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Using multiple graphics processing units to register X-ray micro-CT and SEM/EDX images obtained from a copper ore

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X-ray microtomography provides three-dimensional information about the distribution of minerals within an ore sample and facilitates the three dimensional analysis of packed particle beds. A scanning electron microscope with energy-dispersive X-ray (SEM/EDX) attachment is capable of providing an extremely accurate mineral identification on a polished section of an ore sample. Combining these two imaging modalities offers the opportunity to enhance the analysis of X-ray micro-CT images of ore samples and verify the accuracy of such analyses. However, the non-trivial task of aligning, or registering, the SEM/EDX image to the X-ray micro-CT 3D image, or tomogram, requires significant computing power and time. Graphics processing units (GPUs) are massively parallel processors that have the potential to accelerate this registration algorithm as they provide substantial computing power and high-speed memory. Therefore, their use was studied in this work.

Registration of the images was achieved by maximising their Pearson product-moment correlation coefficient with respect to the 3D transform that maps 2D coordinates in the SEM/EDX image to 3D coordinates in the micro-CT tomogram. The algorithm used here is best described as a multi-scale registration algorithm that uses a brute force search at the lowest resolution, followed by a multi-start global optimisation algorithm, formed from the combination of a Genetic Algorithm and the Gradient Ascent Search algorithm, performed at each scale to locate the global maximum correlation coefficient. Multi-start global optimisation algorithms present substantial opportunities for parallelisation, making them a good fit for GPUs. Multiple levels of parallelism exist in this algorithm as individual correlation coefficients can be calculated using parallel reductions, while thousands of correlation coefficients can be calculated in parallel. Furthermore, portions of the algorithm can be run on multi-core central processing units (CPUs) to utilise all available computing power. This work focusses on the implementation of a parallel algorithm for determining the Pearson product-moment correlation coefficient of thousands of candidate registrations in parallel on a heterogeneous system consisting of multiple GPUs using the Open Computing Language (OpenCL) and the JavaCL library for the Java programming language.

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