Visual guidance to facilitate a robotic ankle-foot orthosis use

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***Abstract*— Due to an increasing population of motor-impaired individuals, the market for wearable robotic devices has been quickly growing. In turn, there has been a prolific amount of research dedicated to developing optimal methods for controlling these devices. Yet, a limited study exists on how a human learns to use the device. Our goal is to develop user guidance to facilitate a wearable robot use via a biofeedback (visual feedback) system. Here, we developed a Graphical User Interface (GUI) to provide visual guidance to a user based on their robotic ankle-foot orthosis performance. We tested the user preference to decide the finial concept using an eye tracker. Four subjects participated in the test and results showed that the foot animation was the most preferred parameter for visual guidance. We plan to conduct the human subject experiments to test feasibility the effects of the visual guidance system.**

Keywords*— *Exoskeleton, Ankle Foot Orthosis, Human Adaptation, Sensory feedback, Visual feedback, Visual guidance

I. Introduction

Wearable robotic devices have emerged as a promising technology in the rehabilitation field to compensate for both functional and physical loss of mobility [1]. Humans required to adapt the movement with a robotic device to maximize assistance efficacy [2]. Otherwise, the robotic devices can result in reduced freedom of the subject's motion, which, consequently, can cause even injuries [3]. Perhaps, robotic devices can be more easily learned through sensory feedback (i.e. touch, visual, sound, etc.) similar to rehabilitation devices [4]; however, a limited study exists [5-6] on a method to help human learning to a robotic device. The overall aim of this study is to develop visual guidance for human adaptation under the hypothesis that the visual guide for a wearable robot, Robotic Ankle-Foot Orthosis (R-AFO), can help participants to use the device. When a subject successfully learns the device use, we expect that the participant presents reduced cost of walking and the R-AFO, worn by the participant, follows desired trajectory with reduced tracking error.

II. Methods

As an initial proof of concept, we developed Graphic User Interface (GUI) (Fig.1(a)), which was presented to a participant during walking while wearing robotic-ankle-foot orthosis. The GUI shows the ankle angle-torque curve, time series of both the ankle torque and ankle angle during a walking and foot animation. For the ankle angle-torque curve and time series ankle torque plots, both of the desired values and subject values are displayed with different colors.

To choose a parameter that most benefits to the user, we conducted a "preference" test. Using an eye-tracking device while walking, the user saw all of the initial concept of the GUI at once and we monitored where the user stared. A user's gaze indicates their interest. The metric used to measure this will be the percentage time of staring.

III. Results and Discussion

A total of four subjects participated in the test to choose the preferred candidate GUI. The results showed that the ankle animation GUI (Fig 1(a). Right) was the preferred. It was also reported to be the easiest to physically see for subjects.

The final concept of the GUI(Fig.1(b)) is the foot animation that displays the participant's foot movement in the sagittal plane. The GUI shows an arrow to instruct user's foot movement direction with magnitude based on the tracking error.

We plan to conduct the human subject experiments to test feasibility of the effects of the visual guidance system (Fig.1(c)). After initially testing with three different R-AFO conditions, we will select two conditions, which presented the minimum (best) and maximum (works) metabolic cost, respectively. Then, we will examine the effect of the visual guidance on the participant's R-AFO use by measuring the metabolic cost change after guidance.

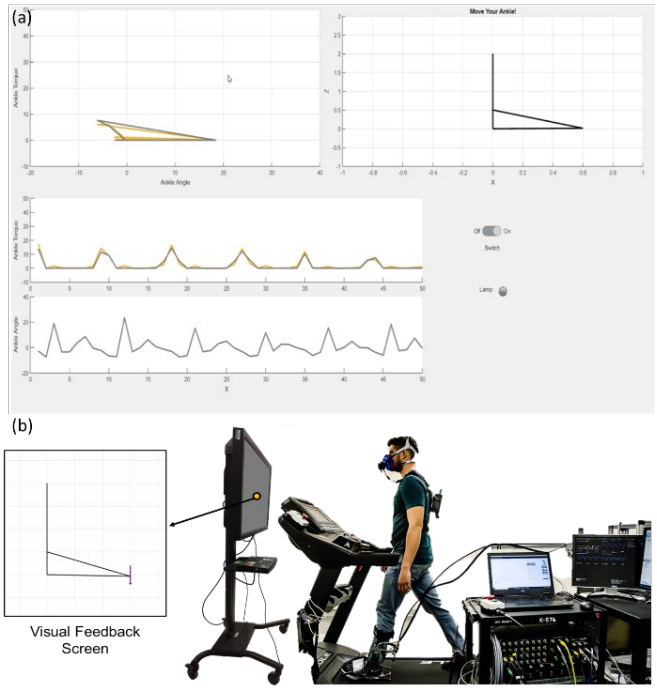

Figure 1 (a) Initial GUI : Upper (from left to right) – Ankle angle torque curve, foot animation. Below(from top to bottom) – Time based ankle torque curve and time based ankle angle curve. (b) experiment setup: visual guidance GUI shows the animation with arrow which indicate the error between desired and actual torque. subjects were asked to try to minimize the length of the arrow during walking with the device.

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