ACE fast
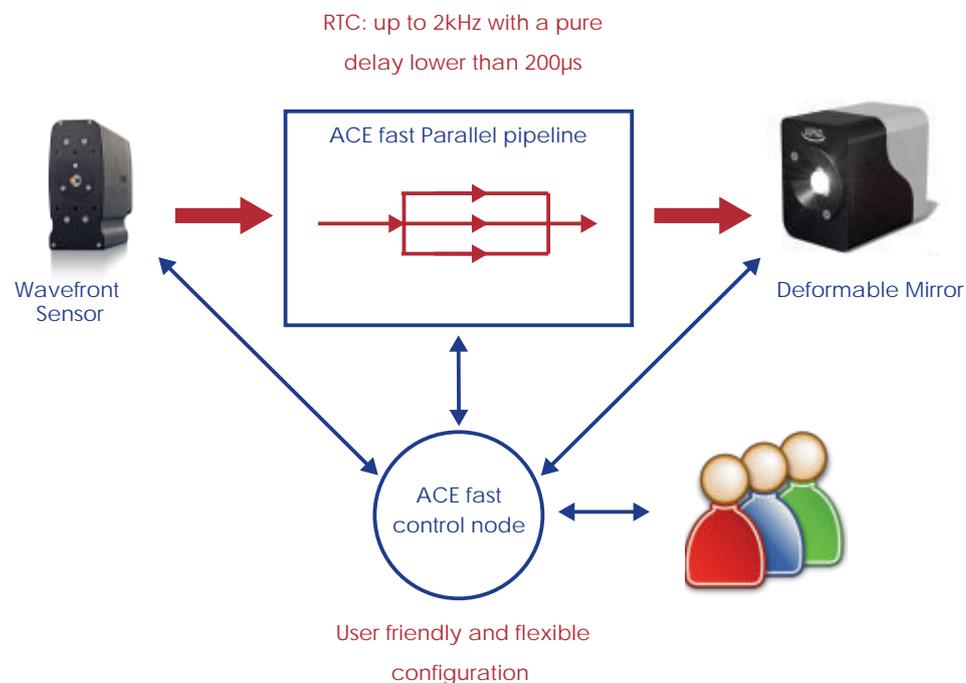
Standard ALPAO Core Engine (ACE) based on the Matlab environment is the perfect choice to control adaptive optics systems. Its open, object-oriented architecture allows the user to rapidly build a robust, user-friendly software solution. ACE can run smoothly up to 800 Hz with a typical delay below 1ms.

For the most demanding applications, ALPAO can provide you with the powerful ALPAO Core Engine fast (ACE fast), running up to 2 KHz with a pure delay lower than 200 µs.

ACE fast takes the best from two different technologies:
- ACE fast parallel pipeline running all time-critical processing.
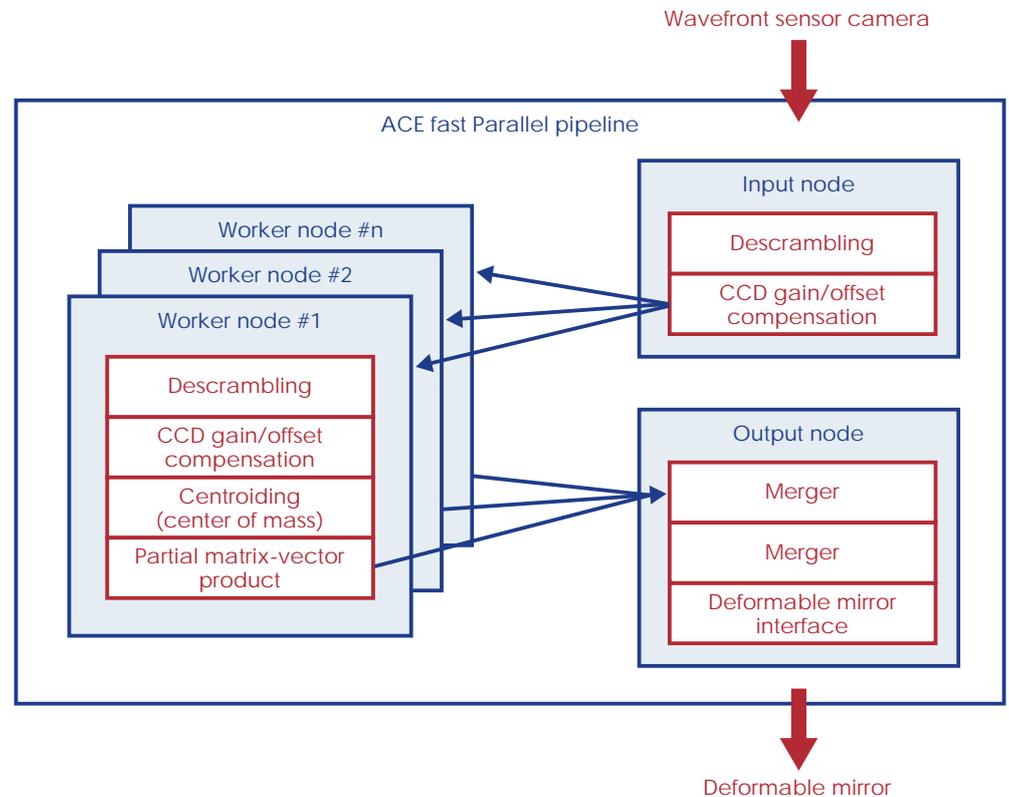- ACE fast control node to configure and monitor the pipeline.

