1

STRUCTURAL ASPECTS

Subjecting the anisotropic network model to a critical examination of its structural features, we identify prevalent patterns of connectivity and relate theoretical and computational results to findings from experiments in the rat's cortex.

1.1 MOTIFS

In this chapter we analyze the strucarl. The term motif referes to... . Studies of Song et al. (2005) and Perin et al. (2011) show stuff. Pernice2011, Sporns , Zhao2011.

Edge counts in neuron clusters

In motifs consisting of 3 to 8 neurons, Perin et al. (2011) reported a striking statistic from their experiment with pyramidal cells in the rat's somatsosensory cortex (layer 5): Counting the number of edges appearing in a clusters of n neurons, they find that clusters with relatively high edge counts appear significantly more often than expected from the network's distance-dependent connection probabilities alone. Do anisotropic networks exhibit a similar feature?

Recruiting the collection of sample graphs once again we analyze the occurrence of edge counts in clusters of n neurons in the different network types. In the main process, after randomly sampling n pairwise different vertices S_n, the motif H in G with vertex set $V(H) = S_n$ is identified and its number of edges $|E(H)|$ is recorded. Repeating this sufficiently often (order 10^6) we obtain edge counts for clusters of 6,8 and 12 neurons in the anisotropic and tuned anisotropic networks as well as in their rewired counterparts. Then, showing difference of the counts in the anisotropic networks and rewired networks, normalized by the rewired counts, we identify an overrepresentation of high edge counts in the neuron similar to Perin et al. (Figure 1.1).

