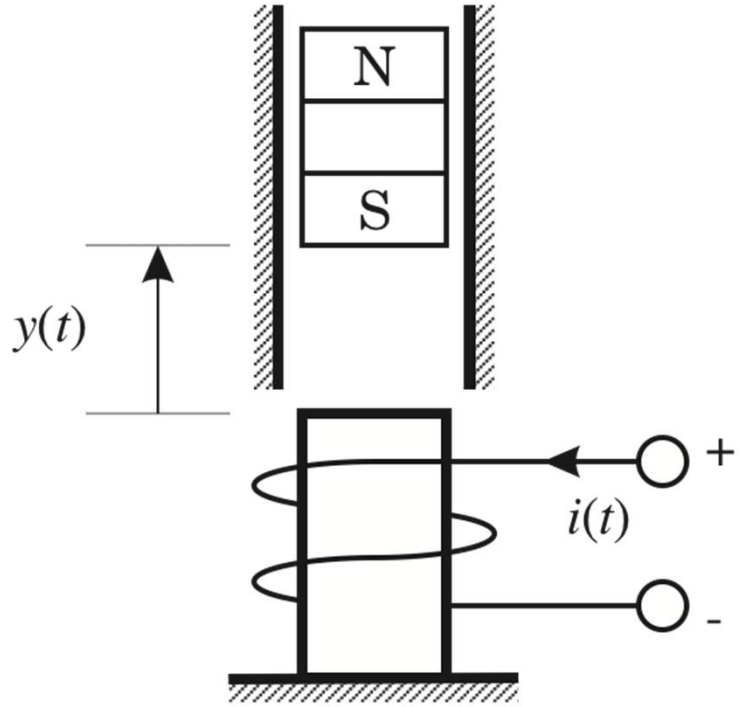
Prediction Case Study: Magnetic Levitation

Magnetic Levitation System

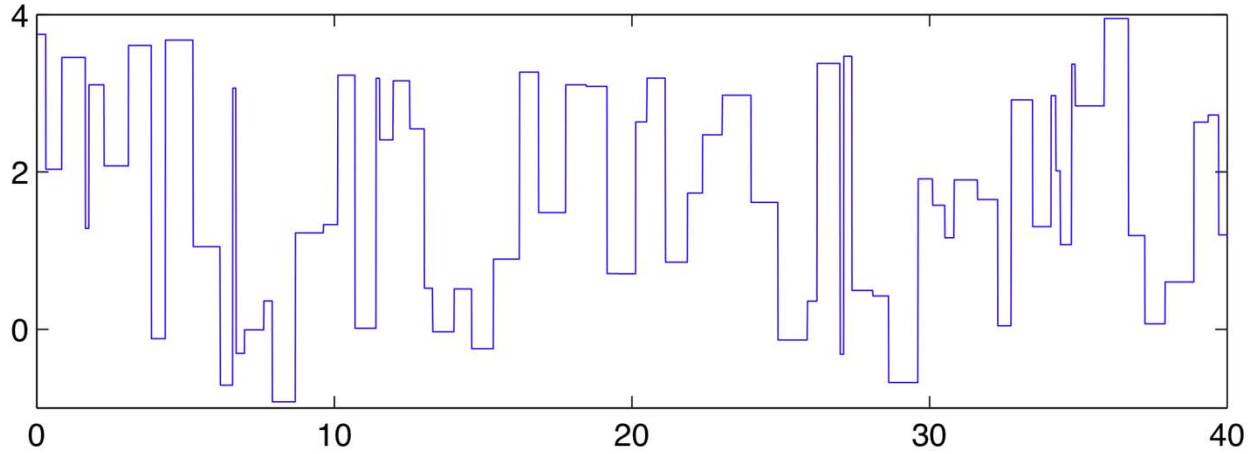


$$\frac{d^2y(t)}{dt^2} = -g + \frac{\alpha}{M}\frac{i^2(t)\mathrm{sgn}(i(t))}{y(t)} - \frac{\beta}{M}\frac{dy(t)}{dt}$$

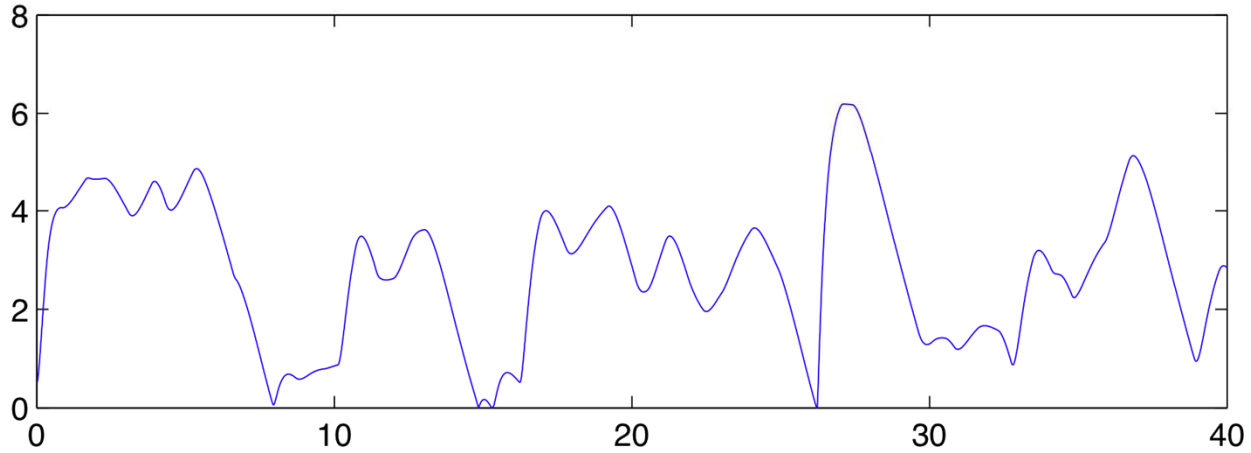
$$\beta = 12, \quad \alpha = 15, \quad g = 9.8, \quad M = 3$$

