LIMBO: Reprogramming and Augmenting Muscle Activities using Electrical Stimulation

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Abstract
Tools and user interfaces are usually designed for users with normal physical condition. Even though more products are built with accessibility considerations, there is still severe lack of opportunity for people with disabilities to use products to their full potential. In this paper, we present the idea of using human muscles as output interface, using functional electrical stimulation (FES). We envision that this would allow for filling the gap between products and a user's capability, thereby promising every product's universal accessibility. To match our behavioral and perceptual capability with the product on use, we can reprogram the way we control our body or give direct muscle motion-feedback. We believe that this idea would create new area and provoke discussion in the field of user interactions and their applications.

Author Keywords
Augmented Human; Functional Electrical Stimulation;

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces

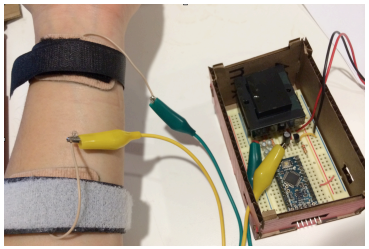

Figure 1. Prototype with a single pair of electrodes.

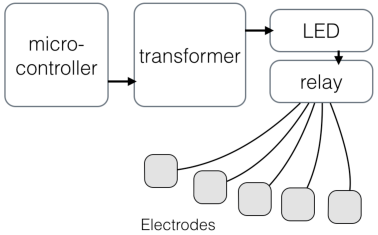

Figure 2. Circuit configuration

Figure 3. Eye tracking software that is used to control hands via eye gestures.

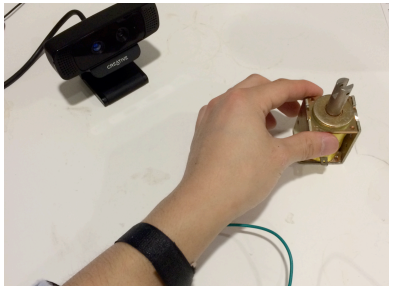

Figure 4. Users' limb motion can get directly adjusted while performing a manual task

Introduction

Designers create interfaces for average users. The criteria for user interface design usually targets around the highest peak of the normal distribution in terms of user abilities. However, they have different skills, perceptual capability, or may have disabilities. This severely limits the quality of life of users who are not average.

We tackle this problem by augmenting the users to let them easily conform to the given environment. We present a system named Limbs-in-Motion-by-Others (LIMBO). This system digitally controls limbs of the user using functional electrical stimulation (FES) [3], thereby letting their body motion get adjusted for a certain task or use of a product. In related works, Tamaki et al. [1] presented an idea of remotely controlling a hand with FES. Kruijff et al. [2] used FES for haptic feedbacks. They showed a promising application area of FES, but did not fully explore the use of this technology for augmenting and/or rewiring our muscle system.

Demo 1: Reprogramming Body

What if users can change the way they control their bodies, e.g. reprogram their disabled leg to be controlled by their fingers? Usually it would not be useful, or even uncomfortable, because we use our fingers independently for other purposes. However, if the users are in a certain context, they might want to use their fingers to control their legs. We present a demo of reconnecting different muscles to different part of a body; a person with disabled legs can drive a car by controlling their leg muscles with their fingers or a disabled person can grab an object with their hands controlled by their eye gestures (Fig 3).

Demo 2: Muscle Actuation as Feedback

We found out that human-computer interaction can be further extended by augmenting the human body as a user interface. Traditionally, user interface elements only give feedback and motor-correction through visua-auditory feedback, however there is also a chance to directly control human body to give a higher dimension of involvement into the computing. Hand gesture-controlled user interfaces could benefit by aligning feedback methods to action (i.e. hand control with hand muscle feedback). This is especially helpful for users with a limited visual/auditory perception, because the input and feedback happens in the same place.

Limitation and Future Work

The muscle stimulation methods we use may not be generalized enough to replicate the wide range of motions and capabilities of the human body. This limits the types of feedback and control that can be actuated by users. Future research may explore wearable design to provide less limited control.

References

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