Aligning the brain:
A Parallel Solution for Tera-pixel Imagery

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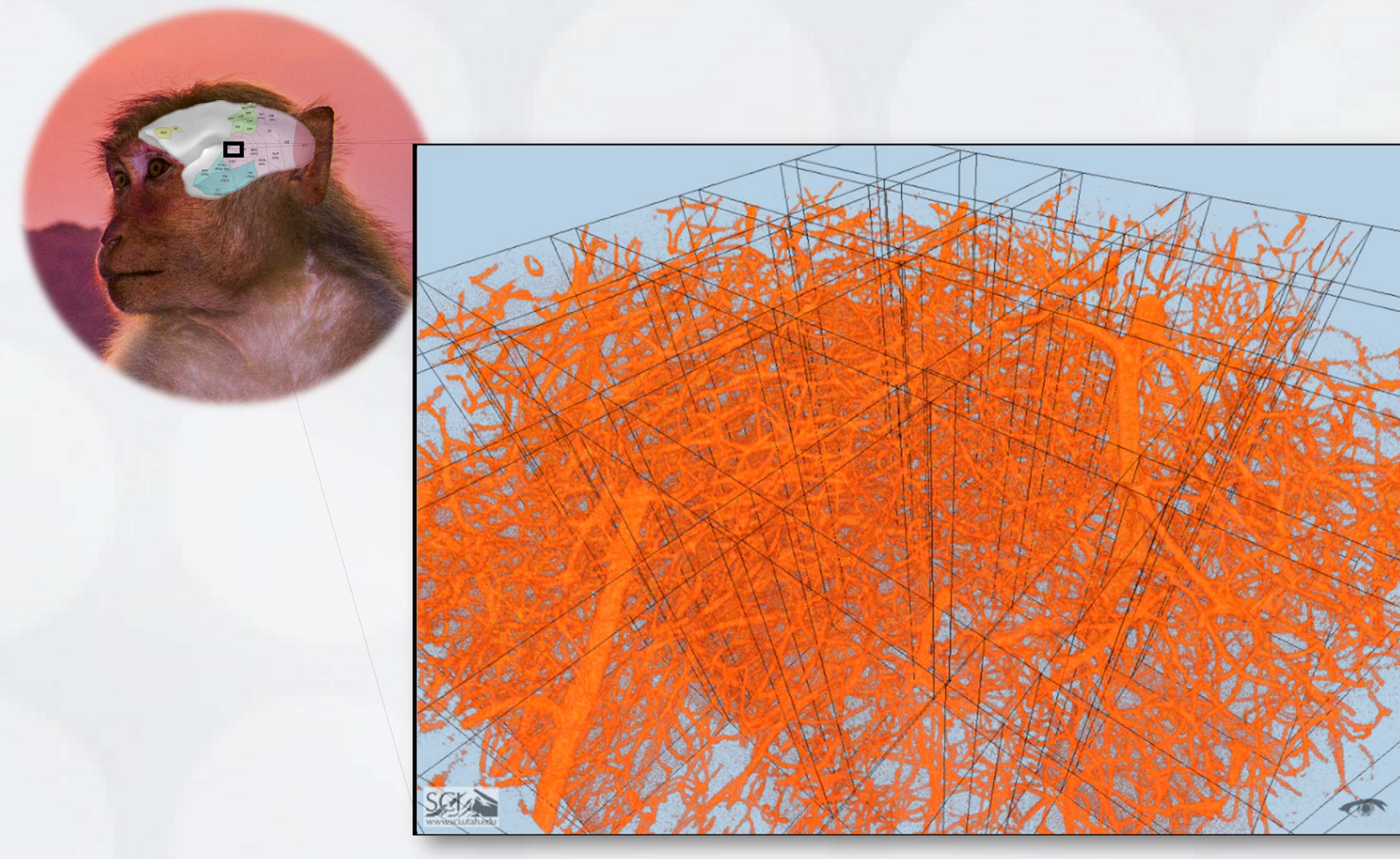
Overview

Brain functions emerge from the coordinated activity of billions of neurons connected in specific ways to form highly dense neural circuits. Obtaining a complete wiring diagram of the brain, particularly of the larger non-human primate (NHP) brain, remains a major challenge, largely due to the lack of algorithmic and computational solutions to handle, analyze and reconstruct the massive amount of neuronal data that are being collected.

