Decoding of motor information in non-human primates using a chronic implantable system

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***Abstract*— Proximal nerve injury is a neurological condition of increasing incidence throughout the world. Complete transection, such as traumatic brachial plexus injuries, is the most severe, resulting in complete dysfunction of the motor and sensory functions of the arm. From the engineering and medical point of view, the ideal treatment would be a direct linkage of the complex nerve signals to the end-organ, providing immediate functional recovery. In the present work, we developed two implantable recording systems that allowed us to simultaneously acquire nerve and muscle signals using a 4-channel thin-film longitudinal intrafascicular electrode (tf-LIFE, SMANIA Inc.) and 9 endomysial muscle electrodes. Movement-dependent muscle activity from the flexor muscles of the forearm was matched in the time domain to the corresponding nerve signals from the median nerve in a *M. fascicularis* using power spectrum analysis and classification with support vector machine. Wavelet denoising allowed us to identify the spikes (i.e. local compound action potentials), which encoded the information for the muscle activation. This work will allow us to develop a neuroprosthetic solution for lesions of peripheral nerves in the future.**

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FUTURE WORK

This work is inside the framework "*Peripheral Nerve Prostheses – A paradigm Shift in Restoring Dexterous Limb Function*", aimed at developing an implantable peripheral nerve prostheses for the treatment of proximal nerve injuries. Our current work focuses on improving noise removal algorithm using SYMLET wavelets, spike detection and sorting using templates, feature detection, and neuromorphic classification.

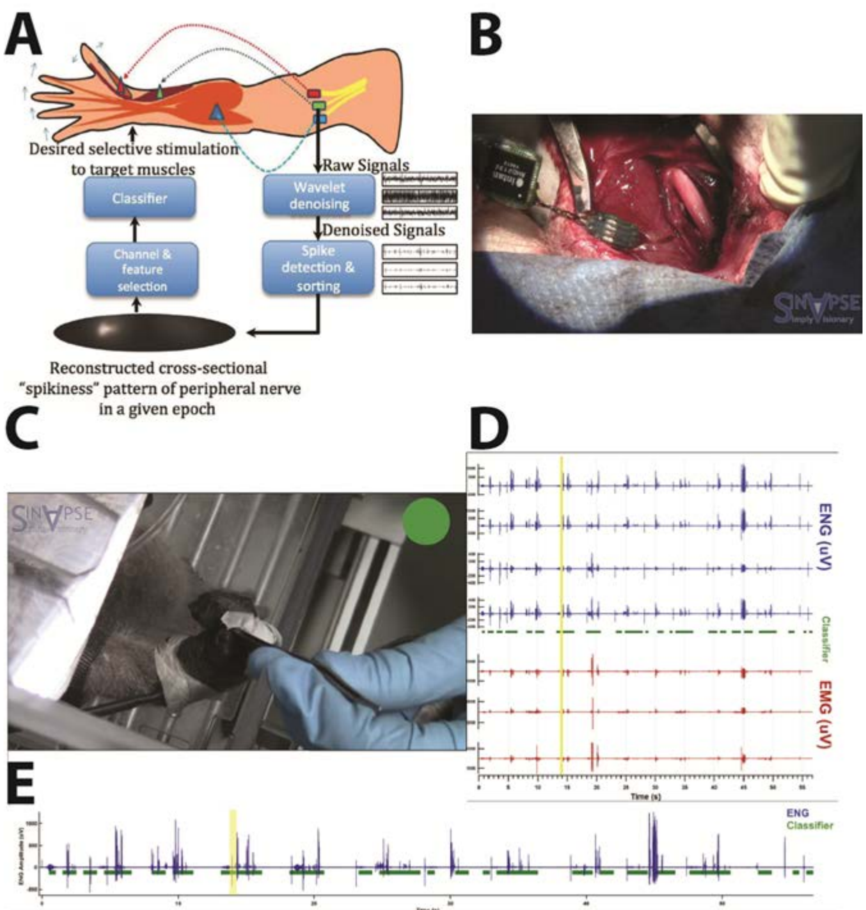

Figure 1. Experimental Design. **A.** Nerve signals were recorded from the nerve bundles corresponding to different muscule groups using tf-LIFE electrodes. Corresponding muscle activity was simultanously recorded with intra-muscular electrodes. All the electrodes were connected to an implanted RHD2132 chip (InTan Tech, Inc.) for data acquisition. Raw signals were then processed offline. After pre-processing and filtering, the muscle activation patterns were matched to the corresponding nerve signal using power spectrum analysis and support vector machine classification. Wavelet denoising was used to identify compound action potentials that coded for muscle contraction. **B.** Photograph showing the location of the implanted neural system with the tf-LIFE and the Intan chip in the median nerve at the brachial level in a *M. fascicularis*. **C.** Photograph of the NHP performing the grasp task while neural signals and forearm muscles were monitored. **D.** Typical recording showing, from top to bottom, the nerve activity from 4 contacts of a tf-LIFE in the median nerve (blue), result of the classification algorithm (green), and muscle activity from the *M. flexor carpi radialis*, *M. flexor digitorium superficialis*, and *M. flexor carpi ulnaris*. **E.** Inset showing the nerve activity recording from the first contact of the tf-LIFE and the resulting classifier. The yellow vertical bands correspond to the time of the photograph in C.