PID neural networks for time-delay systems

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Outline

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PID controller

- not suitable for long time-delay system
- PID parameters are difficult to choose

Artificial neural networks

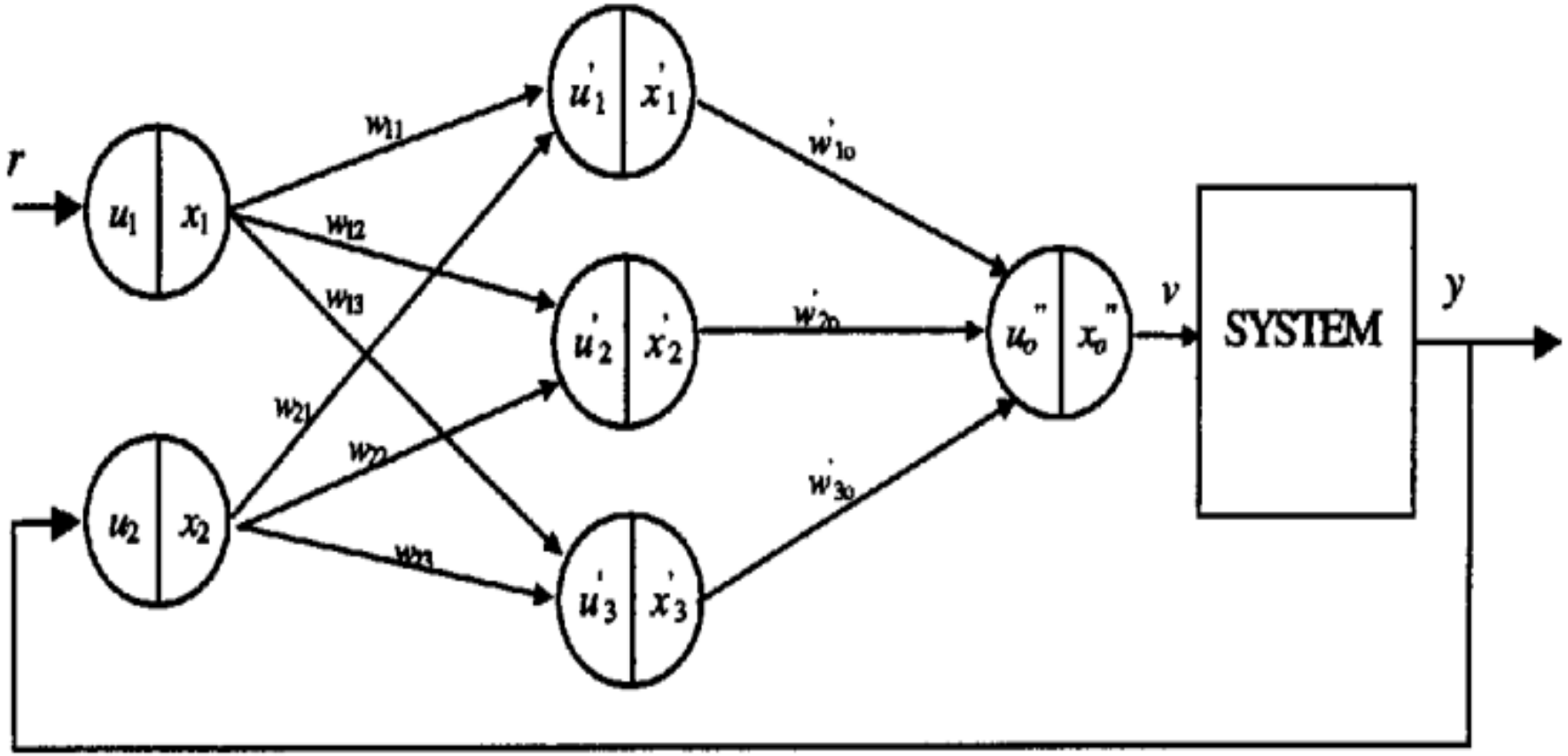
- slow learning speed
- long weight convergence
- uncertain property

PIDNN

- proportional(P), integral(I) and derivative(D) neurons
- back-propagation

Outline

schema


r
u1
x1
w11
w12
w13
w21
w22
w23
u2
x2
u'1
x'1
u'2
x'2
u'3
x'3
w'10
w'20
w'30
u0"
x0"
v
SYSTEM
y

