Integrated real-time feedback control for high-resolution imaging

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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 sensors 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.

Possible master thesis projects are related to distributed/parallel programming and distributed control and optimization 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.

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.

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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.

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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.

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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 persistently exciting and second, we want to do identification of static or descriptor systems, where the input is temporarily invariant and spatially varying.

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