Computer Graphics: Geometry and Simulation
Coursework 2: Simulation

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This report makes references to videos, which can be found in the `videos` directory of the submission. The relevant files are named accordingly within the report.

The code for sections 1 and 2 can be found in the `section-12` directory of the submission, containing the `scene.h` and `mesh.h` files. The code for section 3 can be found in the `section-3` directory, containing the same mesh.h and constraints.h files, with an updated version of the scene.h file. All other files from the original codebase remain unchanged.

1 Linear FEM Matrices & Constrained Time Integration

The linear FEM method works well for small deformations, with no noticeable artefacts occurring, as seen in `bunny-12.mov`, which depicts `bunny-scene.txt`. In contrast, `epcot-12.mov` and `cube86-12.mov`, depicting `epcot-scene.txt` and `cube86-scene.txt` respectively, demonstrate clear artefacts when larger deformations are involved. The cubes in `cube86-12.mov` end up massively sheared and stretched, with the artefacts becoming more pronounced as the simulation progresses. Meanwhile, in `epcot-12.mov`, the Epcot model becomes stretched and flattened as the simulation progresses.

2 Extension: Corotational Elements

Two very obvious improvements can be seen with `cube86-scene.txt` in `cube86-3.mov`, and `epcot-scene.txt` in `epcot-3.mov`. The cubes in `cube86-3.mov` no longer become sheared or stretched, and the Epcot model in `epcot-3.mov` no longer becomes stretched or flattened.

Figure 1 shows the difference between the resting states of linear FEM and corotational elements for the cube scene. The corotational elements maintain the cube's shape, while the linear FEM elements do not.

Figure 2 shows the difference between the resting states of linear FEM and corotational elements for the Epcot scene. Once again, the corotational elements maintain the Epcot model's shape, while the linear FEM elements do not.

On the other hand, `fertility-scene.txt` shows relatively little difference between linear FEM and corotational elements, as seen in `fertility-12.mov` and `fertility-3.mov`.