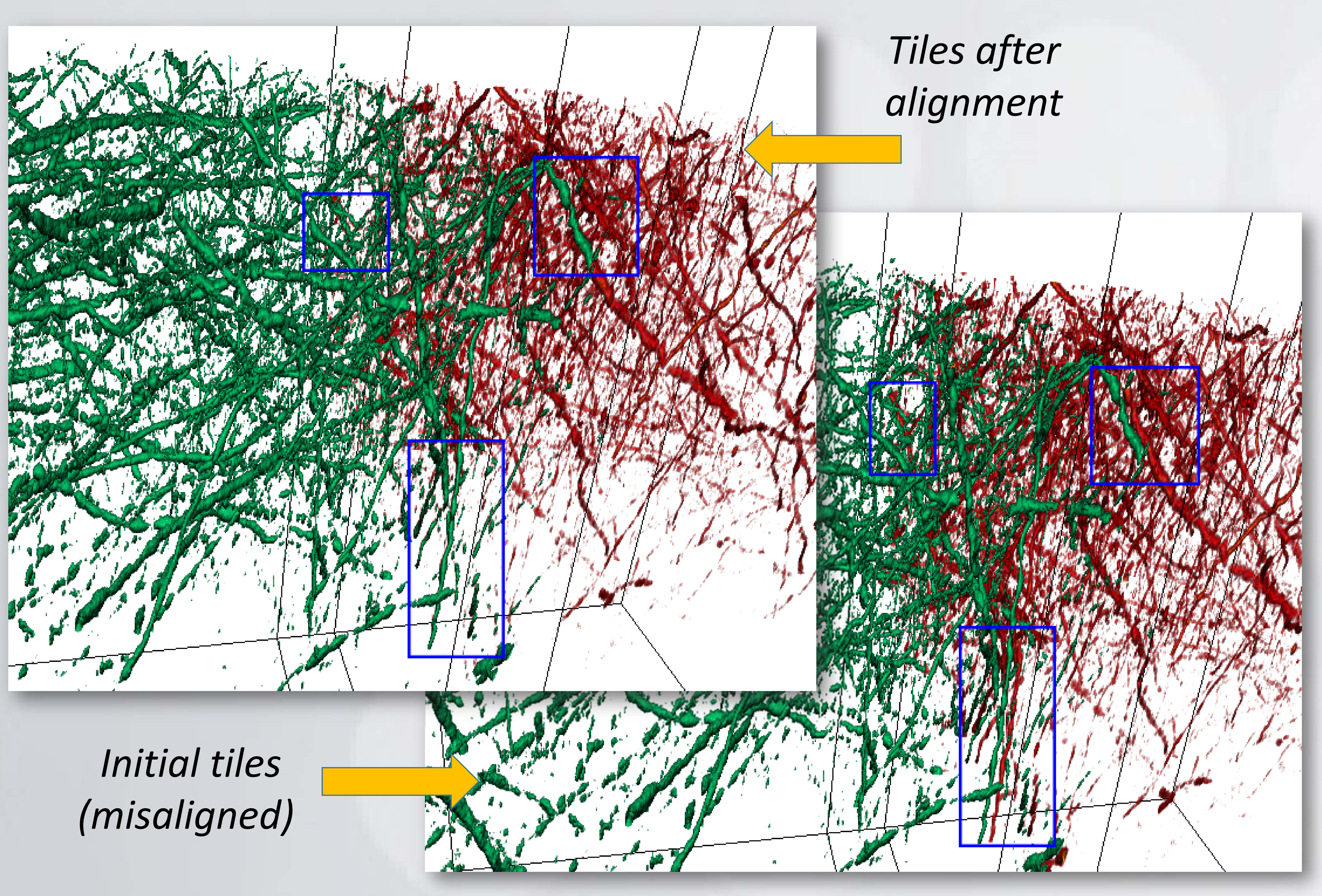
A typical acquisition process uses computer controlled micropositioning stages to acquire multiple overlapping tiles in a two dimensional grid. The process records the tile's physical co-ordinates that are used as initial tile positions. Due to a range of movements in each dimension, the recorded co-ordinates is not precise enough for direct reconstruction.



