First steps towards garment simulation on massive parallelism hardware

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Knowledge Aided Engineering Manufacturing and Related Technologies

Introduction to the topic and related issues

Cloth simulation is a great deal of research for apparel manufacturers, because it can provide them a preview of the final product avoiding the tailoring of the real garment. At the moment, one of the main obstacles to achieve a correct and accurate garment simulation relies above all on prohibitive computational times, far away from the real time or pseudo-real time needed by the designers in order to have a usable tool and not a simple proof of concept.

One of the most common approaches in cloth simulation is to model the fabric as a deformable surface composed of a network of millions of masses and springs, and to perform the garment simulation by solving the model equations. This kind of problem can be effectively simulated in a massive parallel fashion, and therefore, the speedup provided by new massive parallelism hardware can be crucial.

Mathematical representation of the cloth

In the adopted model there are stretching, bending and shearing springs. Stretching and bending springs are located along the warp and the weft directions, while shearing springs are located along the two diagonals (Figure 1). Spring reactions are represented in Figure 2. It is possible to model the anisotropic behavior of the cloth by varying spring constants. It is also possible to define stretch constant alogn warp and weft directions.

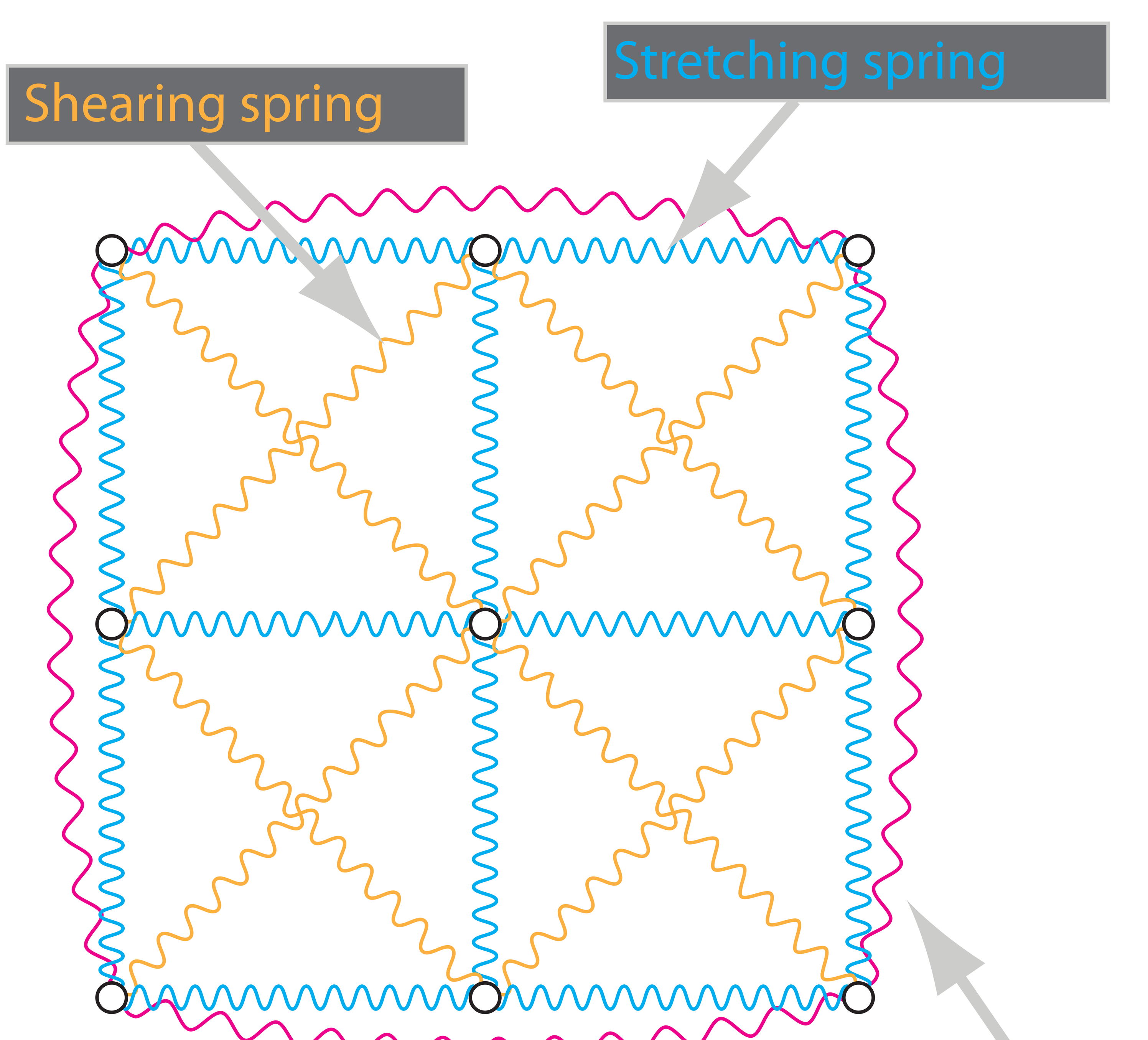


