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Modeling of a dynamic dual-input dual-output fast steering mirror system

Key words: Fast steering mirror; Dynamic system; Input-output coupling, Physical modeling; Subspace identification

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Motivation

- Fast steering mirrors (FSMs) have been widely used in various applications, e.g., telescope systems, retina imaging, and wireless laser communication.
- Model-based control approaches have shown great potential to further improve the performance of closed-loop FSM systems and an accurate model of the open-loop FSM system is crucial for model-based controller design.
- As the sampling rate of the position sensor increases, the dynamics of the FSM becomes evident.
- The input and output channels of the FSM system are coupled, which adds to the difficulty in modeling the dynamics of the FSM system .

Main idea

- A physical model of the FSM system is derived, describing the dynamics and coupling between the inputs and outputs of the FSM system.
- Unknown parameters in the state-space model are identified by the subspace identification algorithm, based on the measured input-output data of the FSM system.
- The variance-accounted-for of the state-space model is better than 97%, not only for the modeling data but also for the validation data set, indicating high accuracy of the model.
- Comparison is made between the proposed dynamic model and the conventional static model, where improvement in model accuracy is clearly observed

Method

1. Modeling the fast steering mirror, FSM-PSD system and representing them in state-space form.
2. Unknown parameters in the state-space model are identified by the subspace identification algorithm, based on the measured input-output data of the FSM system
3. We used the variance-accounted-for of the state-space model to evaluate the accuracy of the model, and compared it to the conventional static model, where improvement in model accuracy is clearly observed.

Major results

- The accuracy of system model is high in the case of random input signals.

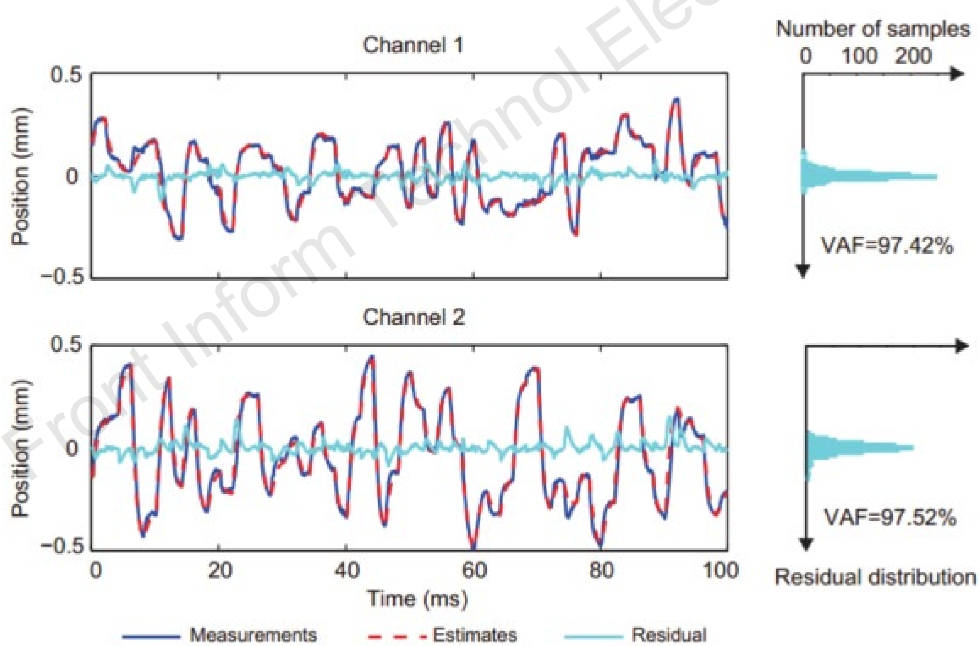

Fig. 8 Comparison between model estimate and measurement in the case of random input signals (only the first 100 ms are plotted). A VAF of more than 97% is achieved for both output channels

Major results

- The accuracy of system model is high in the case of sinusoidal excitations.

