Title: From neurons to muscles: virtual musculoskeletal arm driven by sensorimotor cortex model

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We have developed a multiscale model (MSM) of sensory and motor cortex consisting of several hundred spiking model-neurons. The MSM was trained using spike-timing dependent reinforcement learning to drive a simple kinematic two-joint virtual arm in a motor task requiring convergence on a single target. After learning, networks demonstrated retention of behaviorally-relevant memories by utilizing proprioceptive information to perform reach-to-target from multiple starting positions. We utilized the output of this model to drive mirroring motion of a robotic arm. We then intercalated a realistic virtual musculoskeletal arm between the brain model and the robot arm. This virtual musculoskeletal arm received input from neural excitation for each muscle. It then fed back realistic proprioceptive information, including muscle fiber length and joint angles, which were employed in the reinforcement learning process. The limb position information was also used to control the robotic arm, leading to more realistic movements. This work explores the use of reinforcement learning in a spiking model of sensorimotor cortex and how this is affected by the bidirectional interaction with the kinematic and dynamic constraints of a realistic musculoskeletal arm model. These interactions take place across many spatial and temporal scales that involve both the brain and the arm, requiring the brain model to learn an internal representation of the external limb with its different spatial scales and properties -- torques, elasticity, inertia, etc. The MSM paves the way towards a full closed-loop biomimetic brain-effector learning system that can be incorporated in a neural decoder for real-time prosthetic control.

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