Xtreme motion : control of non-rigid body dynamics of a high precision positioning stage

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Introduction

The trend in the semi-conductor industry is still prescribed by Moore's law which states that the resolution of chips will increase while the costs per functionality will decrease. To comply with this law, positioning systems of lithography machines need to become faster and more accurate. To make the system faster, higher accelerations are required. Newton's Laws prescribe that this can either be done by applying higher forces, or by reducing the weight of the system. The first option is less favorable, since stronger actuators consume more power and produce more heat, which deteriorates the performance of the system. An alternative to increase productivity of lithography machines is to increase the standard wafer diameter from the current 300 mm to 450 mm. But, both larger and lighter stages will be more flexible, which can interfere with the accuracy of the positioning system. This motivates research on the control of high precision flexible motion stages. This abstract discusses some of the challenges that will be faced in this research area.

1 Conventional controllers

Currently, most high precision motion systems are controlled using geometric decoupling and single-input-single-output (SISO) controllers. Assume that the goal of the controller is to achieve good performance at a certain point on the system, denoted by z. The measurement of the position of the system y is typically not performed at the location z, but since it is assumed that the system is rigid, a simple geometric transformation can be used to compute z from y. Moreover, by using geometric decoupling, it is even possible to compute z for all axes in the system separately.

2 Control of flexible motion stages

The approach of the previous section cannot be followed if the system is not rigid, but flexible. In flexible systems the performance z and the measurement y are no longer related via a static, but a dynamic relation. The control problem is visualized clearly by the standard plant formulation, as depicted in Figure 1. It shows that $y \neq z$. The derivation of a control signal to get performance at z using an input u based on a measurement y will be topic of research. Different control strategies such as inferential control modal control, H_∞ control will be investigated.

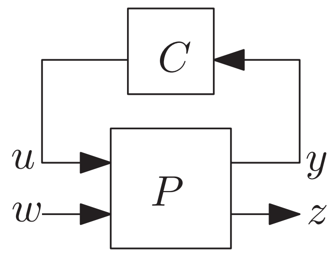

Figure 1: Standard plant system representation. The plant P is controlled with controller C, by applying an input u based on a measurement y. Note that the disturbances w and performance z are different from u and y.

Conventionally, there will be as much actuators in the system as there are rigid body modes. But the extra dynamics in the system will probably require more actuators than rigid body modes to suppress the internal dynamics. In this research, it will be studied, whether extra actuators can be used to improve the performance of the system. When the number of actuators is larger than the number of rigid body modes, the terminology *overactuated* or *non-rigid body control* is used.

The term *performance* has been mentioned a few times now, but presently it is even not clear yet what the performance needs to be for this system. This also depends on the chosen strategy. One approach could be to damp all internal dynamics. This would give a spatially distributed performance specification. An other approach could be to position the point of interest very accurately while the rest of the system is allowed to be in motion. This leads to a performance specification at a certain point on the geometry.

3 Conclusion

A few issues regarding the control of flexible high precision motion stages have been discussed. The key feature of these systems is that the control can no longer be done with decoupling and SISO controllers. The spatial distribution of the system and its internal dynamics have to be taken into account when the system is flexible.