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 visual cortex.

Small-world networks, as described in Section **??**, are characterized by small a average path length and comparably high clustering coefficient. In the of brain networks, small-world

(Watts and Strogatz 1998)

Here we are interested in exploring the question if network anisotropy has effect on the small-worldness of geometric networks. Using distance-dependent networks as a reference, we find that eliminating anisotropy through rewiring does affect the small-world properties to some degree; with rising isotropy in the network, the characteristic path length declines, while the network clustering coefficient increases resulting together in rewired networks to display a higher degree of small-worldness (Figure 1.1).

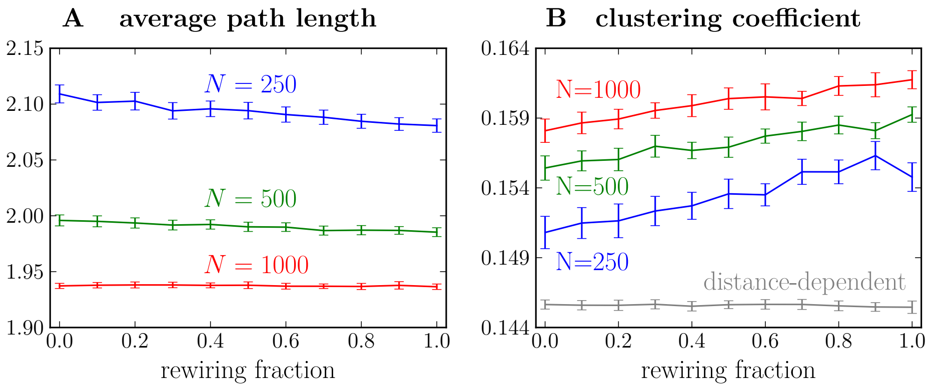

Figure 1.1: Higher degree of small-worldness in isotropic than in anisotropic networks Generating anisotropic networks with different axon widths w and extracting probability p of dcirected connectin between two random nodes, demonstrates the dependency of p on the width parameter w. **A)** At an axon width of over $w = 100$, exceeding the square's side length, the connection probability saturates at $p = 0.5$, as axon bands are essentially "cutting" the square in a connected and unconnected half (`c5b64f3e`). **B)** For small w the connection probability is a linear function of w, allowing the width $w_S/2$ at which $p(w_S) = 11.6$ to be determined by a linear fit as $w_S/2 = 12.6$ (`064f9b10`).

In ER networks avg and cc are ...

Comparing path length we find ...

The analysis . Here we present the influence on anisotropy of

Charactersitic path length

Average path length and so forth

Sporns papers newest Butz

While the transitivity ratio of a network, its correlation with the network's anisotropy degree gives hint of deeper structural relationships found in the subsequent sections.

1.2 TWO NEURON CONNECTIONS

Connectivity in cortical neural networks shows a specific . First described by Markram 1997, finding across have confirmed .

A first result

In anisotropic networks an overrepresentation of reciprocal connections is present. Counting and comparing it with our expectation from Gilbert random graphs $G(n,p)$, In random graphs the probabilities that a random pair of vertices are

$$\begin{aligned} Pr[||\text{unconnected}] &= (1-p)^2, \\ &= 2p(1-p) \quad \text{and} \\ &= p^2 \end{aligned}$$

We can further support our hypothesis that anisotropy does not influence two neuro connection probabilities by calculating them . Taking distance-dependent connection probability $C(x)$ in anisotropic networks from Theorem ?? and the , we find the expressions

$$\begin{aligned} Pr[||\text{unconnected}] &= \int_0^{\sqrt{2}} (1-C(x))^2 f(x)\,dx, \\ &= \int_0^{\sqrt{2}} 2C(x)(1-C(x)) f(x)\,dx \quad \text{and} \\ &= \int_0^{\sqrt{2}} C(x)^2 f(x)\,dx \end{aligned}$$

Maybe simplicity of the model makes stuff wrong. Tune to Perin distance profile.

