SURGE 2021 Project Abstract for the Midterm Review

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Project Title: Modeling Subsurface Mine Detonation

Introduction to the problem statement

The world is polluted with an estimated 45-50 million mines in over 60 countries; which makes neutralisation of mines very crucial. Current practices of the same centre on manual demining, a slow, labour intensive, and often a high risk and expensive process. Mechanised flail systems are often proposed to speed up the process, reduce the cost, and the risk associated with the neutralisation of buried pressure activated landmines.

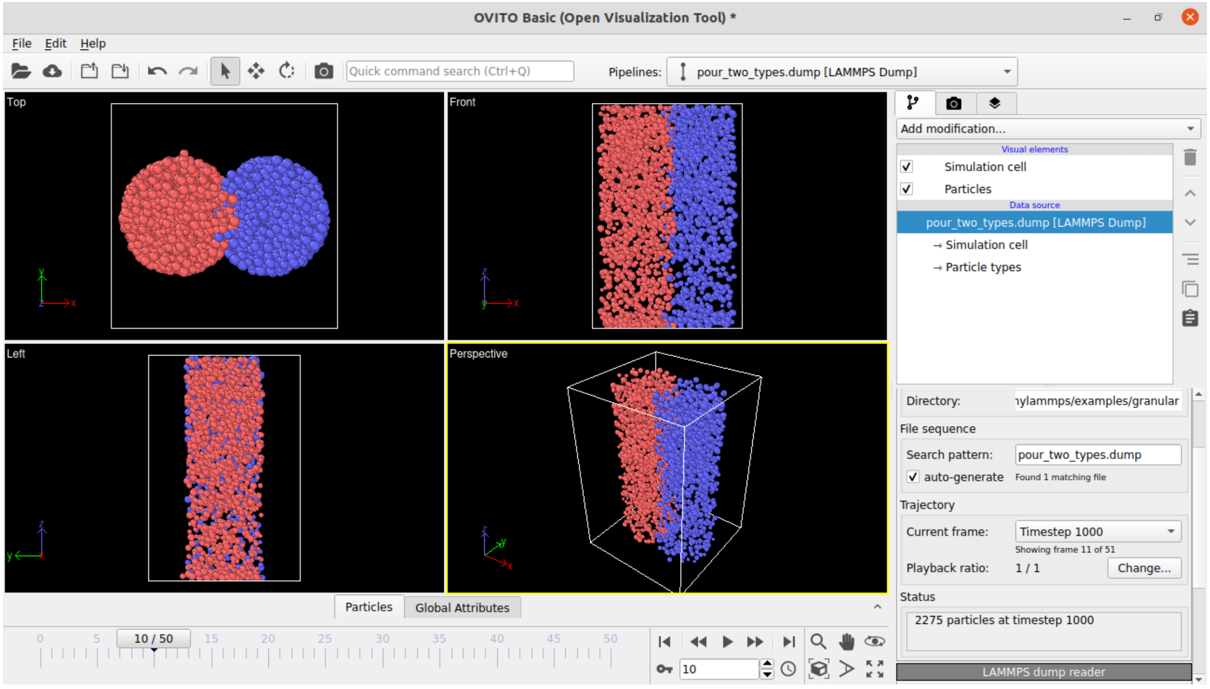
Our aim here is to model a flail system to detect and neutralise mines (to trigger and detonate mines where buried). When a flail hits the ground with force it causes the subsurface mines to detonate. For proper design it is necessary to know the minimum force that the flail must transmit to the ground for a given soil type to ensure the detonation. As a part of the project, we will be analyzing the transfer of stresses from the point of impact of the flail to the location of the buried mine, and see how this varies for the different types of soils. This will require a study of how waves transmit in discrete media like soils. For this, we will be using the LAMMPS (Large scale Atomic/Molecular Massively Parallel Simulator) software.

LAMMPS and OVITO simulations:

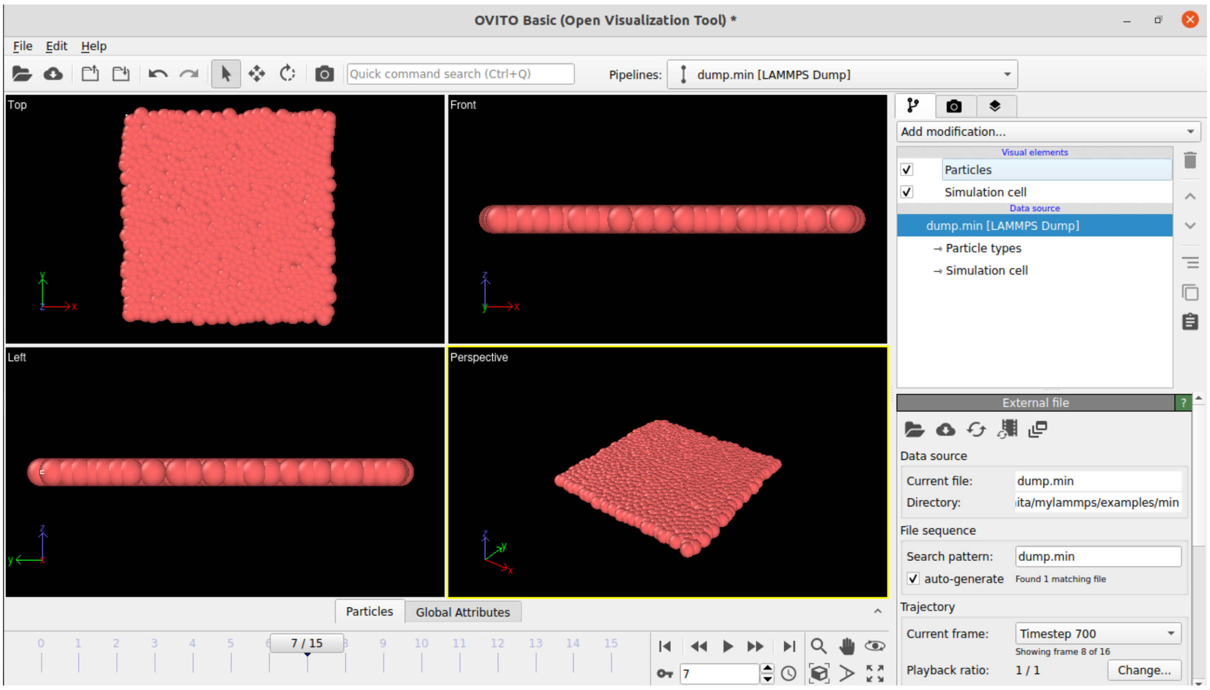
The initial phase of the project began with learning how to write LAMMPS script and also running the generated dump files in OVITO. As a part of this, the following simulations were carried out.

Below are the initial simulations carried out while learning LAMMPS and OVITO.

