

Fast and Exact Discrete Geodesic Computation Based on Triangle-Oriented Wavefront Propagation

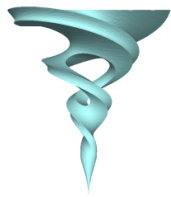
(Supplemental Materials)

Yipeng Qin^{1*} Xiaoguang Han^{2*} Hongchuan Yu¹ Yizhou Yu² Jianjun Zhang¹

¹ Bournemouth University ² The University of Hong Kong (* Joint first authors)

Part I. Model Collection

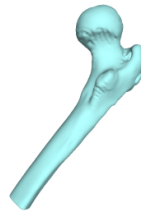
All the 55 models used in the paper for performance testing are listed as follows, which are from the AIM@SHAPE shape repository (A), Large Geometric Models Archive at Georgia Institute of Technology (B), Suggestive Contour Gallery provided by Princeton University (C) and Stanford scanning repository (D).



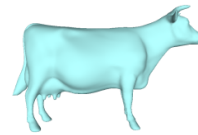
Twirl © A



Sword © A



Femur © A



Cow © C



Venus © A



Foot © A



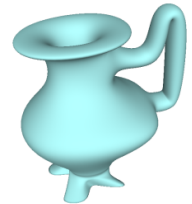
Camel © A



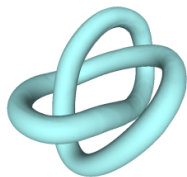
Homer Simpson © A



Dilo © A



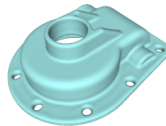
Sketched Vase © A



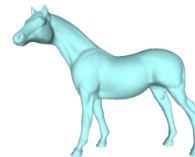
Knot © A



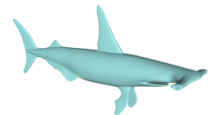
Buste © A



Casting © A



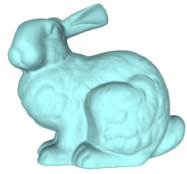
Horse © C



Shark © A



Pegasus © A



Bunny © C



Bimba © A



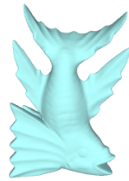
Elephant © A



Hand © A



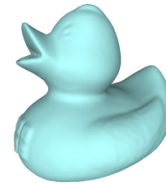
Filigree © A



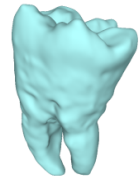
Woodfish © A



Maxplanck © C



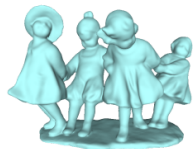
Duck © A



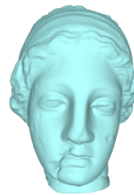
Tooth © A



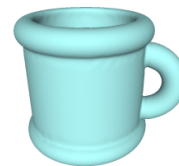
Moai © A



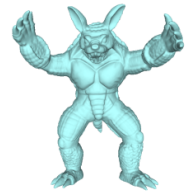
Dancing Children © A



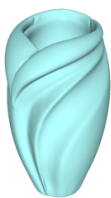
Igea © C



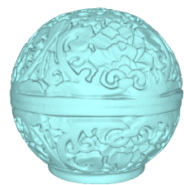
Cup © A



Armadillo © C



Vase © A



Red Circular Box © A



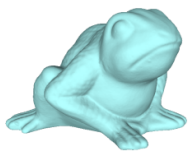
Julius Caesar © A



Pulley © A



Eros © A



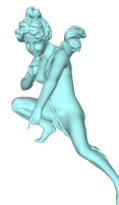
Frog © A



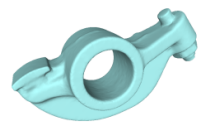
Magalie's Hand © A



Wooden Chair © A



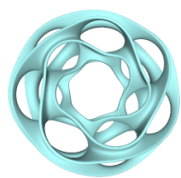
Angel © B



Rocker Arm © A



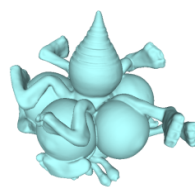
Fertility © A



Heptoroid © C



Pierrot © A



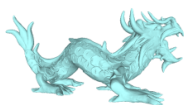
Bozbezbozzel © A



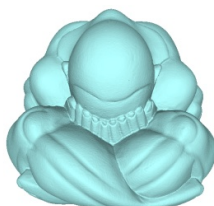
Chinese Dragon © A



Ramesses © A



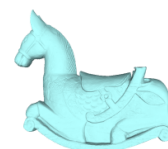
Asian Dragon © D



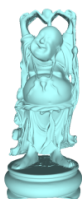
Pensatore © A



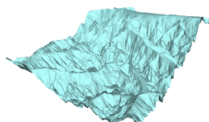
Seahorse © A



IsidoreHorse © A



Happy Buddha © B



Cervino Terrain © A



Neptune © A



Vase Lion © A



Lucy © C

Part II. Performance Comparison

We test state-of-the-art algorithms (ICH^[1], MMP^{[2][3]}, FWP-CH^[4], FWP-MMP^[4]) and our algorithms (VTP-MMP, VTP-CH, VTP-Exhaustive, VTP-Trimming, FTP, OPVTP, VTP) on all 55 models shown above. To evaluate the overall performance, we measure the running time, total number of window propagations and peak memory usage. All the results are shown in Table 1 and Table 2.

Table 1. Performance comparison with state-of-the-art algorithms.
F: means the number of faces of the model.

Model	Performance	Algorithms						
		ICH	MMP	FWP-CH	FWP-MMP	VT-CH	VT-MMP	VTP
Twirl (F: 10K)	Time(s)	0.116	0.134	0.085	0.062	0.091	0.052	0.04
	#window propagations	346,691	260,339	355,482	262,748	361,272	260,380	201,107
	Peak memory(MB)	0.28	13.07	0.29	13.07	0.30	13.07	0.254
Sword (F: 29K)	Time(s)	0.996	1.002	0.748	0.437	0.55	0.336	0.209
	#window propagations	2,973,951	1,537,986	3,019,022	1,634,507	3,009,123	1,559,334	1,499,968
	Peak memory(MB)	0.65	82.18	0.66	82.02	0.66	82.18	0.581
Femur (F: 30K)	Time(s)	0.594	0.604	0.387	0.264	0.36	0.222	0.144
	#window propagations	1,799,106	1,089,745	1,803,536	1,084,237	1,825,281	1,084,096	848,057
	Peak memory(MB)	0.37	58.64	0.38	58.64	0.38	58.64	0.309
Cow (F: 36K)	Time(s)	0.756	0.814	0.453	0.328	0.42	0.263	0.176
	#window propagations	2,047,472	1,257,463	2,049,564	1,250,713	2,084,408	1,255,395	993,393
	Peak memory(MB)	0.69	68.46	0.69	68.46	0.69	68.46	0.598
Venus (F: 43K)	Time(s)	1.379	1.525	0.813	0.579	0.757	0.479	0.27
	#window propagations	3,868,758	2,309,841	3,871,332	2,301,511	3,906,934	2,302,895	1,760,343
	Peak memory(MB)	0.86	125.68	0.86	125.68	0.87	125.68	0.672
Foot (F: 44K)	Time(s)	1.65	1.941	1.096	0.679	0.792	0.534	0.303
	#window propagations	4,056,466	2,558,311	4,057,698	2,548,552	4,095,235	2,550,736	1,963,132
	Peak memory(MB)	1.60	140.86	1.59	140.87	1.61	140.87	1.63
Camel (F: 48K)	Time(s)	0.888	0.877	0.564	0.376	0.501	0.361	0.21
	#window propagations	2,547,675	1,434,054	2,551,711	1,429,049	2,588,770	1,433,425	1,166,711
	Peak memory(MB)	0.57	78.57	0.57	78.57	0.57	78.57	0.441
HomerSimpson (F: 48K)	Time(s)	1.166	1.304	0.815	0.49	0.66	0.381	0.248
	#window propagations	3,052,442	1,853,265	3,054,551	1,845,828	3,101,274	1,850,498	1,482,477
	Peak memory(MB)	0.97	103.48	0.97	103.48	0.97	103.48	0.808
Dilo (F: 54K)	Time(s)	0.9	0.985	0.581	0.4	0.554	0.323	0.238
	#window propagations	2,437,808	1,567,105	2,466,709	1,568,832	2,510,230	1,566,420	1,198,835
	Peak memory(MB)	0.78	80.08	0.79	80.09	0.79	80.08	0.587
SketchedVase (F: 54K)	Time(s)	1.51	1.959	0.881	0.766	0.876	0.629	0.314
	#window propagations	4,299,781	2,788,262	4,319,563	2,798,371	4,548,918	2,926,886	2,119,200
	Peak memory(MB)	0.75	147.74	0.75	147.74	0.77	147.74	0.651
Knot (F: 56K)	Time(s)	1.412	1.576	0.875	0.63	0.77	0.499	0.302
	#window propagations	4,158,394	2,556,797	4,148,550	2,543,995	4,191,262	2,557,102	2,015,140
	Peak memory(MB)	0.45	144.12	0.45	144.12	0.46	144.12	0.36
Buste (F: 60K)	Time(s)	1.444	1.412	0.885	0.558	0.76	0.527	0.299
	#window propagations	3,914,969	2,119,762	3,920,578	2,108,560	3,967,893	2,110,539	1,739,991
	Peak memory(MB)	0.81	117.89	0.81	117.89	0.82	117.89	0.658
Casting (F: 90K)	Time(s)	2.547	2.586	1.499	0.943	1.311	0.743	0.516
	#window propagations	6,288,906	3,485,917	6,307,579	3,468,718	6,363,310	3,474,086	2,995,809
	Peak memory(MB)	1.35	188.33	1.35	188.33	1.36	188.33	1.105
Horse (F: 96K)	Time(s)	3.187	3.129	2.25	1.146	1.567	0.863	0.517
	#window propagations	7,944,765	4,404,199	7,963,743	4,384,422	8,106,166	4,410,197	3,317,318
	Peak memory(MB)	1.81	231.51	1.78	231.53	1.80	231.53	1.384

