Supplement to Decomposed Optimization Time Integrator for Large-Step Elastodynamics

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1 EXPERIMENTAL DATA

In this section we summarize all experimental data from our experiments in the following tables. These tables are referenced in the Evaluation section of our main paper. In these experiments we tested previous methods on PN, LBFGS-H, LBFGS-PD, and DOT on a diverse set of input meshes and simulation settings. We also experimented with a new method where we initialize LBFGS with incomplete Cholesky from the start of time step. In the following tables we refer to this method as LBFGS-HI. Results for our experiments are organized per tables. In each we report for all methods average, per time step, running time *t*, and the average, per time step, iteration count *#iters*, along with details of the relevant simulation settings. In the following an entry of NC indicates the method did not converge.

Model: horse, Script: Stretch (10s), h: 25ms												
#Verts	#Tets	PN		LBFGS-H		LBFGS-HI		L-BFGS-PD		DOT	
		t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters
7K	31K	0.4	4.9	0.2	9.4	0.5	58.6	0.5	49.2	0.3	18.3
38K	156K	4.2	9.7	1.4	15.7	5.4	109.7	7.8	97.4	1.8	24.5
79K	349K	17.9	13.9	5.7	25.7	20.4	174.0	36.7	172.9	6.3	39.8
136K	642K	78.0	20.9	17.8	39.1	44.5	207.2	101.7	236.7	17.6	58.0

Table 1. Scalability test on the horse models with increasing resolution (7K nodes to 136K nodes, tetrahedra count from 31K to 642K) under the dirichlet boundary conditions set on the mouth and tail, pulling it apart.

Model: monkey, #Verts: 18K, #Tets: 75K, Script: TSS (10s)												
h (ms)	E (Pa)	nu	PN		LBFGS-H		LBFGS-HI		L-BFGS-PD		DOT	
			t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters
10	1.0×10^5	0.40	1.2	5.6	0.6	12.0	1.6	54.0	1.9	60.7	0.5	16.9
25	1.0×10^5	0.40	2.4	11.4	1.8	47.6	3.8	146.9	2.9	96.6	1.2	41.9
40	1.0×10^5	0.40	3.7	17.9	2.7	70.0	6.8	269.4	4.0	132.4	2.5	91.7
25	2.5×10^4	0.40	3.5	17.2	2.5	72.1	2.6	105.5	4.2	143.5	1.1	43.0
25	4.0×10^5	0.40	2.1	10.3	1.5	40.0	4.9	192.0	2.3	82.4	1.2	45.1
25	1.0×10^5	0.30	2.2	10.9	1.2	31.6	1.9	92.0	1.7	67.6	0.9	31.6
25	1.0×10^5	0.45	2.4	11.6	2.7	65.9	2.3	113.1	3.3	115.3	1.6	56.5

Table 2. Timestep and material variation test on monkey model with Dirichlet boundary conditions on the two sides, twisthing, stretching, and squashing (TSS) at the same time. We vary timestep among $10ms$, $25ms$ and $40ms$, Young's modulus among 2.5×10^4, 1×10^5, and 4×10^5, and Poisson's ratio among 0.3, 0.4, and 0.45.

Model	#Verts	#Tets	Script	h (ms)	E (Pa)	PN		LBFGS-H		LBFGS-HI		L-BFGS-PD		DOT	
						t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters
hollowCat	24K	100K	X (10s)	10	60K	5.0	15.6	3.0	49.2	2.4	68.6	21.7	317.7	1.9	50.1
hollowCat	24K	100K	X (10s)	25	60K	3.9	13.0	5.8	84.4	4.0	98.5	18.0	267.6	3.5	85.6
Armadillo	27K	147K	X (10s)	10	80K	13.8	20.9	4.8	50.0	3.5	76.3	15.7	200.8	3.7	55.7
Armadillo	27K	147K	X (10s)	25	80K	13.3	20.6	7.4	73.2	5.9	123.2	14.4	204.7	6.5	83.6
horse	7K	31K	LTSS(10s)	25	100K	0.7	8.6	0.9	56.4	0.7	79.3	1.1	104.4	0.5	44.0
bunny	30K	126K	LTSS(5s)	25	100K	6.0	16.4	2.7	46.8	NC	NC	8.9	140.9	1.5	30.9
kingkong	48K	277K	LTSS(10s)	25	100K	48.8	27.1	6.6	34.2	7.0	87.7	24.1	166.7	5.5	47.6
elf	63K	361K	LTSS(5s)	25	100K	72.7	24.7	11.3	41.7	18.7	148.1	35.8	180.1	7.3	44.9
kingkong	18K	81K	TSS (10s)	25	100K	5.2	21.3	1.1	28.3	1.3	55.6	2.2	69.2	0.8	26.3
monkey	18K	75K	TSS (10s)	25	100K	2.4	11.4	1.8	47.6	3.8	146.9	2.9	96.6	1.2	41.9
elf	23K	96K	TSS (10s)	25	100K	4.6	15.7	1.4	28.2	3.3	90.6	5.0	113.4	1.2	32.0
hollowCat	24K	100K	TSS (10s)	25	100K	4.3	13.7	1.0	18.4	3.8	92.4	2.2	59.7	1.0	24.4
horse	38K	156K	TSS (10s)	25	100K	4.2	9.7	7.0	82.6	8.2	161.1	5.4	89.2	3.0	47.1

Table 3. (Larger) Twist & stretch & squash (LTSS/TSS) and rubber band pull - extreme deformation (X) examples.