Granular Package

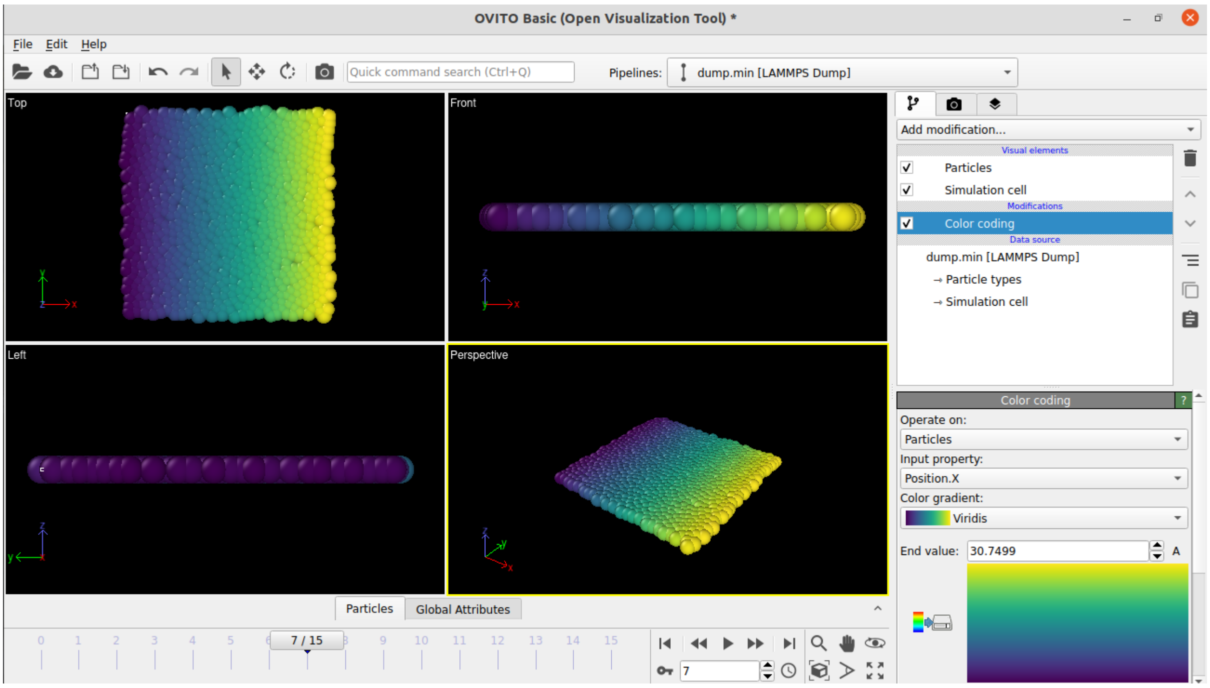


Min Package

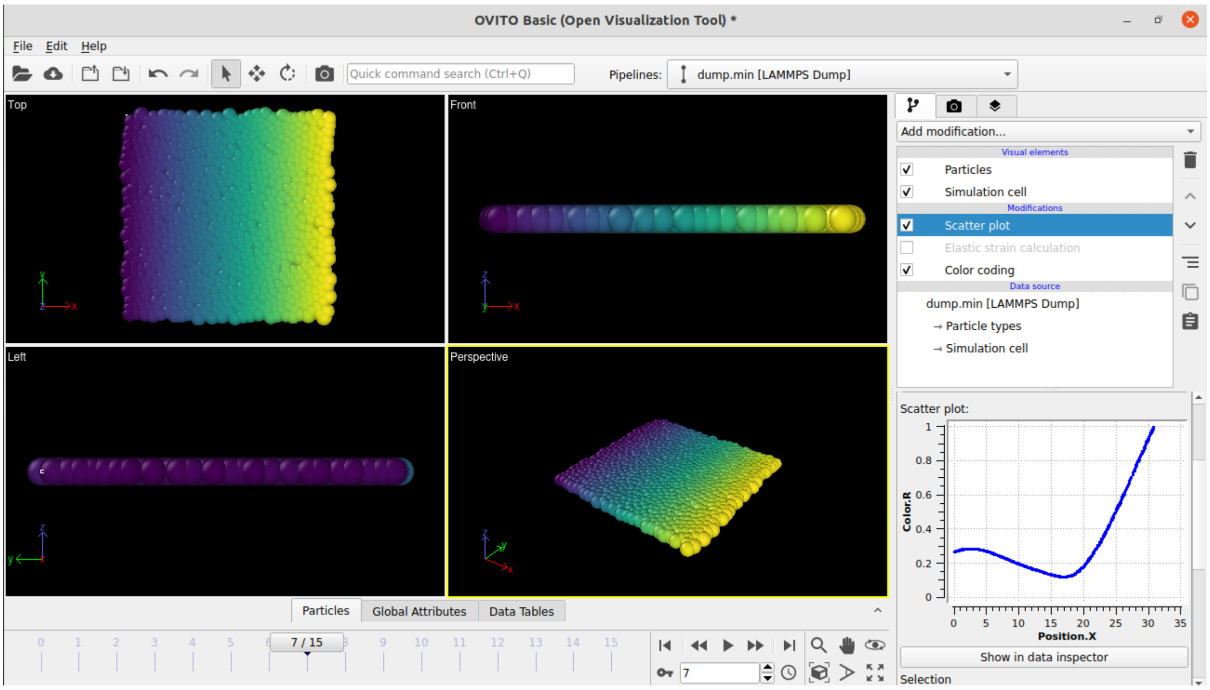


Further learnings included using the OVITO platform properly. Modifications were implemented on the already generated simulations as depicted below.

Color Mapping



Scatter Plot

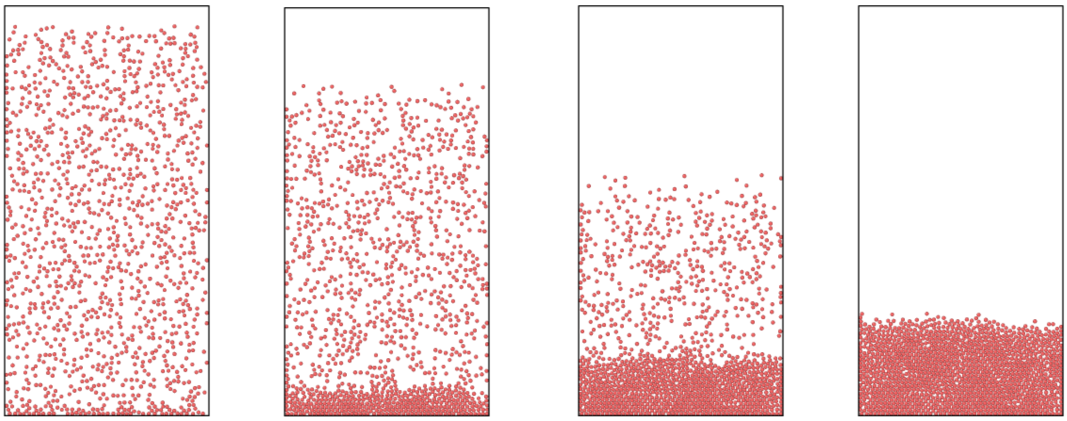


Granular Bed

To begin with the initial simulation, we started by creating a granular bed that would replicate the soil bed.
We started out by taking grain particles with diameter lying in the range (0.95, 1.05) and assigned them random initial velocities in the range of (-2.5, 2.5). The grain particles were allowed to settle in an environment with gravity (-9.8) acting in a negative y axis direction.

Kinetic energy of the entire system was recorded to be around 2728.73 joules initially and the simulation was stopped when it dropped below 0.001 joules.

After some attempts, this is the final grain bed that we have achieved.



(a) (b) (c) (d)

Simulation captures for the settling of particles under the influence of gravity.

Further Course of action

Now, we need to hit the bed with a flail and analyse the stress at various positions of the granular bed.

References

1. DESIGN OF FLAIL FOR SOIL TREATMENT N. Vinković, V. Stojković, D. Mikulić
2. Unravelling flail-buried mine interaction in mine neutralization V.S. Shankhla Defence Research Establishment Suffield
3. Force transmitted below the soil surface by human gait Jude Liu, Radhey Lal Kushwaha