Continue from previous table

Model	Performance	Algorithms						
		ICH	MMP	FWP-CH	FWP-MMP	VT-CH	VT-MMP	VTP
Shark (F: 107K)	Time(s)	4.222	4.827	2.345	1.685	2.081	1.312	0.758
	#window propagations	10,980,857	6,265,563	11,116,740	6,307,618	10,962,701	6,213,042	5,112,354
	Peak memory(MB)	1.21	352.92	1.22	352.94	1.20	352.92	1.015
Pegasus (F: 127K)	Time(s)	3.392	3.64	2.184	1.361	1.814	1.015	0.693
	#window propagations	7,598,676	4,782,987	7,646,452	4,751,645	7,761,300	4,767,038	3,631,004
	Peak memory(MB)	2.03	249.17	2.06	249.17	2.06	249.17	1.696
Bunny (F: 144K)	Time(s)	5.034	4.612	3.056	1.737	2.672	1.304	0.78
	#window propagations	12,305,579	6,485,320	12,327,991	6,451,352	12,491,178	6,454,800	4,943,670
	Peak memory(MB)	1.69	340.45	1.70	340.46	1.71	340.45	1.24
Bimba (F: 149K)	Time(s)	6.018	6.542	3.547	2.248	3.04	1.634	0.982
	#window propagations	12,730,540	7,685,795	12,771,938	7,650,043	12,933,807	7,655,990	5,749,138
	Peak memory(MB)	2.78	407.11	2.79	407.11	2.81	407.11	2.258
Elephant (F: 160K)	Time(s)	7.383	8.019	4.021	2.667	3.452	1.927	1.179
	#window propagations	14,594,865	9,215,918	14,619,409	9,175,973	14,795,030	9,187,716	6,779,937
	Peak memory(MB)	3.89	487.31	3.89	487.31	3.92	487.31	3.157
Hand (F: 176K)	Time(s)	10.385	13.322	5.632	4.214	4.451	3.129	1.638
	#window propagations	21,915,233	13,848,650	22,049,873	13,963,632	22,295,976	13,895,643	10,071,080
	Peak memory(MB)	3.02	733.33	3.06	733.33	3.05	733.33	2.689
Filigree (F: 186K)	Time(s)	3.507	3.719	2.177	1.495	2.178	1.12	0.821
	#window propagations	8,002,484	4,836,918	8,228,318	4,957,377	8,294,639	4,852,485	4,066,106
	Peak memory(MB)	1.80	257.83	1.81	257.85	1.81	257.83	1.49
Woodfish (F: 191K)	Time(s)	11.183	12.116	6.064	3.742	5.094	2.756	1.542
	#window propagations	22,234,036	12,638,238	22,245,833	12,592,783	22,434,888	12,619,027	9,722,818
	Peak memory(MB)	3.60	693.69	3.58	693.69	3.60	693.69	2.899
Maxplanck (F: 210K)	Time(s)	15.405	15.342	8.312	4.914	7.169	3.541	1.891
	#window propagations	30,447,971	16,184,715	30,458,413	16,141,584	30,642,469	16,150,075	12,597,188
	Peak memory(MB)	4.31	887.99	4.31	887.99	4.31	887.99	3.405
Duck (F: 219K)	Time(s)	22.84	21.496	11.411	6.463	9.209	4.538	2.53
	#window propagations	42,760,744	21,077,986	42,790,802	21,728,282	42,977,191	21,059,883	16,821,923
	Peak memory(MB)	5.25	1160.22	5.25	1160.25	5.25	1160.22	3.743
Tooth (F: 220K)	Time(s)	19.403	21.129	9.638	5.898	7.543	3.972	2.339
	#window propagations	33,512,612	18,564,126	33,502,205	18,518,680	33,695,533	18,534,740	14,458,399
	Peak memory(MB)	6.15	1037.37	6.12	1037.37	6.13	1037.37	4.833
Moai (F: 238K)	Time(s)	20.632	21.707	10.616	6.495	8.818	4.286	2.483
	#window propagations	36,344,587	19,904,387	36,363,511	19,849,151	36,615,050	19,858,675	15,085,009
	Peak memory(MB)	6.10	1076.09	6.09	1076.09	6.10	1076.09	4.631
DancingChildren (F: 265K)	Time(s)	9.846	9.634	5.444	3.426	4.736	2.309	1.707
	#window propagations	17,977,851	10,463,582	18,047,429	10,403,108	18,226,736	10,416,158	8,501,699
	Peak memory(MB)	4.21	566.13	4.26	566.14	4.25	566.14	3.569
Igea (F: 268K)	Time(s)	15.211	14.232	8.532	4.586	7.087	3.369	1.995
	#window propagations	32,561,369	17,137,879	32,522,412	17,066,447	32,998,672	17,106,678	12,673,530
	Peak memory(MB)	3.11	890.91	3.10	891.01	3.11	890.92	2.218

