

Towards predictive maintenance via digital twinning: Bridging data-driven and model-based fault detection and isolation

Citation for published version (APA):

Classens, K. H. J., Oomen, T. A. E., Heemels, W. P. M. H., van de Wijdeven, J. J. M., van de Wal, M. M. J., & Aangeneet, W. H. T. M. (2020). *Towards predictive maintenance via digital twinning: Bridging data-driven and model-based fault detection and isolation*. Abstract from 2020 DSPE Conference on Precision Mechatronics (DSPE 2020), Eindhoven, Netherlands.

Document status and date:

Published: 08/09/2020

Document Version:

Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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Towards predictive maintenance via digital twinning: Bridging data-driven and model-based fault detection and isolation *

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Abstract

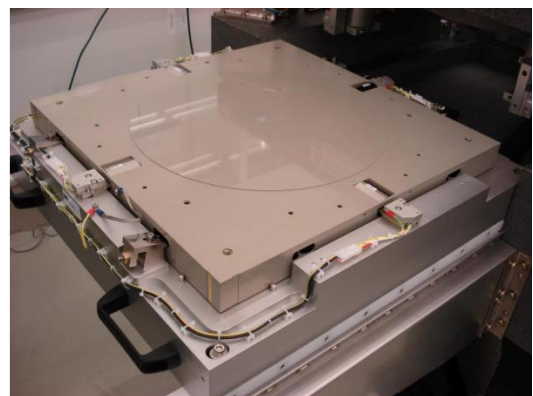
The economic value of high-tech production equipment is to a large extent determined by its productivity. Unexpected faults may result in downtime leading to a loss of productivity. Such unexpected faults arise from defects, ageing and wear of system components. Ideally, critical faults are detected in an early stage and handled such that downtime is minimized. Equipment downtime can be minimized by means of predictive maintenance, which can be pursued via the process of predicting and detecting faults in equipment and pinpointing its origin, which is called Fault Detection and Isolation (FDI).

Typically, models of the system are available prior to commissioning a machine, for instance, through Finite Element Modeling or identified models during system integration. After system integration and control design, the model is generally left unused. Evidently, this model is extremely valuable and can be exploited in the form of a digital twin that is informed with real-time data through a large number of sensors and actuators [1]. A physics-based model is envisaged that is learned from data to improve the predictive capability of this digital counterpart. The underlying physical model enables to isolate the origin of anomalous behaviour, which in turn allows for effective self-healing or specific hardware maintenance.

The envisioned approach involving data-enriched physics-based digital twins is general in nature and therefore likely to be applicable to a large range of systems, including production machines and scientific instruments. The proof-of concept will demonstrate that the envisioned approach can be applied to a broad industrial range of mechatronic systems far beyond wafer scanners. In this way, the present research project (2020-2024) focuses on bridging the gap between data-based approaches and model-based approaches, which are currently largely separated.



(a) Free floating reticle stage.



(b) Overactuated test rig.

Figure 1: Two experimental setups.

[1] T. Oomen, "Advanced Motion Control for Precision Mechatronics: Control, Identification, and Learning of Complex Systems," *IEEE Journal of Industry Applications*, 7(2), 127-140, 2018.

Keywords of the content are: Digital Twinning, Predictive Maintenance, Fault Detection and Isolation, Model Learning

* This work is supported by TKI and ASML Research