COMPUTATIONAL NEURAL MODELING AT THE CELLULAR AND NETWORK LEVELS - TWO CASE STUDIES

Sandeep Pendyam

Dr Satish S Nair, Thesis Supervisor

ABSTRACT

Computational Neuroscience provides tools to abstract and generalize principles of neuronal functions using mathematics, with applicability to the entire neuroscience spectrum. Problems at two levels of the neuroscience spectrum, namely molecular and network, are considered in this thesis.

Chapter two outlines development of a biologicaly realistic computational model that mimics a junction (synapse) between a single pathway between two different brain regions, prefrontal cortex and nucleus accumbens. This pathway is altered in a chronic cocaine condition. The proposed model was used to provide additional insights into the cellular adaptations due to cocaine. This model proved useful for predicting cocaine-induced changes in a molecular target that was experimentally validated by our collaborating neuroscientist. More generally, this model provided a mathematical framework for describing how pharmacological or pathological conditions influence the synapse. Chapter three studies the particular glial configurations of chapter two in more detail.

Chapter four defines a computational structure to study extinction learning in rats using data from another neuroscience collaborator. The principal structures involved in fear extinction are the amygdala (lateral, basal, intercalated cells, and central nucleus), ventro-medial prefrontal cortex, and the hippocampus. A network model is proposed to study the extinction using artificial neural network models implementing in PDP software.