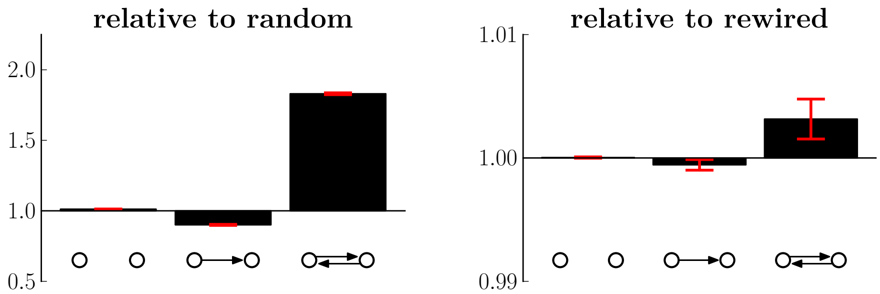

Figure 1.2: Overrepresentation of reciprocal connections in anisotropic networks due to distance-dependent connectivity Extracting the counts of unconnected, one-directionally and bidirectionally connected neuron pairs in the anisotropic sample graphs, overrepresentation of reciprocally connected pairs is identified as a feature of the network's distance dependency as opposed to anisotropy in connectivity. **A)** Showing the quotient of the counts for the three pair types, extracted from the set of sample graphs, with the number of expected pairs in Gilbert random graphs $G(n, p)$, where $n = 1000$ and $p = 0.116$ were matched to the sample graph parameters. While single connections appear less often than in Gilbert random graphs, reciprocal connections are significantly overrepresented. Errorbars SEM. **B)** Comparing appearance of connection pairs in the anisotropic sample graphs with their respective appearance in the rewired sample graphs, we find that eliminating anisotropy does not significantly change the counts for the connection types, indicating that anisotropy does not influence two neuron connection probabilities. Errorbars SEM. (`c5f1462b`)

Let

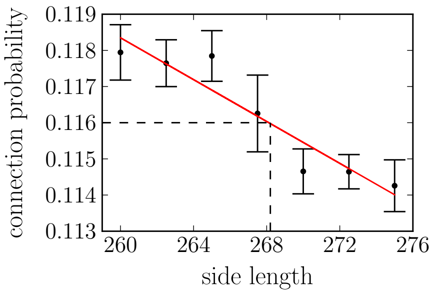

Figure 1.3: (3b78f78f)

With side length 296:

from f11dca65.

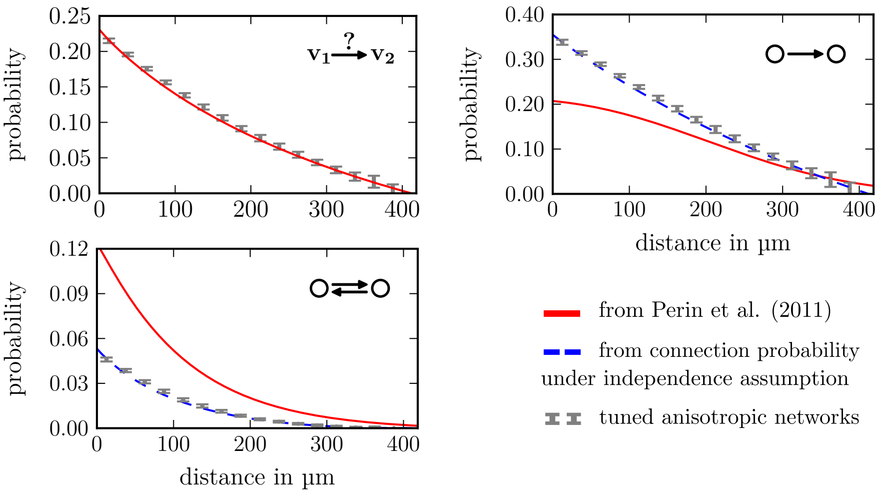

Figure 1.4: Overrepresentation of reciprocal connections independent of Comparison of occurrences of one- and bidirectionally connected neuron pairs in (gray) with profiles found by Perin et al. (2011) (red), shows that overrepresentation of bidirectional pairs is distance-independent and not connected to anisotropy. **A)** Overall connection probability in the adapted anisotropic networks was successfully tuned to reflect connection probability found by Perin et al. **B)-C)** Probabilities for a random neuron pair to display , (875505b0)

1.3 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.

