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Memo

Date
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From: Eric Grolman, Pieter Vonk

To: IFPRI members

Subject
Concept IFPRI project proposal:

Continuum flow modeling in Industry

PI's: Dan Negrut (U. Wisconsin)
Ken Kamrin (MIT)
Nico Gray (U. Manchester)

Project Summary

This project seeks to make the Chrono software package suitable for use in industry to tackle applications that are of interest to IFPRI members. The project aims to improve the user interface by implementing a Python-based interface, expand the range of rheological models available to include free-flowing to cohesive powders, and provide proof that the rheological models are well-posed, as well as introducing simple models for particle segregation. Additionally, the project will provide standard test geometries such as a ring-shear tester, FT4, Granuheap and Granudrum, as well as provide a procedure to either obtain the relevant rheological parameters from measurements in these standard test geometries, or from verified DEM simulations. Additionally, we will provide effective ways to process the data (e.g. Python, Paraview). It is expected that the project will take three years to complete.

Project Goals and Objectives

The primary goal of this project is to make the open-source Chrono software package suitable for use in industry within a three-year timeline. To accomplish this goal, the following objectives must be achieved:
1. Implement a Python-based user interface to improve user experience.
2. Expand the range of rheological models available to include free-flowing to cohesive powders.
3. Provide proof that the rheological models are well-posed, as well as introduce simple models for particle segregation.
4. Provide standard test geometries such as a ring-shear tester, FT4, Granuheap and Granudrum.
5. Develop a procedure to either obtain rheological parameters from measurements in these standard test geometries or from verified DEM simulations.
6. Develop effective ways to enter geometries and process the data (e.g. Python, Paraview).

Project Methodology

In order to achieve the project goals and objectives within the three-year timeline, the following methodology will be used:
1. Create a detailed project plan outlining the tasks to be completed and the timeline for completion.
2. Research existing software packages to determine the best approach for implementation.
3. Develop the Python-based user interface.
4. Implement the range of rheological models.
5. Provide proof that the rheological models are well-posed, as well as introduce simple models for particle segregation.
6. Develop the standard test geometries and method to import into Chrono.
7. Implement the procedures to arrive at the rheological parameters (w. industry help).
8. Develop effective ways to process the data (e.g. Python, Paraview).
9. Test the software package for functionality and accuracy on 3 industrial cases.
10. Obtain feedback from users and make any necessary improvements.

Project Team: The project will be executed in a collaboration between three university groups: University of Wisconsin-Madison (Chrono package), MIT (rheological models, test methods) and The University of Manchester UK (mathematical well-posedness and particle segregation). The team will consist of ...

Project Budget

The level of regular IFPRI project funding is far removed from what the academics require to make the project happen. Therefore, it’s success will depend to a large

extend on their ability to secure additional funds. From IFPRI side we perhaps should consider a combination of project funding and collaboration grant(s), to be discussed.

Conclusion

This project seeks to make the open-source Chrono MPM software package suitable for use in industry. The project aims to improve the user interface by implementing a Python-based interface, expand the range of rheological models available to include free-flowing to cohesive powders, and provide proof that the rheological models are well-posed, as well as introduce simple models for particle segregation. Additionally, the project will provide standard test geometries such as a ring-shear tester, FT4, Granuheap and Granudrum, as well as effective ways to import and to process the data (e.g. Python, Paraview). It is expected that the project will take three years to complete.

The Chrono simulation package

Chrono is an open-source multi-physics simulation software package developed at the University of Wisconsin, Madison and University of Parma, Italy. It is designed to simulate the behavior of a wide range of materials, from deformable-bodied materials to rigid bodies such as rocks and concrete. Chrono combines particle-based methods with continuum mechanics to accurately simulate the dynamics of granular materials. By using Chrono, researchers and engineers can gain insight into the behavior of materials in a wide variety of applications, including the development of materials with improved properties, the optimization of manufacturing processes, and the design of robust and reliable products. In addition, Chrono is an open-source package, allowing users to customize the software to their specific needs. Chrono is used by the US Army, NASA, NIOSH, and hundreds of users worldwide. Its strength is in simulation of automation as it comes up in robotics applications. It is a multi-physics engine, with support for sensor simulation, deformable body mechanics, rigid body dynamics, fluid solid interaction, vehicle dynamics, and granular dynamics. In 2022 it received a $1.875 million project from National Science Foundation to continue its open-source development for the next three years.

With kind regards,

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