Continue from previous table

Model	Performance	Algorithms						
		ICH	MMP	FWP-CH	FWP-MMP	VT-CH	VT-MMP	VTP
Cup (F: 316K)	Time(s)	46.262	50.203	20.175	11.499	16.825	8.34	5.465
	#window propagations	68,373,922	35,226,751	68,454,171	35,150,391	69,021,313	35,266,895	32,580,614
	Peak memory(MB)	11.05	1880.35	11.04	1880.43	11.06	1880.35	9.835
Armadillo (F: 345K)	Time(s)	8.878	7.858	5.196	2.976	4.692	2.206	1.628
	#window propagations	19,132,785	10,298,238	19,193,615	10,215,363	19,584,534	10,258,285	8,084,456
	Peak memory(MB)	2.00	538.32	2.03	538.32	2.01	538.32	1.458
Vase (F: 354K)	Time(s)	35.388	42.203	19.614	10.912	13.569	7.304	4.056
	#window propagations	60,147,611	33,770,683	60,908,787	33,733,987	60,607,873	33,891,566	26,004,542
	Peak memory(MB)	7.00	1860.04	7.01	1860.04	7.00	1860.06	5.743
Red Circular Box (F: 360K)	Time(s)	7.812	7.025	5.375	2.83	4.991	2.195	1.763
	#window propagations	16,771,179	9,368,831	16,875,650	9,267,397	17,247,883	9,275,636	7,781,762
	Peak memory(MB)	1.89	479.66	1.92	479.66	1.95	479.66	1.554
Julius Caesar (F: 386K)	Time(s)	16.331	13.234	9.963	4.861	9.383	3.605	2.372
	#window propagations	34,460,870	17,112,887	34,602,443	17,006,880	35,093,981	17,022,542	12,744,572
	Peak memory(MB)	2.46	877.05	2.49	877.05	2.52	877.05	2.153
Pulley (F: 392K)	Time(s)	29.392	33.032	15.508	9.497	13.325	6.252	4.242
	#window propagations	48,803,681	28,566,263	48,880,682	28,455,748	49,453,462	28,510,288	21,989,818
	Peak memory(MB)	6.03	1537.16	6.05	1537.18	6.12	1537.16	5.030
Eros (F: 394K)	Time(s)	15.341	12.538	9.259	4.567	7.91	3.347	2.623
	#window propagations	28,320,100	14,437,016	28,452,631	14,322,675	28,928,294	14,327,257	11,856,262
	Peak memory(MB)	3.56	752.46	3.61	752.46	3.63	752.46	2.602
Frog (F: 394K)	Time(s)	29.975	26.453	15.663	8.305	12.728	5.719	3.175
	#window propagations	55,709,004	29,663,952	55,703,101	29,603,551	57,143,731	30,435,416	20,134,270
	Peak memory(MB)	5.08	1393.92	5.08	1393.93	5.11	1393.93	3.610
Magalie'sHand (F: 396K)	Time(s)	15.725	13.059	9.658	4.537	8.501	3.503	2.387
	#window propagations	28,775,730	14,885,683	29,864,392	14,824,480	30,829,525	15,577,298	11,324,832
	Peak memory(MB)	4.08	764.60	4.23	764.63	4.31	764.68	2.895
WoodenChair (F: 408K)	Time(s)	28.429	29.839	14.405	8.977	12.511	5.958	4.071
	#window propagations	50,355,149	29,553,762	50,435,328	29,450,039	51,026,008	29,503,171	21,937,266
	Peak memory(MB)	5.65	1541.40	5.67	1541.42	5.67	1541.42	4.935
Angel (F: 474K)	Time(s)	16.42	17.172	9.695	6.366	8.354	4.443	2.877
	#window propagations	35,750,531	21,046,492	36,277,286	21,441,579	36,360,538	20,982,691	15,858,241
	Peak memory(MB)	2.81	1105.82	2.82	1105.82	2.82	1105.82	2.272
Rocker Arm (F: 482K)	Time(s)	36.577	33.286	19.536	11.867	15.449	6.954	4.13
	#window propagations	68,553,846	33,989,638	70,513,186	35,940,386	69,208,037	33,947,674	25,654,638
	Peak memory(MB)	5.29	1797.16	5.42	1797.19	5.32	1797.18	3.70
Fertility (F: 483K)	Time(s)	34.202	30.594	18.306	9.576	14.837	6.719	4.133
	#window propagations	60,924,913	31,420,922	60,920,074	31,321,993	63,236,514	32,461,272	24,686,942
	Peak memory(MB)	5.70	1588.50	5.68	1588.84	5.68	1588.54	4.465
Heptoroid (F: 573K)	Time(s)	42.112	71.431	21.288	17.357	17.634	10.691	5.556
	#window propagations	66,227,523	48,580,064	67,386,876	49,942,806	72,113,378	52,419,840	34,287,452
	Peak memory(MB)	5.78	2520.55	5.92	2520.60	6.07	2520.55	5.284

Continue from previous table

Model	Performance	Algorithms						
		ICH	MMP	FWP-CH	FWP-MMP	VT-CH	VT-MMP	VTP
Pierrot (F: 887K)	Time(s)	102.416	88.012	45.395	24.695	36.26	15.232	9.136
	#window propagations	150,271,829	73,707,582	150,295,550	73,740,134	153,799,315	74,822,570	51,644,860
	Peak memory(MB)	9.17	3569.21	9.21	3569.28	9.42	3569.23	5.614
Bozbezbozzel (F: 911K)	Time(s)	57.35	64.402	28.083	18.558	22.211	11.952	7.005
	#window propagations	90,769,891	55,949,635	91,001,989	55,767,105	92,447,464	56,200,036	38,660,645
	Peak memory(MB)	7.85	2731.02	7.88	2731.02	7.89	2731.02	6.229
Chinese dragon (F: 1,222K)	Time(s)	126.488	160.468	53.518	39.839	47.582	21.553	16.435
	#window propagations	167,453,594	99,261,429	167,627,646	98,941,538	169,903,995	99,337,629	72,865,547
	Peak memory(MB)	11.75	5284.42	11.73	5284.43	11.82	5284.42	9.918
Asian Dragon (F: 1,400K)	Time(s)	73.204	73.092	35.637	23.674	29.492	15.388	9.495
	#window propagations	107,742,094	62,161,583	108,122,218	62,025,717	109,311,094	61,995,300	48,217,896
	Peak memory(MB)	5.18	3354.04	5.21	3354.05	5.25	3354.04	4.373
Ramesses (F: 1,653K)	Time(s)	42.246	34.253	26.193	14.708	22.466	9.691	8.938
	#window propagations	77,345,899	38,983,510	78,805,085	40,122,773	79,642,701	38,664,117	34,128,397
	Peak memory(MB)	3.59	2014.17	3.73	2014.17	3.92	2014.17	2.948
Pensatore (F: 1,996K)	Time(s)	189.217	158.819	81.927	49.049	67.756	24.9	20.328
	#window propagations	252,500,639	129,966,322	253,345,289	129,968,435	256,922,732	130,392,192	88,716,654
	Peak memory(MB)	9.56	6051.50	9.67	6051.53	9.62	6051.53	5.797
Seahorse (F: 2,014K)	Time(s)	200.439	203.342	97.221	58.201	83.202	35.234	21.869
	#window propagations	322,605,156	172,324,693	322,460,340	171,858,409	324,094,284	172,033,093	130,860,212
	Peak memory(MB)	7.55	9294.98	7.53	9295.03	7.65	9295.01	5.767
IsidoreHorse (F: 2,209K)	Time(s)	63.183	49.591	43.972	23.295	35.209	16.547	11.28
	#window propagations	103,331,867	52,406,687	110,210,607	59,846,982	134,929,706	68,234,985	42,350,025
	Peak memory(MB)	4.48	2725.09	4.74	2725.09	5.23	2725.09	3.062
Happy Buddha (F: 2,583K)	Time(s)	320.813	386.681	135.018	99.984	103.901	49.307	33.373
	#window propagations	394,485,853	215,162,089	410,662,438	230,681,707	410,199,299	218,302,329	166,942,683
	Peak memory(MB)	12.25	11408.39	12.88	11410.54	12.82	11408.55	9.337
Cervino Terrain (F: 3,146K)	Time(s)	179.285	117.187	92.968	46.331	72.083	32.869	28.287
	#window propagations	267,838,521	107,191,823	273,131,668	112,447,283	279,286,307	108,256,256	135,012,449
	Peak memory(MB)	6.94	5627.32	7.04	5630.01	7.07	5627.34	5.85
Neptune (F: 4,008K)	Time(s)	455.271	424.331	193.945	120.012	158.912	60.297	47.629
	#window propagations	585,784,159	270,930,198	602,587,831	284,581,696	606,937,112	278,925,270	246,364,008
	Peak memory(MB)	16.96	14225.26	17.14	14219.76	17.65	14221.35	16.38

Continue from previous table

Model	Performance	Algorithms						
		ICH	MMP	FWP-CH	FWP-MMP	VT-CH	VT-MMP	VTP
VaseLion (F: 6,370K)	Time(s)	2012.72	Out of memory	604.662	Out of memory	461.345	Out of memory	145.455
	#window propagations	1,721,300,347		1,729,607,080		1,729,700,093		704,638,382
	Peak memory(MB)	52.17		52.24		52.21		39.257
Lucy (F: 14,464K)	Time(s)	8894.87	Out of memory	2415.88	Out of memory	1809.91	Out of memory	549.934
	#window propagations	6,837,670,602		6,841,729,337		6,859,484,793		2,808,823,718
	Peak memory(MB)	78.29		78.28		78.31		69.42

Table 2. Performance comparison with variants of our VTP algorithm.
F: means the number of faces of the model.

