Final: AlienGLRenderer: Cloth Simulation

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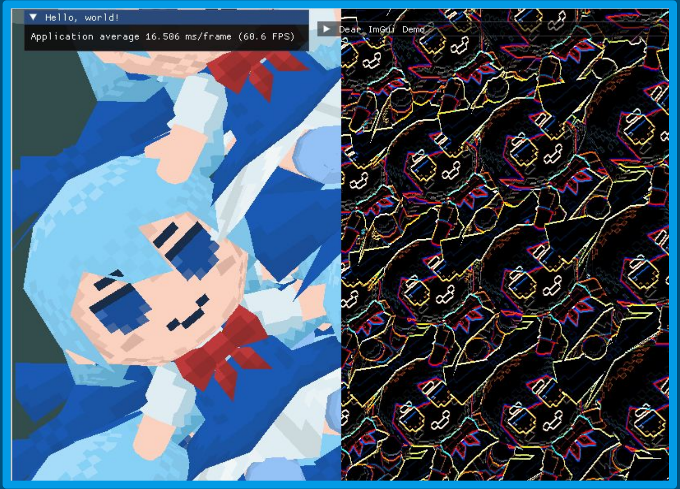
Link to presentation: https://docs.google.com/presentation/d/1kTidNlouo0Z4JUA38zkX3oHS2g0vJ7p8UtcZK0oS1vM/
Link to project: https://github.com/dinoplane/gl_alien_renderer

Inspiration

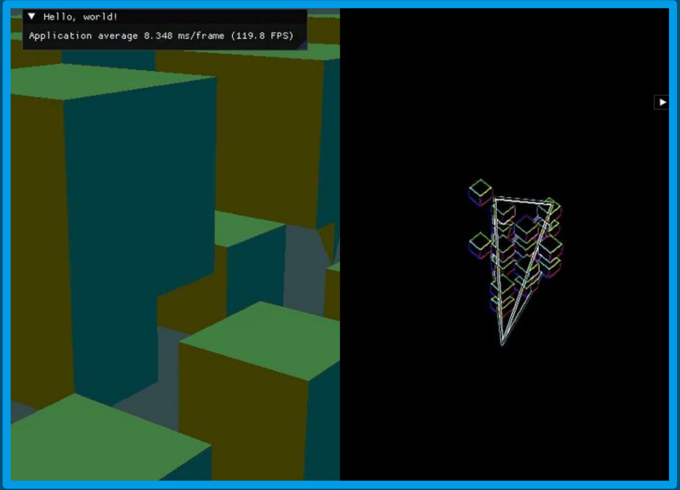
AlienGLRenderer

- A sandbox renderer in OpenGL
  - Streamline creation of simple scenes
  - Help me reinforce CG concepts
- Current features:
  - Post-processing
  - Instancing
  - Frustum culling
  - Gltf Model Loading
  - Scene Loading

