CPS: SYNERGY: A Novel Biomechatronic Interface Based on Wearable Dynamic Imaging Sensors

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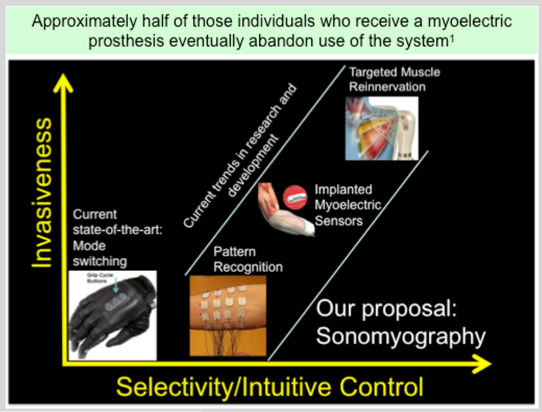
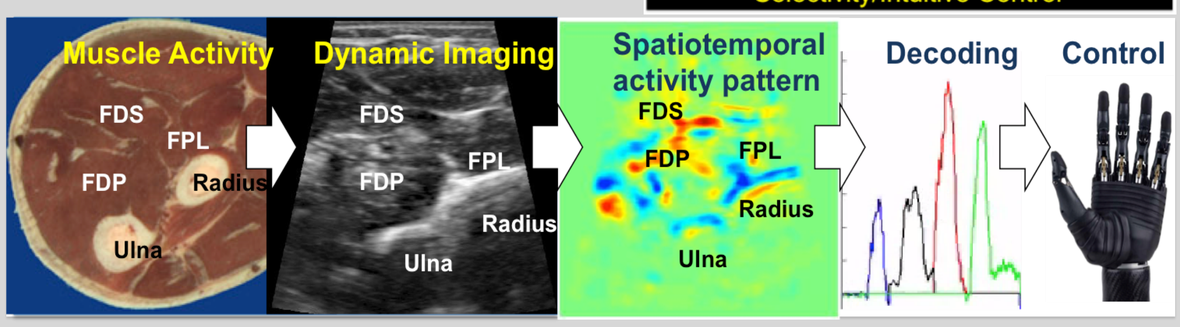
Sonomyographic control: A new method for controlling biomechatronic interfaces

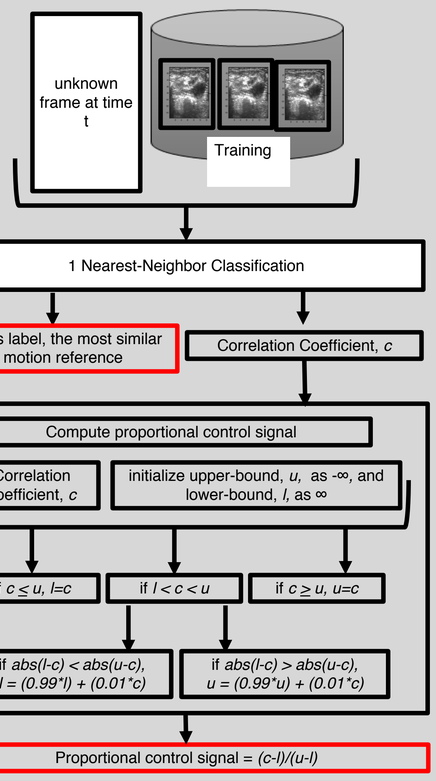
Non-intuitive control is one important factor in upper extremity myoelectric prosthesis abandonment. We have developed a novel noninvasive technology that uses ultrasound imaging to sense the activity of spatially resolved and individually controllable muscle compartments in the residuum. This technology overcomes many of the limitations of conventional myoelectric control.

