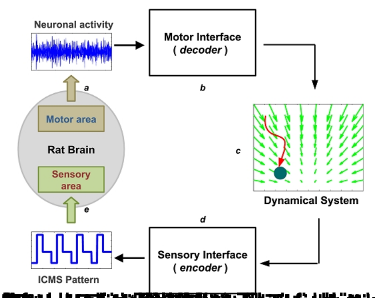
A study on a bidirectional brain-machine interface inspired by corticospinal control of movement.

A brain-machine interface (BMI) is a device which creates a direct communication between the nervous system (NS) and an artificial system. Different kinds of BMIs exist although many efforts still have to be made in order to develop clinical practice relying on such a kind of devices, which mainly aim at restoring functions of patients suffering from amputations, locked-in syndrome or other kinds of motor or perceptive impairments.

A number of classifications for BMIs exist, according to the criterion which is embraced to group the devices. A first classification relies on the neural signal which is recorded; it groups BMIs in Electroencephalographic (EEG) BMIs, Electrocorticographic (EcoG) BMIs or intracortical BMIs. A second classification identifies input BMIs and output BMIs. Input BMIs deliver patterns of electrical stimulation to Central NS (CNS) or Peripheral NS (PNS) in order to restore a particular impaired function, such as Cochlear implants help in restoring auditory functions. Output BMIs instead record the neural activity and decode it for clinical purposes or to predict the stimuli which elicited the activity itself. An output BMI might be regarded as closed-loop (bidirectional) or open-loop whether the NS gets any feedback information back dealing with the state of the decoding (closed-loop) or not (open-loop). In particular, the feedback might be merely visual or might be provided as a pattern of electrical stimulation.

The aim of the thesis is to study a bidirectional intracortical BMI on rats whose decoding procedure is inspired by the corticospinal control of movement. In particular, according to recent findings, it is assumed that the control policy implemented by the CNS is in the form of convergent muscular force fields characterized by an equilibrium point which is the target position of the limb. These force fields, whose origin can be found in the spinal circuitry, might be regarded as motion primitives and their combination by the CNS might generate complex limb movements. The CNS therefore may encode the limb movement as a Cartesian trajectory (like a moving target point corresponding to the limb effector) as the spinal cord is able to translate such an abstract representation into patterns of muscular forces acting on the limb itself and leading it towards the target. Nonetheless, such a control policy, relying on force fields, is stable and robust towards sudden and undesired perturbations.

The procedure characterizing the BMI studied in the thesis is called dynamic shaping and a BMI based on this procedure is called dynamic BMI (dBMI), as stated in previous works by the supervisors. Its general block diagram is shown in figure 1.



[illegible] www.pubblitesi.it [illegible]