Model	Performance	Algorithms				
		VTP-Exhaustive	VTP-Trimming	FTP	OPVTP	VTP
Twirl (F: 10K)	Time(s)	0.112	0.041	0.060	0.043	0.04
	#window propagations	197,217	192,691	191,053	192,235	201,107
	Peak memory(MB)	0.251	0.252	0.243	0.25	0.254
Sword (F: 29K)	Time(s)	3.639	0.24	0.315	0.261	0.209
	#window propagations	1,468,797	1,451,652	1,512,011	1,459,627	1,499,968
	Peak memory(MB)	0.576	0.573	0.61	0.57	0.581
Femur (F: 30K)	Time(s)	0.75	0.17	0.175	0.159	0.144
	#window propagations	832,253	808,575	812,559	830,433	848,057
	Peak memory(MB)	0.305	0.296	0.30	0.31	0.309
Cow (F: 36K)	Time(s)	0.76	0.23	0.211	0.181	0.176
	#window propagations	977,109	944,698	952,731	970,775	993,393
	Peak memory(MB)	0.594	0.584	0.59	0.59	0.598
Venus (F: 43K)	Time(s)	1.908	0.31	0.302	0.292	0.27
	#window propagations	1,732,229	1,676,392	1,705,248	1,744,113	1,760,343
	Peak memory(MB)	0.66	0.658	0.659	0.661	0.672
Foot (F: 44K)	Time(s)	2.2	0.42	0.361	0.374	0.303
	#window propagations	1,935,202	1,885,004	1,905,123	1,942,112	1,963,132
	Peak memory(MB)	1.621	1.594	1.45	1.47	1.63
Camel (F: 48K)	Time(s)	0.799	0.26	0.261	0.222	0.21
	#window propagations	1,145,645	1,101,856	1,112,089	1,133,446	1,166,711
	Peak memory(MB)	0.437	0.419	0.44	0.45	0.441
HomerSimpson (F: 48K)	Time(s)	1.316	0.341	0.304	0.279	0.248
	#window propagations	1,455,144	1,421,497	1,424,124	1,458,000	1,482,477
	Peak memory(MB)	0.798	0.779	0.79	0.791	0.808
Dilo (F: 54K)	Time(s)	0.794	0.272	0.305	0.251	0.238
	#window propagations	1,178,516	1,138,802	1,147,055	1,166,106	1,198,835
	Peak memory(MB)	0.578	0.570	0.575	0.581	0.587
SketchedVase (F: 54K)	Time(s)	2.695	0.354	0.451	0.349	0.314
	#window propagations	2,082,535	2,042,643	2,082,301	2,080,132	2,119,200
	Peak memory(MB)	0.642	0.645	0.65	0.64	0.651
Knot (F: 56K)	Time(s)	1.906	0.376	0.399	0.350	0.302
	#window propagations	1,998,630	1,926,644	2,000,353	2,003,573	2,015,140
	Peak memory(MB)	0.359	0.347	0.358	0.359	0.36
Buste (F: 60K)	Time(s)	1.376	0.371	0.362	0.363	0.299
	#window propagations	1,684,666	1,655,014	1,659,081	1,695,365	1,739,991
	Peak memory(MB)	0.646	0.631	0.640	0.651	0.658
Casting (F: 90K)	Time(s)	2.965	0.761	0.62	0.6	0.516
	#window propagations	2,948,477	2,861,050	2,896,291	2,931,236	2,995,809
	Peak memory(MB)	1.089	1.072	1.088	1.09	1.105
Horse (F: 96K)	Time(s)	3.184	0.67	0.651	0.641	0.517
	#window propagations	3,262,520	3,157,608	3,240,048	3,283,168	3,317,318
	Peak memory(MB)	1.368	1.344	1.350	1.369	1.384

Continue from previous table

Model	Performance	Algorithms				
		VTP-Exhaustive	VTP-Trimming	FTP	OPVTP	VTP
Shark (F: 107K)	Time(s)	6.821	0.855	0.908	0.919	0.758
	#window propagations	5,032,274	4,886,346	4,983,023	5,058,816	5,112,354
	Peak memory(MB)	1.011	1.0	1.011	1.012	1.015
Pegasus (F: 127K)	Time(s)	3.06	0.767	0.861	0.873	0.693
	#window propagations	3,559,660	3,470,668	3,491,952	3,558,053	3,631,004
	Peak memory(MB)	1.671	1.652	1.65	1.68	1.696
Bunny (F: 144K)	Time(s)	4.557	0.872	1.044	0.908	0.78
	#window propagations	4,801,056	4,686,252	4,755,872	4,875,712	4,943,670
	Peak memory(MB)	1.22	1.146	1.20	1.22	1.24
Bimba (F: 149K)	Time(s)	7.005	1.094	1.428	1.27	0.982
	#window propagations	5,655,097	5,464,752	5,595,011	5,700,385	5,749,138
	Peak memory(MB)	2.239	2.171	2.20	2.249	2.258
Elephant (F: 160K)	Time(s)	7.686	1.282	1.579	1.558	1.179
	#window propagations	6,679,878	6,521,389	6,607,611	6,728,077	6,779,937
	Peak memory(MB)	3.116	3.066	3.109	3.149	3.157
Hand (F: 176K)	Time(s)	14.187	2.196	1.955	2.003	1.638
	#window propagations	9,975,156	9,654,198	9,924,021	10,134,178	10,071,080
	Peak memory(MB)	2.680	2.623	2.652	2.721	2.689
Filigree (F: 186K)	Time(s)	3.031	0.88	1.255	1.0	0.821
	#window propagations	3,977,864	3,877,297	3,870,035	3,928,044	4,066,106
	Peak memory(MB)	1.467	1.443	1.439	1.451	1.49
Woodfish (F: 191K)	Time(s)	12.921	1.832	2.01	2.054	1.542
	#window propagations	9,535,507	9,326,365	9,453,888	9,641,025	9,722,818
	Peak memory(MB)	2.873	2.796	2.80	2.889	2.899
Maxplanck (F: 210K)	Time(s)	20.913	2.426	2.569	2.663	1.891
	#window propagations	12,250,767	12,035,550	12,194,999	12,578,888	12,597,188
	Peak memory(MB)	3.334	3.285	3.30	3.399	3.405
Duck (F: 219K)	Time(s)	30.999	3.74	2.919	3.54	2.53
	#window propagations	16,323,333	15,828,827	16,297,522	16,887,512	16,821,923
	Peak memory(MB)	3.655	3.490	3.650	3.79	3.743
Tooth (F: 220K)	Time(s)	24.13	2.74	3.05	3.11	2.339
	#window propagations	14,130,211	13,841,486	14,035,011	14,397,995	14,458,399
	Peak memory(MB)	4.741	4.658	4.71	4.80	4.833
Moai (F: 238K)	Time(s)	25.846	2.965	3.64	3.276	2.483
	#window propagations	14,748,182	14,421,835	14,676,991	15,097,323	15,085,009
	Peak memory(MB)	4.548	4.467	4.49	4.74	4.631
DancingChildren (F: 265K)	Time(s)	8.352	1.837	2.285	2.143	1.707
	#window propagations	8,344,456	8,143,451	8,195,406	8,360,313	8,501,699
	Peak memory(MB)	3.524	3.49	3.501	3.533	3.569
Igea (F: 268K)	Time(s)	16.214	2.124	2.377	2.41	1.995
	#window propagations	12,310,461	12,114,442	12,533,960	12,664,898	12,673,530
	Peak memory(MB)	2.168	2.151	2.212	2.210	2.218