Training Data

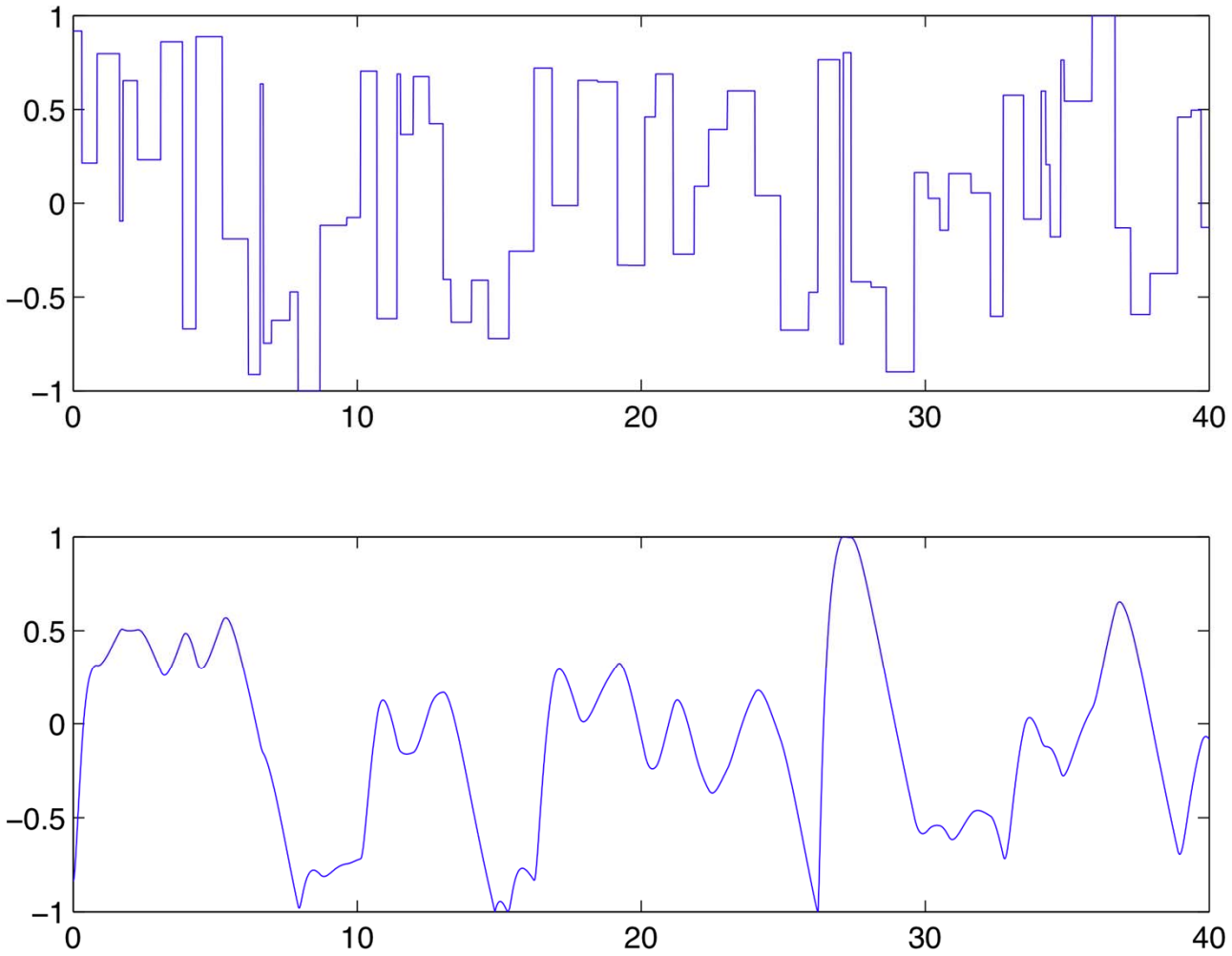
Skyline Function



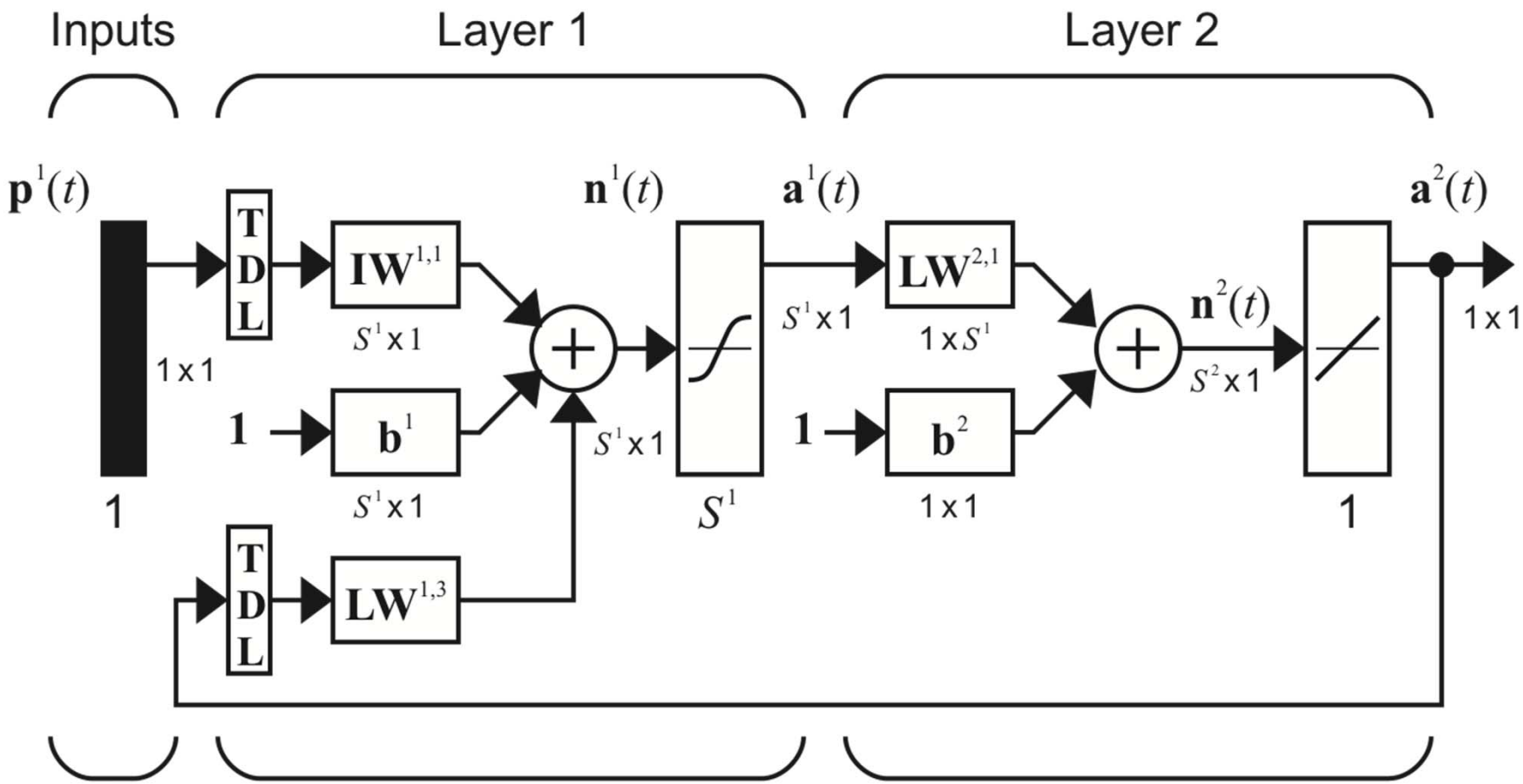
Sampling Rate = 0.01 sec



Scaled Training Data

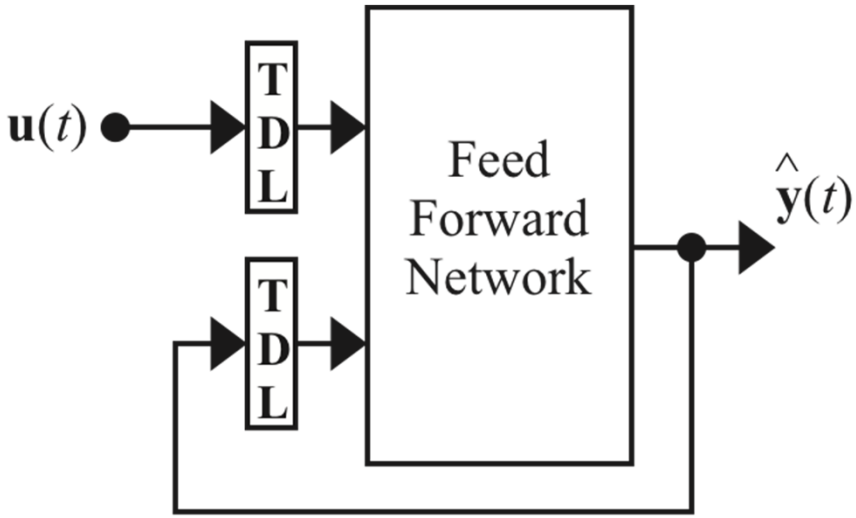