Figure 1 - Spring arrangement

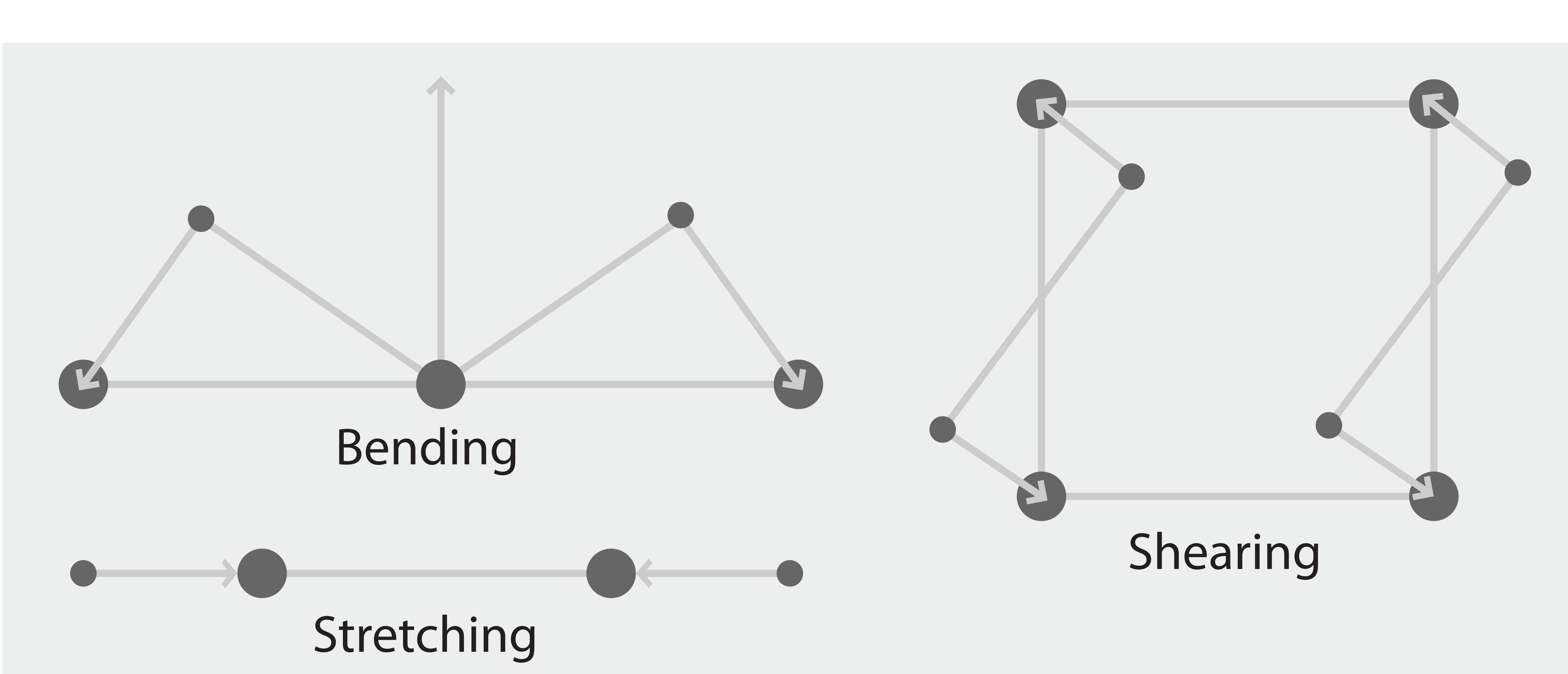
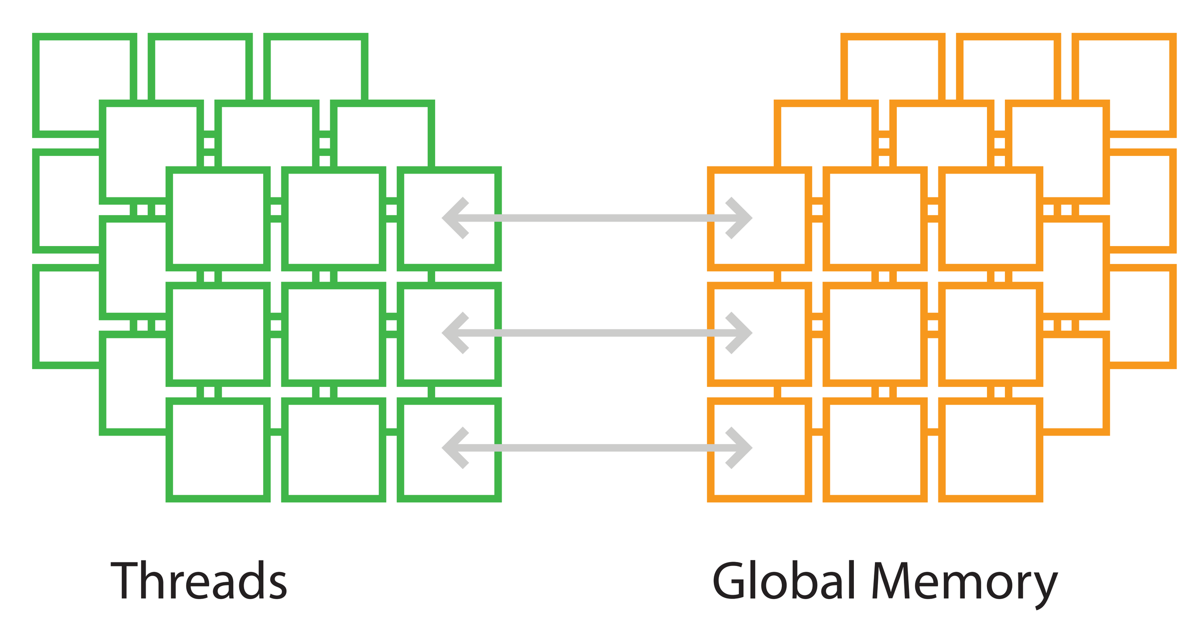


Figure 2 - Spring reactions

Employed Data Structure

Vectorial data are arranged in a three-dimensional matrix of depth three to store components along the three axes. Threads are batched in blocks of depth three. In this way, each thread computes only one component of a three-dimensional vector, and therefore the overall parallelization of the algorithm is increased by a factor three with respect to the standard approaches in which each thread works with the whole vector. In this way it is possible to work efficiently in double precision, because each thread can access data in only one memory transaction, either in double precision and in single precision.

