Control Systems Technology

Headed by Maarten Steinbuch

The Control Systems Technology (CST) group develops new methods and tools in the area of Systems & Control Theory and Engineering, and Mechatronics. Our research focuses on understanding the fundamental system properties that determine the performance of mechanical engineering systems. We need this knowledge for the design of the high-tech systems of the future.

Focus of our research
In our Control Systems Technology (CST) group we have chosen strategic focuses on applications in High-Tech Systems, AgroFood, Health (robotics for care and cure), Smart Mobility (connected cars and clean vehicles) and Energy (fusion plasmas), thereby creating natural links with the Brainport region Eindhoven and far beyond.

We want to develop new methods and tools in the area of Systems Theory, Systems and Control Engineering and Mechatronics.

Subprograms
1. Model-based Control, identification and Design of Motion Systems
We develop new techniques based on identification, iterative learning control and feedback control. The development of design principles for the mechanical design of high-tech systems focuses on the research question of how to design for stiffness with high reproducibility and manufacturability, and sometimes for low cost and low thermal sensitivity.

2. Hybrid and Networked Control Systems and Systems Engineering
Intelligent traffic systems, resource-aware control for lithographic systems, automotive and logistic systems and infrastructure (waterways) are part of our life nowadays. Our research focuses on distributed control of physical systems over shared communication networks, resource-aware (event-triggered) control, as well as structured supervisory control and system structured supervisory control and system design methods.

3. Robotics
In our Robotics subprogram we aim to advance the state-of-the-art in robotics in health-related and AgroFood applications. To

Highlights in the CST-groups
The Robot Soccer team which was the world champion in 2012, 2014 and 2016, the eye-surgery robot PRECEYES was first used successfully on humans in 2016.
enable robots to perform a wide variety of household tasks we are investigating the cognitive abilities of domestic service robots for both the domestic (care) as well as the medical (cure) application.

4. Automotive Powertrains
Our research is heading towards integrated powertrain control, in which energy and emissions management of the overall powertrain is fully integrated. Moreover, our research on new high-tech powertrain concepts for hybrid and electrical drive trains with different applications ranging from ships, tugs (maritime) towards cars and trucks (automotive) is resulting in new innovations.

5. Control of fusion plasmas
Our main focus is on the control of magneto-hydrodynamic instabilities and the control of distribution of the current density, temperature and particle distribution in the plasma. Therefore we use new sensor designs, system identification and control oriented modelling.

Advanced feedforward
Tom Oomen is involved in a research project set up with Océ. The Océ Arizona printer is a large flatbed printer (4m x 2m) for printing large format objects using UV on different media, including rigid media such as exhibit displays. The TU/e has an Arizona printer in its lab for research and education on learning control, system identification, multivariable control, and robust control. In addition, the Arizona exhibits interesting phenomena including inferential control and position-dependent dynamics. Tom: “The Arizona is being used to profile various advanced motion control algorithms and is in the lab of the Control Systems Technology group. In our recent research, together with Sjirk Koekbakker at Océ and several Ph.D. and M.Sc. students, we have developed new methods for advanced feedforward control. These methods go beyond the traditional trade-off between performance of flexibility to changing tasks.

To understand the potential of this, typical feedforward controllers, like mass-feedforward as taught in basic control courses, are still the most standard in commercial systems. Iterative Learning Control (ILC) algorithms can achieve much better performance, but these do not allow the task to be changed, and these thus cannot be used directly be used for printing systems. Our new advanced feedforward control algorithms combine the advantages and enable high performance for varying printing tasks. This shows a very strong potential for commercial usage, especially since these algorithms automatically tune the parameters and require significantly less effort by the control engineer. To show the potential of the method, we have equipped the printer with a penholder, which allows for demonstrating the benefits of the new algorithms.

Finally, besides the use in printing systems, the developed approach has also been implemented on wirebonders and diebonders at NXP and waferscanners at Philips and ASML.”

CST and the industry
In our research group we work together with several high-tech industrial companies as ASML, TNO, Philips, Marel, Océ but also with various SME industries.

Graduation project
Martijn Goorden
‘In my graduation project I built a simulation model to analyze the performance of ICT networks. It mainly dealt with ICT systems with many users, such as MyTUE, Outlook, SkypeForBusiness and cloud storage services. ICT departments of companies buy these kinds of software packages, but they have to build the required hardware infrastructure themselves. Designing and dimensioning these kinds of systems is difficult because the environment is constantly changing: new software, faster hardware, and the changing needs of users. In my graduation assignment I made a model that could analyze the performance of the complete network of software and hardware even before the system is built.’

‘The challenge in this graduation assignment was to apply my knowledge of modeling complex systems to a problem in a totally different discipline. My assignment came from ASML, and they were specifically looking for a mechanical engineer, not an information technology expert. I am very happy with the supervision I got from within the group. Even though the application area was new to them, my supervisors were able to ask the right critical questions about my methodology and results.

What I missed, were contacts at the TU/e, because I did my graduation project at ASML. I would have enjoyed exchanging experiences with other master’s students.

Right now, I’m doing a PhD in the same group. Over the next few years I will be working on supervisory control for locks and bridges, commissioned by Rijkswaterstaat.’

Steerable catheters
Rolf Gaasbeek
I gained my Master’s degree CST at this university. I chose this track because of my interest in robotics and mechatronics. For my PhD I chose the CST group because it has a strong reputation in the field of mechatronics. Additionally, there were several industry-focused research opportunities available in the group.

For me personally it is important that the research I do actually finds application in (high-tech) industry. My work/challenge is on the edge of what is physically possible and I know, if succeeded, will help save lives.
People with cardiovascular disease (CVD) are often treated or diagnosed with catheterization. The catheters are generally steered through simple mechanical pull wire systems, which suffer from hampering maneuverability and limited accuracy. The use of SMA actuators (Shape Memory Alloy) in catheters allows the catheter to comply with more complex blood vessels by allowing the catheter to have multiple bending segments, limited dimensions and a small bending stiffness. In this research we aim to realize high-performing control of a SMA-actuated catheter tip, so that this tip can be accurately steered.

My advice to Master’s students who want to follow a PhD, is to try to get involved in a long-term academic project (more than 3 months, this could be your graduation project). You will notice that you become more familiar with your research than the people around you, maybe even including your supervisors. In my experience two things can happen; (1) you are completely fed-up with the project, (2) you get excited by becoming ‘the expert’. If you are a type 2; you should really consider doing a PhD.’

**Associate Professor René van de Molengraft**

René teaches Signals in the first of the bachelor’s program, the OGO project Robotic Arm in the second year and the Robots Everywhere project in the USE learning trajectory Robotics. In the master’s program he teaches the elective course Embedded Motion Control.

René: ‘Next to the theoretical part, our education also has a practical side: doing experiments yourself is an essential component. Right from the first Signals course, students start experimenting with different lab setups.

In the course we follow the developments in the research closely and include them in the education. Our research group focuses on systems and control engineering: designing controls that allow machines or equipment to do their jobs. The various applications of systems and control engineering is reflected in the research group’s subprograms.

The software side of systems is becoming more important, both in design and implementation. For example, the optional course Embedded Motion Control designs software that lets robots do tasks by themselves in an unknown environment.

As an MSc graduate you will be able to analyze, design and implement machine control systems and use the very latest control engineering, so that you can adjust the machine’s behavior.

My advice to graduate students is: do what you like best, what excites you. Come see our group’s labs, ask the scientists about the work they do and watch robots playing football.’