Integrated real-time feedback control for high-resolution imaging

Baptiste Sinquin, Reinier Doelman, Stojan Trajanovski, Chengpu Yu and Michel Verhaegen

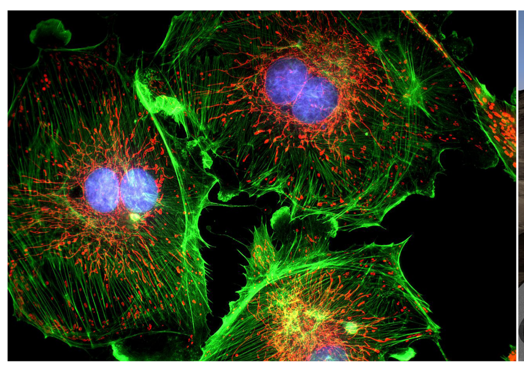
Ambitions

In the iCON project we aim to develop a framework for high-resolution imaging systems that integrates system identification and model-based control techniques. We develop this framework for application in microscopy, astronomy, optical coherence tomography and nanoscopy.

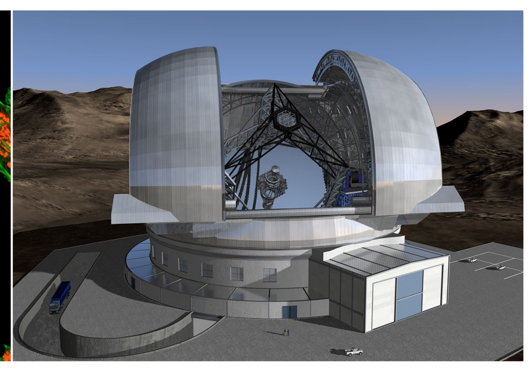
The particular challenge we try to tackle comes from extremely large adaptive optics imaging systems, in which there may be tens of thousands of sensor elements and actuators in wavefront sensors and deformable mirrors respectively. To deal with the associated computational complexity, we research and develop distributed identification and control methods with linear computational complexity and that allow for distributed implementation on multi-core or GPU systems.

The end result we try to achieve is a better balance in instrument design between imaging resolution on one hand, and size, cost and complexity on the other. Therefore iCON will be a key enabling technology for developing low cost high resolution imaging instruments.

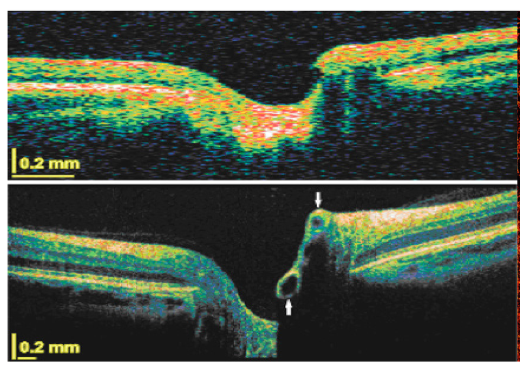
Applications



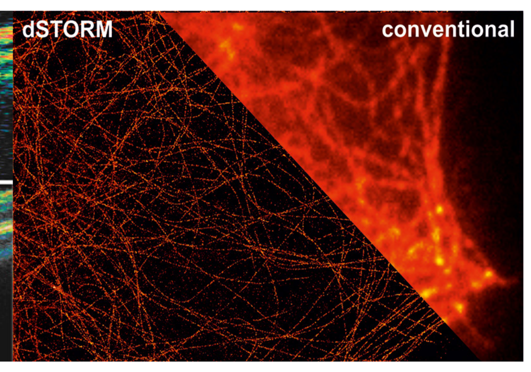
Microscopy



Astronomy



Optical Coherence Tomography



Nanoscopy

The project setting

ERC Advanced Grants allow exceptional established research leaders of any nationality and any age to pursue ground-breaking, high-risk projects that open new directions in their respective research fields or other domains.

The duration of the project is a period of 5 years, starting in 2014.

The iCON project aims at the development of new computational tools for image restoration by real-time feedback control with full images recorded by a CCD camera.

European Research Council

Established by the European Commission

TU Delft

Programme components

Distributed Identification
- Turbulence
- Deformable mirror and wavefront sensor

Distributed control
- Filtering
- Reference tracking
- Constraint handling

Experiment Design
- Distributed programming
- Real-time implementation

Distributed controller design

To control a deformable mirror with thousands of actuators based on even more wavefront measurements at high update frequencies, we are researching distributed control methods. Currently, we focus on distributed feedback control, distributed model predictive control and distributed optimization methods.

