From Muscle to Motion: Simultaneous Grip and Wrist Prediction with a Compact Wearable Ultrasound System during Dynamic Reaching

Miniaturized Wearable Ultrasound System for Simultaneous Prediction of Wrist Angle and Grip Force During Dynamic Reaching

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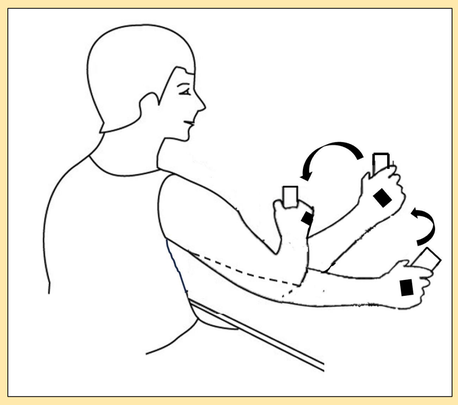
Research Questions

Can a miniaturized, wearable ultrasound system leveraging M-mode data accurately and simultaneously predict wrist angle and grip force during dynamic, multi-positional arm movements to support real-time prosthetic control ?

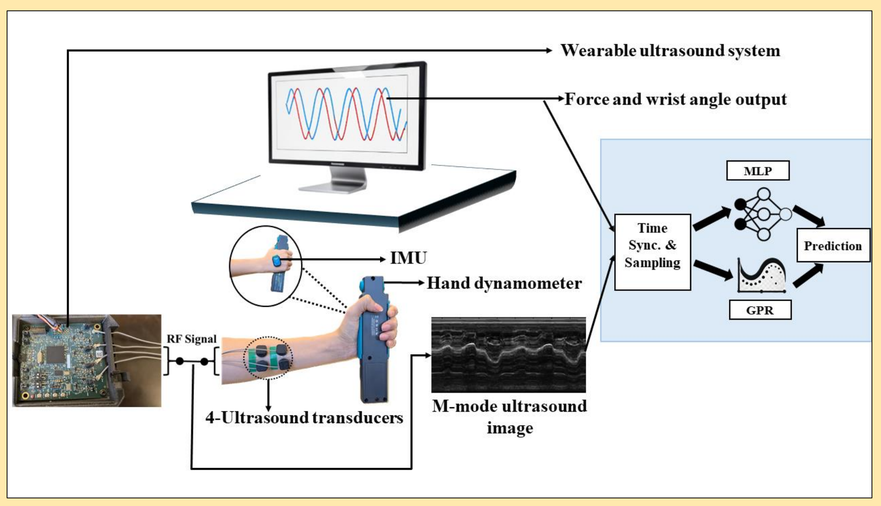
Background & Motivation

- Simultaneous control of wrist and grip is essential for natural, functional upper-limb prostheses.
- Traditional surface EMG (sEMG) suffers from noise, crosstalk, and low spatial resolution.
- Sonomyography (SMG) using ultrasound offers higher fidelity by capturing muscle deformation.
- Most SMG systems are bulky and focus on isolated or static tasks.
- This work miniaturizes SMG hardware and tests it during **dynamic, multi-positional reaching**—moving closer to **real-world, socket-integrated prosthetic control**.

