3D-GAZE AND MOVEMENT: A NOVEL METRIC OF VISUAL ATTENTION TO MEASURE UPPER LIMB PROSTHETIC FUNCTION

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ABSTRACT

A lack of sensory feedback is often highlighted as a limiting factor to the use of powered upper limb prosthetic devices. From a functional perspective, sensory feedback is hoped to reduce cognitive burden and lessen the need for visual attention to task. However, standardized methods to quantify visual attention are limited, and there is a large technological burden with certain methods. We developed a novel method of integrating eye and motion tracking during defined functional tasks, which allows identification of eye gaze behaviour in relation to object interaction and body kinematics for each segment of movement.

Twenty able-bodied participants with normal upper limb function and 10 prosthetic users participated in the study. They performed two functional upper limb tasks, a pasta box task and a cup transfer task, with synchronized upper limb motion capture and eye tracking data collection. Using the kinematic data, each movement was segmented into 4 movement phases: Reach, Grasp, Transport, and Release, and eye fixations were analyzed according to: current location being acted on by the hand ('Current'), the future location that the hand will act on when it has completed its current action ('Future'), and the hand itself when no other AOI is being fixated (Hand). The results of one transhumeral prosthetic user, using two different prosthetic devices compared to normative results, is presented.

The prosthetic user showed significantly slower movement times, spending a disproportionally longer time in the *grasp* phase compared to the other phases. With respect to eye behaviour, in the *reach* phase, the prosthetic user spent relatively more time fixated particularly on the myoelectric terminal device compared to the body powered condition, with both prosthetic conditions having a greater ratio of fixation time to hand than normative subjects. During *transport* of the object, the ratio of eye fixation to hand was dramatically increased in both prosthetic conditions compared to normative. This resulted in the prosthetic users spending relatively less time during transport fixating on the target to where they were moving the object (ie. reduced "look ahead" fixations).

This novel method of eye gaze behaviour analysis precisely quantified the visual attention demands of a prosthetic user during functional tasks, and created a normative data set for comparison. There were some interesting differences between myoelectric and body powered prosthetic performance that may have been due to proprioceptive feedback. Measuring changes in visual demand with new interventions may give insight into the relative importance of vision in accomplishing tasks for prosthetic users.

ACKNOWLEDGEMENTS

This work was sponsored by the Defense Advanced Research Projects Agency (DARPA) BTO under the auspices of Dr. Doug Weber through the DARPA Contracts Management Office Grant/Contract No. N66001-15-C-4015.