Afstuderen in de groep Advanced Control Design Methods (ACDM)

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Abstract

In deze korte nota wordt een overzicht gegeven van de mogelijke afstudeer onderwerpen binnen de groep ACDM onder leiding van Prof. Michel Verhaegen.

Key words: System Identification of LPV systems, Fault Tolerant Control, Distributed Control

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1 Matrix Organisatie Afsturdeerwerken DCSC - Verhaegen

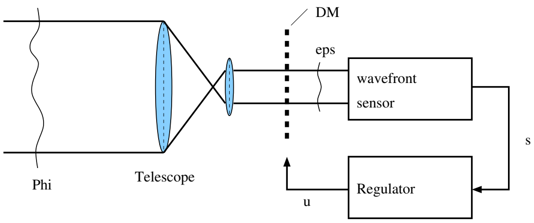
Fundaments *Applications*	**Fault Tolerant Control**	**Distributed Control**	**Identification of LPV systems** **Filtering**
Micro-Electronic Mechanical Systems (MEMS) • 5 DOF magnetic levitation optical Delay line • Adaptive Optics • Active Noise/Vibration Control (In-Mar) • Smart Rotor • Iterative Learning Control of a wafer stepper (Lithography) • Smart Control of a Micro-Satellite	X	X	X
Automotive • X-by-wire technology (SKF) • Global Chassis control (TNO-SKF) • Smart Car (SKF)	X		X

Fundaments *Applications*	**Fault Tolerant Control**	**Distributed Control**	**Identification of LPV systems** **Filtering**
Aircraft • Garteur Case Study of FTC • UaV helicopter	X		X
Systems Biology • Identification of large scale models that describe fermentation processes		X	X
Wind Energy • Smart Rotor for Active Vibration Control • Condition Monitoring for Offshore Wind park (ECN)	X	X	X

2 Example MSc Projects

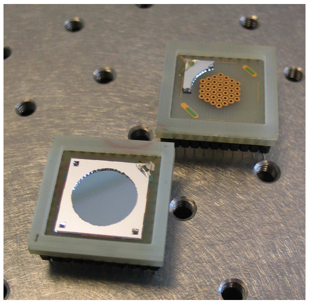
2.1 *Controller Updating in Adaptive Optics*

2.1.1 *Background material*



One Application of *Adaptive Optics* is in ground based Telescopes to improve image quality of *Space Observations.*

One of the key devices of an AO system is the deformable mirror (DM).



Produced by OKON technologies — Delft

Delft houses 3 different partners that work on the core technology of AO:

(1) *The development of sensors and actuators:* In Delft novel wavefront sensors and DM are designed by Dr. Gleb Vdovin (president of OKON) making use of micro-electronics production methods (to produced silicon wafers).
(2) *TNO:* TNO Science and Industries have a long tradition in the development of optical scientific instruments for space applications.
(3) *DCSC:* Advanced Control Design

2.1.2 *Project 1 Summary*

By the PhD student Karel Hinnen, an H_2 optimal feedback controller is designed and tested on a breadboard test facility of TNO. This controller has 112 inputs and controls the 37 piezo actuators of the DM. The data driven design currently collects in open-loop data for the identification of an LTI model of the wavefront abberation. This model is used in an analytic solution of the H_2 optimal feedback problem.

The task of the MSc student is to update the controller in order to cope with variations in the abberation, e.g. due to changing turbelence conditions. The updating needs to be done while the controller is active and requires closed-loop identification.

2.1.3 Project 2 Summary

Making the procedure briefly described in the previous subsection applicable to large telescopes requires extension to the case with in the order of 10^4 sensors and actuators. The challenge is to extend the developed procedures by the DCSC to this class of systems.

In the DCSC team recently an identification method for distributed systems has been developed. This method solves a number of small (local) identification problems in stead of the full complex one.

2.2 Iterative Learning Control (ILC)

2.2.1 Background material

To get high accuracy performance in motion control, the principle of ILC has been proposed by Prof. Tomizuka (UC Berkeley). ILC is used to improve the tracking accuracy of a moving mechatronic object by adapting the input when the motion is repetitive.

One Application of *ILC* can be found in the micro-electronic industry, e.g. in lithography, where use is made of a waferstepper to very accurately position the wafer before it is exposed to the laser beam. Since the goal in the micro-electronic industry is typically to produce identical circuits in large volume, repetition of the motion is naturally built in.

