Realization of High Resolution Human-Machine Interfaces by Advanced Materials

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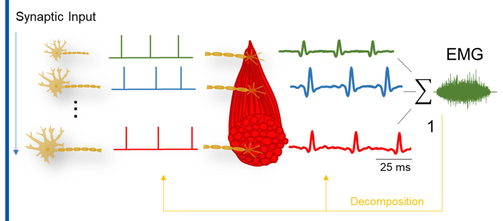
Introduction

The ability to decode hand gestures is critical for natural human-machine interaction, immersive virtual reality, and creation of effective prosthetics. Although technologies such as video tracking have been applied for hand gesture recognition, they restrict the user's mobility as they need to capture images of the body with several optical devices surrounding the user, and the cameras must maintain clear line-of-sight with all movements. Therefore, bioelectronics that are able to directly acquire and communicate the electrical activity of the human peripheral nervous system to machines have the potential to overcome these limitations. However, it is challenging to non-invasively acquire high-resolution electrophysiology signals that allow representation of ongoing muscle activity of the body. Effective contact and adhesion between conformable high-density electrodes and human skin are essential for the success of this kind of interface. We thus present a novel device that combines conformable electronics and organic mixed-conducting particulate composites (MCPs) to acquire reliable and high-spatiotemporal resolution muscle activity at the level of individual motor neuron action potentials.

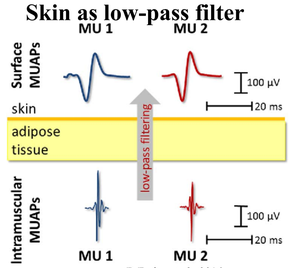
High-Density surface electromyography

Motor Unit Control



D Vecchio et al., 2020,
Journal of Electromyography and Kinesiology

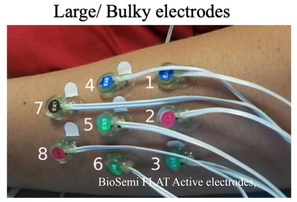
Skin as low-pass filter



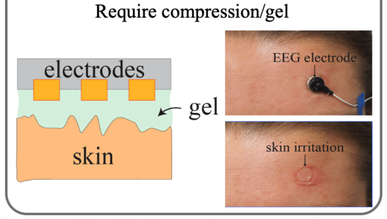
D Farina et al., 2016,
Proceedings of the IEEE

Challenges that limit the spatial resolution of surface EMG

Large/ Bulky electrodes

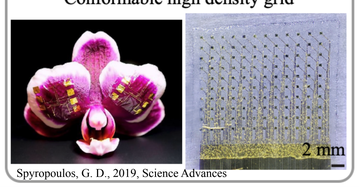


Require compression/gel



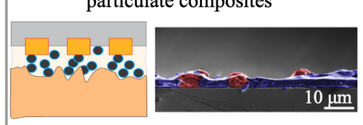
Anisotropic conducting composites enable high-spatiotemporal resolution recording from skin surface

Conformable high density grid



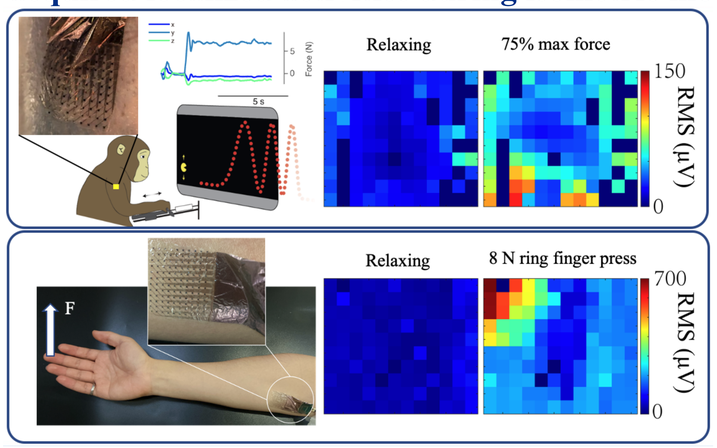
Spyropoulos, G. D., 2019, Science Advances