Song motifs:

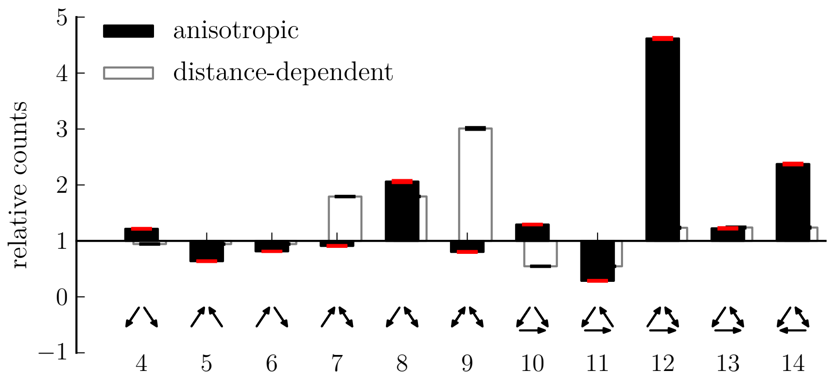

Figure 1.5: Relative occurrence of three-neuron patterns Extracting the counts of three-node motifs in anisotropic (filled bars) and distance-dependent networks (unfilled bars), the quotient of the obtained count with the number of occurrences expected from the two-neuron connection probabilities in the networks (rs =, „ cf.) shows the over- and underrepresentation of specific motifs in the network (red and black errorbars are SEM). In anisotropic networks pattern number "12", for example, appears around five times more often than we would expect from the occurrence two-neuron connections. The relative counts for anisotropic networks resemble the findings of Song et al. (2005) and differ significantly from the counts in distance-dependent networks, implying that anisotropy has a strong influence on the relative occurrence of three-neuron patterns. (`4839ce41`)

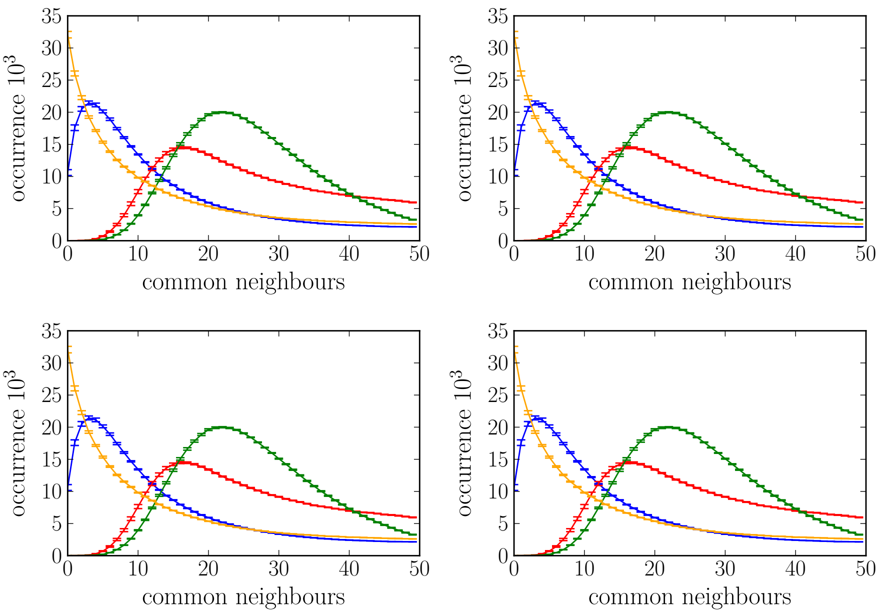

Figure 1.6: In-degaree distrbution not affected by varying degrees of anisotropy (77995b6b).