Developmental Connectivity Schemes and Their Performance Implications

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Abstract

The development of connectivity between brain networks (e.g., thalamo-cortical, cortico-thalamic, cortico-cortical) proceeds via a combination of axon and dendrite growth. Connectivity tends to be extremely sparse; it has been estimated that the probability of contact between two neocortical excitatory cells that are 0.2-0.3 mm apart is less than 0.1, and between two such cells that are more than 1mm apart, $p < 0.01$ (Braitenberg & Schuz, 1998). When one group or layer of neurons (A) generates a set of projections to another (B), interesting computational constraints can be educed as a function of characteristics of the originating and receiving networks. First some conditions are described that are clearly undesirable (e.g., if any cells in A produce no contacts in B, part of the "signal" from A presumably cannot be transmitted to B). Remaining conditions include a number of distinct cases with different information-theoretic utility, suggesting differential value for certain connectivity schemes over others. We characterize the tradeoffs among utility and costs and their dependence on different classes of strategies by which axons from A are assigned to dendrites in B. It is shown that hypergeometric distributions optimize a range of measures of these costs as compared to competing projection distributions.