I occasionally post my progress here: https://x.com/isacsac2017



```
▼ Hello, world!
Application average 16.506 ms/frame (60.6 FPS)
```



```
▼ Hello, world!
Application average 8.348 ms/frame (119.8 FPS)
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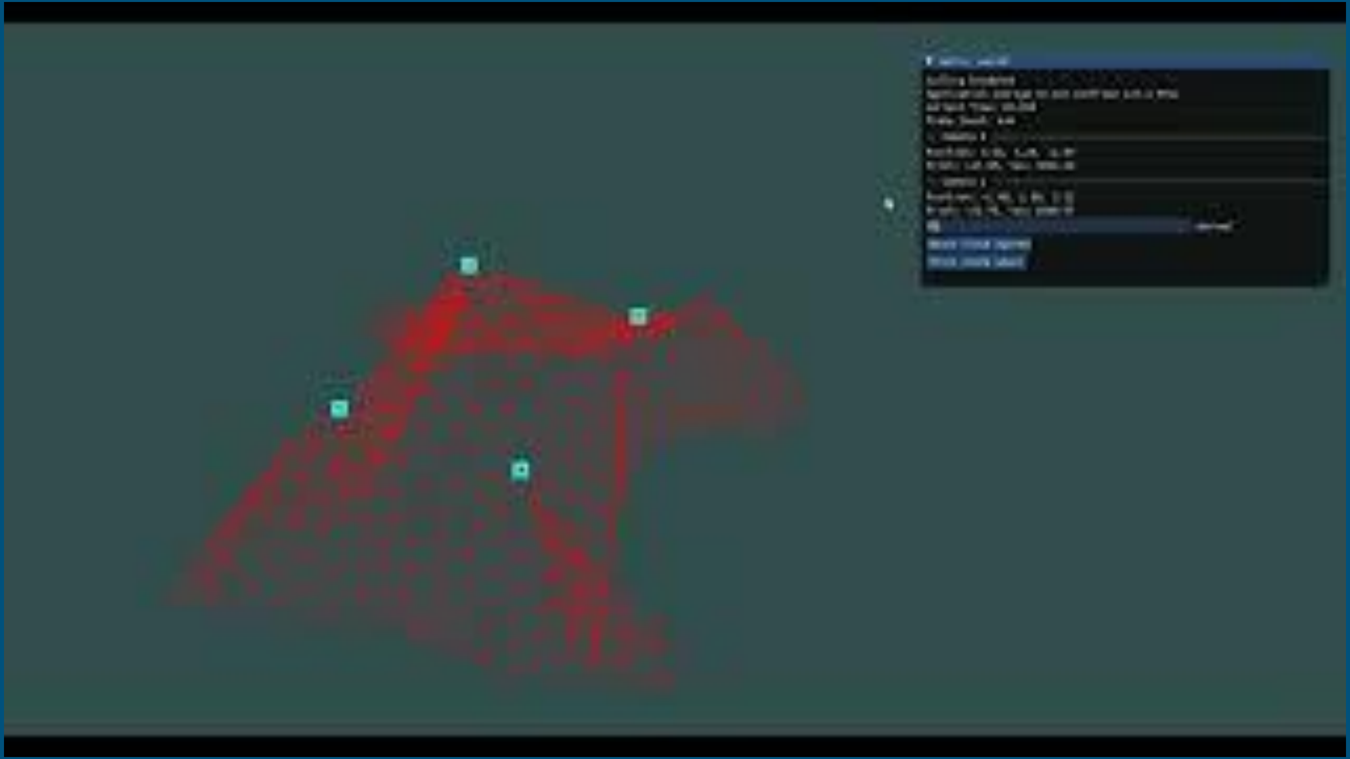
Questions

- How efficiently can we render a cloth with the DEP algorithm?
- How do we implement this?
- What problems arise when implementing the simulation in C++ / OpenGL?

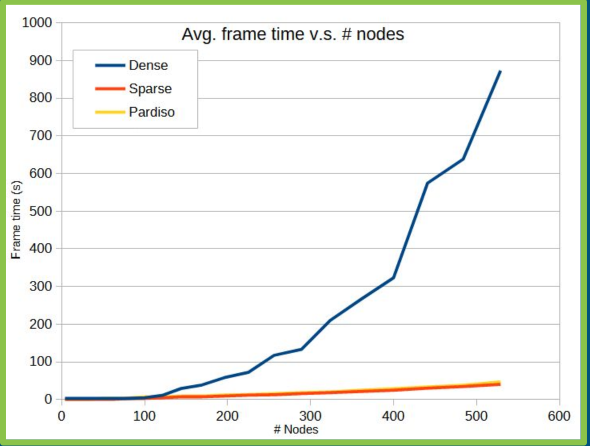
Questions

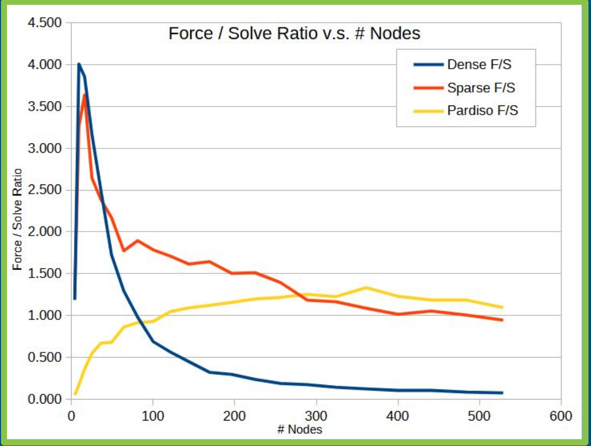
- How efficiently can we render a cloth with the DEP algorithm?
  - Current Best: 256 - 289 nodes (768 - 867 DOFs) at ~30FPS
  - With a slight caveat maybe more?
- How do we implement this?
  - Use sparse matrices
  - Use faster solvers (ONLY IF THEY ARE THE BOTTLENECK)
- What problems arise when implementing the simulation in C++ / OpenGL?
  - Memory alignment
  - API design issues
  - Numerical Degeneracies

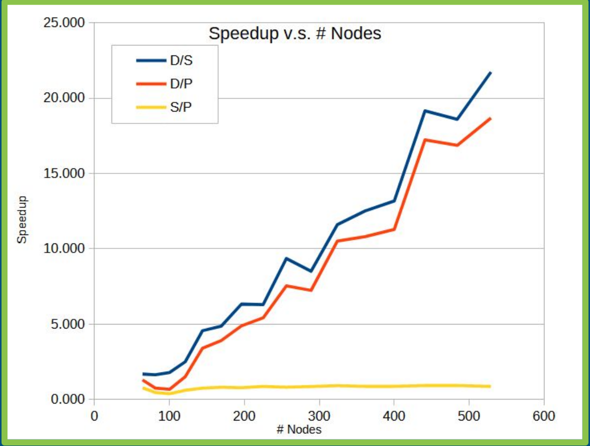
Results



Results - Cont.