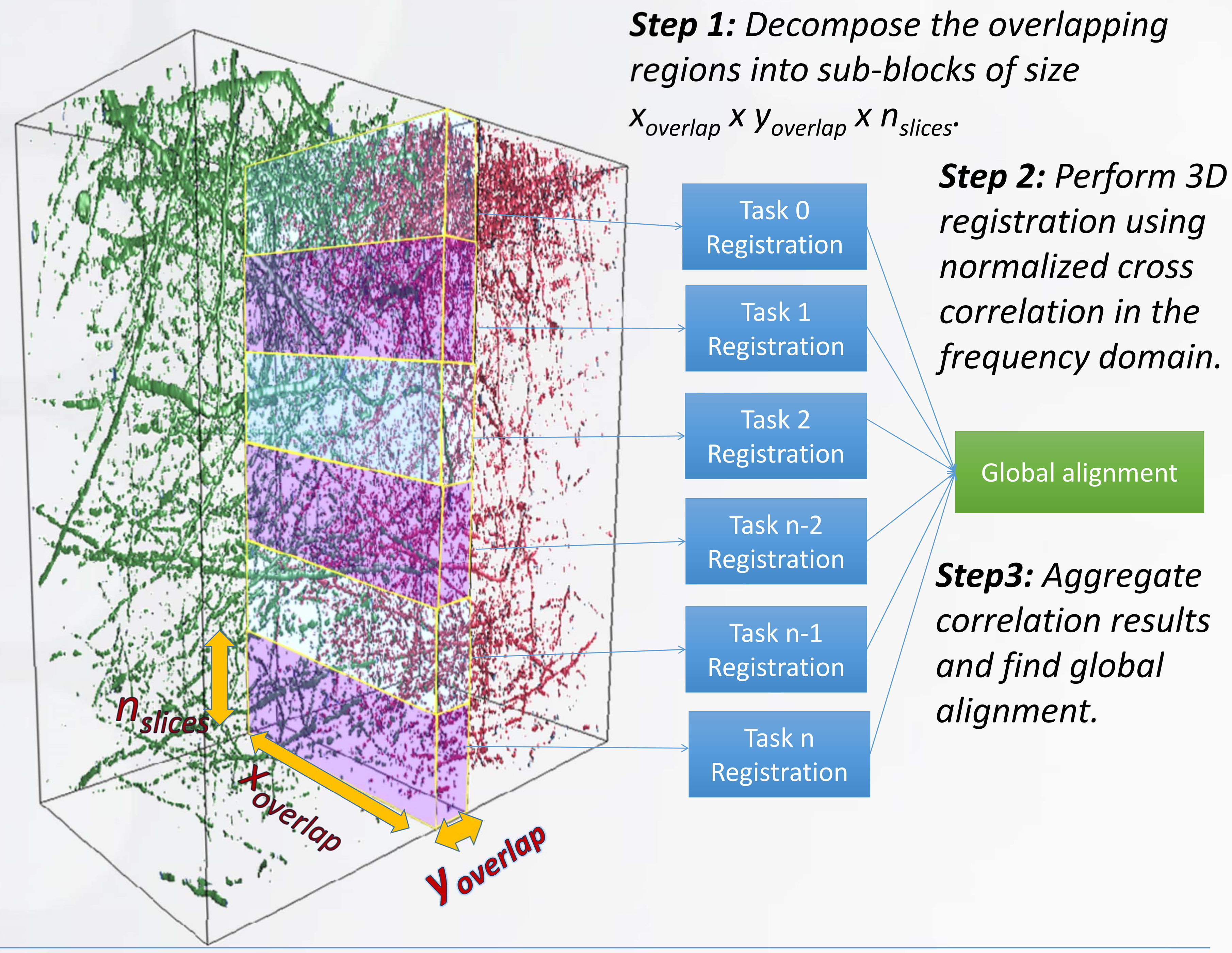
Part of the brain dataset (each volume contains 1B voxels)

Parallel Pairwise Registration

The alignment process is non-trivial and takes a lot of computing time on commodity PC's at terascale. A scalable solution is therefore highly desired.

