

What Robotics may yet Learn from the Brain

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Although neurons as computational elements are 7 orders of magnitude slower than their artificial counterparts, the primate brain grossly outperforms robotic algorithms in all but the most structured tasks. Parallelism alone is a poor explanation, and much recent functional modelling of the central nervous system focuses on its modular, heavily feedback-based computational architecture, the result of accumulation of subsystems throughout evolution. We discuss this architecture from a global functionality point of view, and show why evolution is likely to favor certain types of aggregate stability. We then study synchronization as a model of computations at different scales in the brain, such as pattern matching, restoration, priming, temporal binding of sensory data, and mirror neuron response. We derive a simple condition for a general dynamical system to globally converge to a regime where diverse groups of fully synchronized elements coexist, and show accordingly how global "polyrhythmic" patterns can be transiently selected and controlled by a very small number of inputs or connections. We also quantify how synchronization mechanisms can protect general nonlinear systems from noise. Applications to some classical questions in systems neuroscience and robotics are discussed.