Outline

Input-output function

$$x_i(k) = u_i(k)$$

$$x_1'(k) = u_1'(k)$$

$$x_2'(k) = x_2'(k-1) + u_2'(k)$$

$$x_3'(k) = u_3'(k) - u_3'(k-1)$$

$$x_1''(k) = u_1''(k)$$

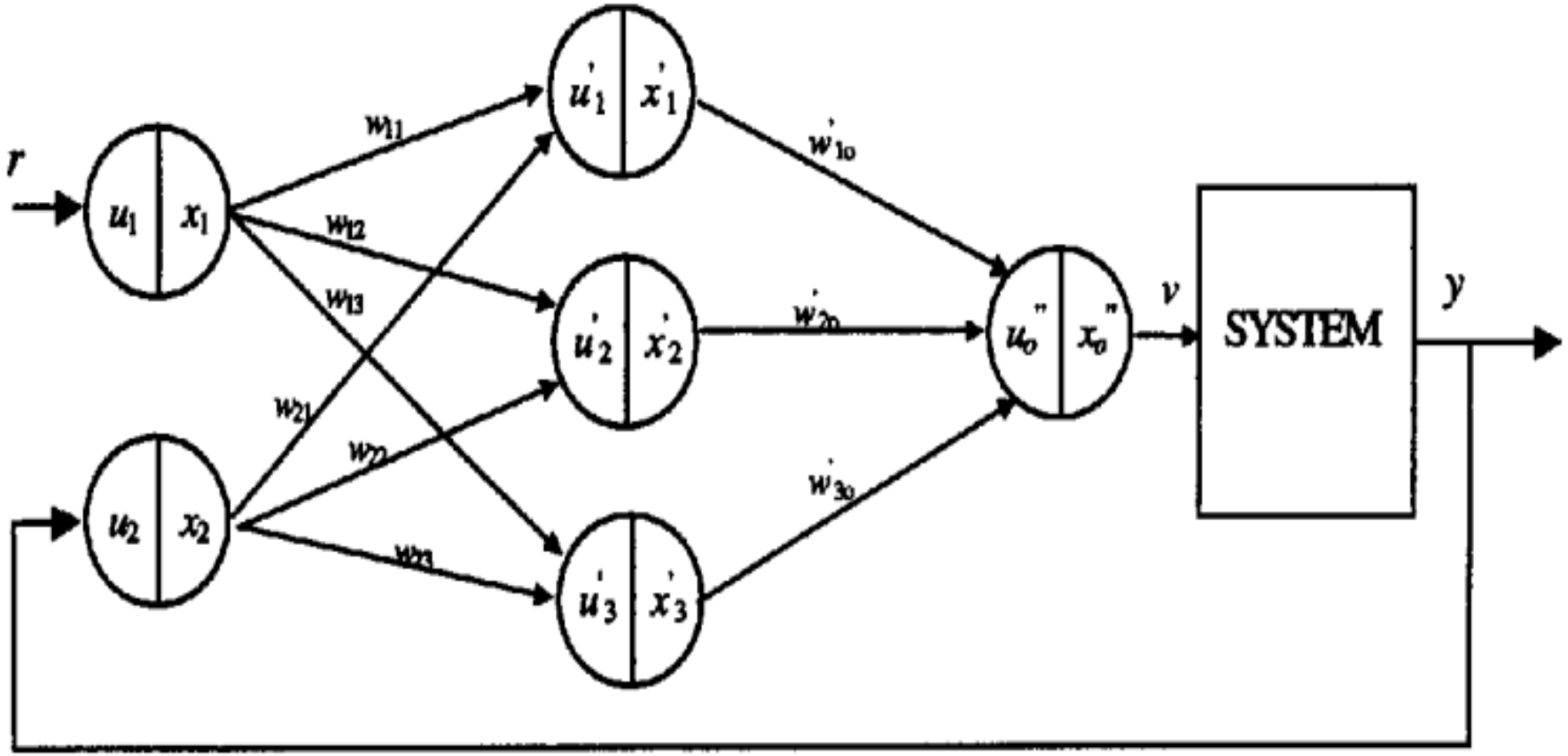
Objective function

$$J = \sum_{k=1}^{n} [r(k) - y(k)]^2$$

$$w'_{j0}(n_0 + 1) = w'_{j0}(n_0) - \eta_j * \frac{\partial J}{\partial w'_{j0}}$$

