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Biomorphic circuits and systems for control of robotic and prosthetic limbs

Francesco Tenore

Professional Staff
Postdoctoral Fellow Johns Hopkins University
Applied Physics Laboratory Laurel, MD 20723

ABSTRACT OF THE TALK

Rhythmic motions of lower and upper limb prostheses for patients suffering from spinal cord injury (SCI) and amputees can be controlled and modulated using silicon neurons, designed in Very Large Scale Integration (VLSI) technology, that mimic pattern generation circuits found in the human spinal cord. Furthermore, synchronized patterns with arbitrarily offset phases between them can easily be implemented using this technology. This allows locomotory gaits of any kind to be programmed *in silico* to control bipedal robotic locomotion. It is also possible to use these circuits to control hand movements in prosthetic upper limbs using the same approach: the neurons' oscillatory behavior can trigger rhythmic movements that can be started or stopped at any phase, thus enabling the production of discrete movements in upper limb prostheses.

To do this, it is also necessary to successfully decode dexterous movements using available biosignals, such as (residual) myoelectric activity from amputated limbs and neural signals from the motor cortex, then show that the

technology developed is suitable for real-time applications, particularly control of multi-degree-of-freedom upper limb prostheses.

These systems have been validated on different platforms, dependent on the type of prosthesis required. For lower limb prostheses, a bipedal robot with servomotors actuating its hips and knees was used to prototype walking motions generated by silicon neurons. Upper limb (finger) control was achieved in a Virtual Integration Environment (VIE), characterized by real-time animations of hand and finger motions based on any type of input biosignal, from non-invasive surface myoelectric signals to neural signals from the motor cortex.