Optimal dataset transformations for ultrasound simulation

(Abstract)

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The simulation of ultrasound propagation through soft biological tissue has a wide range of practical applications. These include the design of transducers for diagnostic and therapeutic ultrasound, the development of new signal processing and imaging techniques, studying the distortion of ultrasound beams in heterogeneous media, ultrasonic tissue classification, training ultrasonographers to use ultrasound equipment and interpret ultrasound images, model-based medical image registration, and treatment planning and dosimetry for high-intensity focused ultrasound [1]. The simulation is computationally demanding and therefore done on parallel systems, for example supercomputer clusters.

The input may be a CT scan, 3D polygon model, etc. As the simulation itself is executed on a Cartesian grid input data has to be preprocessed before the simulation can begin. This transformation of the input data to the required representation is memory demanding problem and can be described by a data dependency graph. This graph can be split into tasks that may be executed in parallel if there are no dependencies between them. A specific order and mapping of tasks on processing units is called working plan. The optimal work plan has the shortest runtime.

The problem of creating the optimal plan is similar to finding optimal strategy for a mathematical game called pebble game [2]. This article evaluates existing algorithms for creating a pebbling strategy for the presented dataset transformation. Available main memory of each processing unit, latency of communication and I/O operations have to be considered by the algorithms so already loaded or computed blocks of data can be reused by the same processing unit.

References:

[1] T. L. Szabo, Diagnostic Ultrasound Imaging (Elsevier, Burlington, 2004), pp. 4–6.

[2] J. E. Savage, Models of computation, exploring the power of computing, (2008), p.698.