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Estimation of Hammerstein nonlinear systems with noises using filtering and recursive approaches for industrial control

Key words: Hammerstein nonlinear systems; Neural fuzzy network; Data filtering; Hybrid signals; Industrial control

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Motivation

- Noises generally exist in practical industrial applications, and often present colored noise.
- The neural fuzzy model (NFN) has both the self-learning ability of the neural network model and the reasoning ability of the fuzzy model.
- The intermediate variable of the Hammerstein system is unmeasurable, increasing the difficulty of parameter estimate.

Main idea

- An NFN-based Hammerstein system is proposed by combining the advantages of the structure of Hammerstein system and NFN model.
- The strategy presented here decouples the parameter estimate of the nonlinear block from that of the linear block using designed hybrid signals, which can solve the problem of unmeasurable intermediate variable information.
- Data filtering is introduced to derive a filtering-based recursive extended least squares (RELS) algorithm for the Hammerstein nonlinear systems with noise, which can reduce the influence of moving average noise and improve estimate accuracy.

System model

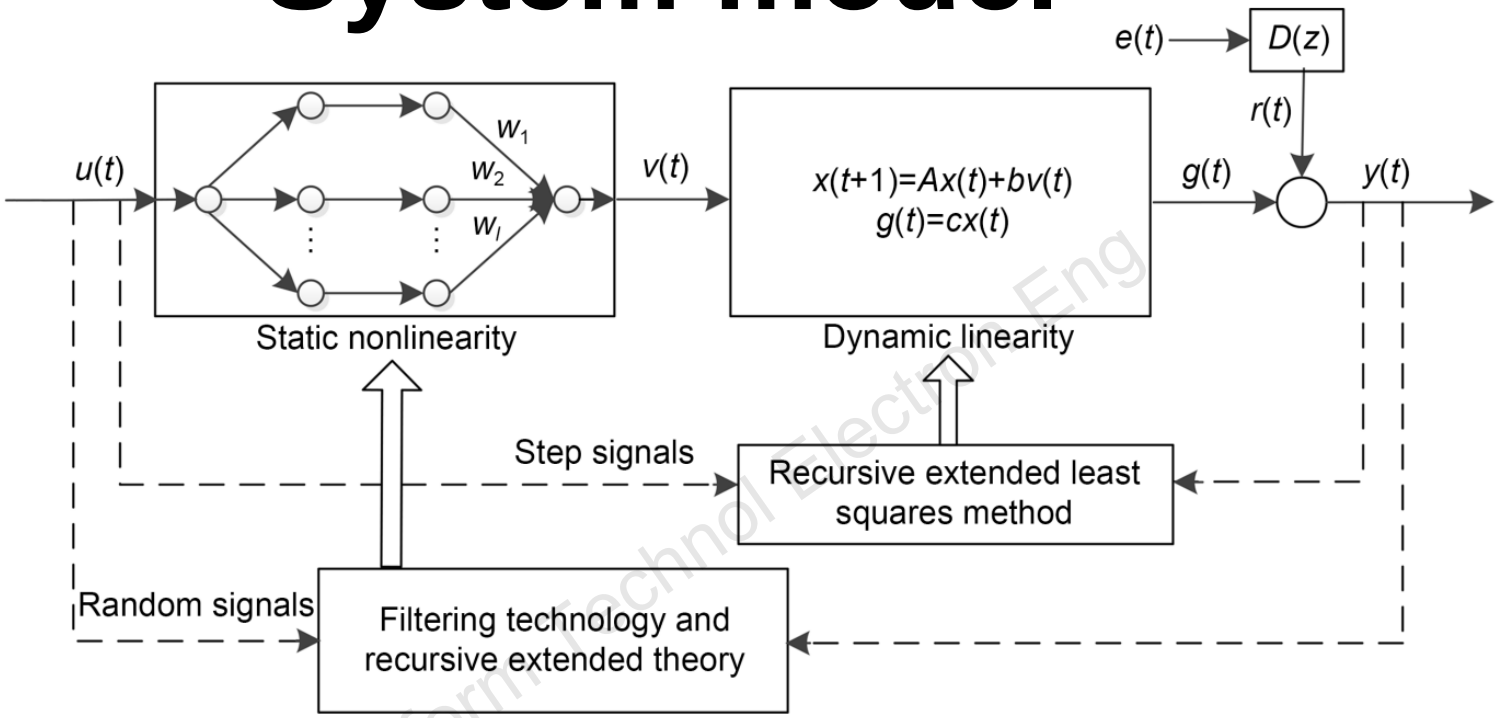


Fig. 1 Hammerstein nonlinear systems

Step 1: The parameters of the state–space model are estimated using the RELS algorithm by using the input–output of step signals.

Step 2: Based on input–output random signals, the parameters of the NFN model is estimated by employing the data filtering technology and recursive extended theory.