NARX Network

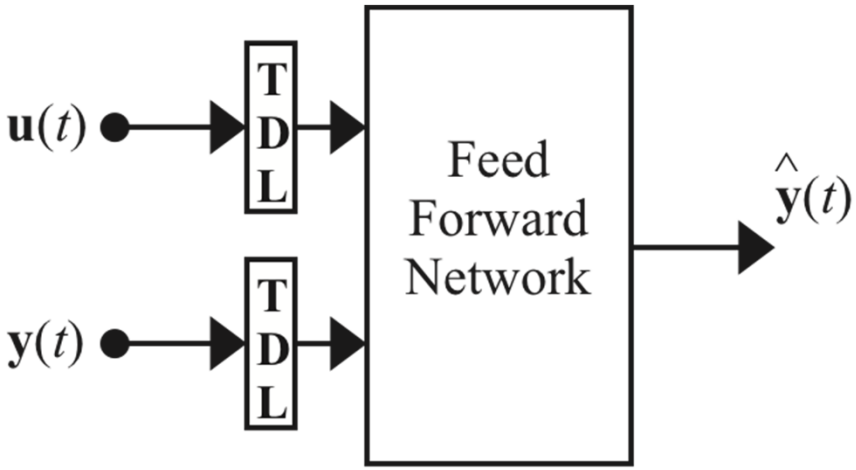


$$y(t) = f\left(y(t-1), y(t-2), \mathrm{K}\ , y\left(t-n_y\right), u(t-1), u(t-2), \mathrm{K}\ u\left(t-n_u\right)\right)$$