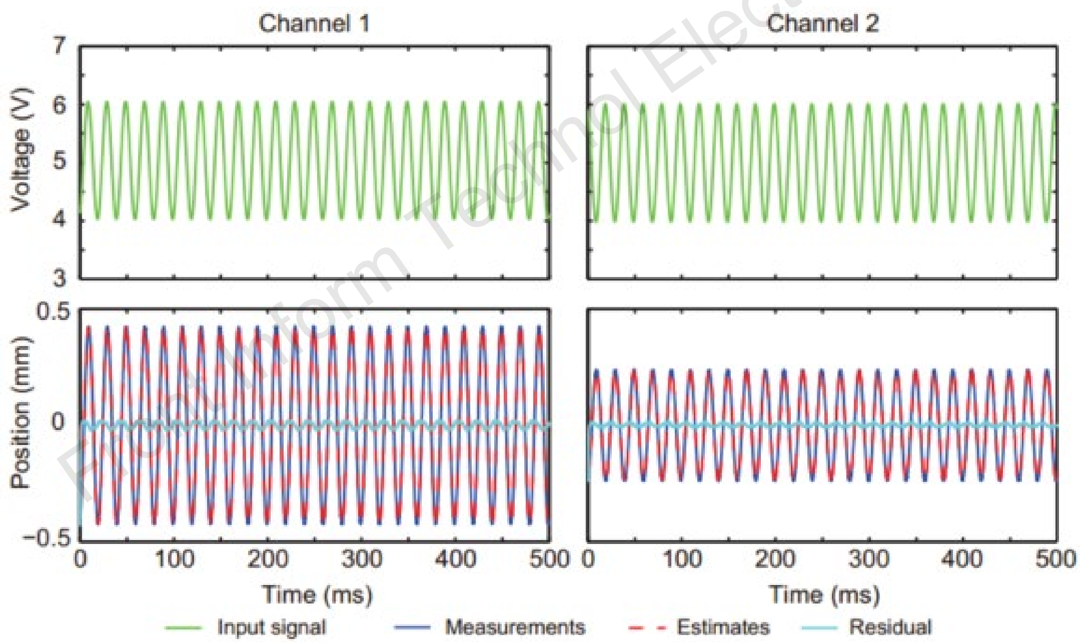

Fig. 9 Comparison between measurements and model estimates in the case of sinusoidal excitations

Major results

- The accuracy of system model is high in the case of ramp excitations.

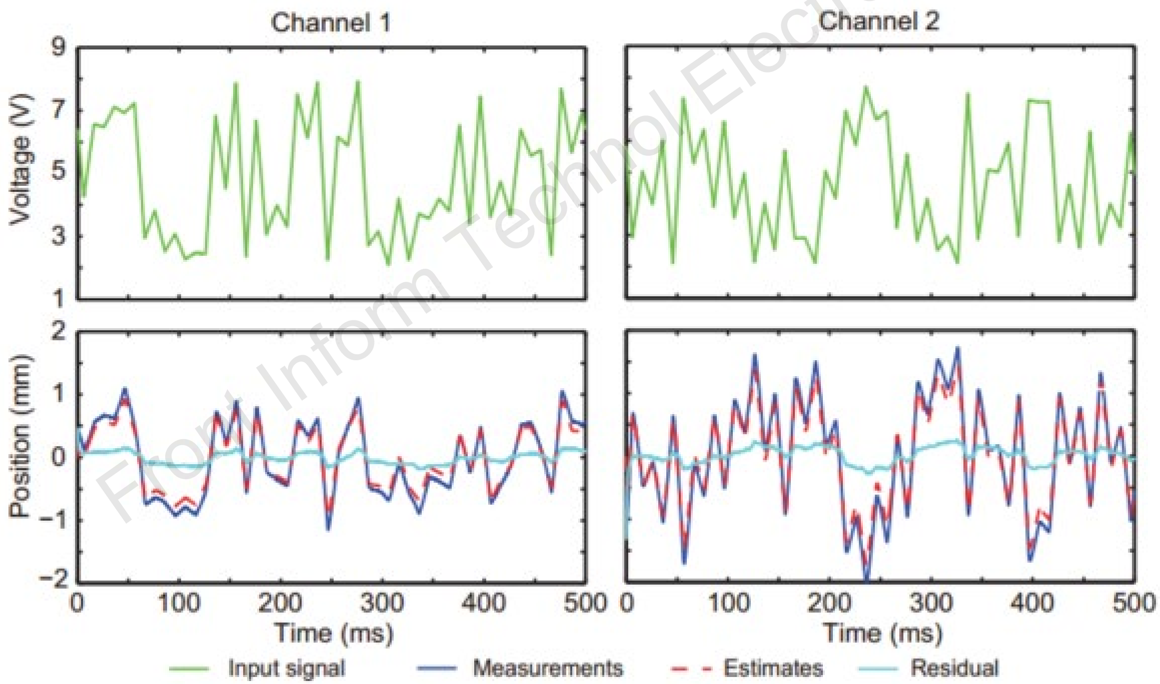

Fig. 10 Comparison between measurements and model estimates in the case of ramp excitations

Conclusions

- Modeling of an FSM system was discussed, with the dynamics and input-output coupling of the FSM system considered..
- The model was built based on physical principles and identified from input-output data of the system by subspace identification.
- Experimental results showed that the VAF values for the dynamic-coupling model are all better than 97%, in the cases of sinusoid, ramp, and random test signals, indicating high accuracy of the model.