Inferential motion control of a wafer stage: from disturbance observers to position-dependency

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Description of poster

Ever-increasing positioning accuracy and acceleration requirements lead to a situation where the flexible dynamics in precision motion systems are no longer negligible. As a result,

1. a rigid-body approach can no longer be used to accurately infer the positioning of unmeasured performance locations, e.g., the point-of-exposure in lithography, from non-collocated sensor measurements, as illustrated in the top left of Figure 1;
2. the system dynamics become position dependent for varying sensor positions or performance locations.

As a consequence, traditional control design approaches are insufficient and advanced model-based techniques are required to achieve the desired performance [1].

In this research, (i) an observer-based method is proposed for control of unmeasured performance variables in flexible mechanical systems [1, 2]. Additionally, (ii) an observer-relevant system identification approach for identifying position-dependent dynamics is developed as this is critical for performance of high-precision motion systems [2, 3]. As an illustration, two mode shapes of the identified position-dependent model of a wafer stage are shown in the right of Figure 1.

The observer-based method is applied to a prototype wafer stage with pronounced flexible dynamics, as depicted in the bottom left of Figure 1 and schematically represented in the top left of Figure 1. Early results are shown in the middle of Figure 1, where the proposed method is compared to a conventional PID controller. It is concluded that this method is capable of eliminating the steady-state error induced by the deformation, by taking flexibilities into account, while the conventional controller is incapable of mitigating this error. Hence the proposed method leads to a major increase in positioning performance.

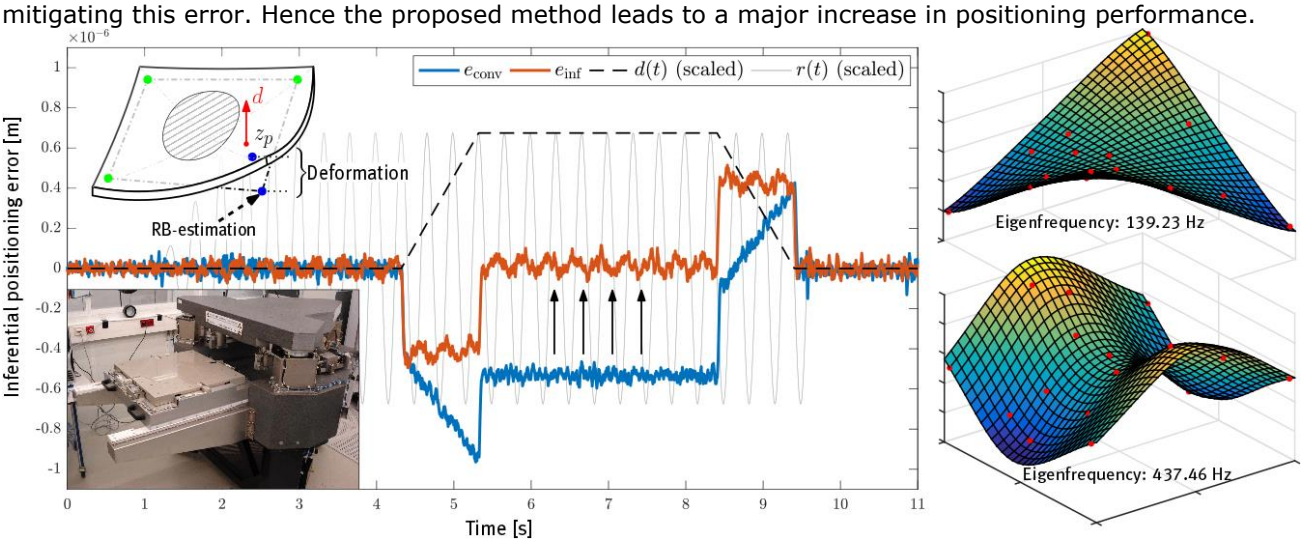

Figure 1
Left: resulting positioning error for the conventional controller (blue) compared to the observer-based controller (red). Showing that the observer-based controller eliminates the deformation error, whereas conventional methods are incapable of dealing with the flexible behavior. Right: two mode-shapes of the identified position-dependent model of the wafer stage setup.

References

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