1

STRUCTURAL ASPECTS

1.1 DEGREE DISTRIBUTION

The in- and out-degree of vertex in a directed graph describes the number of incoming and outgoing connection from and to other vertices (cf. Definition ??). As a fundamental concept in graph and network theory, the degree distribution is integral in the categorization of networks and allows for the estimation of graph properties.

Degree distribution was shown to have strong impact on the dynamics of neuronal networks models commonly used in computational neuroscience research (Roxin 2011). Increasing in-degree variance for example could be connected to the appearance of oscillations in the network. Extracting degree distributions from biological networks however, remains a challenge as many neurons need to be tracked simultaneously to obtain enough data to confidently estimate degree distributions.

Here we analyze in- and out-degrees in the anisotropic network model. First we find that compared to the binomial in-degree distribution of a Gilbert random graph model, in-degrees of vertices in anisotropic networks display higher variance and their distribution is skewed to the left (Figure 1.1). However, this specific in-degree profile is not an intrinsic property of anisotropy, as the distribution remains stable under manipulation of the anisotropy degree and closely matches the profile of a purely distance-dependent network (Figure 1.2). This result agrees with findings of Perin et al. (2011, Fig. S3), who were able to recreate degree distributions from their experiment with layer V thick-tufted pyramidal cells in neonatal rats from the extracted distance-dependent connection profiles alone.

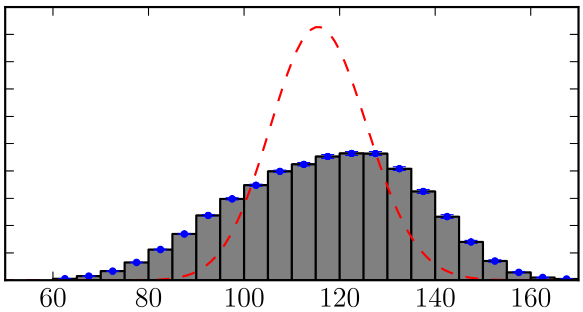

Figure 1.1: In-degree distribution in anisotropic networks the binomial distribution of Gilbert random graphs From 250 anisotropic networks in-degree distributions were extracted and are shown in a histogram plot, errorbars SEM. In red the binomial degree distribution of a Gilbert random graph model with matching parameter set (number of vertices, connection probability) shows . Skewness is (9326138e)

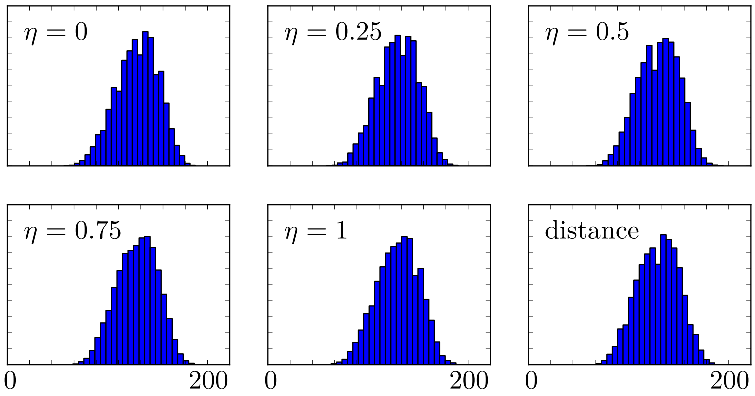

Figure 1.2: In-degree distribution not affected by varying degrees of anisotropy

While the out-degree distribution of vertices in the anisotropic network also shows itself stable under rewiring, its distribution is drastically different from the out-degree distribution in a comparable distance-dependent network (Figure 1.3). The asymmetric, long-tailed distribution is identified as an artifact of the anisotropic network's spatial confinement; a neuron, closely located near a surface edge, might have an axon projection out of the square causing minimal out-degree or, projecting through the entire length of the surface, may have maximal out-degree, that can be estimated by the maximal axon length of in the surface of $s\sqrt{2}$. The maximal expected number of out going connections becomes

$$N\frac{ws\sqrt{2}}{s^2} = N\frac{w}{s}\sqrt{2} \approx 350,$$

with $N = 1000$ and $\frac{w}{s} = 0.252$, reflecting the maximum out-degree extracted from the simulated anisotropic networks (Figure 1.4).

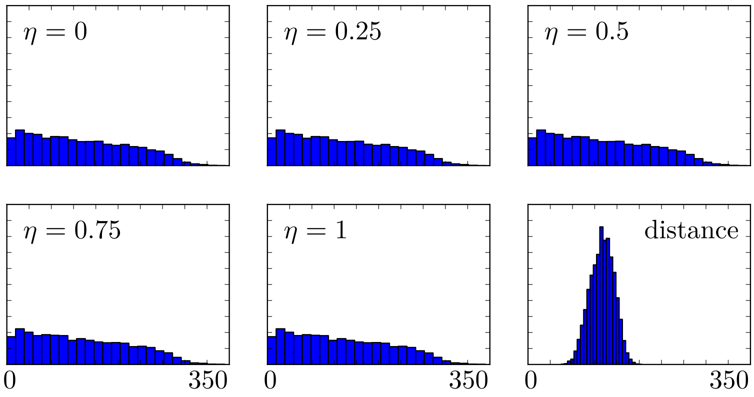

Figure 1.3: Out-degree distribution is does not artefact of boundary conditions

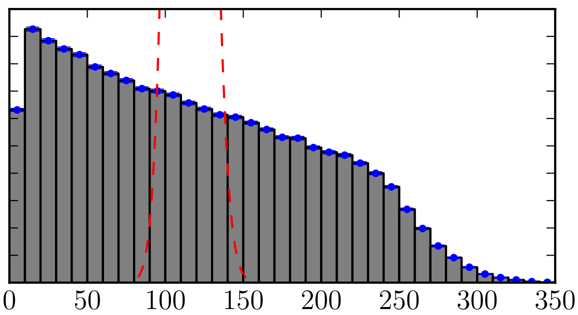

Figure 1.4: s The incline at the beginning is only barely visible due to the choice of bin size. Supplementary figures (**??**) (`019555b0`)

1.2 SMALL WORLD PROPERTIES

Sporns papers

1.3 MOTIFS

BIBLIOGRAPHY

Perin, Rodrigo, Thomas K. Berger, and Henry Markram (2011). A synaptic organizing principle for cortical neuronal groups. *Proceedings of the National Academy of Sciences* 108.13, pp. 5419–5424. DOI: 10.1073/pnas.1016051108.

Roxin, Alex (2011). The Role of Degree Distribution in Shaping the Dynamics in Networks of Sparsely Connected Spiking Neurons. *Frontiers in Computational Neuroscience* 5. DOI: 10.3389/fncom.2011.00008.

Symbol	**Description**
L	Length
Ma	Mach number
p	Pressure