27 Parallel and Series-Parallel Forms



Parallel Architecture

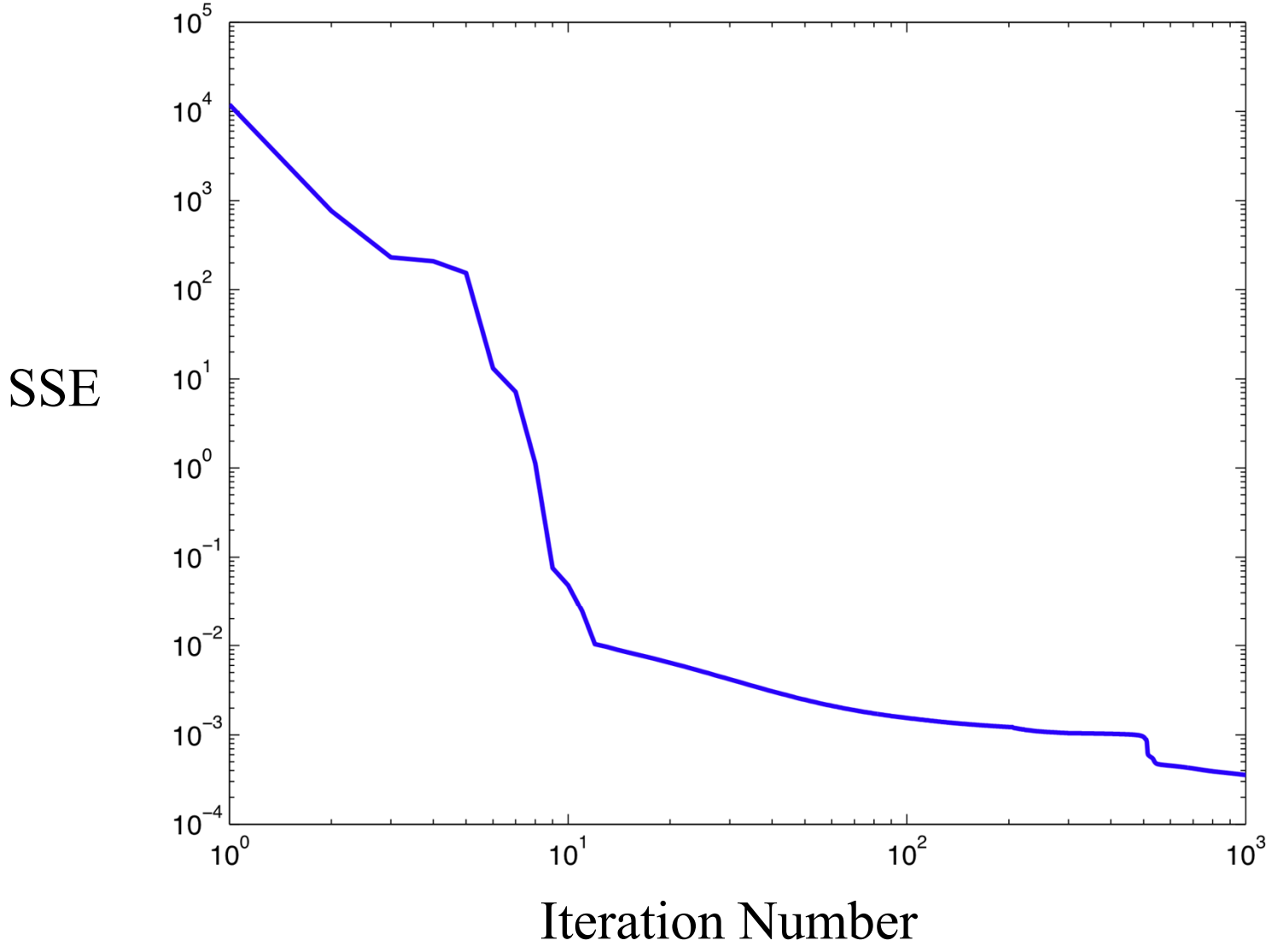


Series-Parallel Architecture

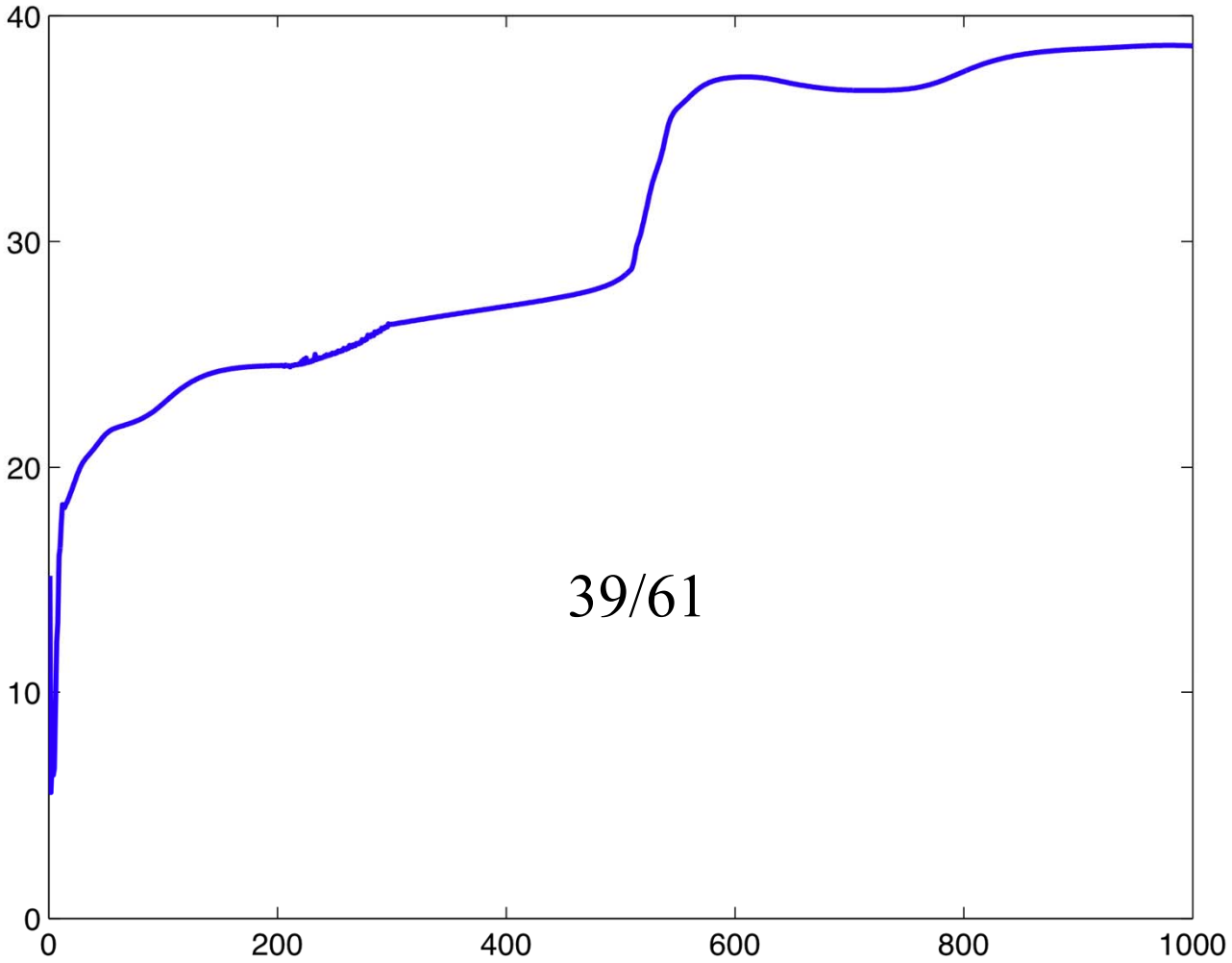
$$\mathbf{p} = \begin{bmatrix} u(t-1) \\ u(t-2) \\ y(t-1) \\ y(t-2) \end{bmatrix} \qquad \mathbf{t} = \begin{bmatrix} y(t) \end{bmatrix}$$

