
Matrix-based vs. matrix-free real-time reconstruction with FEWHA for a MORFEO like setting

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Abstract

The Multiconjugate adaptive Optics Relay For ELT Observations (MORFEO) is one of the key Adaptive Optics systems on the ELT. It aims to achieve a good wavefront correction over a large field of view, hence, involves a tomographic estimation of the 3D wavefront disturbance. The reconstruction of the turbulent layers in the atmosphere has to be done in real-time and is ill-posed, which makes it a challenging task for reconstruction algorithms.

We focus on the Finite Element Wavelet Hybrid Algorithm (FEWHA), which uses a wavelet basis to represent the turbulence layers in the atmosphere. Originally this algorithm is formulated in a matrix-free and iterative way, however, FEWHA can be represented as a matrix-vector-multiplication (MVM) as well. The iterative approach has several advantages, e.g., no precomputation of the inverse and on the fly parameter updates, but also some drawbacks. Here we study the performance of the matrix-based vs. the matrix-free FEWHA for a MORFEO like test setting using ESO's end-to-end simulation tool OCTOPUS. We will deal with questions like: Does the iterative approach affect the reconstruction quality in comparison to a direct solver? What is the computational performance of the matrix-free FEWHA on a CPU vs. the matrix-based FEWHA on a GPU? How much does pipelining influence the overall run-time?

Keywords: MORFEO, FEWHA, tomography, real time, wavelets, iterative, matrix free, matrix vector multiplication

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