$$w_{ij}(n_0 + 1) = w_{ij}(n_0) - \eta_i * \frac{\partial J}{\partial w_{ij}}$$

schema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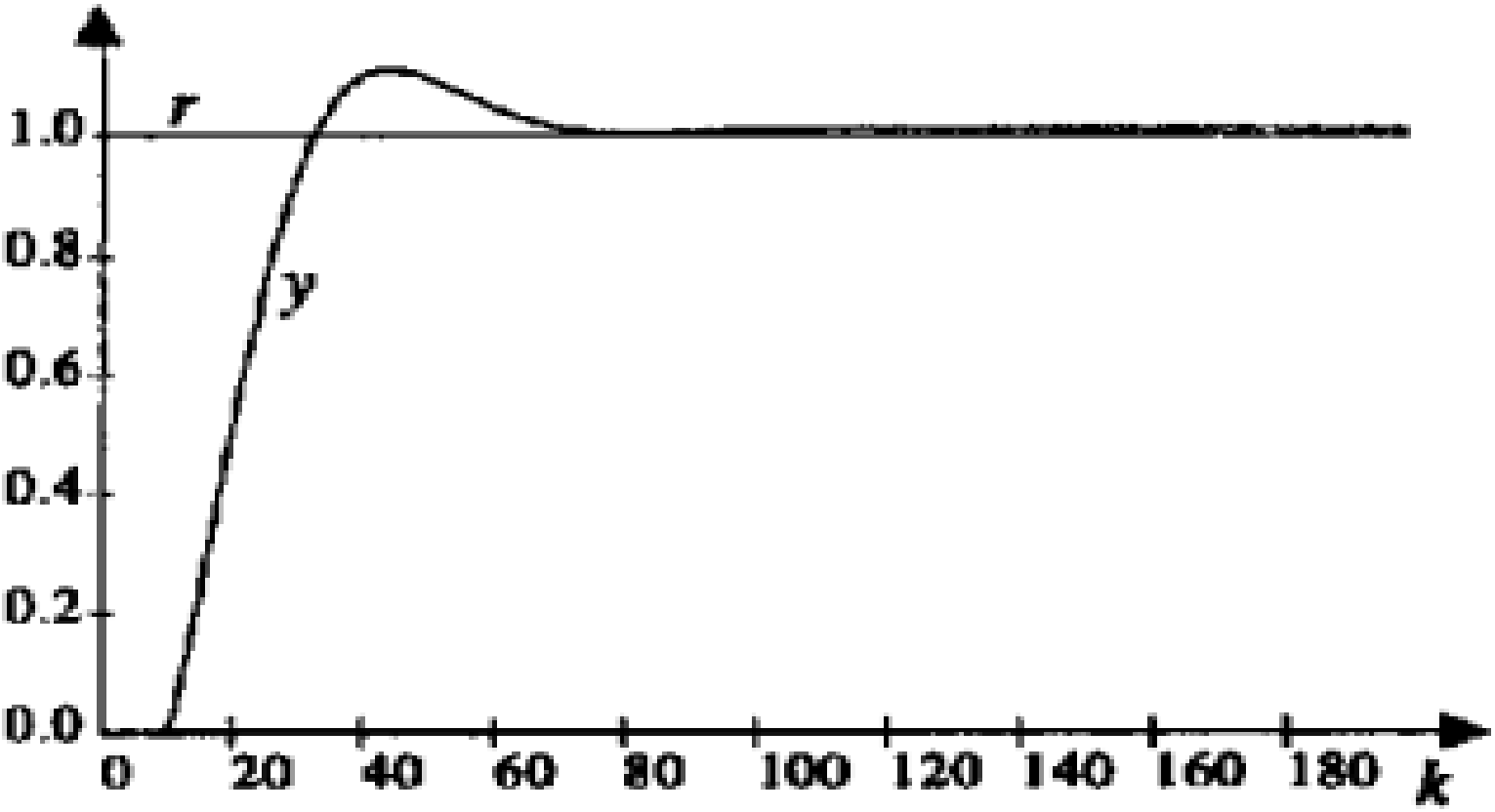
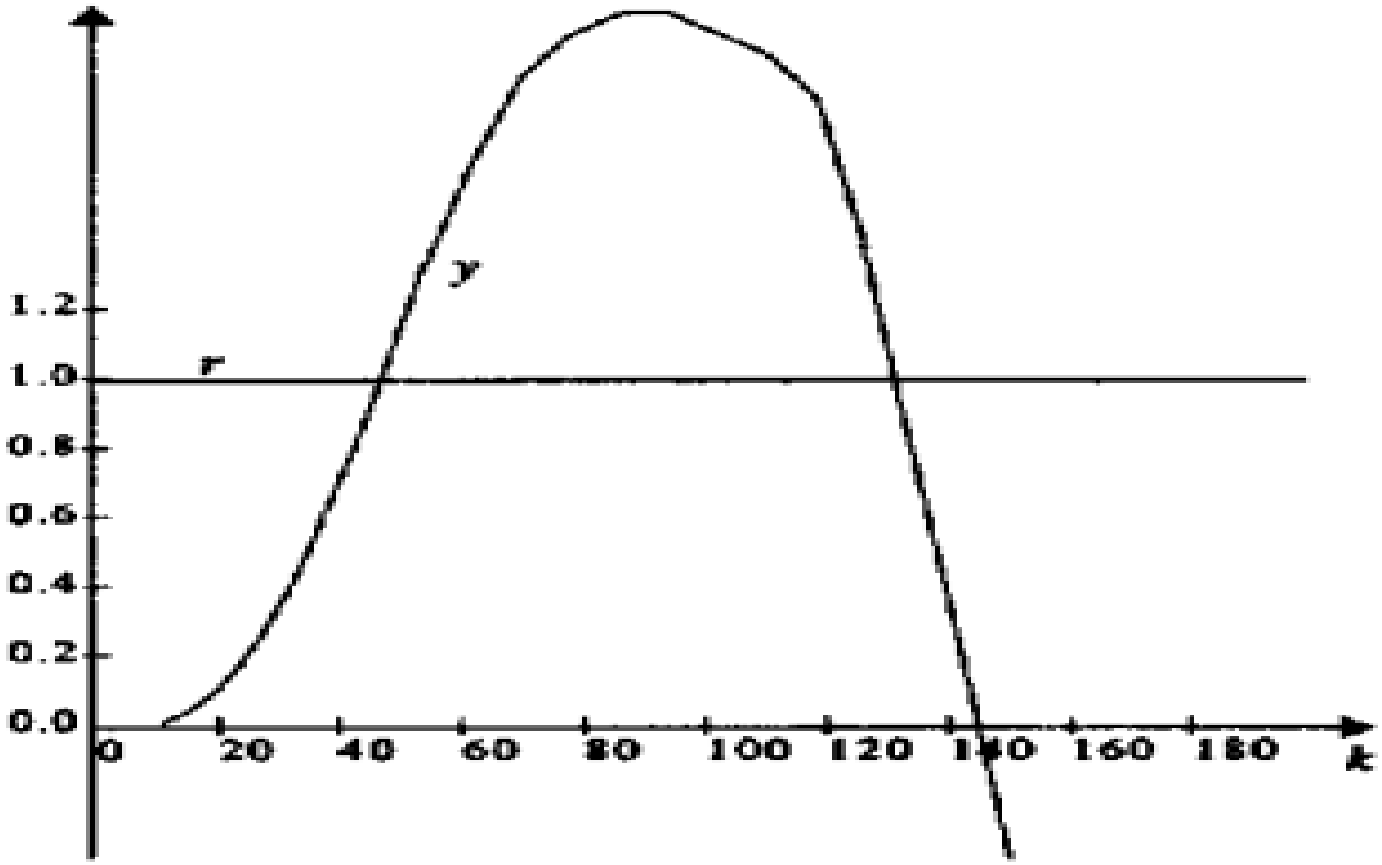
Example

$$\begin{aligned} y(k+1) &= 1.368 * y(k) - 0.368 * y(k-1) \\ &\quad +0.0092 * v(k-10) + 0.066 * v(k-11) \end{aligned}$$

Using PIDNN



Using PID



Conclusion

- No need to calculate the system parameters
- Short convergence time.