Another application is in Time Wavefront Replication (TWR) in the automobile industry for durability analysis. An example of testing new car chairs is displayed in Figure 2.2.1. Here the goal is to reproduce the motion components of a car or even full car prototypes undergo in their actual use in a

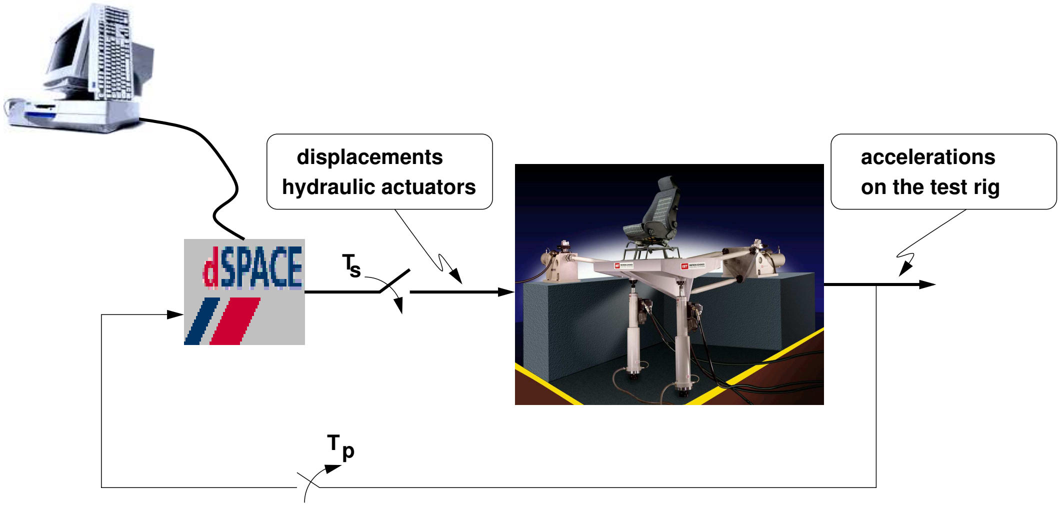


Fig. 1. Test set-up for durability and comfort analysis at Bertrand-Faure (France)

laboratory environment on a testrig. Because of the technology push in the car manufacturing industry to reduce the environmental impact of cars, the use of novel materials and active control, induce a dominant nonlinear behavior.

2.2.2 Project 1 Summary

The identification of LPV to approximate the nonlinear mechatronic dynamics.

2.2.3 Project 2 Summary

A new ILC update law has recently been proposed at DCSC. This law is derived based from a state feedback control problem and hence allows to control the convergence of the ILC process. This law has just been derived for SISO systems. In the MSc project, the method needs to be extended for MIMO models and their uncertainty description. On the practical site, testing this approach on the various ILC test set ups in the lab need to be performed.

2.3 5 DOF magnetic leviation positioning of an optical delay line

2.4 Identification of large scale biological networks

Systems Biology.

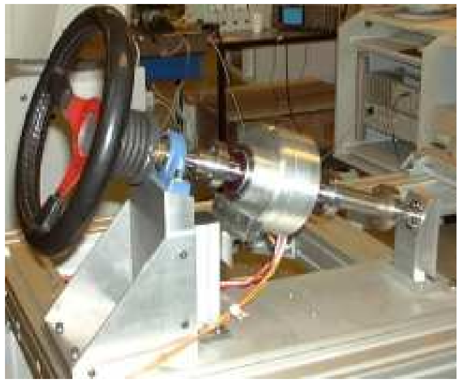


Fig. 2. Test set-up for testing new drive-by-wire technology at SKF

2.5 Fault Detection and Controller Reconfiguration

2.5.1 Background material

Control technology is being used for increasingly safety critical tasks. That means that when the controller fails, the safety of the controlled systems is endangered. A number of reasons push the development of control laws and their implementation that can diagnose the onset of system component failures and when necessary to reconfigure the law in order to guarantee safe continuation of the plant operation or to execute a safe shut down.

There are a vast number of approaches, both in the area of control engineering and software engineering to develop methods for diagnosis and controller reconfiguration.

2.5.2 Project 1 Summary

One class of methods is based on symbolic manipulation and aims at detecting plant degradation when functional relationships between the existing components breaks down due to failure. Such a recent development the the SaTool [1] of Prof. Mogens Blanke (Aalborg University, Denmark). The goal of the project is make this tool applicable for designing a fault tolerant X-by-wire drive system currently under development by SKF, see Figure 1

2.5.3 Project 2 Summary

The second class of methods is based on detection of failures from signal derived from an operational plant. The DCSC has a long tradition in this area through the development of filtering, identification and robust controller

[1] //gateway.system.ee.univpm.it/blanke

Fig. 3. The stanford Test-bed for testing fault tolerant control methods

reconfiguration methods. The goal of the project is to extend the Fault Detection methods to Linear Parameter Varying Models and to validate this new design in e.g. the SKF test bed shown in Figure 1. In such a validation study a comparison needs to be made with state of the art research going around the world, e.g. at Stanford.