4-10-1 Network

Network Training

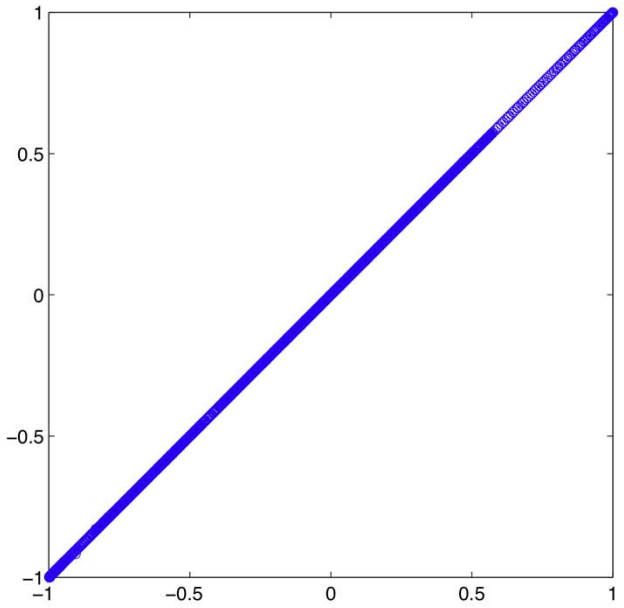


27 Effective Number of Parameters

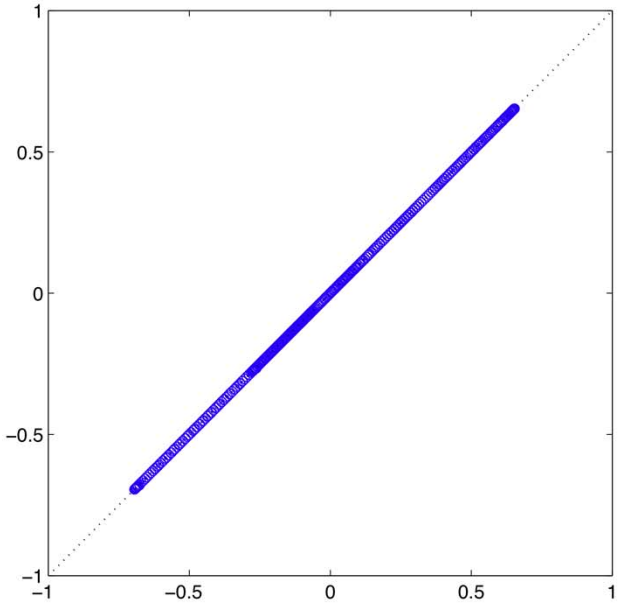


Scatter Plots

Training

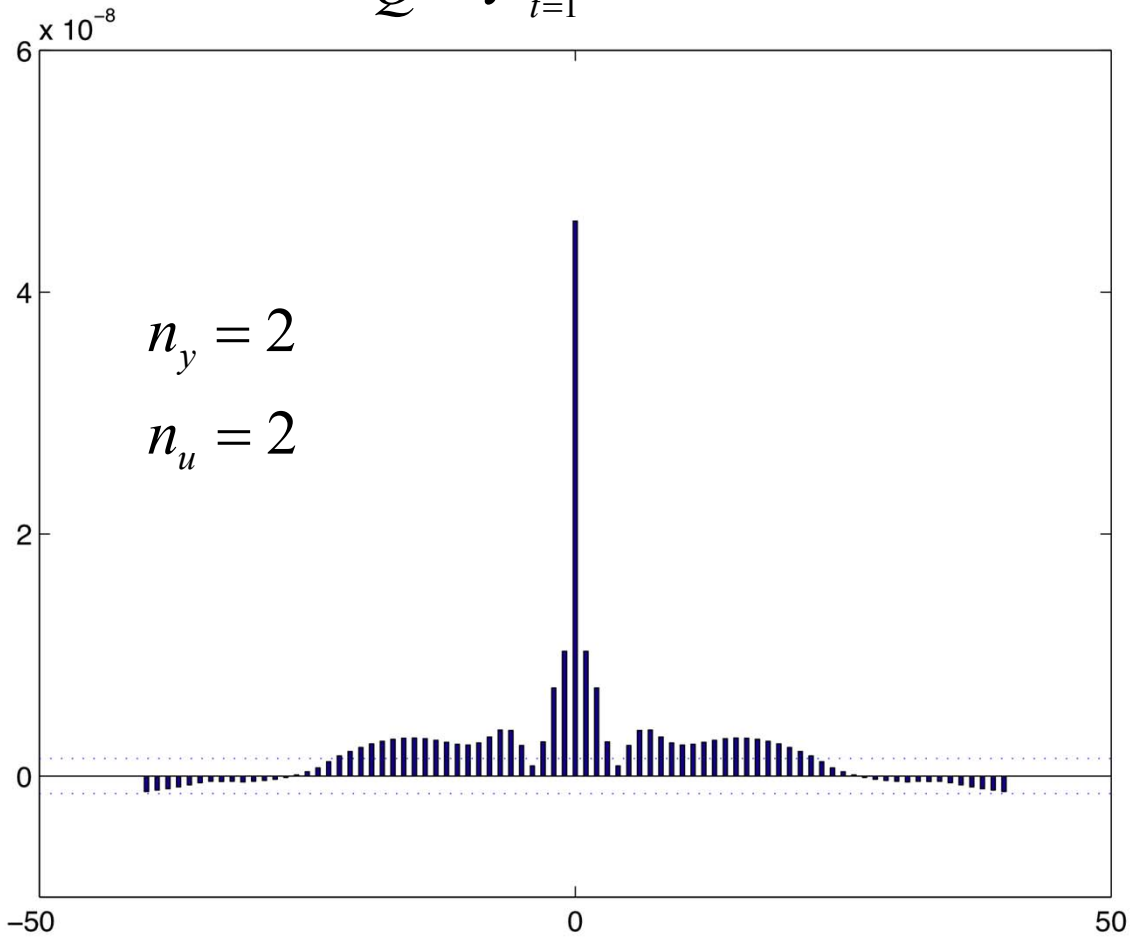