Methods

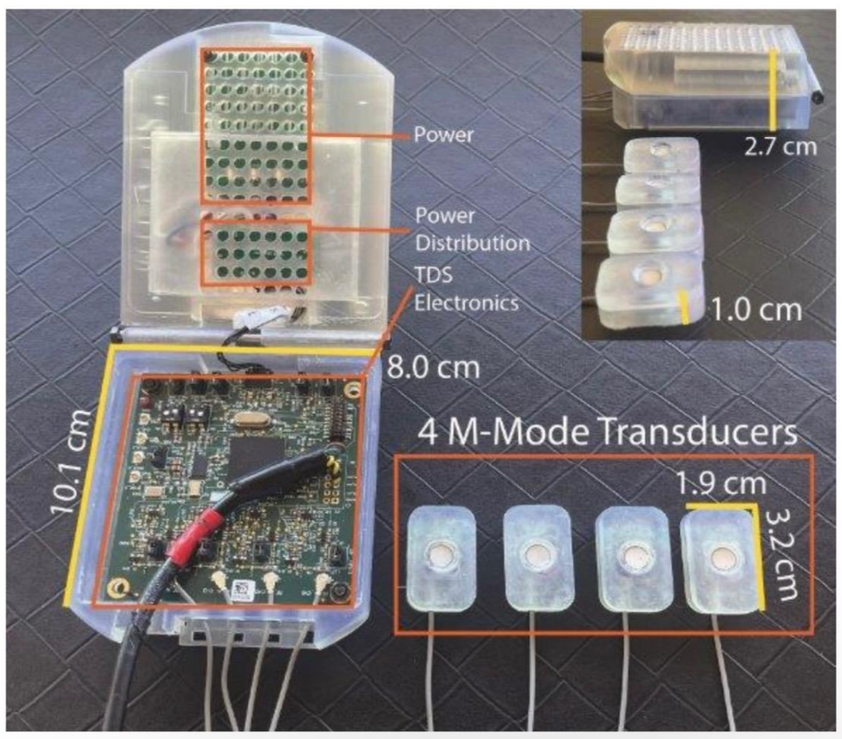


Different arm positions with dynamic movements



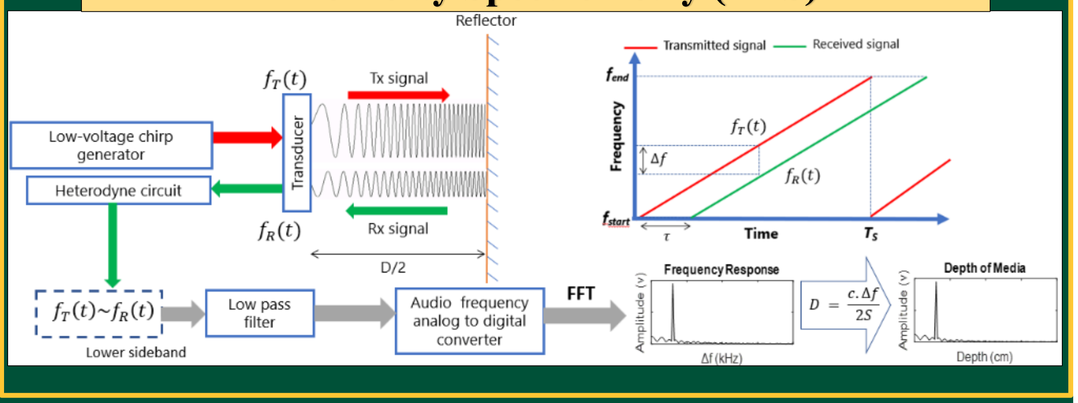
Experimental setup

Miniaturized Wearable Ultrasound System



System Under Test	Voltage (V)	Current (mA)	Power (mW)
Analog TDS	±5	41	205
Chirp	+3.3	12	40
Microcontroller	+3.3	174	576
Power system	+7.4	259	1.92

Time Delay Spectrometry (TDS)



