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Modeling Cross-Modal Neural Plasticity with interacting nearest neighbor Ising spin systems in *d*-dimension (*d=1,2*)

B.B.U.P. Perera[1*] and J.R. Wedagedera[2§]

[1]Department of Mathematics, University of Kelaniya, Sri Lanka.
[2]Department of Mathematics, University of Ruhuna, Sri Lanka.
*upeksha@kln.ac.lk, §janak@maths.ruh.ac.lk

In early cognitive science it was thought that different sensory modules function independent of each other but, recently, in contrary to this, it has been argued that *cross-modal interactions* are present and the cortical pathways previously thought to be sensory-specific are modulated by signals from other modalities.
The brain is a complex, and nonlinear system and brain state variables exhibit high dimensional chaos and the neuron interactions are mostly happening among nearest-neighbors, so the collective aspects of this system may be studied similarly to other collective systems and the activities pertaining to neo columns can be mathematically modeled.
Using the hypothesis that the mammalian neocortex functions as an associative memory the dynamics of the system is formulated via Hopfield model by the simultaneous simulation of different Hopfield networks, coupled to each other.
An abstract model in which the interactions coming from different sensories are treated as interaction between two interconnecting networks (with their own interactions) is purposed. A single network consisting of number of neurons acting identical to each other is approximated via Edward-Anderson (EM) Model – assuming each neuron is in either on or off (±1) state and influences by other neurons with random couplings. The nature of these couplings as well as the topology of the lattice where the spins are localized give rise essentially to a different model/ dimension of the problem. This paper addresses the model of two interacting nearest neighbor Ising spin systems in *d*-dimension (*d=1,2*). A Hamiltonian for the model is purposed.
The equilibria of the model is investigated via analytical solution to the free-energy $f(\beta)$ using the large deviation theory and additionally, Monte-Carlo simulations were carried-out for the above model Hamiltonian, which verifies the analytical results.

Keywords: Ising spin system, cross-modal interactions, large deviation, free energy