Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., author comment AC1
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Reply on RC1

Emmanuel Wyser et al.

Author comment on "An explicit GPU-based material point method solver for elastoplastic problems (ep2-3De v1.0)" by Emmanuel Wyser et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-200-AC1, 2021

Reviewer #1

The authors implemented an explicit GPU-based solver within the material point method framework and tested using two- and three-dimensional problems. Results seem to agree with the expected values validating this MPM - GPU architecture. I would like to suggest the publication of this work. Nonetheless, some minor points should be addressed first.

We would like to acknowledge the reviewer for the time spent on the revision of our work.

Comment # 1 The authors mentioned that this GPU architecture speeds up information transfer between nodes and material points. As stated, this is one of the most computationally expensive operations in MPM. Nevertheless, finding material points new location after the mesh returns to its original position is another process that is computationally expensive (in many cases more expensive than information transfer between nodes and material points). I would like to know if the GPU architecture proposed also improves this step. If yes, the author could indicate it in the paper. If not, it would be interesting if the author discusses the possibility of combining some techniques (e.g. Pruijn N.S. 2016) together with GPU's to improve MPM computations.

Pruijn N.S. 2016. The improvement of the material point method by increasing efficiency and accuracy. TU Delft Master Thesis.

Reply # 1 The reviewer points out the computationally expansive operation of finding material point's new locations after the mesh has been reset at the end of a time step. We used a regular background mesh (as opposed to triangular mesh or non-constant element size), therefore, it is straightforward to find material point's new location. To find in which element e a material point p is located, we use the following equation

$$e = (\text{floor}((z_p - z_{min})/\Delta z) + n_{el,z} \times \text{floor}((x_p - x_{min})/\Delta x)) + n_{el,x} \times n_{el,z}\text{floor}((y_p - y_{min})/\Delta y), \quad (1)$$

where $n_{el,x}$ and $n_{el,z}$ are the number of elements along $x-$ and $z-$directions, x_{min}, y_{min} and z_{min} are the minimum x, y, and z coordinate of nodes. However, this is far less trivial when irregular background mesh is used and such equation can not be used any more.

Such concern is out of the scope of our contribution since our implementation only consider a regular background mesh. This concern also explain why we selected a regular background mesh.

We looked at the reference suggested by the reviewer. From an overlook of the mentioned research work, we think a GPU-based implementation of the brute force method is possible, but this would require deeper investigations. This could be the subject of future studies. We strongly think such method could benefit from the computational power of GPUs.

Comment # 2 The authors include a damping value D in the simulations. This value is not well validated. It seems that several simulations were needed to find it, giving the idea that D is not related to the material properties and geometry and is more of an artificial way to reach the desirable results. The authors should elaborate better on the reasons for using this specific damping value.

Reply # 2 It is true that the damping value is not well validated. From a broader perspective and to our knowledge, no studies thoroughly investigated and quantified the influence of damping. However, the common range between 0.05 and 0.15 is usually selected by researchers (e.g., Wang et al., 2016b; Wang et al., 2016a) for dynamic analysis. This range was found sufficient to damp out dynamic oscillations while not producing spurious plastic yielding or an over-damped system, as mentioned in Wang et al., 2016a. As such, we decided to use a damping value of D = 0.1, since reasonable propagations were obtained and no spurious plastic yielding were noticed.

As raised by the reviewer, we will elaborate better on the reasons of this specific value and will clarify accordingly the lack of validation of this damping value within the main body of the text. We will also mention the need for future studies addressing this concern.

Comment # 3 In line 32, the authors mentioned that ”The background mesh can be reset”. As far as I know, the background mesh must be reset. I recommend changing the verb ”can” for a better one.

Reply # 3 We agree with the reviewer. We will change the verb in the revised manuscript.

Change # 3 L.32 The background mesh is reset

Comment # 4 I am wondering if the variables in line 75 are the same as in equations 2 and 3 since different punctuations were used (e.g. A and uˆ).

The authors include a damping value D in the simulations. This value is not well validated. It seems that several simulations were needed to find it, giving the idea that D is not related to the material properties and geometry and is more of an artificial way to reach the desirable results. The authors should elaborate better on the reasons for using this specific damping value.

Reply # 4 We recognize here that this is a mathematical typo. Variables in line 75 are the same as in Eqs. 2 and 3. We will fix this in the revised version of the manuscript.

Comment # 5 Finally, I recommend reading the paper again to correct some typos detected.. Reply # 5 We acknowledge the reviewer’s recommendation and we will read the manuscript again to correct remaining typos.

Reply # 5 We acknowledge the reviewer’s recommendation and we will read the manuscript again to correct remaining typos

Author comment # 1 We additionally extended the original single GPU code and implemented a multi-GPU version using the message passing interface standard. We provide the new section below, which then will be included (with some simplifications) into the manuscripts during the revision stage. This new section can be found in a supplement .pdf file to our response.

Please also note the supplement to this comment:
https://gmd.copernicus.org/preprints/gmd-2021-200/gmd-2021-200-AC1-supplement.pdf