm can improve gait functionality in people with gait impairment [1]. Inspired by these results, some researchers in the field have designed systems that aim to assist gait by manipulating arm swing, for example by conveying vibrotactile cues to the users' arm [2]. However, this approach does not physically assist the user like a therapist would, and to the best of our knowledge there is no system that can provide such a level of assistance without being cumbersome to wear. In this paper, we present a new compact and lightweight cable-based exosuit. To minimize size and complexity, the cable is only used to propel the arm forward, relying on gravity to cause the arm to swing back.

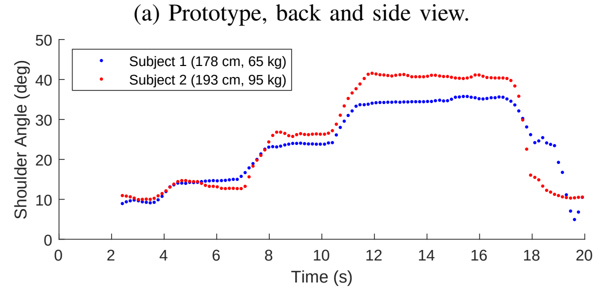
II. Work To Date

Figure 1(a) shows our prototype. The pulley and cable system is actuated by a small DC Motor (6V 20.4:1 Metal Gearmotor 25Dx65L from Pololu). The system is equipped with an inertial measurement unit (IMU) on the arm to measure the sagittal-plane shoulder angle.

To demonstrate that the exosuit is powerful enough to lift the weight of an arm, we characterized it on two healthy volunteers who were holding their arms limp. We commanded a series of PWM step inputs to the motor, and recorded the corresponding quasistatic angles measured by the IMU on the arm. Figure 1(b) shows the results. In previous work a thorough evaluation of arm-swing angles was done for varying walking speeds, slopes, and height of participants [3], and it was found that shoulder angles during arm swing have values that are for the most part below 30°. We see from Figure 1(b) that our system performs most consistently



(a) Prototype, back and side view.



(b) Preliminary results of open-loop step inputs to the motor.

Fig. 1: Prototype and preliminary results

in those angle ranges, while there was a larger difference between the tests at higher angles, which we can take as an indication that the motor selection is appropriate.

III. Ongoing Work

Our exosuit is motivated by previous work that predicts a healthy arm-swing pattern using online measurements of the angular velocity of the thighs [4], which has not been utilized/implemented by anyone to date. We are currently designing a controller to track the generated arm trajectory using an IMU mounted on the thigh. In addition, we are further optimizing the sizing of the motor to track dynamic (rather than quasistatic) arm motions.

References

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