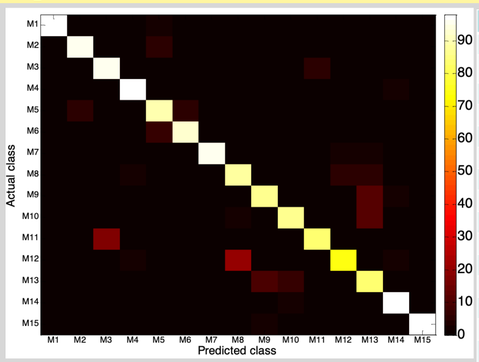




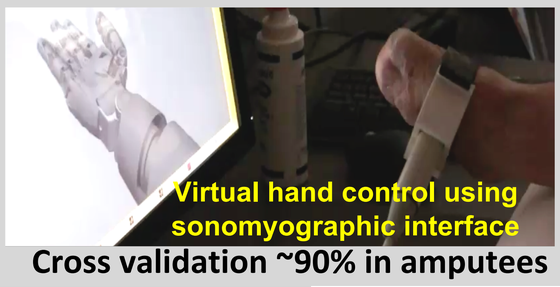
Real-time Grasp Classification

Image analysis pipeline



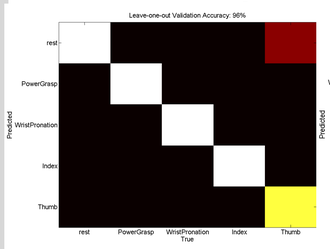


Average classification accuracy: 91%

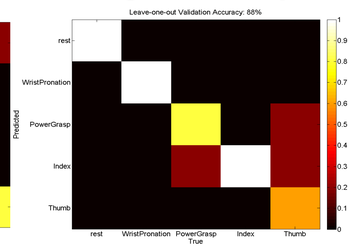


Cross validation ~90% in amputees

Traumatic amputee

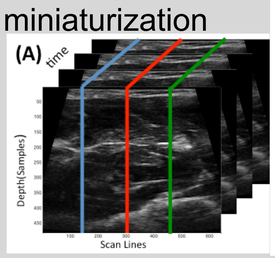


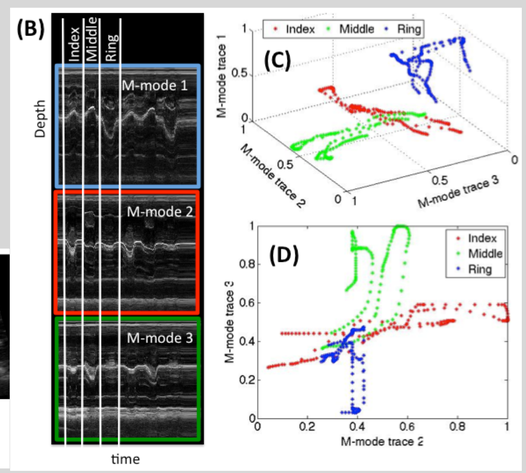
Congenital amputee



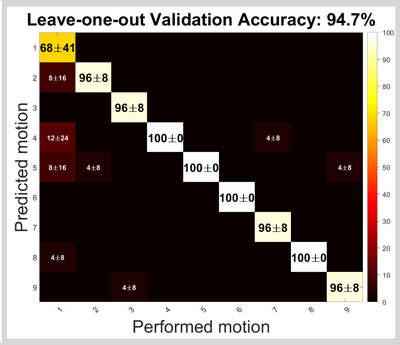
Sparse Sensing

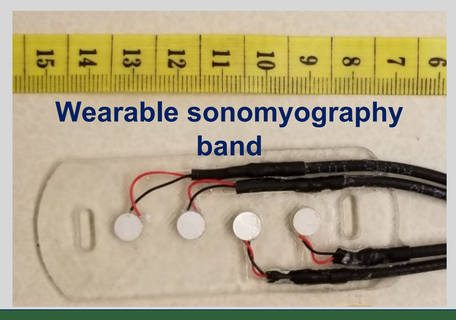
Sparsely-sampled scanlines have enough information for classification, enabling miniaturization