Model	#Verts	#Tets	Script	h (ms)	Core i7-8700K @ 3.7GHz, 6 cores (12)										Xeon @ 2.4GHz, 16 cores (32)									
					PN		LBFGS-H		LBFGS-HI		L-BFGS-PD		DOT		PN		LBFGS-H		LBFGS-HI		L-BFGS-PD		DOT	
					t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters
hollowCat	24K	100K	TSS (10s)	25	4.3	13.7	1.0	18.4	3.8	92.4	2.2	59.7	1.0	24.4	9.9	13.7	2.2	18.6	6.5	92.3	3.4	59.7	1.4	23.5
monkey	18K	75K	TSS (10s)	25	2.4	11.4	1.8	47.6	3.8	146.9	2.9	96.6	1.2	41.9	5.8	11.3	3.7	46.9	6.8	150.7	3.9	96.6	1.9	52.4
horse	38K	156K	TSS (10s)	25	4.2	9.7	7.0	82.6	8.2	161.1	5.4	89.2	3.0	47.1	10.1	9.7	13.2	81.8	13.9	160.7	8.2	90.4	4.9	59.1
kingkong	48K	277K	SS (10s)	25	31.9	17.2	5.0	23.6	6.1	72.7	7.1	65.6	4.1	30.0	46.5	17.2	9.1	23.7	11.3	71.0	10.1	64.5	5.3	32.4

Table 4. Machine comparison. We set the number of domains in DOT to match the number of cores on the machine. SS stands for Dirichlet boundary conditions on the two sides, stretching and squashing.

Model	#Verts	#Tets	Script	PN		LBFGS-H		LBFGS-HI		L-BFGS-PD		DOT-16K		DOT-8K		DOT-4K		DOT-2K		DOT-1K		DOT-512		DOT-256	
				t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters	t (s)	#iters
horse	7K	31K	S (10s)	0.4	4.9	0.2	9.4	0.5	58.6	0.5	49.2	N/A	N/A	N/A	N/A	0.2	11.6	0.3	17.1	0.3	20.3	0.3	22.5	0.4	29.0
	38K	156K	S (10s)	4.2	9.7	1.4	15.7	5.4	109.7	7.8	97.4	1.6	21.9	1.7	23.1	1.9	28.4	2.2	34.6	2.4	39.3	2.4	42.5	2.6	49.0
	79K	349K	S (10s)	17.9	13.9	5.5	25.7	20.4	174.0	36.7	172.9	6.4	40.8	6.9	46.0	7.8	54.6	7.9	58.4	8.0	64.2	8.7	73.5	9.4	84.5
horse	7K	31K	SS (10s)	0.4	4.2	0.5	28.5	0.6	65.0	0.5	53.9	N/A	N/A	N/A	N/A	0.4	23.2	0.5	32.5	0.5	38.0	0.5	43.0	0.6	51.0
	38K	156K	SS (10s)	3.46	7.9	5.8	69.2	7.0	142.3	6.4	95.6	2.7	37.3	3.0	40.1	3.5	47.7	3.9	56.3	4.1	62.5	3.4	58.6	3.0	56.7
kingkong	18K	81K	SS (10s)	3.6	14.6	1.1	28.0	1.3	55.8	1.7	58.1	N/A	N/A	0.8	22.3	0.8	22.2	0.7	23.3	0.7	24.5	0.8	26.9	0.8	30.1
	48K	277K	SS (10s)	31.9	17.2	5.0	23.6	6.1	72.7	7.1	65.6	4.7	29.9	4.1	29.6	4.2	31.4	4.0	34.5	4.0	37.3	4.0	40.8	3.9	44.1
bunny	30K	126K	SS (5s)	3.6	9.6	1.8	26.4	NC	NC	3.0	58.8	1.1	17.2	1.1	19.0	1.2	23.1	1.2	22.4	1.3	25.8	1.3	29.4	1.5	37.8
kingkong	18K	81K	TSS (10s)	5.2	21.3	1.1	28.3	1.3	55.6	2.2	69.2	N/A	N/A	0.9	26.0	0.9	26.0	0.8	27.2	0.8	29.4	0.8	29.7	0.9	34.6
monkey	18K	75K	TSS (10s)	2.4	11.4	1.8	47.6	2.6	105.5	2.9	96.6	N/A	N/A	1.3	40.5	1.3	43.6	1.4	46.0	1.5	52.6	1.7	63.7	1.8	73.3
elf	23K	96K	TSS (10s)	4.6	15.7	1.4	28.2	3.3	90.6	5.0	113.3	1.2	30.7	1.2	30.3	1.2	32.0	1.2	32.7	1.2	34.3	1.2	34.4	1.2	40.8
hollowCat	24K	100K	TSS (10s)	4.3	13.7	1.0	18.4	3.8	92.4	2.2	59.7	1.1	25.7	1.1	25.9	1.0	24,4	1.0	25.0	1.0	26.4	1.0	28.4	1.0	30.0
horse	38K	156K	TSS (10s)	4.2	9.7	7.0	82.6	8.2	161.1	5.4	89.2	3.0	43.2	3.4	45.6	3.8	52.0	4.2	61.1	4.5	69.6	4.1	68.7	3.6	66.7

Table 5. Ablation study on DOT ($h = 25ms$). We set different block sizes for DOT to run with different number of decompositions for each example. Here S stands for the stretch test case.