VOICE RECOGNITION FOR PROSTHETIC CONTROL CASE STUDY

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Client - 48-year-old male, height is 5’7” and is 135lbs, shoulder disarticulation patient. Employed as a heavy equipment operator until August 2000. Client sustained traumatic brain injury and subsequent loss of motor control on left upper extremity (flail arm), with effect on left lower extremity through quad weakness and drop foot. Client is posturally effected with incomplete hemiparesis and also exhibits minor speech impairment.

The client stated that he had numerous falls that lead to multiple dislocations and chronic pain in left upper extremity. The client elected to amputate the left upper extremity in April 2004 to assist with pain management and postural consideration.

The client expressed desires to regain some of his independence in his personal living. His expressed needs ranged from independent donning of his AFO, dressing, meal preparation, to some minor home improvement projects. His current daily arrangements included extensive assistance from his wife and family members for his activities of daily living (ADL).

The client contacted our clinic looking for upper extremity prosthetic information. He was interested in his prosthetic options to help with his ADLs and limited functional envelope. He has received prior speech, physical, and occupational therapies to promote a restored independent life and exhibits normal cognitive abilities.

Myo signal testing on the effected side did not provide a consistent usable signal source due to the paralysis of the thoracic region. Current voluntary myo or switch control strategies would depend on inputs from the effected side which are limited or non-existent. Involving inputs from the contralateral side could potentially reduce the current level of function on that side and diminish ability for consistent prosthetic control. With these challenges, a call was made to Liberating Technologies to seek out ideas for possible control strategies. Craig Wallace with LTI made mention of a prototype mode selection device that was voice activated. The voice recognition device was a new direction that had not been field tested thus far. This concept offered possibilities for ease of inputs and deliberate mode selection without relying on contralateral inputs to meet the goal of bi-manual assistance.

INITIAL SETUP

The concept of control strategies in the first stage include the currently available Boston Elbow 3, mode selection program, a miniature microphone, voice recognition module, and 2 touch pads for device directional control. The touch pads and microphone were mounted as a triangulated keyboard to allow control inputs from the patient’s chin. The close proximity of the microphone to the mouth would help keep inputs more direct and controlled. (Figure 1)
The voice commands were initially set up as a direct device command system. The voice recognition module measured 2.5” wide, 4.75” long, and 2.0 deep. (Figure 2) This module was trainable to recognize the patients’ voice patterns for direct mode selection. Each device was assigned an input number and a corresponding command word. The device command word has the flexibility of being a word that can be given by the patient consistently. These included; hand, wrist, elbow, shoulder, and included other outputs as needed. These inputs could be further developed for pre-positioning of the terminal device, elbow or wrist as desired by client.

Giving a voice command for the device required would initiate prosthetic control. The command module, upon acceptance of the command, will verbally state confirmation of the selected device with a mounted speaker. (Initially the default was set to the previous device, due to limited module/elbow interface development.) Once the selected device was engaged, the patient would use his chin to nudge the proportional touch pads, and control its’ desired movements.

In the clinic this control appeared to work well. The commands were received, the desired device would be activated, and control of the device worked reasonably well considering the amount of further practice needed and the effect of the client’s hemi pareses.

In the real outdoor world, the voice command module showed how receptive it was to “outside” commands. Although only a passenger, the client’s radio was able to provide the needed frequency patterns to erroneously give active commands to the clients’ prosthesis, which proved frustrating and unacceptable for long-term assistance.

SECOND SETUP
The second level of development in control strategy included the voice command module using two words to activate it. The first word acts as a key to “unlock” or wake up the system, and then is followed by the device command word. This added level of command input has appeared to reduce erroneous operation, but has become slightly more cumbersome and time consuming for the client. After a couple of weeks of use in this configuration the system stopped working consistently, and more development time in the interface between the voice command and BE3 software became evident.
THIRD SETUP

The third change to the control strategy has been the temporary elimination of the voice recognition module while further communication development is pursued. The current control strategy has a proven track record which will allow for longer field trials to allow the patient to build on successes. The hand is now the constant default device, and this arrangement allows the first response of inputs to be simple, and of immediate assistance using the myo hand or ETD. If further positioning is needed, mode selection is obtained through a third touch pad by chin input using rotation mode selection.

Further development goals include using direct device mode selection, pre-selected positioning, with default to a particular group of motors, and a comprehensive visual interface program for clinical facility fine-tuning.

FOURTH SETUP

The newest (and current) fourth control strategy now includes the previous “unlock” control with direct mode control to each function with the hand currently set to default. Through the use of the new computer interface, the motor functions can be altered to suit the desired control speeds and directions, and allows the system more flexibility in the field.

The client currently uses the prosthesis approximately 4 hours daily at home practicing integration into his ADLs and is pleased with the potential assistance it can provide. Ken has been provided a donning tree for independent donning and doffing, but is not independent as he is still using his wives’ assistance for donning.

The client has been encouraged to work with an Occupational Therapist for further training in prosthetic use and techniques. To date our feedback and interaction with the clients’ OT has been minimal as experience with upper extremity prosthetics is limited.

CONCLUSION

The clients’ feedback is positive to its potential. Our clinical assessment is a work in progress. We will continue to evolve the current socket and frame design to minimize the socket trim lines and improve independent donning and doffing. The client would benefit from an experienced therapist to integrate his usage into his ADL’s and provide us with additional feedback to refine design parameters.

The practical application of voice recognition mode select could after practitioners alternative control strategies to unique clients. It has great potential to preposition and select default devices for 3-4 device control designs. We look forward to continued development in the following months.