ABSTRACT

Human Brain is the most remarkable machine devised by nature. Not only does it allow us to adapt very fast, it also gives us some very unique higher order abilities, such as ability to think, be aware, observe ourselves and volitionally choose our actions. This makes us superior to all other life forms. Adaptation in the human brain happens due to activity dependent formation of structured connections between neurons, both within the same cortical area and across different cortical areas, forming local and global feature maps. These connections form based on the Hebb's learning principle for synaptic plasticity that is dependent on synchronized neural activity. While local feature maps are mostly formed during early post-natal years, global feature maps continue to form throughout the adult life as we acquire new skills. Over the years, various models have attempted to capture the essence of feature map formation. However, due to incomplete understanding of how precisely coordinated brain-wide neural activity arises, it is not fully understood how global feature maps are formed. Moreover, most models have ignored aspects of top-down control such as attention and awareness that could possibly be influencing the formation of these feature maps. This thesis has attempted to explore the adaptation aspects of the brain, by looking at the formation of both local and global feature maps. The thesis begins with the design of neuromorphic structures, capturing aspects of local computing in the brain. Hardware models of some widely studied visual feature maps like Ocular Dominance and Orientation Selectivity have been developed. A unique Quantum-Hebbian model of formation of global feature maps has been proposed that assigns a unique causal role to top-down factors such as attention and subjective experience in the formation of global feature maps, and hence in shaping our brains. The thesis concludes with an evolutionary model of the brain, based on the Penrose-Diosi relation for self-collapse of a quantum system in superposition, that looks at how brains of different species differ in their adaptation levels as well as their higher order capabilities.