APPLICATION INDEPENDENT ASSESSMENT OF CAPACITY FOR MYOELECTRIC CONTROL

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INTRODUCTION

There is a growing need for objective and quantitative tools to measure the outcome of assistive technologies (AT), such as powered prostheses and communication aides for people with disabilities [1,2]. The most typical types of assessment are task completion tests or performance tests, where the user performs specific tasks relating to practical daily activities and the time required for task completion is used as the assessment.

The main purposes for such outcome measurements are the assessment of patient improvements, the selection of appropriate AT devices for patients and the evaluation of newly developed AT devices. The appropriate choice of an assessment method requires careful consideration, because assessment results can be influenced by many factors. For instance, applications to AT device selection, where a therapist would investigate the outcome differences for different AT devices; assessment results may be influenced primarily by task proficiency, which thus makes the appropriate selection of an AT device difficult.

This paper introduces a basic form of assessment that is both task- and application-independent, which focuses on the operation capacity of an input device to an AT. In most AT devices, single or multiple switches are widely accepted as the de facto standard input devices, so the proposed method evaluates the operation capabilities of single switches.

At the same time, there are also a number of research projects that are seeking to develop augmentative and alternative input methods for AT devices. However, because of the wide variety of impairments, certain restrictions still remain on increasing the number of candidate input methods. Accordingly, we are working on general purpose myoelectric interfaces that are compatible with various commercial AT devices. Preliminary evaluations of the myoelectric interface are also presented in this report.

METHODS

General-purpose myoelectric switch interface module (EMG Switch)

Figure 1 is a photograph of the prototype switch interface module, which has one input port, three output ports, two volume adjustments and three LED indicators for each output port. The input port receives the sensor outputs, which are integrated myoelectric signals ranging from 0-5V. The two volume adjustments are used to adjust amplifier gain and threshold, which are described below.

The specifications for the output ports are illustrated in Figure 2. The switch module has two thresholds to determine the output signals. Threshold-1 is adjusted using the volume in Figure 1 (threshold adjustment) and Threshold-2 is fixed (4.7V). Output-1 and Output-2 maintain ON states when the input signal exceeds Threshold-1 and Threshold-2, respectively. Output-3 turns to an ON state when the input signal exceeds Threshold-2 and maintains an ON state while the input signal is above Threshold-1. Users can maintain an ON state with low myoelectric signal intensities using Output-3.

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Application independent assessment

Eleven essential items for simple switch assessments are reported in [3]. These items were identified by a focus group meeting with six occupational therapists. We selected five items which relate to the operation capability of single switches: namely, (1) “Switch Close Delay”, (2) “Switch Open Delay”, (3) “Switch Endurance Period”, (4) “Switch Repetition Time”, and (5) “Switch Timing Spread”.

(1) “Switch Close Delay” and (2) “Switch Open Delay” refer to response times, as the time elapsed between stimuli and the switch open/close operations. (3) “Switch Endurance Period” refers to period during which a user is able to maintain switch closure. (4) “Switch Repetition Time” relates to the speed of switch operations. (5) “Switch Timing Spread” relates to the ability to use scanning methods that enable single switch users to select elements from some candidates, such as characters from a virtual keyboard or options from a menu. One of the elements is highlighted, and the highlight moves from one element to the next at pre-set times. The user, therefore, requires the capability to operate a switch in synchronization with the highlight movement. This “Switch Timing Spread” assesses whether response times are premature or delayed, where a premature response indicates the time prior to the target timing and a delayed response indicates the time lag after the target.

Assessment tool

A prototype assessment software tool was designed to be used on a personal computer (PC). Figure 3 shows a screen shot of the tool. There is a target cross-shape (small, light-color) on the center. The operator is asked to move another cross-shape (large, dark-color) to overlap the centers of the two cross-shapes. The operation procedure is similar to that of a claw vending machine or toy crane machine. First, the horizontal movement is activated with a switch operation. Once the horizontal movement is terminated, it can not be activated again. Then, the operator deals with the vertical alignment. After the vertical motion, in the case of a claw vending machine, a crane and a claw are activated, but in the case of this tool, window zooming is activated. The tool window can be zoomed by repeating the switch operations.
Figure 4 shows another assessment mode for the tool, which is referred to as a BLIND mode, in contrast to the BASIC mode in Figure 3. Half of the window is shaded in order to hide the cross-shape. Movement of the large cross-shape is visible in the BASIC mode; therefore we can predict appropriate timings for switch operations. The purpose of the BLIND mode is to remove prediction effects in order to evaluate the response times of the switch operations.

There are two different switch activation modes; a direct mode and a toggle mode. The function of the direct mode switch is the same as a simple mechanical switch, where the output signal is maintained in an ON state during switch closure. In contrast, the output signal from the toggle mode switch toggles back and forth between the ON and OFF states.

Table 1 summarizes single switch operation capabilities that are assessed with the prototype tool. It should be noted that, for the current software version (ver.1.1), the switch operation capabilities (1), (2) and (5) were assessed in terms of the distances between the two cross-form centers, whereas the result for (4) is the number of switch repetitions. Capability (3) is not yet quantitatively evaluated with this version.

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**Experimental setup**

The experimental setup for evaluations with the proposed assessment method is as follows. As this is a preliminary evaluation, one healthy man participated in this experiment. The myoelectric switch interface (referred to as EMG switch) and a variable pressure switch (joggle switch; Esterline Corporation) were used. The joggle switch can adjust the actuation force by rotating the switch-cover from 200 grams to 1,500 grams. We used 1,500 grams (refer to switch A) and 200 grams (refer to switch O) pressure settings for the experiments in order to evaluate operation capability with different activation pressures. These switches were connected with the PC using a USB switch interface box (Nandemo Switch USB; Techno-tool Corporation).
RESULTS

Figures 5-8 presents the results of one assessment (average ± standard errors; 100 replications) for “Switch Close Delay”, “Switch Open Delay”, “Switch Repetition Time” and “Switch Timing Spread”, respectively. These results suggest that the differences among different kinds of switches can be assessed with this method.

DISCUSSION

This paper has only addressed the differences among types of switches, but assessment results differ due to different operation skills of people, between AT devices, and due to environmental conditions. This method can be applied to evaluations of such factors. Socket fitting for myoelectric prostheses may also be assessed with this method.

A general-purpose myoelectric switch interface was also introduced in this report. We believe that clinical information concerning various applications of the myoelectric interface can contribute in the wider application of powered hand prostheses.

The relationships between application independent and application dependent assessments must be examined in future works.

REFERENCES