Crushing a Foam Microstructure

Problem Description

This calculation demonstrates two important strength of MPM. The first is the ability to quickly generate a computational representation of complex geometries. The second is the ability of the method to handle large deformations, including self contact.

In particular, in this calculation a small sample of foam, the geometry for which was collected using microCT, is represented via material points. The sample is crushed to 87.5% compaction through the use of a rigid plate, which acts as a constant velocity boundary condition on the top of the sample. This calculation is a small example of those described in [1]. The geometry of the foam is created by image procesing the CT data, and based on the intensity of each voxel in the image data, the space represented by that voxel either recieves a particle with the material properties of the foam's constituent material, or is left as void space. This particle representation avoids the time consuming steps required to build a suitable unstructured mesh for this very complicated geometry.

Simulation Specifics

Component used: MPM

Input file name: foam.ups

Instruction to run input file: First, copy foam.ups and foam.pts.gz to the same directory as sus. Adjust the number of patches in the ups file based on the number of processors available to you for this run. Uncompress the pts file **gunzip foam.pts.gz**.

The command: **pfs foam.ups** will divide the foam.pts file, which contains the geometric description of the foam, into number of patches smaller files, named foam.pts.0, foam.pts.1, etc. This is done so that for large simulations, each processor is only reading that data which it needs, and prevents the thrashing of the file system that would occur if each processor needed to read the entire pts file. This command only needs to be done once, or anytime the patch distibution is changed. Note that this step must be done even if only one processor is available.

To run this simulation: **mpirun -np NP sus foam.ups** where NP is the number of processors being used.

Simulation Domain: 0.2 X 0.2 X 0.2125 mm

Number of Computational Cells:
102 X 102 X 85 (Level 0)

Example Runtimes:

3 hours (32 processors, 2.4 GHz Xeon)
11 hours (2 processors, 3.0 GHz Xeon)

Physical time simulated: 3.75 seconds

Associate scirun network: foam.srn

Results

Figure 1 shows a snapshot of the simulation, as the foam is at 50% compaction.

In this simulation, the reaction forces at 5 of the 6 computational boundaries are also recorded and can be viewed using a simple plotting package such as gnuplot. At each timestep, the internal force at each of the boundaries is accumulated and stored in "dat" files within the uda, e.g. BndyForce_zminus.dat. Because the reaction force is a vector, it is enclosed in square brackets which may be removed by use of a script in the inputs directory:

```
cd foam.uda.000
../inputs/ICE/Scripts/removeBraces BndyForce_zminus.dat
gnuplot
gnuplot> plot "BndyForce_zminus.dat" using 1:4
gnuplot> quit
```

These reaction forces are similar to what would be measured on a mechanical testing device, and help to understand the material behavior.

References

[1] A.D. Brydon, S.G. Bardenhagen, E.A. Miller, and G.T. Seidler. Simulation of the densification of real open-celled foam microstructures. *Journal of the Mechanics and Physics of Solids*, 53:2638–2660, 2005.

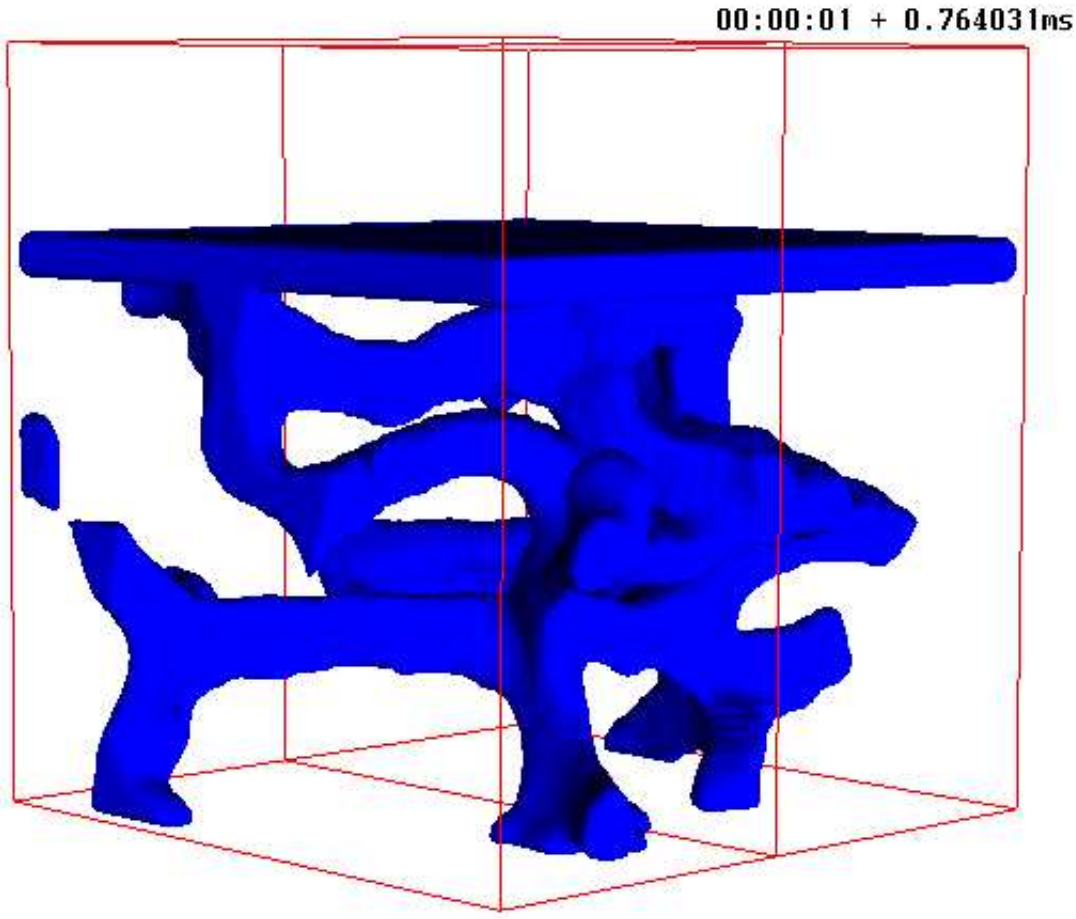

Figure 1: Compaction of a foam microstructure.