Continue from previous table

Model	Performance	Algorithms				
		VTP-Exhaustive	VTP-Trimming	FTP	OPVTP	VTP
Cup (F: 316K)	Time(s)	91.437	6.241	6.788	6.753	5.465
	#window propagations	32,361,352	29,710,676	32,080,266	32,702,102	32,580,614
	Peak memory(MB)	9.782	8.793	9.770	9.98	9.835
Armadillo (F: 345K)	Time(s)	5.196	1.829	2.141	1.975	1.628
	#window propagations	19,193,615	7,596,092	7,745,552	7,884,201	8,084,456
	Peak memory(MB)	2.03	1.396	1.399	1.401	1.458
Vase (F: 354K)	Time(s)	47.964	4.324	4.650	5.112	4.056
	#window propagations	25,461,130	24,848,861	25,400,117	25,978,005	26,004,542
	Peak memory(MB)	5.609	5.438	5.80	5.82	5.743
Red Circular Box (F: 360K)	Time(s)	7.203	1.882	2.471	2.577	1.763
	#window propagations	7,583,520	7,384,425	7,426,105	7,509,066	7,781,762
	Peak memory(MB)	1.518	1.521	1.525	1.53	1.554
Julius Caesar (F: 386K)	Time(s)	10.683	2.9	3.119	3.03	2.372
	#window propagations	12,417,028	12,044,577	12,322,351	12,708,557	12,744,572
	Peak memory(MB)	2.116	2.073	2.149	2.152	2.153
Pulley (F: 392K)	Time(s)	32.359	4.44	5.501	5.599	4.242
	#window propagations	21,472,248	21,090,529	21,518,838	22,007,199	21,989,818
	Peak memory(MB)	4.911	4.882	5.01	5.12	5.030
Eros (F: 394K)	Time(s)	11.146	3.199	3.59	3.265	2.623
	#window propagations	11,493,579	11,249,885	11,456,266	11,665,873	11,856,262
	Peak memory(MB)	2.525	2.430	2.521	2.598	2.602
Frog (F: 394K)	Time(s)	24.242	4.179	4.559	4.388	3.175
	#window propagations	19,324,968	19,356,277	20,838,259	20,221,979	20,134,270
	Peak memory(MB)	3.479	3.518	3.69	3.62	3.610
Magalie'sHand (F: 396K)	Time(s)	8.802	2.712	3.508	2.958	2.387
	#window propagations	11,095,197	10,626,126	10,948,457	11,111,123	11,324,832
	Peak memory(MB)	2.861	2.775	2.875	2.881	2.895
WoodenChair (F: 408K)	Time(s)	34.168	4.273	5.019	4.961	4.071
	#window propagations	21,544,323	20,858,337	21,488,002	21,881,208	21,937,266
	Peak memory(MB)	4.866	4.747	4.856	4.928	4.935
Angel (F: 474K)	Time(s)	14.23	3.175	3.812	3.705	2.877
	#window propagations	15,525,223	15,126,178	15,397,863	15,718,815	15,858,241
	Peak memory(MB)	2.239	2.202	2.212	2.251	2.272
Rocker Arm (F: 482K)	Time(s)	36.586	4.655	4.83	5.169	4.13
	#window propagations	24,289,066	24,380,006	25,013,422	25,723,699	25,654,638
	Peak memory(MB)	3.43	3.49	3.68	3.71	3.70
Fertility (F: 483K)	Time(s)	30.432	4.961	5.905	5.502	4.133
	#window propagations	23,589,123	23,873,376	24,995,619	24,523,539	24,686,942
	Peak memory(MB)	4.345	4.359	4.64	4.311	4.465
Heptoroid (F: 573K)	Time(s)	47.982	7.359	8.425	7.46	5.556
	#window propagations	33,930,378	33,605,904	33,900,519	34,370,470	34,287,452
	Peak memory(MB)	5.254	5.238	5.24	5.39	5.284

Continue from previous table

Model	Performance	Algorithms				
		VTP-Exhaustive	VTP-Trimming	FTP	OPVTP	VTP
Pierrot (F: 887K)	Time(s)	74.345	10.325	13.149	11.713	9.136
	#window propagations	49,306,554	49,909,353	54,026,799	51,796,977	51,644,860
	Peak memory(MB)	5.326	5.521	5.88	5.73	5.614
Bozbezbozzel (F: 911K)	Time(s)	45.808	7.884	9.601	8.768	7.005
	#window propagations	38,123,582	36,572,880	37,691,146	38,404,143	38,660,645
	Peak memory(MB)	6.171	5.942	6.058	6.209	6.229
Chinese dragon (F: 1,222K)	Time(s)	133.271	17.996	19.245	18.052	16.435
	#window propagations	72,048,774	69,750,625	71,568,095	72,635,813	72,865,547
	Peak memory(MB)	9.842	9.611	9.789	9.802	9.918
Asian Dragon (F: 1,400K)	Time(s)	49.954	13.763	13.011	11.415	9.495
	#window propagations	46,926,451	46,316,630	46,523,513	47,572,141	48,217,896
	Peak memory(MB)	4.036	4.017	4.10	4.20	4.373
Ramesses (F: 1,653K)	Time(s)	36.667	9.834	13.125	10.669	8.938
	#window propagations	32,930,864	32,144,860	32,478,771	33,036,958	34,128,397
	Peak memory(MB)	2.853	2.879	2.842	2.901	2.948
Pensatore (F: 1,996K)	Time(s)	97.4	21.606	25.879	23.201	20.328
	#window propagations	84,606,295	85,631,449	88,479,353	88,527,448	88,716,654
	Peak memory(MB)	5.728	5.75	5.79	5.792	5.797
Seahorse (F: 2,014K)	Time(s)	206.269	24.674	29.061	28.843	21.869
	#window propagations	126,848,230	125,823,913	126,316,839	129,482,659	130,860,212
	Peak memory(MB)	5.596	5.589	5.593	5.75	5.767
IsidoreHorse (F: 2,209K)	Time(s)	25.143	12.622	17.449	13.428	11.28
	#window propagations	41,341,363	39,453,625	40,457,511	40,760,043	42,350,025
	Peak memory(MB)	3.002	2.919	2.985	2.998	3.062
Happy Buddha (F: 2,583K)	Time(s)	381.02	34.973	41.205	42.453	33.373
	#window propagations	164,137,340	159,542,907	165,473,466	167,592,235	166,942,683
	Peak memory(MB)	9.160	9.084	9.32	9.59	9.337
Cervino Terrain (F: 3,146K)	Time(s)	124.557	31.251	42.257	36.542	28.287
	#window propagations	121,895,449	132,331,239	125,640,081	125,847,948	135,012,449
	Peak memory(MB)	4.95	5.77	5.76	5.75	5.85
Neptune (F: 4,008K)	Time(s)	665.847	58.49	64.011	60.187	47.629
	#window propagations	239,054,124	239,375,390	243,102,352	244,573,921	246,364,008
	Peak memory(MB)	15.62	15.962	16.1	16.19	16.38

Continue from previous table

Model	Performance	Algorithms				
		VTP-Exhaustive	VTP-Trimming	FTP	OPVTP	VTP
VaseLion (F: 6,370K)	Time(s)	2560.92	160.497	174.235	162.705	145.455
	#window propagations	687,375,867	681,210,620	686,216,897	702,119,736	704,638,382
	Peak memory(MB)	38.481	38.385	38.45	39.22	39.257
Lucy (F: 14,464K)	Time(s)	16559	615.215	617.343	608.414	549.934
	#window propagations	2,703,707,866	2,733,324,263	2,668,122,127	2,734,517,299	2,808,823,718
	Peak memory(MB)	66.096	66.848	67.81	68.01	69.42

Part III. Distribution of Window Propagations

In this part, we count prime propagations and secondary propagations (which are defined in the paper) when applying our VTP algorithm to all 55 testing models and the results are shown in Table 3.

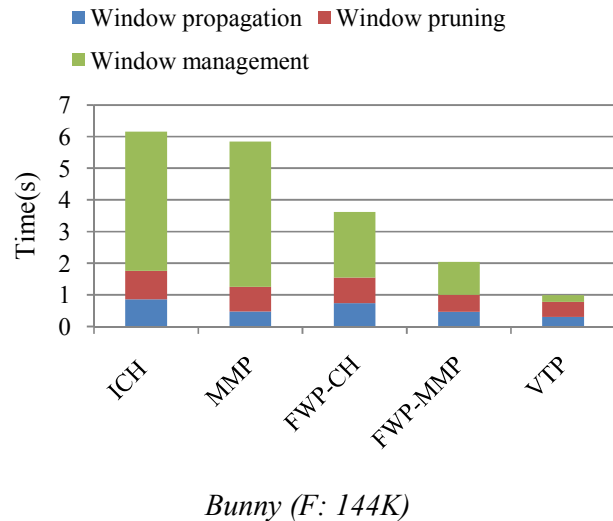
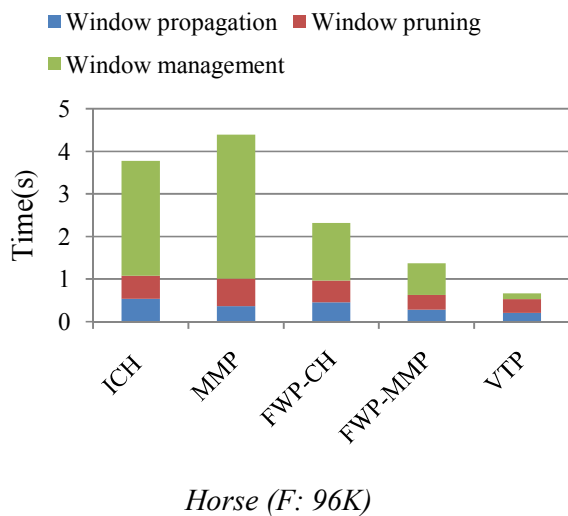
Table 3. *Distribution of Window Propagations*