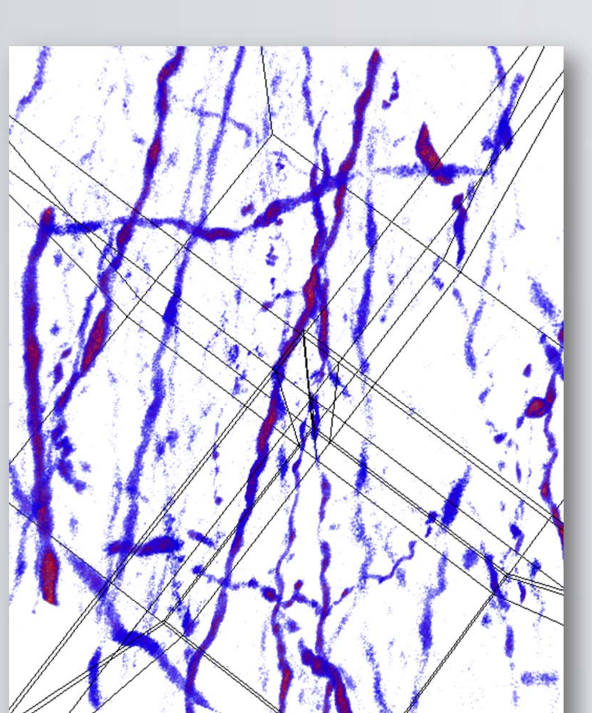


To effectively utilize HPC resources, it is important to distribute the workload efficiently on a number of computing resources. To this aim we developed a task based parallel workflow, outlined below.

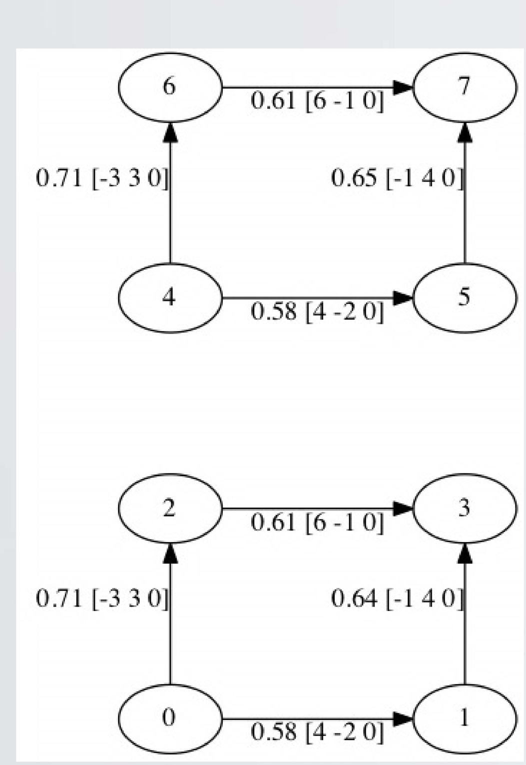


Global Alignment

To obtain a globally optimal tile displacement we form an undirected weighted graph where the nodes correspond to the tiles and the edges correspond to the tile displacements. We compute a minimum spanning tree of this graph to find the final tile positions. Alignment results for a simple configuration of 4 tiles sub-divided into 2 sub-blocks per tile (resulting in 2 graphs) is shown below.