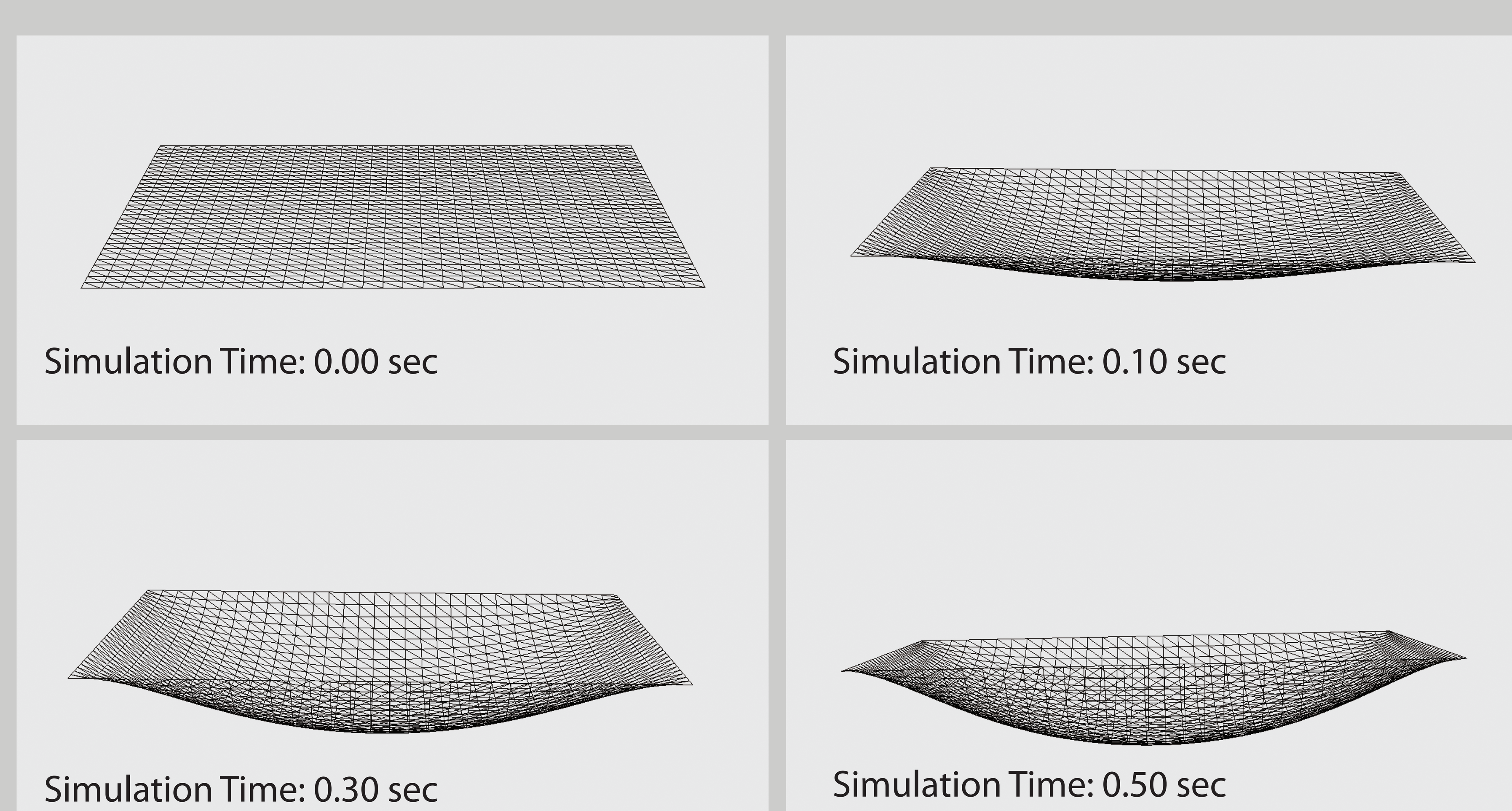


Results and Performances

Our current implementation can simulate and visualize the behavior of a cloth simply constrained on the borders and subjected to the gravity. It is possible to modify the subdivision of the cloth by varying the mesh resolution and modify the cloth behavior by varying the spring constants.

With a mesh composed by 16384 particles using a single device TESLA S1070 the performances are the following:

- ~80 GFLOPS in single precision
- ~25 GFLOPS in double precision



Acknowledgments

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