Testing

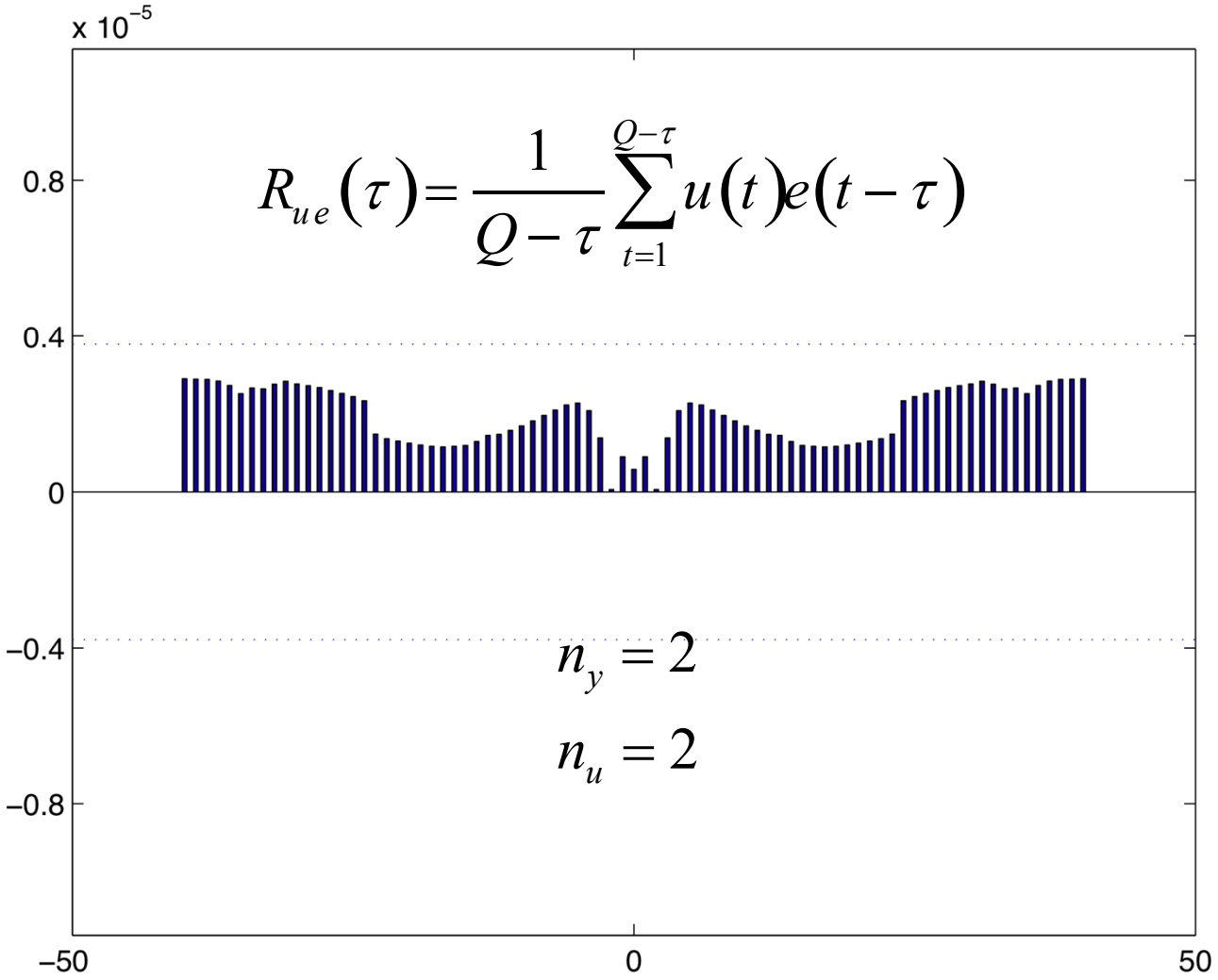


Prediction Error Autocorrelation

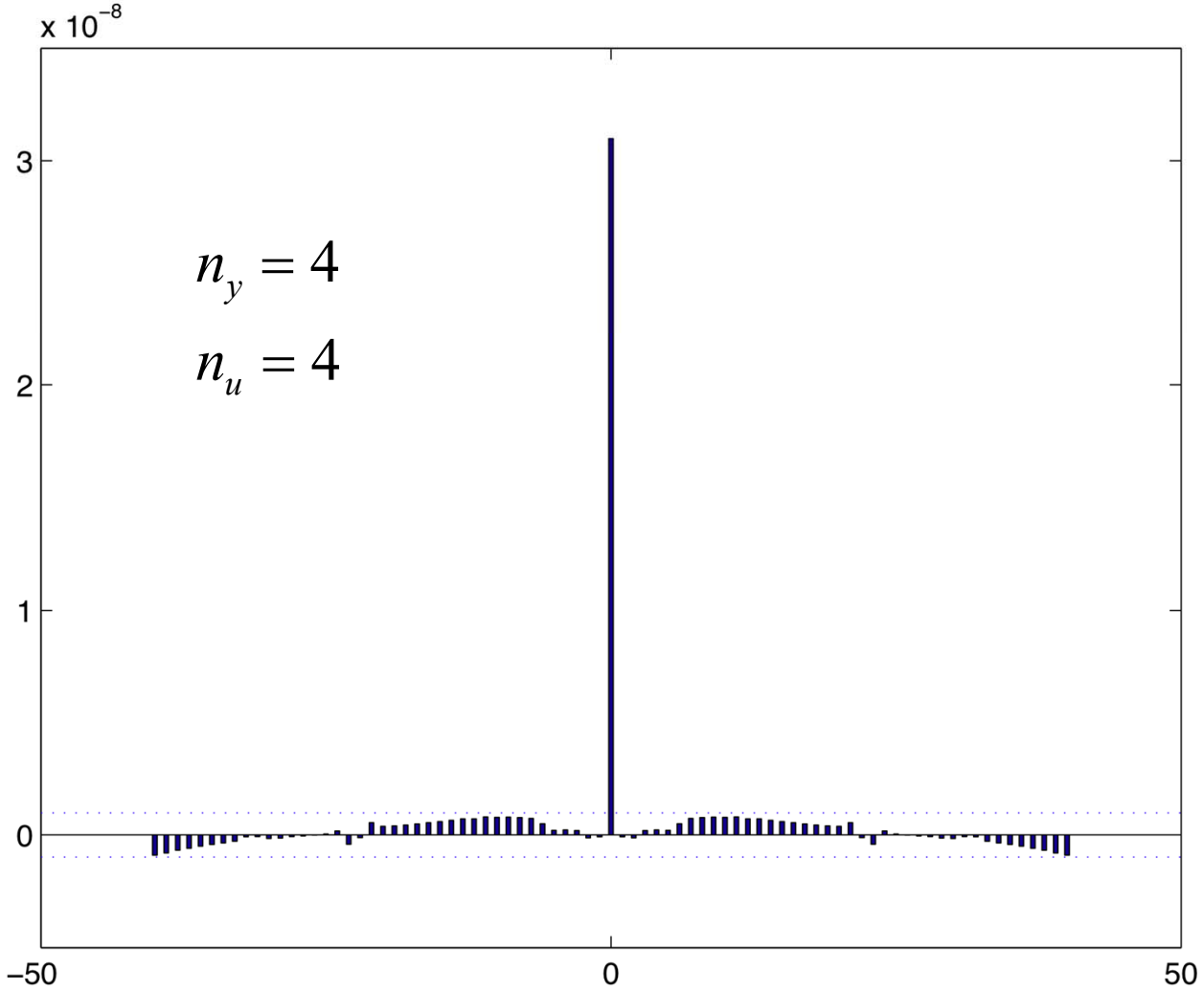
$$R_e(\tau) = \frac{1}{Q-\tau}\sum_{t=1}^{Q-\tau} e(t)e(t-\tau)$$



