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Brain memory working. Optimal control behavior for improved Hopfield-like models

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The celebrated 1982 Hopfield Neural Network is a dynamic brain model with symmetric and constant synaptic weights. It has been recognized, recently even by Hopfield itself, the necessity of developing more realistic representations incorporating the asymmetry. Indeed, symmetry appears a too restrictive simplification. Dynamically, it is forcing –in an unrealistic way– the recognition of every incoming pattern, always going towards a minimum or a saddle of an underlying Lyapunov-like energy function, always existing in the symmetric case. Physiologically, symmetry is not reliable, since the role of axons and dendrites is not exchangeable. Some authors (e.g. Krotov, Parisi) also dispute the constancy of the synaptic matrix. First at all, we present a general framework producing Hopfield-like vector fields of gradient type, encompassing the existing symmetric models (2021 Hopfield, Krotov) as particular cases. Moreover, we introduce dynamic synaptic weights controlled during the dynamics according to a suitable multiobjective variational principle. As a result, the deriving dynamics incorporates relevant features observed in the real memory functioning: pattern recognition, pattern learning, pattern generating undetermined dynamics (wandering) and finally the possibility of forgetting and restoring memories.