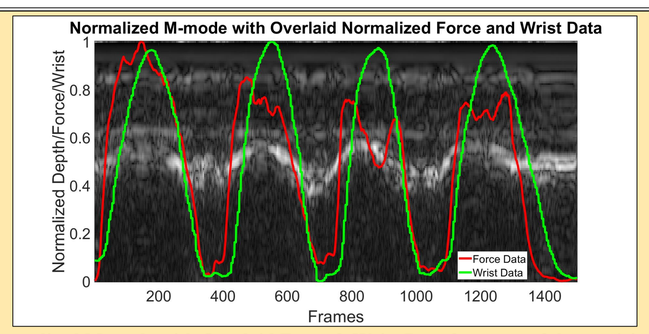
SCAN ME

Questions? Please reach out : arima@gmu.edu

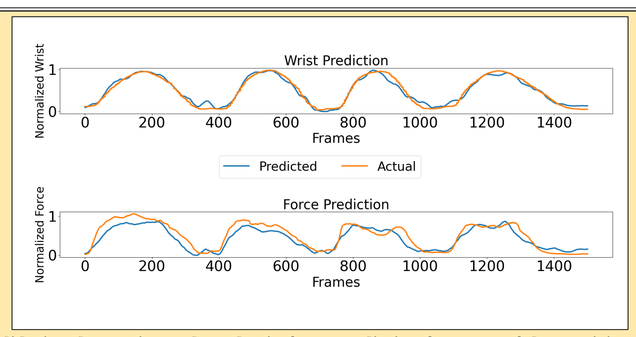
Results

Performance Metrics Across All Participants

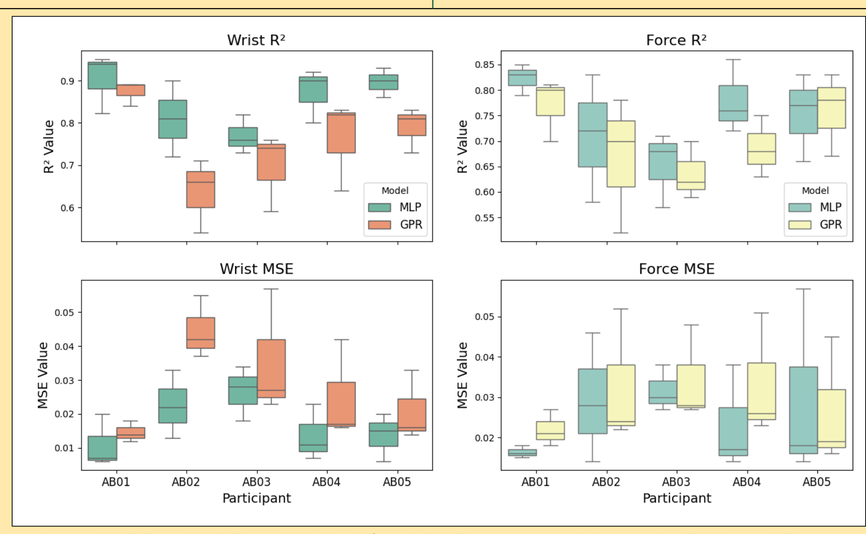
Participant ID	MLP Results				GPR Results			
	Wrist (R^2)	Wrist (MSE)	Force (R^2)	Force (MSE)	Wrist (R^2)	Wrist (MSE)	Force (R^2)	Force (MSE)
AB01	0.904	0.011	0.823	0.016	0.873	0.015	0.770	0.022
AB02	0.810	0.023	0.710	0.029	0.637	0.045	0.667	0.033
AB03	0.770	0.027	0.653	0.032	0.697	0.036	0.637	0.034
AB04	0.873	0.014	0.780	0.023	0.763	0.025	0.687	0.033
AB05	0.897	0.014	0.753	0.030	0.790	0.021	0.730	0.027
Average	**0.851**	**0.018**	**0.744**	**0.026**	**0.752**	**0.028**	**0.698**	**0.030**



Normalized M-mode with Overlaid Force & Wrist Data from one of the participants



Validation data wrist angle and grip force prediction from one of the participants



Comparison of MLP and GPR models for R^2 and MSE across participants for Wrist and Force metrics.

Conclusion

- ✓ A miniaturized ultrasound system with MLP enables accurate, simultaneous prediction of grip force and wrist angle during dynamic movements.
- ✓ Future work will expand movement diversity and apply recurrent models to enhance real-time control for users with limb differences.

APPLIED BIOSENSING LAB
George Mason University