Modelling the development of the retinogeniculate pathway

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Summary

How does the visual system develop before the onset of visually-driven activity? By the time photoreceptors can respond to visual stimulation, some pathways, including the retinogeniculate pathway, have already reached a near-adult form. This rules out visually-driven activity guiding pathway development. During this period however, spontaneous waves of activity travel across the retina, correlating the activity of neighbouring retinal cells. Activity-dependent mechanisms can exploit these correlations to guide retinogeniculate refinement. In this thesis I investigate, by means of computer simulation, the role of spontaneous retinal activity upon the development of ocular dominance and topography in the retinogeniculate pathway.

Keesing, Stork, and Shatz (1992) produced an initial model of retinogeniculate development driven by retinal waves. In this thesis, in addition to replicating their initial results, several new results are presented. First, the importance of presynaptic normalisation is highlighted. This is in contrast to most previous work on ocular dominance requiring postsynaptic normalisation. Second, the covariance rule is adapted so that development can occur under conditions of sparse input activity. Third, the model is shown to replicate development under conditions of monocular deprivation. Fourth, model development is analysed using different spatio-temporal inputs including anticorrelations between on- and off-centre retinal units.

The layered pattern of ocular dominance in the LGN is quite different to the stripe patterns found in the cortex. The factors controlling the patterns of ocular dominance are investigated using a feature-based model of map formation (Obermayer, Ritter, & Schulten, 1991). In common with other models, variance of the ocularity feature controls the pattern of stripes. The model is extended to a three-dimensional output array to show that ocular dominance layers form in this model, and that the retinotopic maps are organised into projection columns. Future work involves extending this three-dimensional model to receive retinal-based, rather than feature-based, inputs.

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