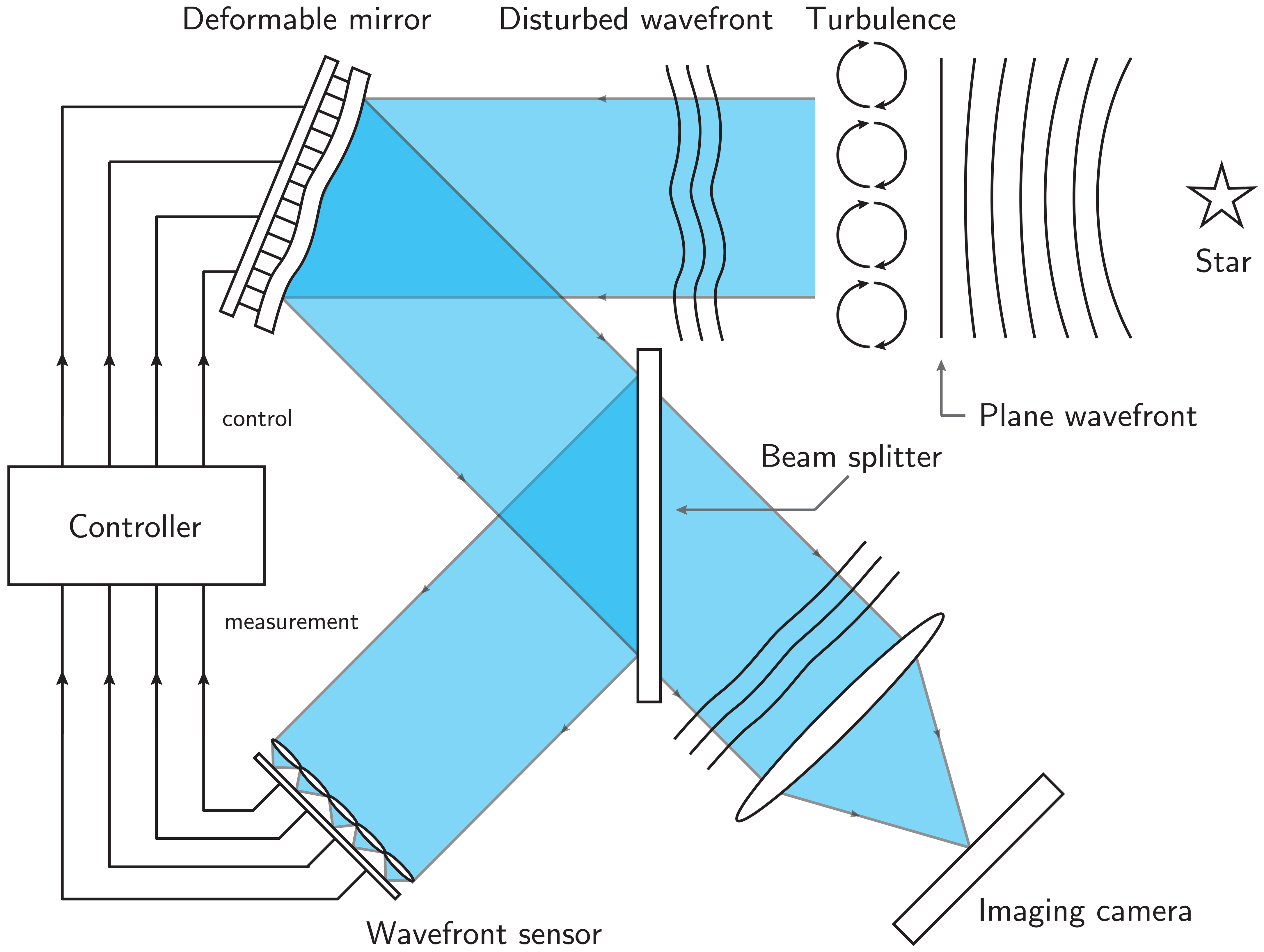
If you are interested in doing a Master thesis project on this topic, please contact Reinier Doelman, Baptiste Sinquin, Stojan Trajanovski or Michel Verhaegen.

Experimental validation

To bring the distributed identification and distributed control and optimization together, we want to experimentally validate our designs by implementing them for real-time use.

Possible master thesis projects are related to distributed/parallel programming and real-time implementation of the algorithms.

If you are interested in doing a Master thesis project on this topic, please contact Baptiste Sinquin, Stojan Trajanovski or Michel Verhaegen.



Turbulence modelling

The turbulence can be described as a stochastic process with known statistical properties. By modeling the turbulence we try to find a state-space system model with white-noise input such that the corresponding system output has the desired statistical properties.

If you are interested in doing a Master thesis project on this topic, please contact Baptiste Sinquin or Michel Verhaegen.

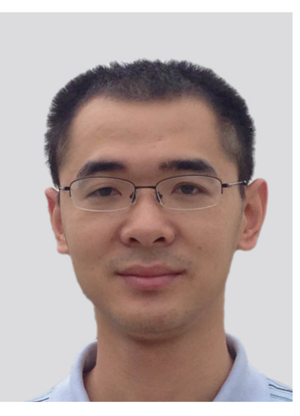
System identification

We are interested in two identification problems. First, we want to do distributed identification of the system dynamics (mirror and wavefront sensor) where the input is persistantly exciting and second, we want to do identification of static or descriptor systems, where the input is temporally invariant and spatially varying.

If you are interested in doing a Master thesis project on this topic, please contact Chengpu Yu or Michel Verhaegen.

Prof. M. Verhaegen

Prof. M. Verhaegen received the prestigious ERC (European Research Council) Advanced Grant for the iCON project. His current activities focus on transfer of knowledge about new identification, fault tolerant control and data-driven controller design methodologies to industry.



Chengpu Yu

Chengpu Yu received the Ph.D. degree in electrical engineering from Nanyang Technological University (NTU), Singapore, in 2014. He is currently with DCSC as a postdoc. His research interests include medical imaging, system identification, and distributed optimization.

Stojan Trajanovski

I am a postdoctoral researcher at TU Delft, The Netherlands, where I also obtained my PhD degree. My research focuses are optimization algorithms, distributed algorithms; GPU related issues (e.g, CUDA programming), control theory and graph theory problems with applications in AO.

Baptiste Sinquin

Baptiste graduated from the Ecole Centrale Lyon, France, in 2014 and is currently persuing a PhD. His research interests include subspace identification, distributed convex optimization and experimental aspects with a focus on high performance computing.

Reinier Doelman

I research distributed and robust feedback control methods. I currently focus on systems theory, convex optimization, distributed filtering, control and reference tracking by using semidefinite programming.

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