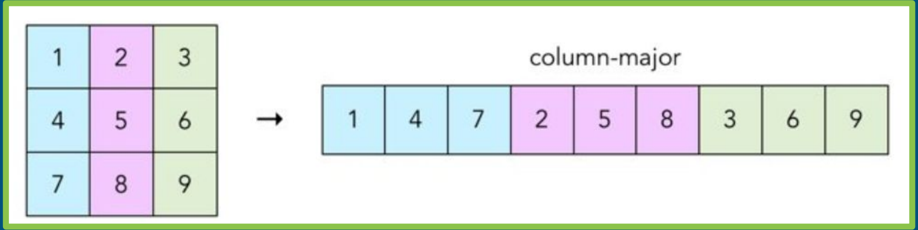
Implementation #1

Transcription of python version

- Numpy -> Eigen
- Dense Matrices
- Double -> floats

~30 FPS: 169 - 196 nodes (507 - 588 DOFs)

529 Nodes: 1.145 FPS



1	2	3
4	5	6
7	8	9

→

column-major

1	4	7	2	5	8	3	6	9

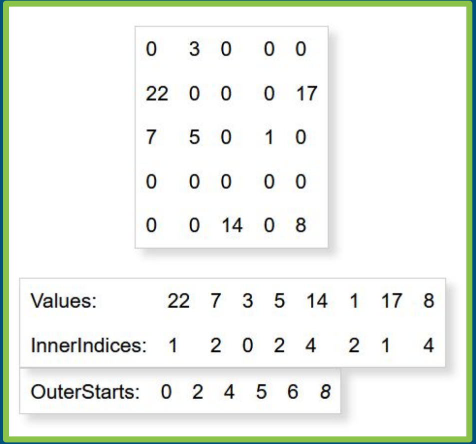
Implementation #2

Use Sparse Matrices

- Floats -> Doubles
- Dense Matrices -> Sparse Matrices
- Not Multithreaded
  - Actually didn't help that much
  - Cache coherency (false sharing)
- Fixed a major bug

~30 FPS: 484 nodes (1575 DOFs)

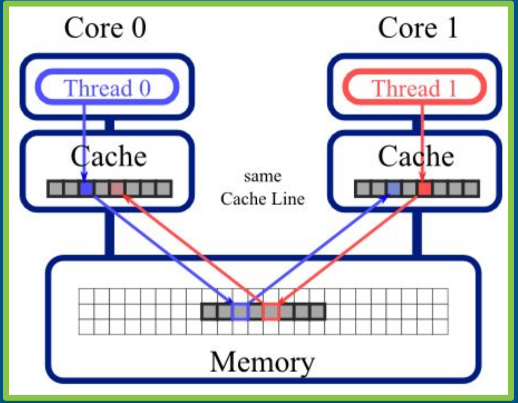
1764 Nodes: 4.098 FPS



0	3	0	0	0
22	0	0	0	17
7	5	0	1	0
0	0	0	0	0
0	0	14	0	8

Values:	22	7	3	5	14	1	17	8
InnerIndices:	1	2	0	2	4	2	1	4

OuterStarts:	0	2	4	5	6	8



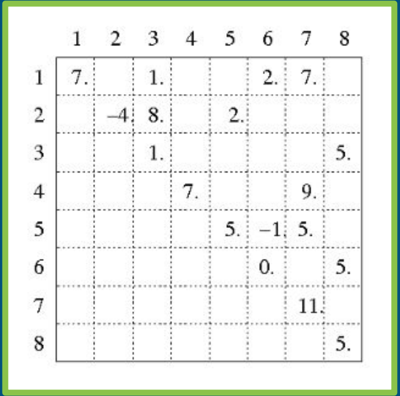
Implementation #3

Third implementation: using PARDISO

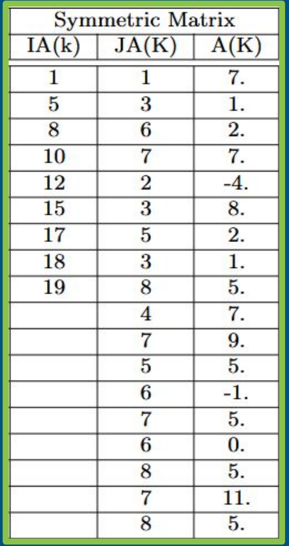
- Full Matrix -> Upper triangular
- Column major -> Row major

~30 FPS: 484 nodes (1575 DOFs)

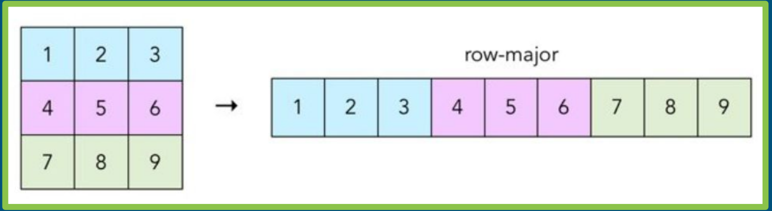
1764 Nodes: 4.435 FPS