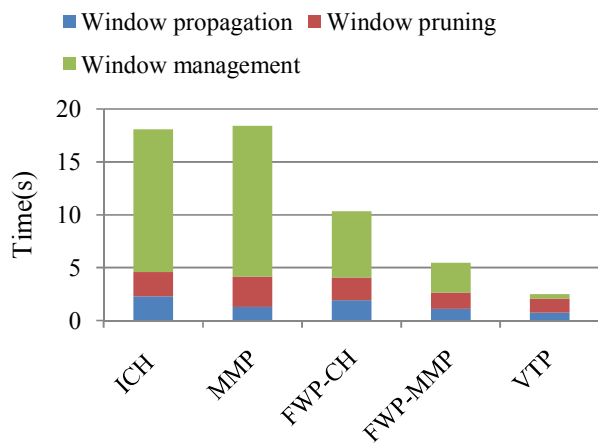
Model	Prime Propagation	Secondary Propagation	Model	Prime Propagation	Secondary Propagation
Twirl (F: 10K)	181,258 (90.13%)	19,849 (9.87%)	Cup (F: 316K)	31,974,614 (98.14%)	606,000 (1.86%)
Sword (F: 29K)	1,278,123 (85.21%)	221,845 (14.79%)	Armadillo (F: 345K)	7,589,687 (96.88%)	494,769 (3.12%)
Femur (F: 30K)	811,336 (95.67%)	36,721 (4.33%)	Vase (F: 354K)	25,656,081 (98.66%)	348,461 (1.34%)
Cow (F: 36K)	948,889 (95.52%)	44,504 (4.48%)	Red Circular Box (F: 360K)	7,562,316 (97.18%)	219,446 (2.82%)
Venus (F: 43K)	1,712,462 (97.28%)	47,881 (2.72%)	Julius Caesar (F: 386K)	12,487,132 (97.98%)	257,440 (2.02%)
Foot (F: 44K)	1,892,852 (96.42%)	70,280 (3.58%)	Pulley (F: 392K)	21,670,966 (98.55%)	318,852 (1.45%)
Camel (F: 48K)	1,116,892 (95.73%)	49,819 (4.27%)	Eros (F: 394K)	11,625,065 (98.05%)	231,197 (1.95%)
HomerSimpson (F: 48K)	1,413,690 (95.36%)	68,787 (4.64%)	Frog (F: 394K)	19,820,175 (98.44%)	314,095 (1.56%)
Dilo (F: 54K)	1,134,338 (94.62%)	63,278 (5.47%)	Magalie's Hand (F: 396K)	11,123,250 (98.22%)	201,882 (1.78%)
SketchedVase (F: 54K)	1,954,114 (92.21%)	165,086 (7.79%)	WoodenChair (F: 408K)	21,509,489 (98.05%)	427,777 (1.95%)
Knot (F: 56K)	1,945,416 (96.54%)	69,724 (3.46%)	Angel (F: 474K)	15,334,919 (96.7%)	523,322 (3.3%)
Buste (F: 60K)	1,659,429 (95.37%)	80,562 (4.63%)	Rocker Arm (F: 482K)	25,031,230 (97.57%)	623,408 (2.43%)
Casting (F: 90K)	2,894,850 (96.63%)	100,959 (3.37%)	Fertility (F: 483K)	23,588,373 (95.55%)	1,098,569 (4.45%)
Horse (F: 96K)	3,228,746 (97.33%)	88,572 (2.67%)	Heptoroid (F: 573K)	32,713,658 (95.41%)	1,573,794 (4.59%)
Shark (F: 107K)	4,836,798 (94.61%)	275,556 (5.39%)	Pierrot (F: 887K)	49,770,152 (96.37%)	1,874,708 (3.63%)
Pegasus (F: 127K)	3,512,633 (96.74%)	118,371 (3.26%)	Bozbezbozzel (F: 911K)	37,829,441 (97.85%)	831,204 (2.15%)
Bunny (F: 144K)	4,821,561 (97.53%)	122,109 (2.47%)	Chinese Dragon (F: 1,222K)	72,158,751 (99.03%)	706,796 (0.97%)
Bimba (F: 149K)	5,655,427 (98.37%)	93,711 (1.63%)	Ramesses (F: 1,653K)	32,179,666 (94.29%)	1,948,713 (5.71%)
Elephant (F: 160K)	6,615,185 (97.57%)	164,752 (2.43)	Asian dragon (F: 1,400K)	46,086,665 (95.58%)	2,131,231 (4.42%)
Hand (F: 176K)	9,750,820 (96.82%)	320,260 (3.18%)	Pensatore (F: 1,996K)	85,513,983 (96.39%)	3,202,671 (3.61%)

Filigree (F: 186K)	3,780,259 (92.97%)	285,847 (7.03%)	Seahorse (F: 2,014K)	125,193,965 (95.67%)	5,666,247 (4.33%)
Woodfish (F: 191K)	9,424,327 (96.93%)	298,491 (3.07%)	IsidoreHorse (F: 2,209K)	41,155,754 (97.18%)	1,194,271 (2.82%)
Maxplanck (F: 210K)	12,262,103 (97.34%)	335,085 (2.66%)	Happy Buddha (F: 2,583K)	161,199,855 (96.56%)	5,742,828 (3.44%)
Duck (F: 219K)	16,525,857 (98.24%)	296,066 (1.76%)	Cervino Terrain (F: 3,146K)	117,649,848 (87.41%)	17,362,601 (12.59%)
Tooth (F: 220K)	13,955,247 (96.52%)	503,152 (3.48%)	Neptune (F: 4,008K)	240,451,272 (97.6%)	5,912,736 (2.4%)
Moai (F: 238K)	14,674,697 (97.28%)	410,312 (2.72%)	Vase Lion (F: 6,370K)	685,613,146 (97.3%)	19,025,236 (2.7%)
DancingChildren (F: 265K)	8,179,485 (96.21%)	322,214 (3.79%)	Lucy (F: 14,464K)	2,756,860,479 (98.15%)	51,963,239 (1.85%)
Igea (F: 268K)	12,444,139 (98.19%)	229,391 (1.81%)	Mean	96.25%	3.75%
			Standard Deviation	0.026	0.026

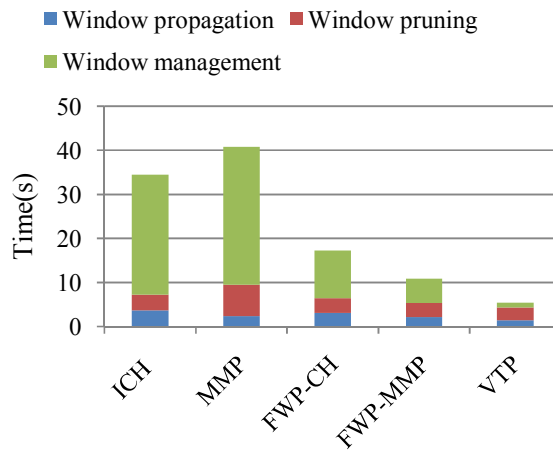
Part IV. Comparison of Running Times of Three Common Components

To profile the running times of the three individual components (window propagation, window pruning and window management) in state-of-the-art algorithms and our VTP algorithm, in addition to the two models (Armadillo and Asian Dragon) used in the paper, we also show the results on 8 other models with various resolutions.

