Driven Random Dynamic Reservoir with Homeostatic Variance Control

1 Model Description

1.1 Dynamics

$$x_i^{t+1} = \tanh\left(g_i^t I_i^{t+1}\right) \tag{1}$$

$$I_i^{t+1} = \sum_{j=1}^{N_{\mathrm{net}}} W_{ij} x_j^t + \sum_{k=1}^{N_{\mathrm{in}}} E_{ik} e_k^{t+1} \tag{2}$$

$$g_i^{t+1} = \mu_g \left[\mathrm{Var}_{\mathrm{target}} - \left(x_i^t - \langle x_i \rangle\right)^2\right] \tag{3}$$

1.2 Parameters / Settings

W_{ij} is a sparse random matrix with connection probability $\mathrm{cf}_{\mathrm{net}}$. Nonzero entries were drawn from a Gaussian distribution $\mathcal{N}(\mu = 0, \sigma = \sigma_{\mathrm{conn}}/\sqrt{N_{\mathrm{net}}\mathrm{cf}_{\mathrm{net}}})$. Diagonal entries were always set to zero.

E_{ij} is also a sparse random matrix with connection probability $\mathrm{cf}_{\mathrm{in}}$. Nonzero entries were drawn from a Gaussian distribution $\mathcal{N}(\mu = 0, \sigma = \sigma_{\mathrm{conn}}/\sqrt{N_{\mathrm{in}}\mathrm{cf}_{\mathrm{in}}})$.

e_i^t are activities of an input layer of size N_{in}, which are independently drawn from a uniform $[0, 1]$ distribution for each time step. External input is turned off after $t_{\mathrm{ext.off}}$.

By changing individual gain values g_i, the homeostatic control tries to drive the activity variance of every cell to the value given by $\mathrm{Var}_{\mathrm{target}}$. However, this mechanism is also switched off after $t_{\mathrm{ext.off}}$. This is done because we can assume that homeostatic processes would biologically act on much slower timescales than changes in input. Before $t_{\mathrm{ext.off}}$, we can set μ_g to relatively high values to let homeostasis converge under external drive.

See all parameters in Table 1.

Table 1: Model Parameters

Parameter	**Value**
N_{net}	500
N_{in}	10
$\mathrm{cf}_{\mathrm{net}}$	0.1
$\mathrm{cf}_{\mathrm{in}}$	0.1
σ_{conn}	1.0
μ_g	0.0005
$\mathrm{Var}_{\mathrm{target}}$	0.1
n_t (Sim. Steps)	200000
$t_{\mathrm{ext.off}}$	100000

2 Results

Exemplary results are shown in Fig. 1.

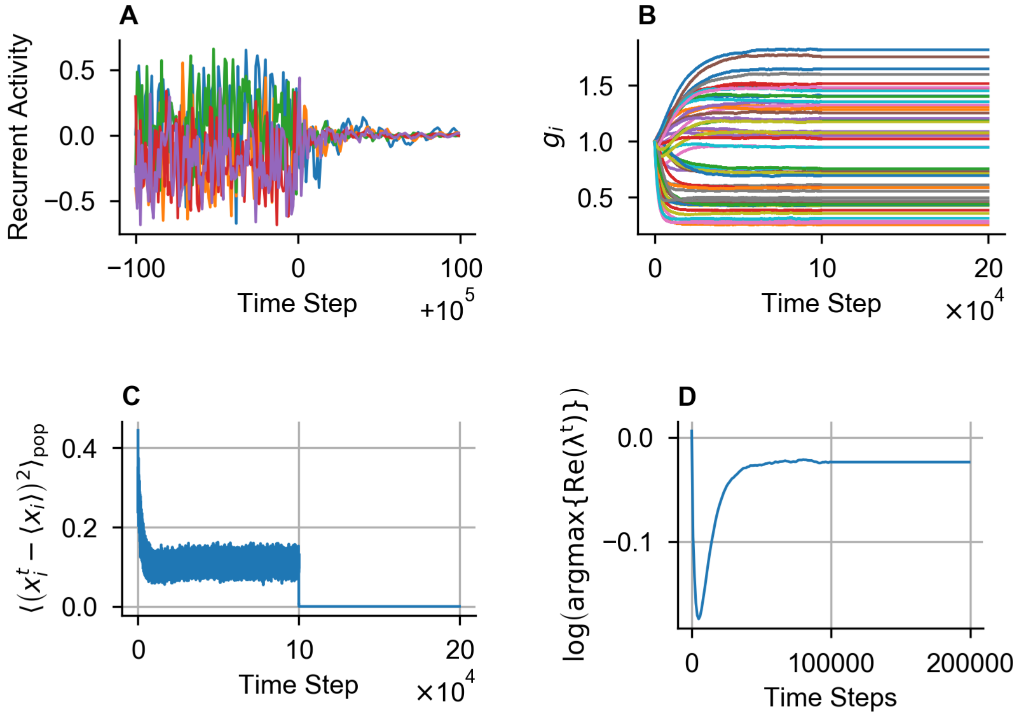

Figure 1: **A**: Sample of activity within $[t_{\mathrm{ext.off}} - 100, t_{\mathrm{ext.off}} + 100]$. **B**: Gain dynamics of $N_{\mathrm{net}}/10$ exemplary neurons. **C**: Population mean of squared activity. **D**: Log. of largest real part of eigenvalues of $g_i^t W_{ij}$.