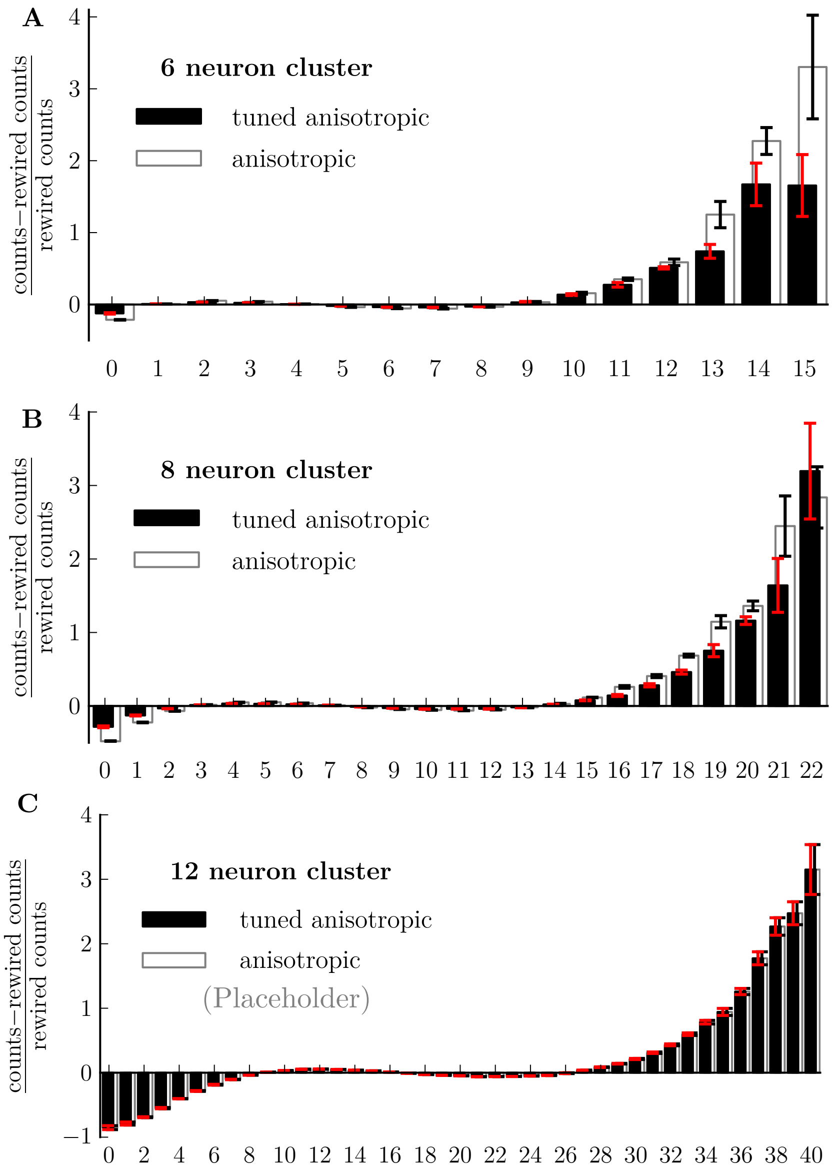

Figure 1.1: Increased occurrence of high edge counts in neuron clusters in anisotropic networks Showing the quotient of the difference Extracting the counts of three-node motifs in anisotropic (filled bars) an (`something`)

Anisotropic networks inherently carry a connection principle that goes beyou

we find that this effect is even stronger in comparison with distance-dependent networks (Figure 1.2).

Here

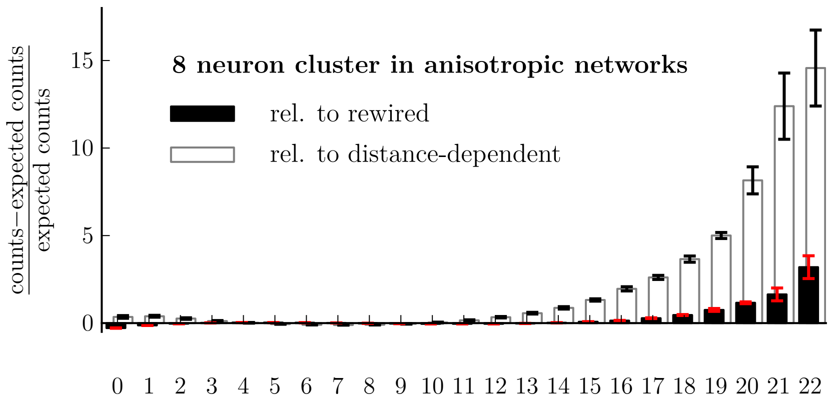

Figure 1.2: Stronger overrepresentation of clusters with high edge counts when compared with distance-dependent networks Showing we find that the overrepresentation of motifs with high edge counts is stronger (`7c826e10`)

common neighbor rule as underlying principle?

In their study, Perin et al. follow their report of increased edge counts in neuron clusters with the observation of a "common neighbor rule". Relying once again on their data in the rat's somatsensory cortex, Perin et al. find that not only do neuron pairs with a high number of common neighbor count appear significantly more often than expected, but also that such pairs display a higher probability of being connected. In fact, the relationship between pair connectivity and number of common neighbors appears to be linear. Perin et al. also report that this effect is most pronounced when only considering common in-neighbors, that is other neurons that are projecting to both neurons in the pair.

Here we also investigate our networks for the existence of such a common neighbor relationship. Simultaneously recording connection probabilities and the number of common neighbors between pairs of neurons, we find inherent dependencies between the two quantities in all network types (Figure 1.4).