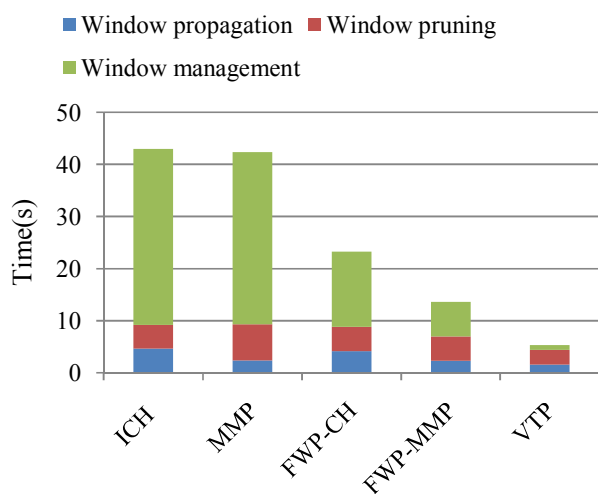




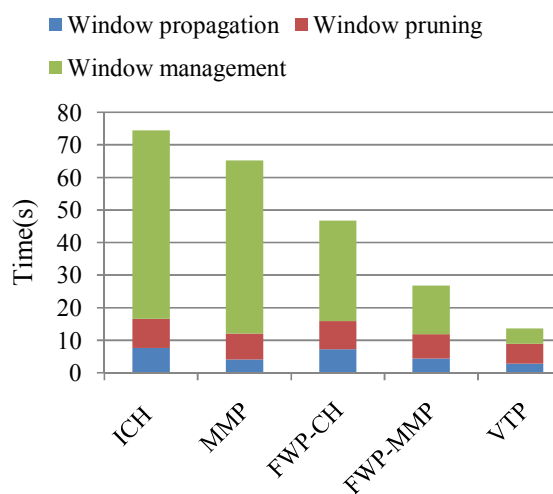
Igea (F: 268K)



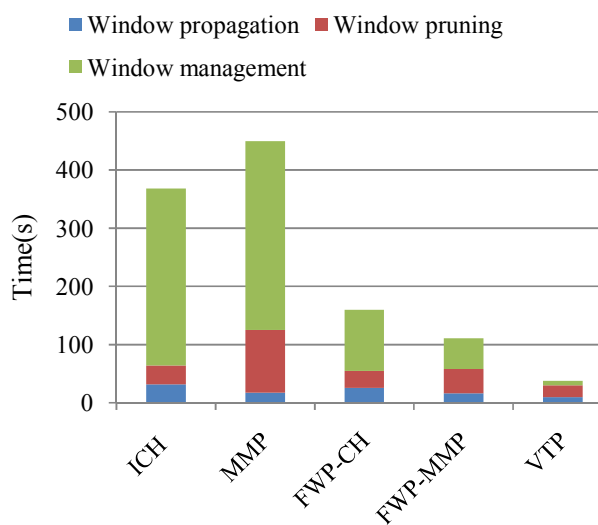
Pulley (F: 392K)



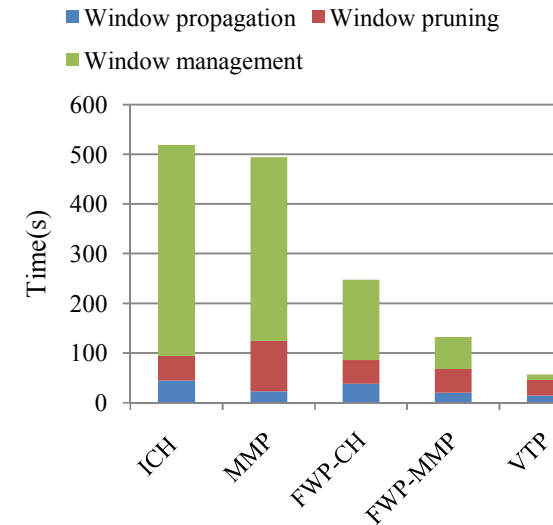
Rocker Arm (F: 482K)



IsidoreHorse (F: 2M)



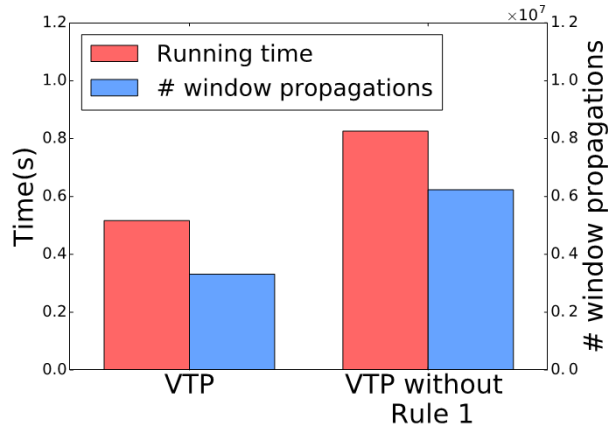
Happy Buddha (F: 2.6M)



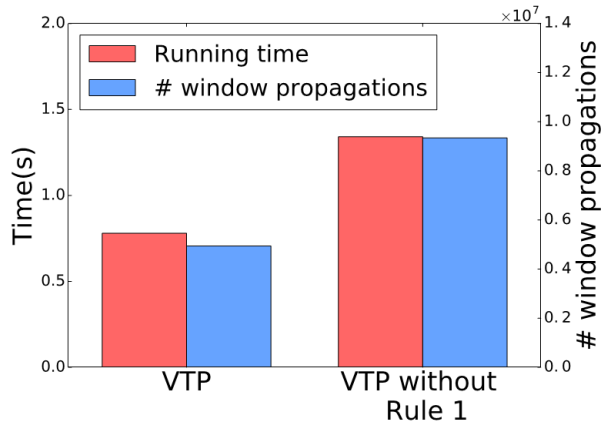
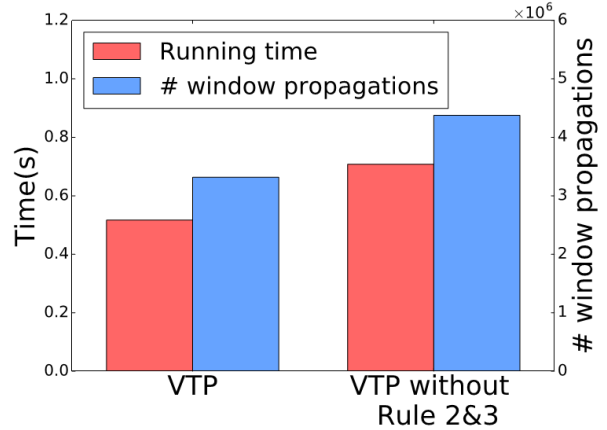
Neptune (F: 4M)

Part V. Ablation Study

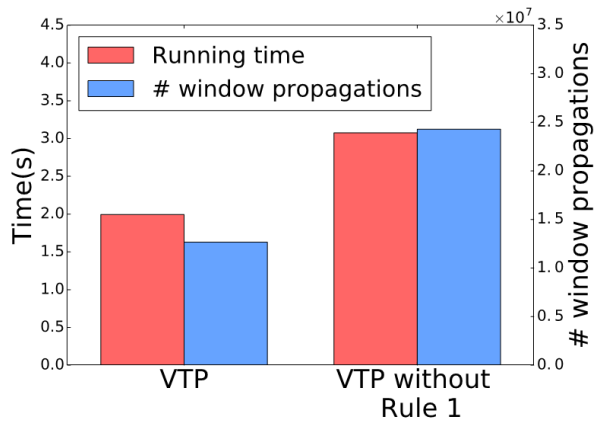
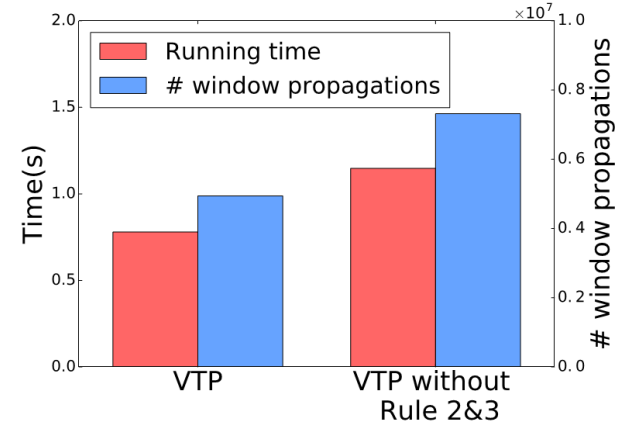
In this part, we show more performance comparisons of our VTP algorithm with and without Rule 1 and comparisons with and without Rules 2&3. The results on the same 8 models used in Part IV are shown below.