Error/Input Crosscorrelation



27 Prediction Error Autocorrelation



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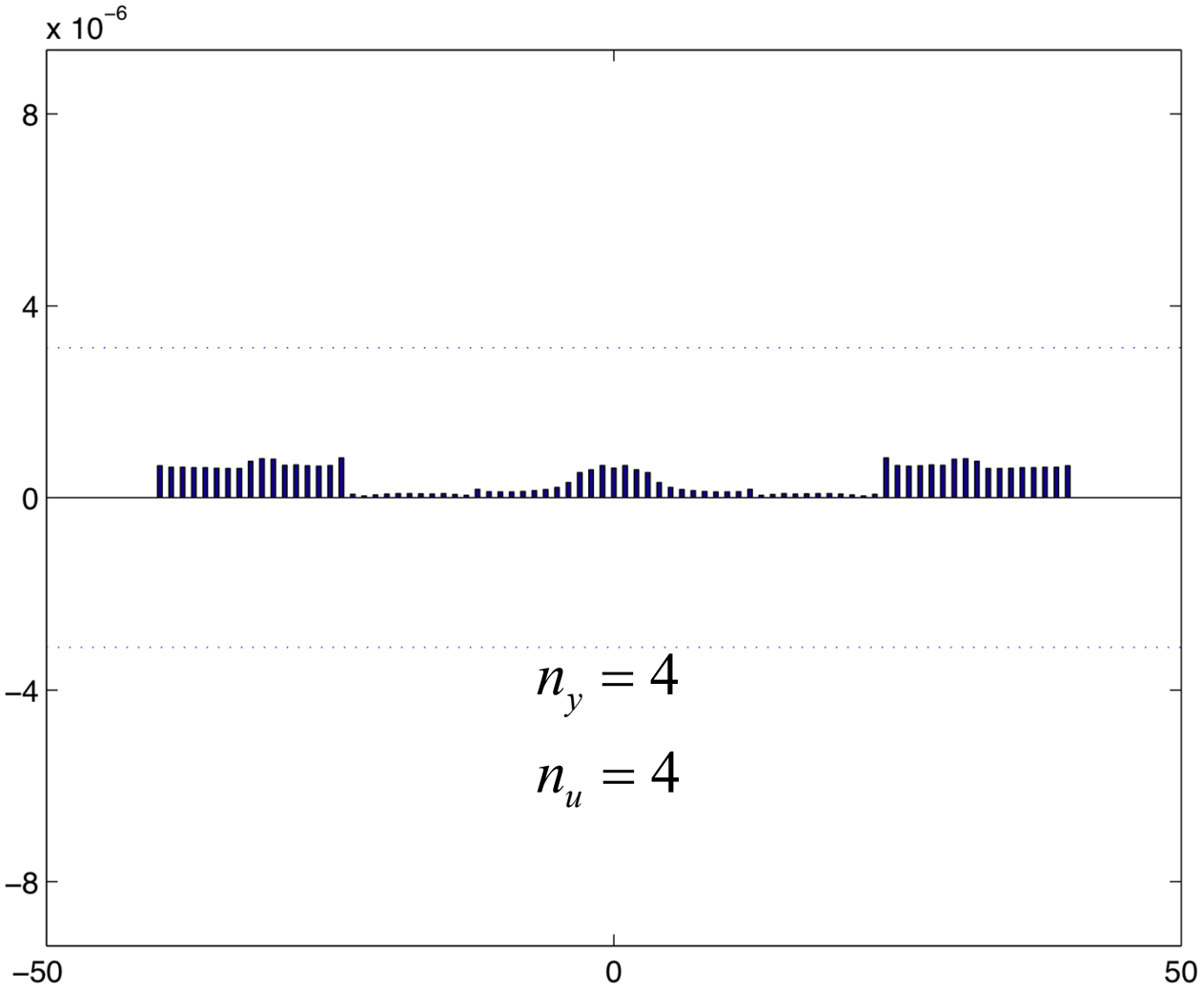
Error/Input Crosscorrelation



