The Interface Between Man and Machine

Vincent R. Hentz

Brain-machine interfaces (BMIs) offer the promise of restoring communication, enabling control of assistive devices, and allowing volitional control of extremities in paralyzed individuals. The initial interface was mechanical. Levers and pulleys transferred power of innervated muscle to terminal device. Levers, pulleys, and harnesses were replaced by motors placed inside device and powered by gas or electricity. Control used on/off switches for modulation control by surface electrodes placed over muscles under voluntary control. Where muscle control was lacking but voice remained, the advent of computers led to voice recognition allowing a paralyzed individual to use the voice to control a device, e.g., a robotic arm.

Better computers led to signal processing hardware and software that could recognize any biological system that generated an electromagnetic output and transform this output to control artificial devices, such as attached prostheses, or distant limb substitute such as a robotic arm.

Collaborations between clever prosthetists and biomedical engineers led to miniaturization of motors, new light-weight materials, and more sophisticated prosthetic design with advanced power sources, osseo-integration, sophisticated EMG signal recognition, processing and terminal devices (prosthetic fingers) with "feeling". Engineers can now transform almost any novel prosthetic concept into a working device

The unsolved issue remains "how to control a complex device in real-time?" Needed is a novel neural-machine interface to help improve the function of new-generation prosthetic limbs or upper motor neuron paralyzed limbs. Proposed and under investigation are:

Targeted Reinnervation: Nerves that once innervated a severed limb are surgically redirected to proximal muscle and skin sites

Neural Control of Implantable Muscle Electrodes: An implantable magnetometer controller translates wrist motion into digital motion, or control by electromagnetic signals recorded from the scalp, or from intraneural electrodes,

Stem-cell augmented electrodes: Neural stem cell-seeded probe to facilitate integration of a synthetic prosthesis with the surrounding brain tissue, combining cells and microdevices to preserve skeletal muscle function.

Bions for neuromuscular stimulation

Real improvements will be the result of collaborations between engineers, neurophysiologists. upper limb surgeons and many others.