	1	2	3	4	5	6	7	8
1	7.		1.			2.	7.	
2		−4	8.		2.			
3			1.					5.
4				7.			9.	
5					5.	−1	5.	
6						0.		5.
7							11.	
8								5.



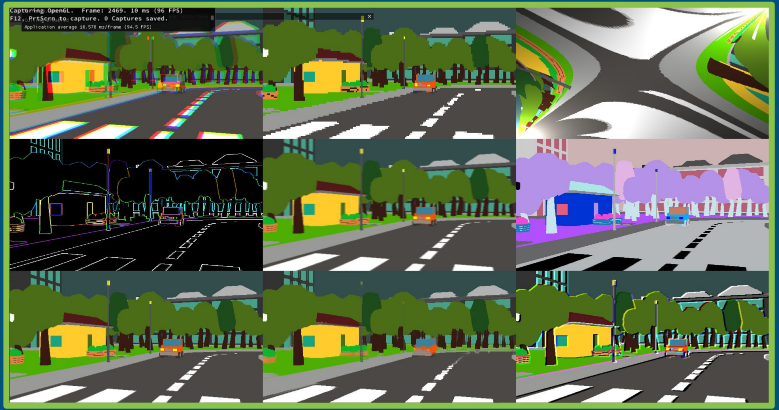
Symmetric Matrix		
IA(k)	JA(K)	A(K)
1	1	7.
5	3	1.
8	6	2.
10	7	7.
12	2	-4.
15	3	8.
17	5	2.
18	3	1.
19	8	5.
	4	7.
	7	9.
	5	5.
	6	-1.
	7	5.
	6	0.
	8	5.
	7	11.
	8	5.



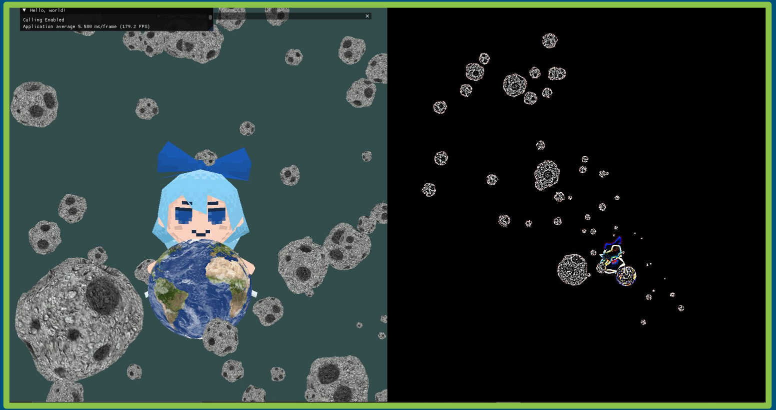
Comments

- OpenGL kinda sucks
  - Memory Alignment
- C++ is hard
  - Template metaprogramming is hard to debug
- Degeneracies
  - Arise when the young modulus is too large, the # nodes too large, the timestep too large etc.
  - Tweaking parameters is needed
- Eigen (reasonably) doesn’t have sparse matrix slicing
  - Develop intuition about how matrix slicing works.

Thank you!



```
Capturing OpenGL.  Frame: 2469. 10 ms (96 FPS)
F12, PrtScrn to capture. 0 Captures saved.
Application average 10.578 ms/frame (94.5 FPS)
```



```
▼ Hello, world!
Culling Enabled
Application average 5.580 ms/frame (179.2 FPS)
```

References

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