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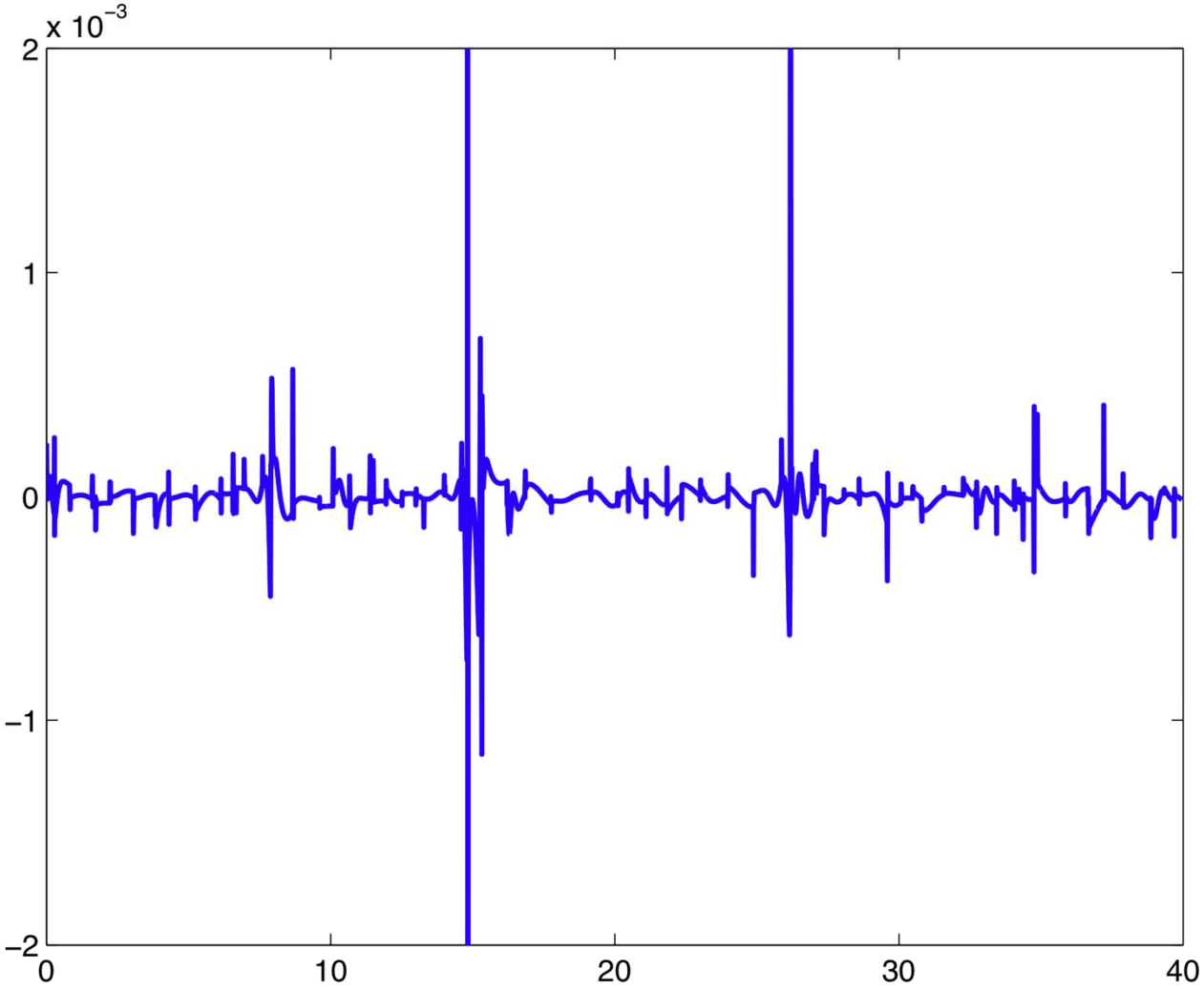
Prediction Errors



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Iterated Prediction