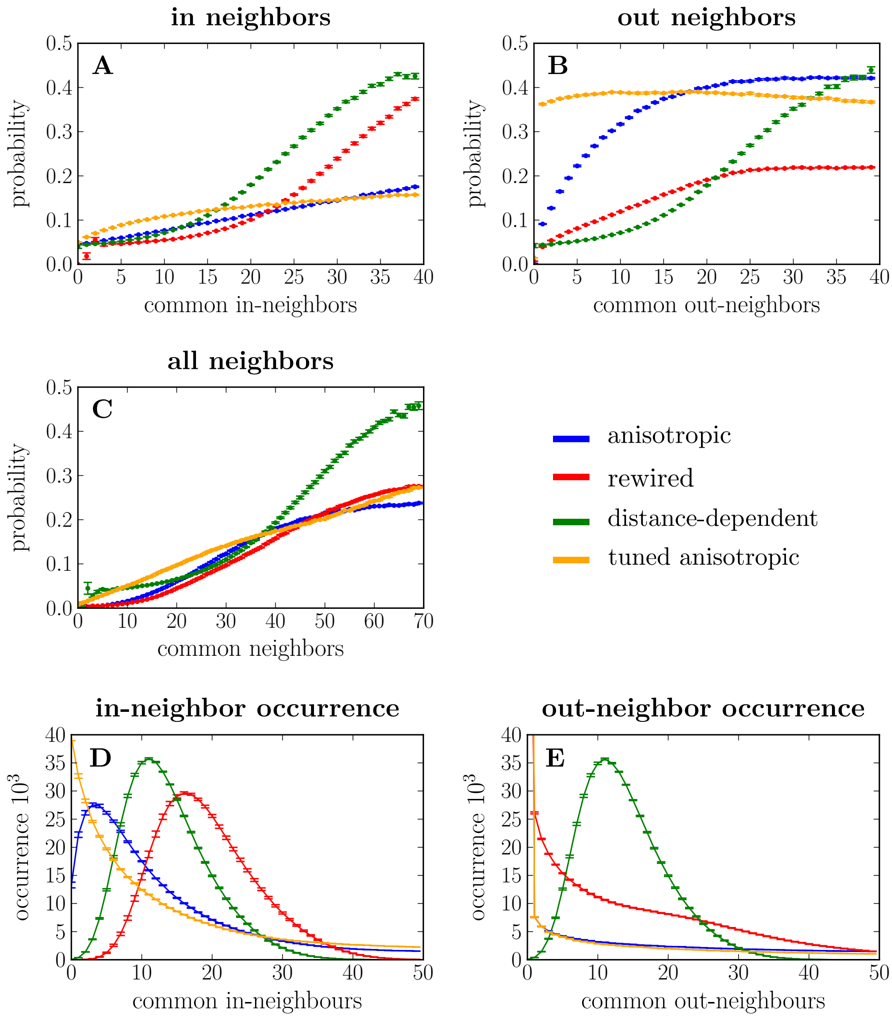

Figure 1.3: Distance-independent overrepresentation of reciprocal connections (`something`)

First, we immediately note the sharp difference between in- and out-neighbors in their effect on connection probabilities in anisotropic networks, as well as in rewired networks. Only in distance-dependent networks it appears that in- and out-neighbors can be considered equivalent in their influence on connection probabilities (Figure 1.4 A-B). Furthermore, while the distribution of the number of common neighbors is consistent in distance-dependent networks, the other network types display a characteristic distribution of common out-neighbors (Figure 1.4 D-E). This observation clearly relates back to the drastically different out-degree distributions in the different networks found in Section **??**.

Both for in- and out-neighbors we find characteristic . Here the profiles split into two categories, networks with anisotropy in connectivity (blue, orange) and distance-dependent networks (red, green) . Clearly anisotropy

A high variance in in-neighbor distribution might

arguably might lead to advantages in computation

To few have common in-neighbors (functionally unrelated) or some pair with a many common inputs (functionally related).

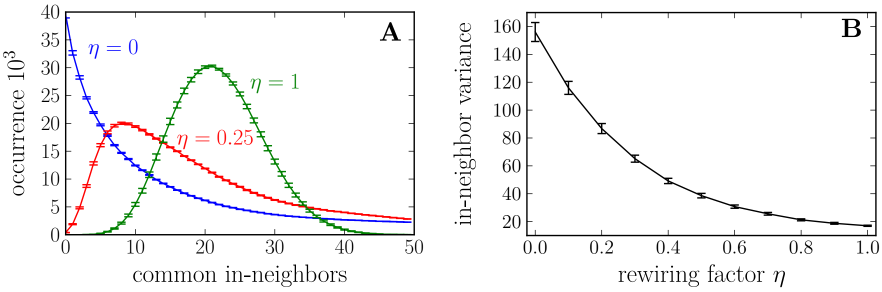

Figure 1.4: Anisotropy increases variance of common input distribution Recording common in-neighbor counts for random neuron pairs in tuned anisotropic networks and their rewired versions reveals increased variance in networks with a high degree of anisotropy. **A)** Common in-neighbor distribution for original tuned anisotropic networks ($\eta = 0$, blue) and rewired versions with 1/4 of all edges rewired ($\eta = 0.25$, red) and completely rewired ($\eta = 1$, green). (`5841710e`) **B)** Variance of the common in-neighbor distributions declines with increasing rewiring factor η; highest variance is found in networks with the highest degree of anisotropy ($\eta = 0$). (`ffcefe9b`)