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Interactive comment on "Fast and efficient MATLAB-based MPM solver (fMPMM-solver v1.0)" *by* Emmanuel Wyser et al.

Anonymous Referee #2

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This manuscript presents a vectorized material point method for MATLAB and quantifies the increase in computational efficiency gained from using vectorized rather than iterative code. To my knowledge, this paper provides the only formal analysis of the performance gains from vectorizing MPM code. The presented vectorization approach could be easily implemented within existing and future MPM models. However, as already thoroughly noted by Referee #1, many details of the algorithms, setup of simulations, and numerical analysis are missing. I would like to add the following comments to those already given.

General comments:

-I found the structure of the paper to be confusing, especially in Section 4, where results from five test cases are reported. These test cases are all nearly exact reproductions

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of previously-published work. The first two test cases – the elastic compaction of a column (Section 4.1) and elastic cantilever beam (Section 4.2) – appear to solely serve as benchmark examples for verification of the MPM model, though this is not clearly stated. The third test case – elasto-plastic column collapse (Section 4.3) – also appears to serve as further verification of the model until it is used again in Section 4.4, where the main results of the paper concerning the computational efficiency gained from vectorization are presented. A fourth test case (collision of two elastic disks) is also presented in 4.4 for further analysis of computational efficiency. The final test case (elasto-plastic landslide) is then presented in Section 4.5, which seems to serve the dual purpose of further model verification and a geomechanical application.

-The motivation behind most of the test cases is not clear, especially on the first read. Section 4 would benefit from a short introduction (before 4.1) that outlines what test cases were selected and for what purpose.

-It may help readability if the test cases for elasto-plastic column collapse and collision of two elastic disks are separated into an entirely different section from the rest of the examples, as these two test cases provide the main results in the paper regarding the computational efficiency gained by vectorization.

-Many of the statements regarding the effectiveness of cpGIMPM vs. uGIMPM vs. CPDI are misleading or lacking in detail:

-Line 288: in what way did domain updates based on the deformation gradient result in failure?

-Line 301: “[The elasto-plastic MPM solver] demonstrates the inability of the MPM variants based on a domain update (GIMPM or CPDI) to resolve extremely large plastic deformations when relying on the normal components of the deformation gradient or its stretch part to update the material point domain”. This is too general of a statement. There are many cases in which these domain updates would work well; for example, if simple shear is minimal and the "stretch" update is used (Coombs et al 2020). A

similarly-flawed statement is made in the conclusion section (lines 394-396). Better conclusions regarding GIMPM/CPDI might incorporate the performance gains reported using the vectorization scheme for calculation of the shape functions and the difference in computational efficiency measured for GIMPM vs CPDI.

-Line 305: As already pointed out by Referee #1, it should be noted that the determinant of the deformation gradient-type GIMPM domain update is problematic for simple compression problems. Have the authors tried updating the GIMPM domains with the "corner" scheme from Eqs 35-37 in Coombs et al (2020)? Perhaps it would be more robust.

-There does not appear to be any reference to Fig. 1 in the main text. The caption for Fig. 1 also appears to lack any description of panels B and C.

-The list of the three steps of a typical MPM cycle at the beginning of Section 3.1 seems misplaced and is somewhat repetitive of the description of MPM in the previous sections. I suspect this list should link with Fig. 1 and may be more appropriately located within Section 2.

Minor comments:

- Fig 2. In the caption, "GIMP" should be changed to "GIMPM" to match the rest of the paper. The authors have already fixed the error in Fig. 2b regarding which nodes are associated with the GIMPM domain

-Line 39: which numerical considerations from MILAMIN are used? This is not specifically addressed

-several citations are missing parentheses (e.g. lines 52 and 84).

References:

Coombs, WM, Augarde, CE, Brennan, AJ, Brown, MJ, Charlton, TJ, Knappett, JA, Ghaffari Motlagh, Y & Wang, L (2020). On Lagrangian mechanics and the implicit

material point method for large deformation elasto-plasticity. Computer Methods in Applied Mechanics and Engineering 358: 112622.

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