Abstract:

A fundamental problem faced by the brain is that of perceptual grouping. Primitive image elements, such as edges and lines, must be grouped or segmented depending on whether they belong to a common object, or whether they belong to separate objects. Different mechanisms have been proposed to account for how the brain accomplishes this task. One mechanism has it that grouping is achieved via hard-wired connections from low- to high-level visual areas resulting in a "grandmother cell" type of circuitry where each possible thing represented in the brain is coded by the firing rate of a single cell. If the preferred stimulus is present, the cell fires at a high rate, and otherwise the cell remains quiet. Experiments by Hubel and Weisel have provided convincing evidence that this mechanism at least partly explains responses of cells in low-level visual areas, however, this theory breaks down when considering the complexity of the visual world and the number of such cells that would be required to represent all possible things that the visual system can perceive and understand. Ultimately, additional mechanisms must be leveraged to account for the diversity and flexibility of visual representations. Here, I propose that neural synchrony and asynchrony may be temporally multiplexed with the existing rate code to augment the low-level information with grouping/segmentation labels. I provide a detailed mathematical model based on the Hodgkin-Huxley equations that shows how this can be achieved and further provide psychophysical evidence that supports the model.