Anisotropic conducting particulate composites

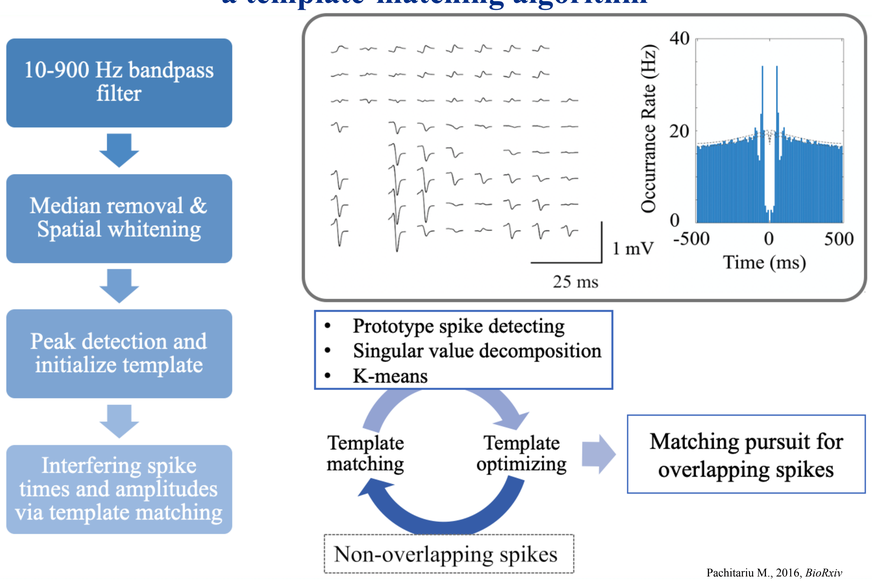


Yao D., 2022, Advanced Science
Jastrzebska-Perfect, P., 2020, Science Advances

MCP acquired localized activities during isometric movement



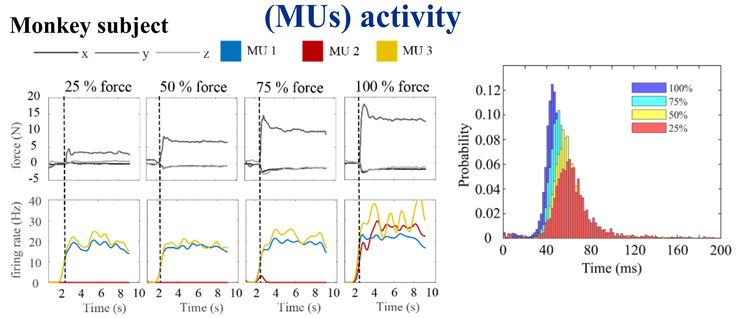
Motor spikes can be clustered into putative "single units" using a template-matching algorithm



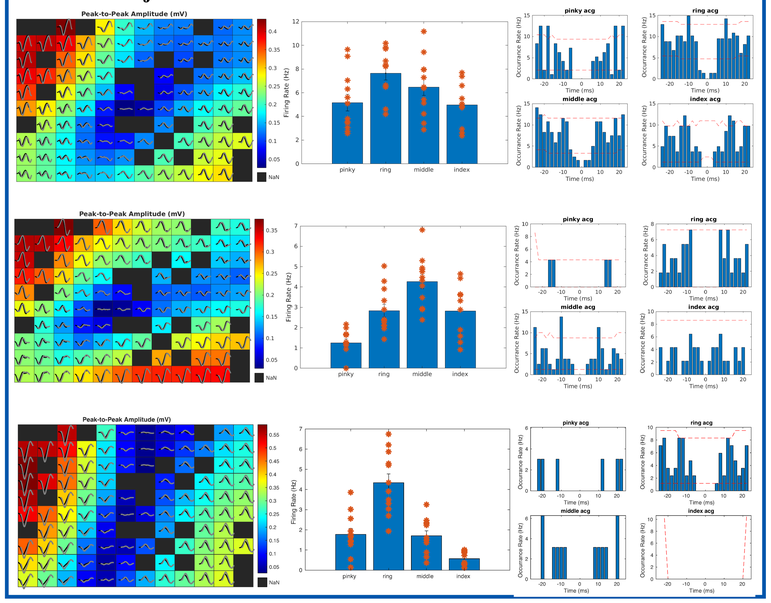
Pachitariu M., 2016, *BioRxiv*

Stable isometric movement modulate motor units (MUs) activity

Monkey subject



Human subject



Summary

- Conformable high-density electrodes combined with anisotropic conducting particulate composites resolve high-spatiotemporal electrophysiological data from surface of skin

- Surface detected spikes can be clustered into putative single motor units

- These motor units are correlated with behavior

Acknowledgements

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