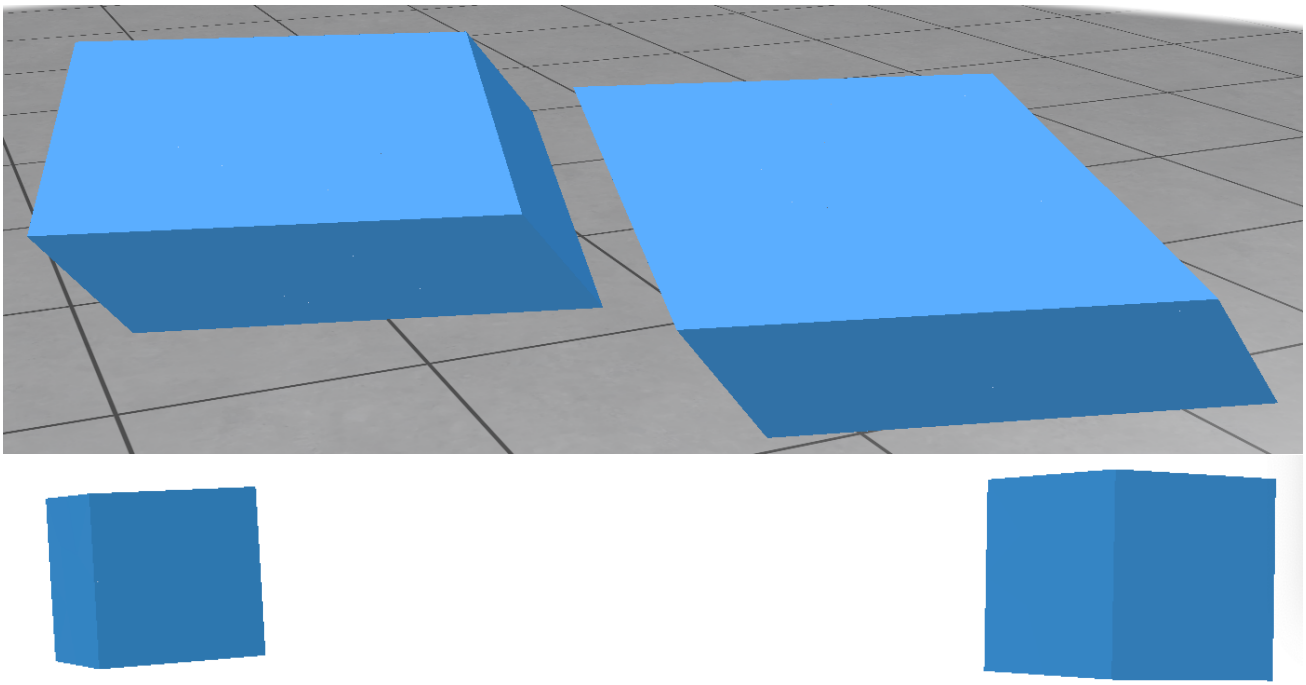

Figure 1: Comparison of linear FEM (top) and corotational elements (bottom) for the cube scene.

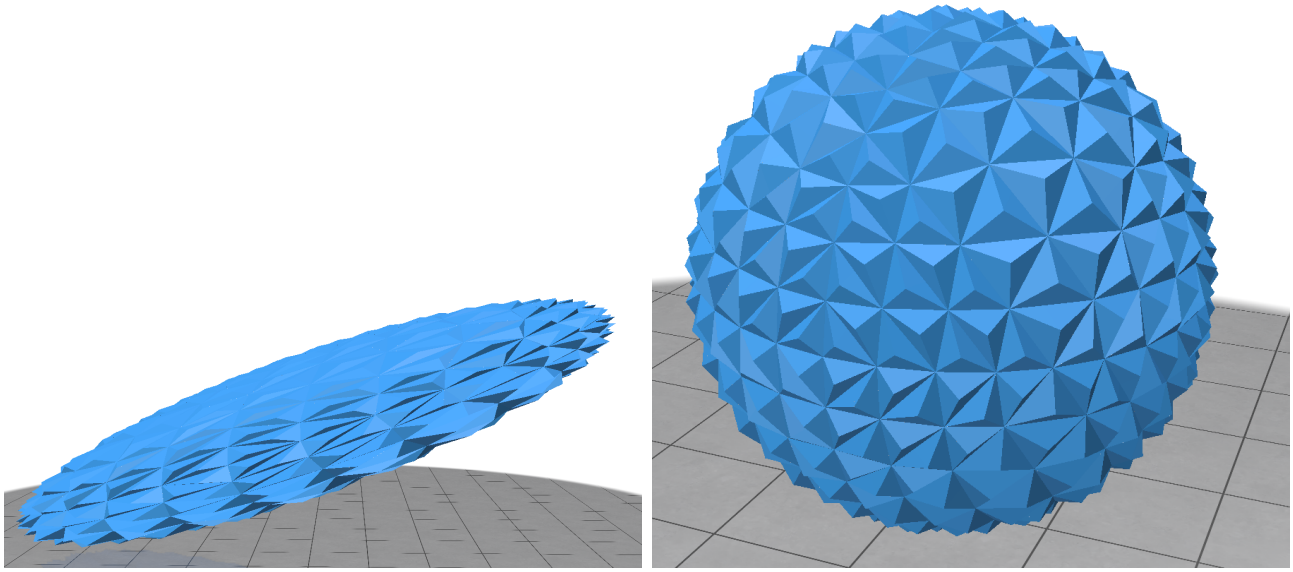

Figure 2: Comparison of linear FEM (left) and corotational elements (right) for the Epcot scene.

Despite the improvements in many cases, it comes at a cost. The corotational elements are much more computationally expensive. This is most noticeable in the `epcot-scene.txt` simulation, where the frame rate drops significantly when using corotational elements, which can be seen in `epcot-3.mov`, compared to `epcot-12.mov`.