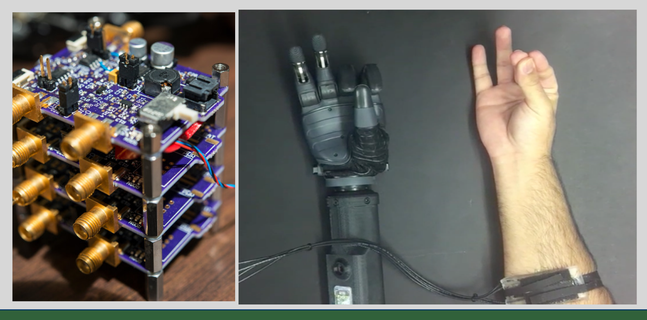




High classification accuracy with just 4 single-element ultrasound transducers

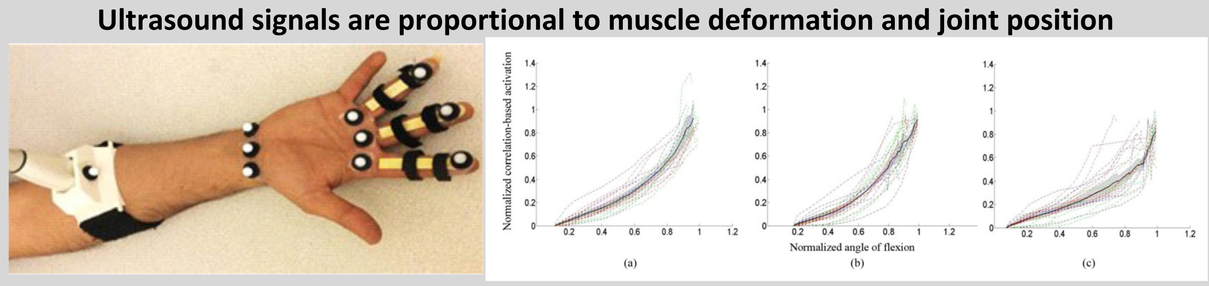




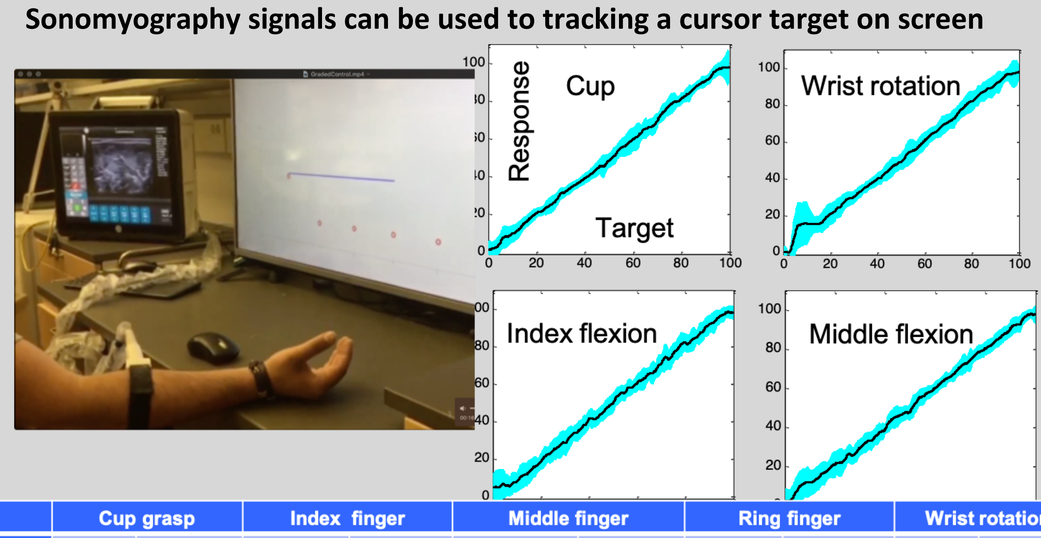


Evaluating proportional position control of multiple degrees of freedom using sonomyography

Ultrasound signals are proportional to muscle deformation and joint position

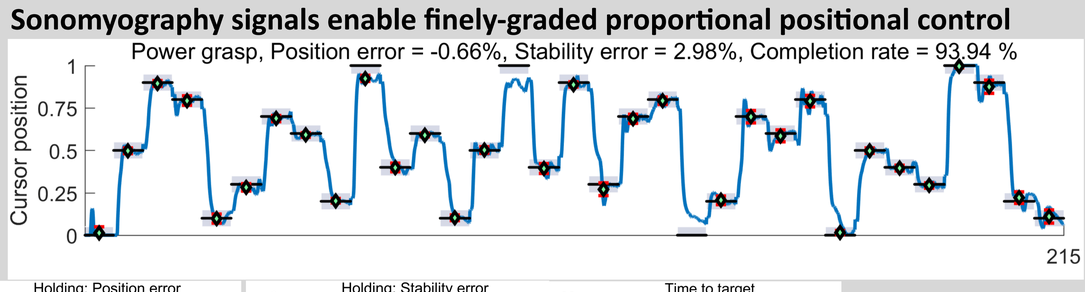


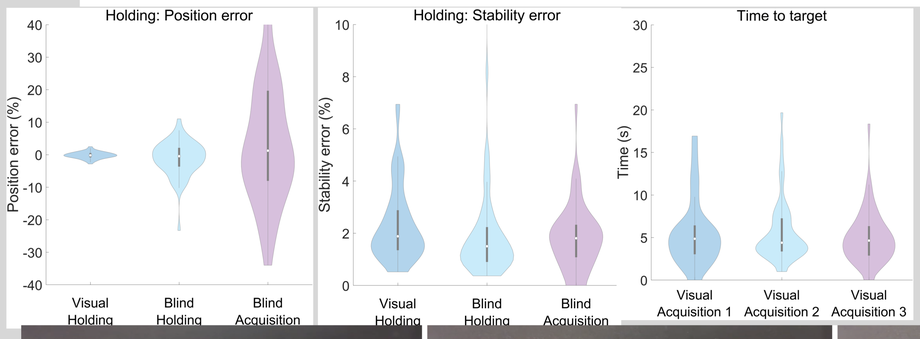
Sonomyography signals can be used to tracking a cursor target on screen