RTC: up to 2kHz with a pure delay lower than 200µs

Wavefront Sensor

ACE fast Parallel pipeline

Deformable Mirror

ACE fast control node

User friendly and flexible configuration

KEY FEATURES:

- State of the art Real Time Computer:
Up to 2kHz.
A pure delay as low as 200µs.

- Open solution:
Modification of the code running on the control node.

PRODUCT DATASHEET
ACE *fast*
rev. B
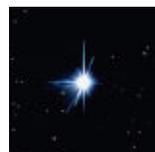
▪ ACE *fast* PARALLEL PIPELINE

The parallel pipeline is the backbone of ACE fast. It is optimized for low latency processing of wavefront sensor pixels. The hardware platform is a Linux cluster, selected and configured by Alpao for each application. The hardware performances are evolving so fast that hardware is selected at the very last moment.

Wavefront sensor camera

ACE fast Parallel pipeline

Input node

Descrambling

CCD gain/offset compensation

Worker node #n

Worker node #2

Worker node #1

Descrambling

CCD gain/offset compensation

Centroiding (center of mass)

Partial matrix-vector product

Output node

Merger

Merger

Deformable mirror interface

Deformable mirror

This pipeline is scalable and distributes the workload over several workers:

▪ A worker is the basic processing unit of ACE fast.

- A worker can be seen as a special kind of process, capable of low latency communication with other workers thanks to an Alpao proprietary protocol.

- A dedicated CPU core and L2 cache area is allocated to each worker, to minimize unwanted interaction between workers.

- The number of workers can be adapted to meet the most demanding requirements.

- Each worker handles one part of the wavefront sensor image (a pixel packet)

- All workers can run on the same physical node, or be distributed over several nodes (typically 1 node = 1 machine).

▪ A node is a machine, or server that is part of the ACE fast pipeline.

- Each worker node runs a Linux operating system, with a specific kernel optimized for low-latency, low jitter and high frame-rate processing

- All nodes are interconnected using a fast network. The standard is 1 or 10 Gbit Ethernet, but Infiniband may be required for the most demanding applications

■ Two nodes have a specific role:
- The input node, interfacing the frame grabber for the wavefront sensor camera (CameraLink or Gigabit Ethernet).
- The output node, interfacing the drive electronics for the deformable mirror (dedicated PCIe board).
Both input and output nodes may be in the same machine, to ensure reliable performance timing and to detect any uncontrolled jitter.

■ ACE *fast* CONTROL NODE

The ACE fast pipeline is optimized for performance, not to control, configure and monitor. A more user-friendly interface is necessary, especially during the integration, test and maintenance phases of the AO project (ACE fast pipeline can run alone during normal operations).

The ACE fast control node is based on the Alpao Core Engine toolbox, already powering more than 30 adaptive optics systems worldwide. The ACE layer is based on the standard Matlab® environment.

The following functionalities are provided:

■ Step-by-step operation of the ACE fast pipeline: Interactive manipulation of the input/output data from each processing stage. This mode is mainly used for debugging.

■ Non-intrusive monitoring of all data steams such as:
- raw images
- centroids (aka slopes)
- reconstructed wavefront map and Zernike decomposition
- deformable mirror command vector...

■ Configuration of each worker process such as:
- For the input node:
- Integration time
- CCD gain
- CCD readout mode
- For the worker nodes:
- CCD dark and flat images for gain/offset compensation
- Threshold level
- Target centroids (aka reference slopes)
- Partial Command Matrix
- For the output node:
- Integrator gain
- Deformable mirror offsets

■ Script-based generation of all calibration data such as:
- Reference centroids
- Influence matrix
- Dark and flat images

▪ OPEN SOLUTION

An ACE fast system is not only a set of hardware & software components: it's a full working solution, tested and optimized with real input/output devices. ALPAO delivers a complete ready-to-use system, using fieldproven algorithms for each processing stage.

Such a running system is the best starting point, but it's only a Launchpad for your project. The ACE fast can be modified by the user, and evolve as new ideas comes out.

Alpao can implement new worker algorithms on demand. But the easiest way to modify the behavior of the ACE fast system is by adjusting the Matlab® code running on the control node. Most ideas can actually be tested and implemented by analyzing the data stream of the running pipeline and adjusting its configuration parameters.

Advanced control algorithm need extensive off-line calibrations, but will usually not impact the backbone of the processing pipeline. For example:

▪ Fast calibration of the mirror/sensor coupling using Hadamard matrices can be implemented 100% in Matlab script from the control node. There is no need to change the pipeline.

▪ Online optimization of the servo loop using modal control can require complex analysis of the running pipeline. But again, this can be done using Matlab® scripts: it will only impact the content of the command matrix, but not its format.

▪ A weighted centroid algorithm can be implemented by changing the CCD gain maps. This trick would be hard to debug directly on the pipeline, but can be easily debugged and documented in the Matlab® side of ACE fast.

Core Engine

Getting AO results has never been so fast!