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An Integrated Sonomyographic Prosthetic Control System

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Institution Receiving Award: GEORGE MASON UNIVERSITY
Program: DMRDP
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Funding Mechanism: Restoring Warfighters with Neuromusculoskeletal Injuries Research Award - Research Level 2 - Pilot Clinical Trial
Partnering Awards:
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PUBLIC ABSTRACT

Focus Area: Our proposal focuses on optimization of Warfighter performance following limb trauma or loss. We seek to advance a new paradigm for intuitive control of upper extremity prosthetics known as sonomyography (SMG) toward clinical translation. Our proposed project is responsive to the mission of the Clinical and Rehabilitative Medicine Research Program for Neuromusculoskeletal Injury Rehabilitation (JPC8).

Who Will the Project Help: The proposed research will lead to the development of products and knowledge for improving rehabilitation and functional restoration of injured Service members with upper-extremity amputation. A total of 1,705 Service members sustained major deployment-related lower- and upper-limb amputations during Operation Enduring Freedom (OEF), Operation New Dawn (OND), and Operation Iraqi Freedom (OIF) and other follow-on operations. The most frequent cause of major limb amputation was a blast injury (91%) and primarily affect the lower limbs, although nearly 17% of the amputations affected the upper limbs, and the function of the upper extremities is far more difficult to replace satisfactorily. The number of amputees returning to duty has increased significantly in recent conflicts, with nearly 20% of Service members with a single limb loss returning to duty compared to 3% in earlier conflicts. Other studies show that nearly 47% of upper-extremity amputees remain in active duty.

How Will the Project Help Them: Major amputations of the lower and upper limbs due to combat injuries have life-long profound impacts on the ability of individuals to participate in activities of daily living. The function of the upper extremities is far more difficult to replace than that of the lower extremities. Currently available prosthetics only enable patients to perform a limited range of tasks. Thus, it is not surprising that Service members with upper-limb amputation are unsatisfied with the restoration of function provided by their prostheses and frequently abandon their use.

Until recently, there were few good prosthetic options for military Service personnel beyond split hooks. Although prostheses have become more complex and more able to make complex movements, the means for patients to control these movements continues to be inadequate. A major challenge continues to be enabling fine dexterous manipulation of the prosthetic hand essential for many activities of daily living.

Our research proposes a fundamentally different noninvasive method for sensing the activity of muscles using ultrasound waves. This method uses technology currently used clinically for noninvasive medical imaging to visualize the contraction of muscles deep underneath the skin surface overcoming many of the challenges associated with the skin-surface electrodes. This method is called SMG: the use of ultrasound to map the activity of muscles in the body. Computer algorithms can then analyze these images of muscle activity in the residual stump to automatically infer the user’s intended movement. Our preliminary proof of concept results show that SMG can overcome many of the limitations of conventional myoelectric control algorithms and provide dexterous control with robust classification accuracy and little training need.

Potential Clinical Applications, Benefits, and Risks: Our feasibility studies have demonstrated a number of potential clinical benefits of SMG, including (1) robust individual finger control and simultaneous control of multiple movements; (2) proportional positional control enabling fine dexterity; (3) short training time; (4) ability to sense motor activity even in complex neuromuscular injuries with significant scarring that impairs myoelectric sensing; (5) ability to sense and decode multiple movements at transradial and transhumeral levels. In addition, we envision that training and user adaptation could be positively impacted. Real-time ultrasound imaging of the residual musculature enables individuals with limb loss to visualize the residual functionality of their muscles even when they may not be able to isolate phantom limb sensations. This project will enable us to translate SMG technology to prototypes ready for future clinical trials to fully evaluate these clinical benefits.

Projected Timeline to Achieve Patient-Related Outcome: At the end of this project (4 years), we will have a prototype device that is ready for take-home clinical trials. We anticipate that the take-home clinical trials in a military population to evaluate functional patient-related outcomes can be completed in another 3 years. Simultaneously, we will apply for regulatory approval and we will work closely with our industry collaborators on the team to manufacture and market the device as soon as approval is received. We anticipate that, in approximately 7 years, we will have an approved device that is ready to be used by Warfighters with limb loss.

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