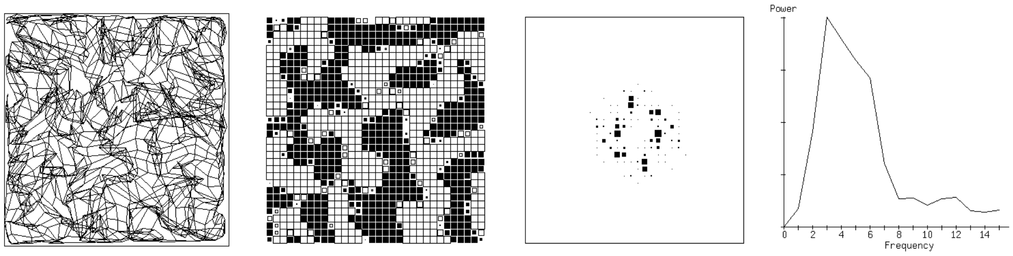
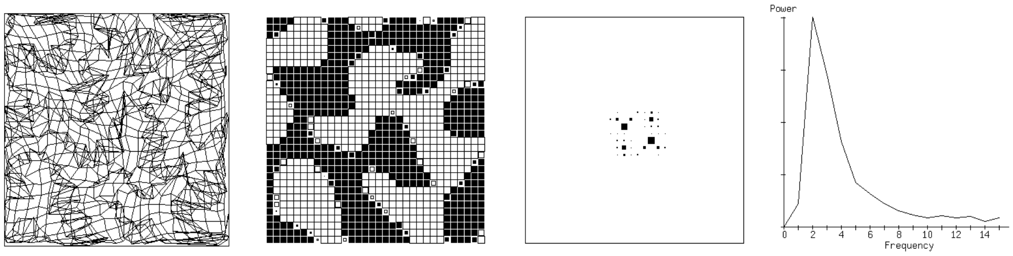
(a)



(b)



(c)

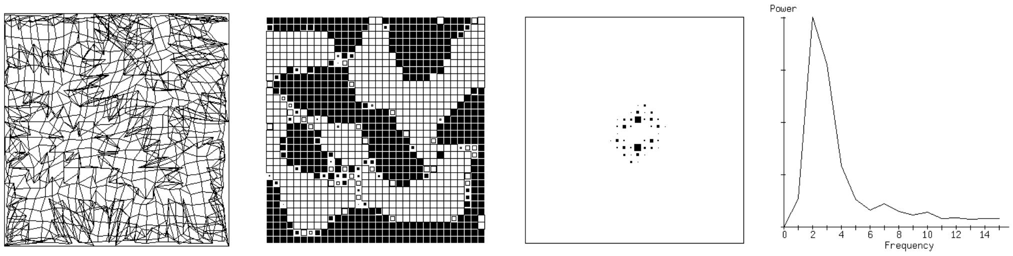


Figure 6.5: Effect of varying the width of cortical interactions. We show the cortical topography averaged over both eyes, the stripe pattern, the fourier transform of the stripes, and the power spectrum of the fourier transform for each case. (a) $\sigma_c = 1.0$. (b) $\sigma_c = 2.0$. (c) $\sigma_c = 3.0$. Note that stripe width tends to increase with σ_c.

σ_c	L_N	L_C	Total
1.0	5281.7	958.4	6240.1
2.0	4787.4	913.3	5700.7
3.0	4639.0	1064.8	5703.8

Table 6.2: Length of cortical wiring required for various σ_c.

(a)

(b)

(c)