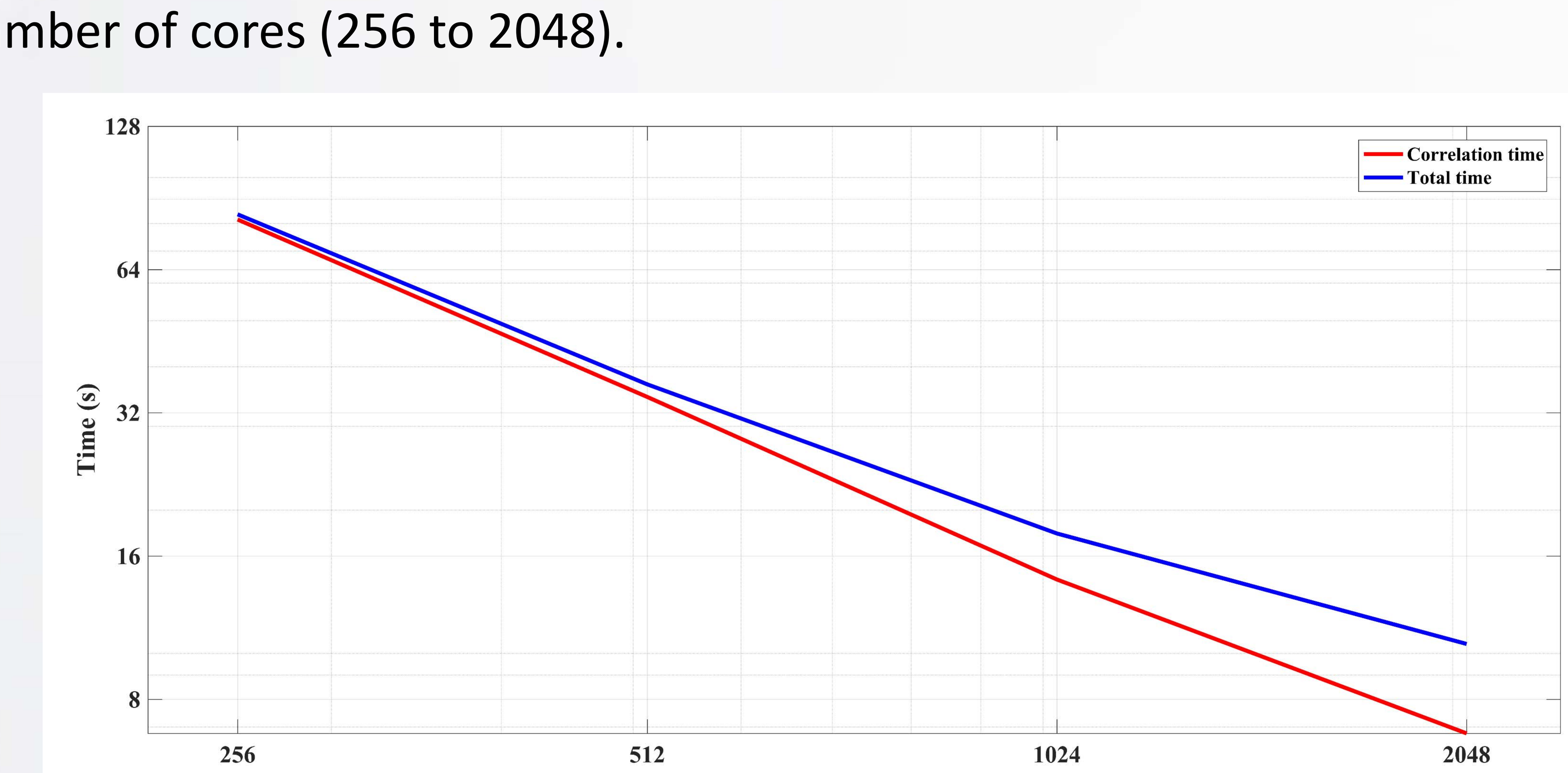
(a) Global alignment result



(b) Displacement graph

Performance Scaling

Initial results report strong scaling on Shaheen II, a supercomputer in KAUST (King Abdallah University of Science and Technology), for varying number of cores (256 to 2048).



Correlation time: time spent to compute the optimal tile offsets. Total time: includes time required for data read, transfer, correlation result collection and final graph production.