Evaluation of Cellular Automata–Based Static Recrystallization Model Capabilities supported by Parallel Execution

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The evolution of material microstructure in metallic materials plays a crucial role in determining the final exploitation properties of the manufactured components. However, accurate numerical modelling of phenomena responsible for microstructure evolution requires the use of large computational domains to properly capture grain morphology and their representative interactions. Therefore, simulations of microstructural phenomena, such as static recrystallization (SRX), are computationally demanding and often limited by execution time when implemented on fine-resolution computational domains. However, this high computational cost can be significantly reduced by applying parallelization strategies, either through GPU computation [1] or distributed computing techniques that decompose the computational domain across multiple CPU processing units [2,3].

Therefore, this work investigates the use of advanced parallelization techniques to accelerate a cellular automata (CA) based model of static recrystallization. The study focuses on data-parallel approaches in which computations for individual CA cells are performed independently in multiple computing threads. Particular attention is given to the most time-consuming parts of the algorithm, including the grain growth phase, space update procedures, and nucleation processes, which dominate the overall simulation time. The application of shared-memory parallelization using technologies such as OpenMP, DPC++, or the newer C++ standard enables relatively straightforward adaptation of an existing sequential code to a multithreaded version by parallelizing loops that iterate over the CA space. This approach allows efficient utilisation of modern multicore processors without fundamental modifications to the underlying physical model, thus maintaining the model's predictive capabilities. Computational experiments demonstrate that, for sufficiently large problem sizes, significant reductions in execution time can be achieved, especially for the most computationally intensive stages of the algorithm.

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