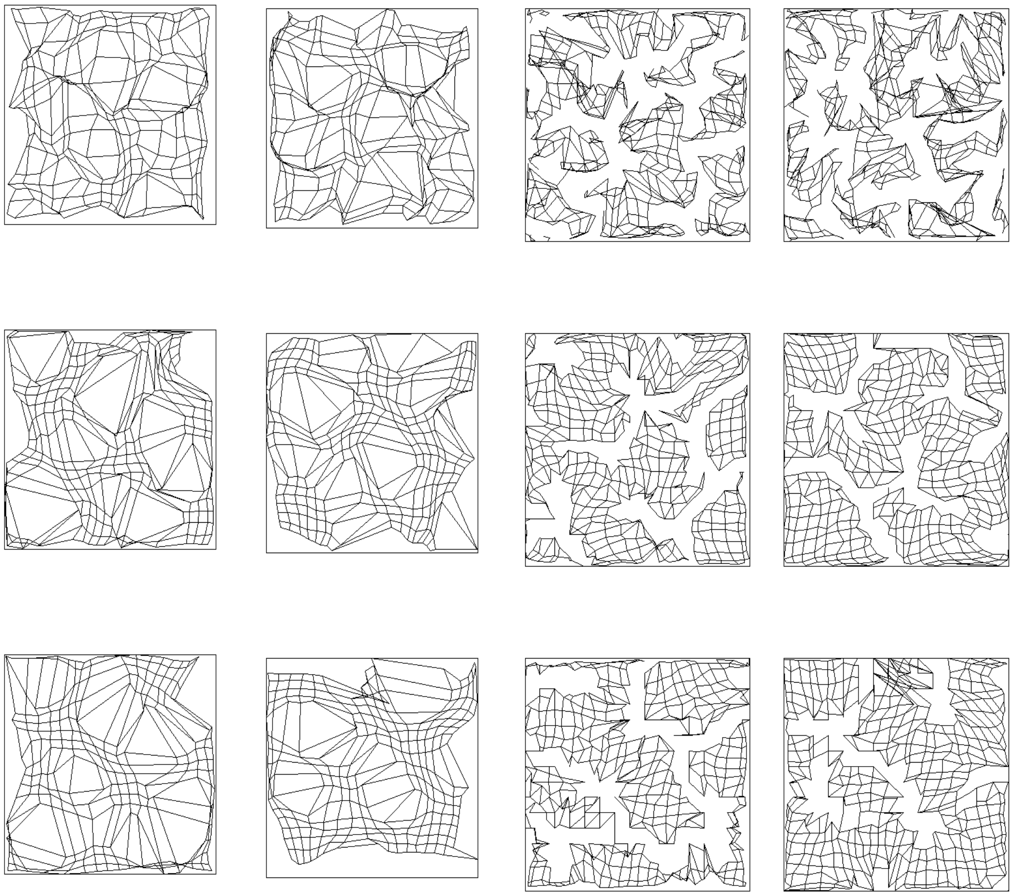


Figure 6.6: Retinal and cortical topography for varying extent of cortical interactions. For each σ we show the retinal topographies for the left and right eyes, followed by the cortical topographies for the left and right eyes respectively. (a) $\sigma = 1.0$. (b) $\sigma = 2.0$. (c) $\sigma = 3.0$.

h	L_N	L_C	Total
-0.1	5296.2	1529.0	6825.2
-0.05	5164.4	1258.4	6422.8
0.0	5108.2	973.3	6081.6
0.05	5002.5	1048.2	6050.7
0.10	4857.4	809.0	5666.4
0.15	4654.7	662.0	5316.7
0.20	4622.4	579.5	5201.8

Table 6.3: Length of cortical wiring required for various values of h.

each retina had been convolved individually with a gaussian function to produce local correlations within each eye, the activity a_j of each unit j in each retina was replaced with $ha_j + (1-h)a'_j$, where a'_j is the activity of the corresponding unit to j in the other eye, and h specifies the degree of correlation between the two eyes. Thus by varying h we can vary the degree of correlation between the eyes: if $h = 0$ they are uncorrelated, and if $h = 0.5$ they are perfectly correlated (i.e. the pattern of activity is identical in the two eyes). Results for a progression of values of h are compared in figure 6.7, with the retinal and cortical topographies for each case in figure 6.8. The following effects can be seen as h increases:

- Cortical units take longer to saturate at complete dominance for one or the other eye.
- The topography of the map becomes smoother.
- Stripe width *decreases*.

Improvement of the topography is expected: as the two eyes become more correlated, more information becomes available to cortical units regarding the relative positions of units in the two retinae, and thus the two maps are aligned to a greater extent. From intuitive arguments similar to those made in chapter 5 we also expect the observed reduction in stripe width: greater correlation between the two eyes increases the desire to keep cortical units representing corresponding positions in the two eyes together.

The effects of zero and negative correlations between the eyes were also studied. These results are compared in figure 6.9, and the retinal and cortical topographies in figure 6.10. The degree of *negative* correlation appears to have little effect on stripe width.

We calculated the lengths of cortical wire required for results of each value of h, as shown in table 6.3. It can be seen that the correspondence term L_C decreases very rapidly as the correlation between the two eyes increases: this reflects the fact that the maps from the two eyes become increasingly accurately aligned as the correlations increase (see figures).

It is difficult to directly compare these wire lengths with those calculated for the results of the elastic net and Kohonen-type algorithms in chapter 5, due to varying stripe widths. However, we can see that for roughly comparable stripe widths, the present model gives wire lengths of approximately the same magnitude as those found in chapter 5.

6.4 Further characterization of the model

6.4.1 Dead units, stability, and saturation

The basic mechanism of the model is that of competitive learning [Rumelhart & Zipser 1986]. The model thus shares the same problem of "dead" units: that is, units which do not capture any patterns and hence whose weights do not progress beyond their initial values. Various mechanisms have been proposed to avoid this problem (for review see [Hertz et al 1991]), and in the present model we adopt a form of "conscience" mechanism [Hertz et al 1991]. Here the activity of each cortical unit in response to a pattern is divided by the number of times it has won the competition so far. This serves to roughly equalize the number of times each cortical unit wins the competition, and thus ensures that dead units do not occur. This could be implemented