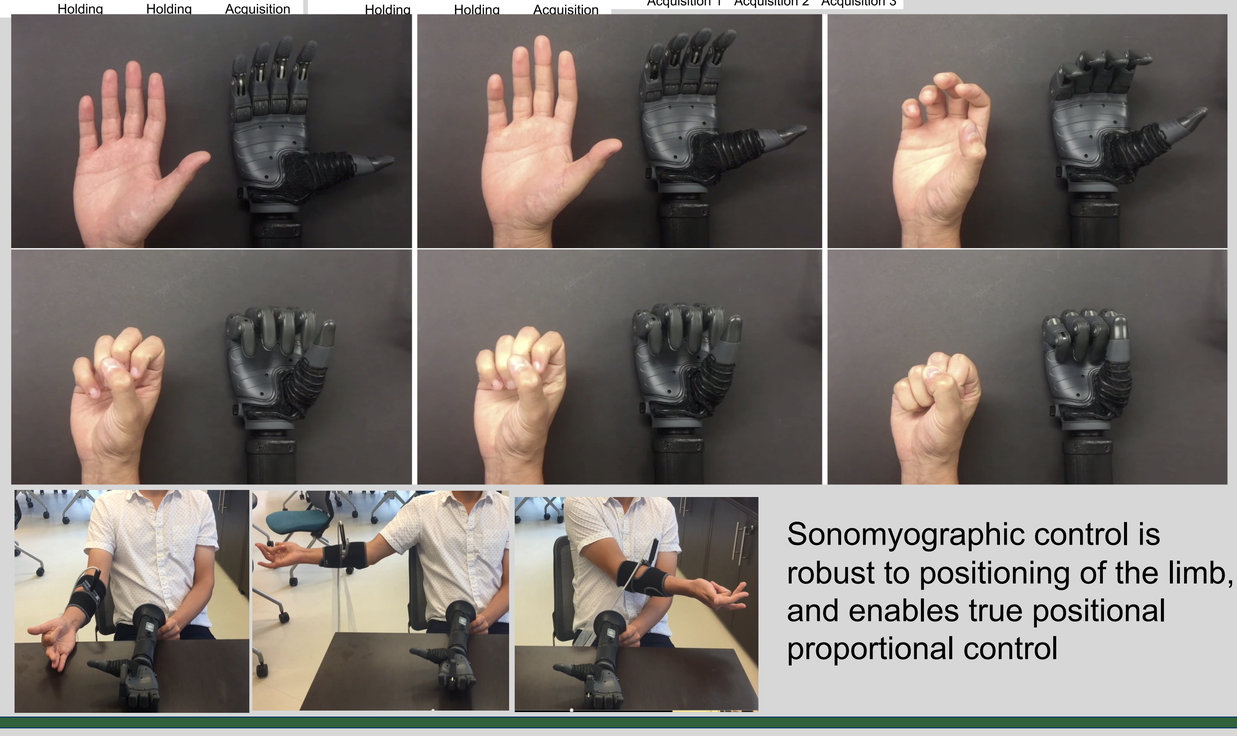
	Cup grasp		Index finger		Middle finger		Ring finger		Wrist rotation	
	Flexion	Extension	Flexion	Extension	Flexion	Extension	Flexion	Extension	Flexion	Extension
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.99	0.99	0.99
MCE	3%	3%	4%	4%	3%	3%	5%	4%	3%	4%

Sonomyography signals enable finely-graded proportional positional control





Subjects can maintain position with low stability error even without visual feedback



Sonomyographic control is robust to positioning of the limb, and enables true positional proportional control

Conclusions

We have developed ultrasound imaging-based sensing strategies for intuitive proportional control and real-time motion classification. We evaluated target tracking and target holding tasks in able bodied subjects and amputees, and also evaluated the role of feedback in proportional position control tasks using sonomyography. Able-bodied subjects and amputees could control multiple degrees of freedom using sonomyography.

This work was supported by the National Science Foundation CPS grant 1329829 Contact: ssikdar@gmu.edu