Major results

1. The pH control results

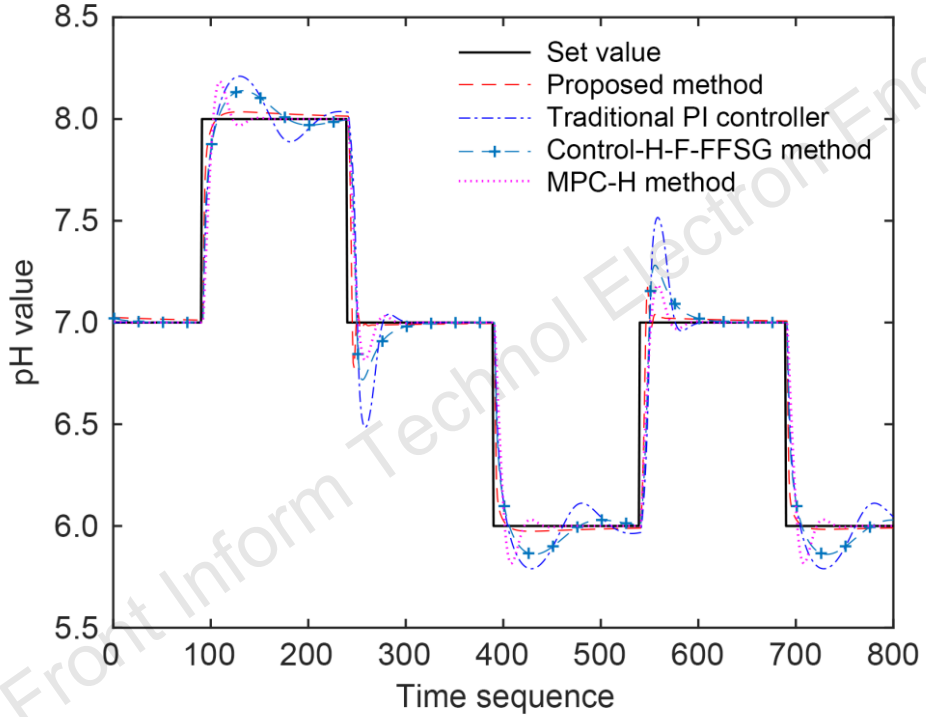


Fig. 2 Set value tracking output response

As can be seen in Fig. 2, for selecting different pH values, the presented control method can track, with effect, the set values with better overshoot and a higher response speed.

Major results

2. The control results of continuous stirred tank reactor

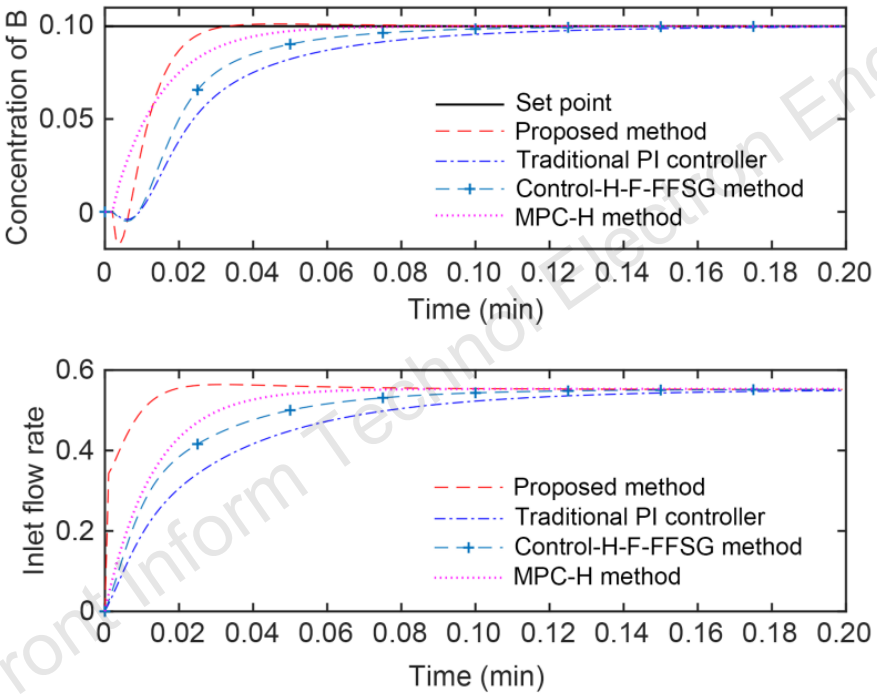
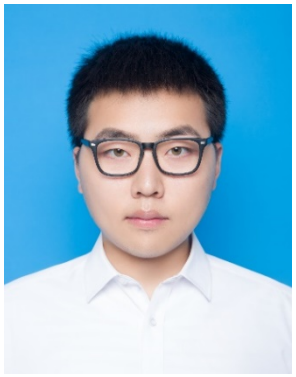


Fig. 3 Results of setting value 0.1

In terms of adjustment time, the proposed method has a noticeable reduction compared with the MPC-H method, Control-H-F-FFSG method, and traditional PI controller, which further proves the validity of the proposed control scheme.

Conclusions

- The presented Hammerstein system can be used for modeling nonlinear processes, such as pH process and continuous stirred tank reactor process.
- Using the special structure of the Hammerstein system to design the nonlinear process control system, a feasible scheme for nonlinear system control is provided.



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