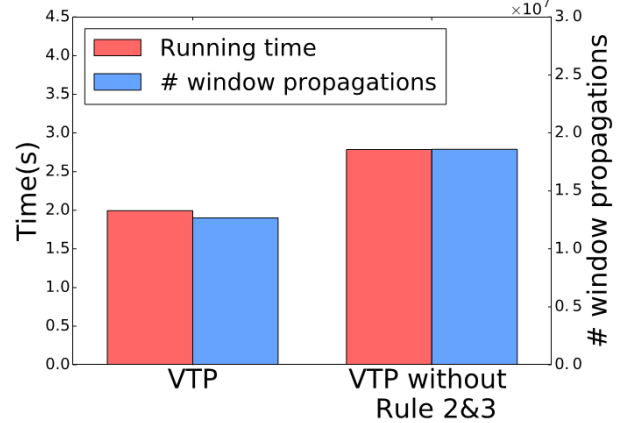
Horse (F: 96K)

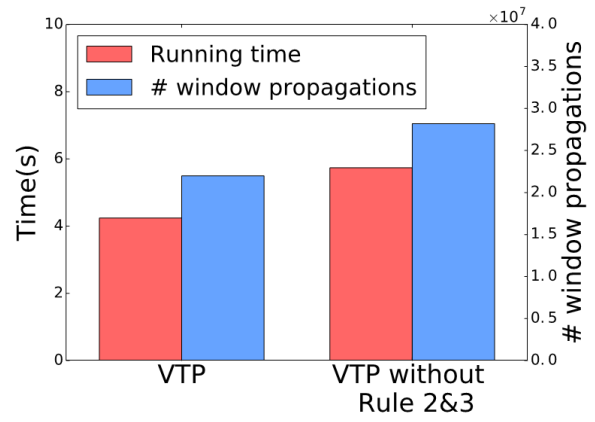
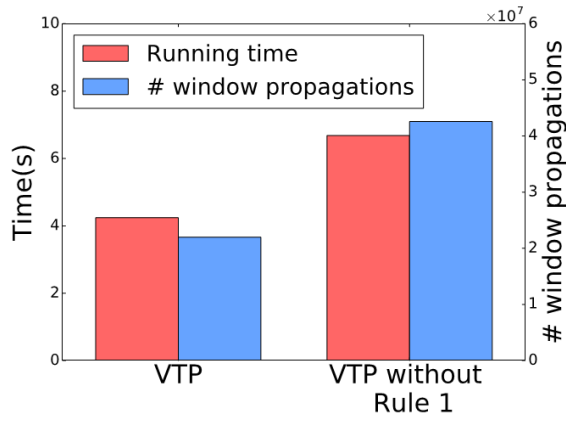


Bunny (F: 144K)

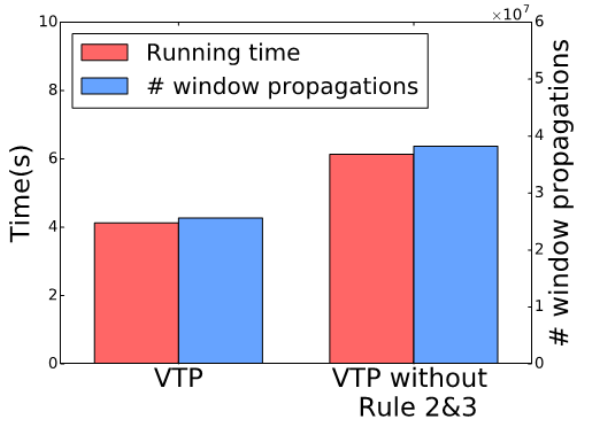
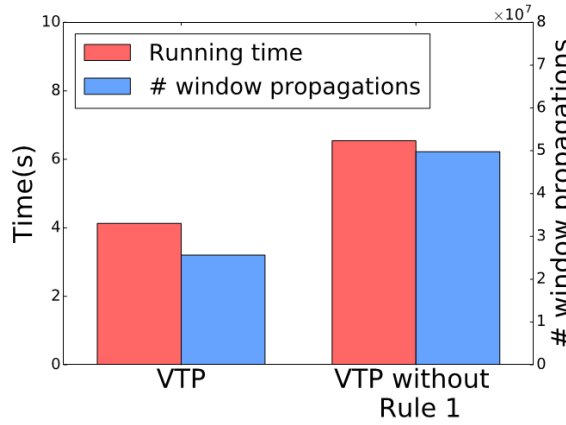


Igea (F: 268K)

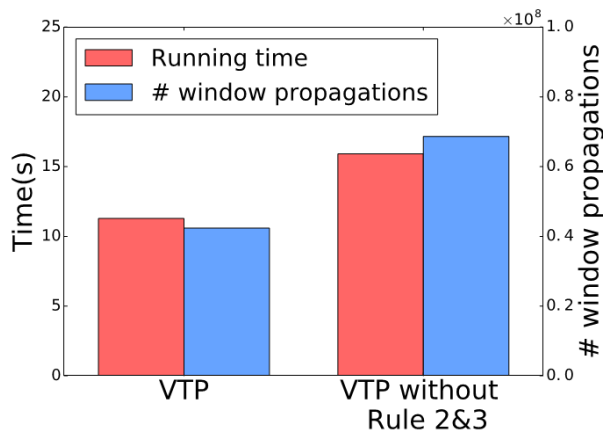
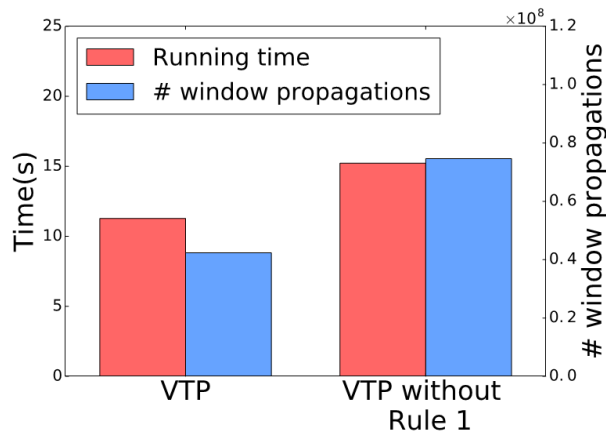




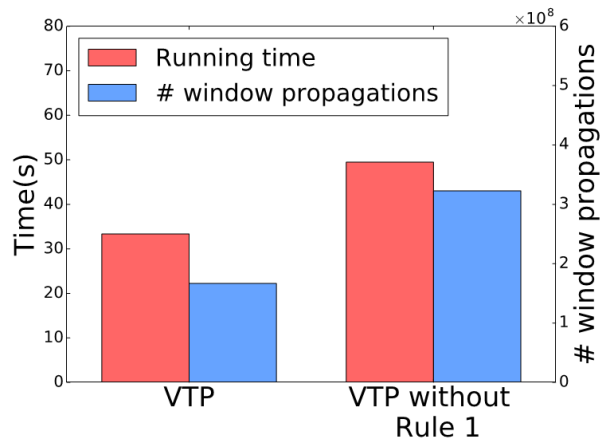
Pulley (F: 392K)



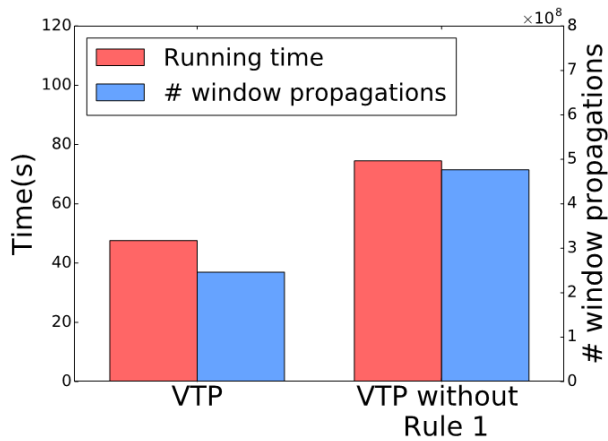
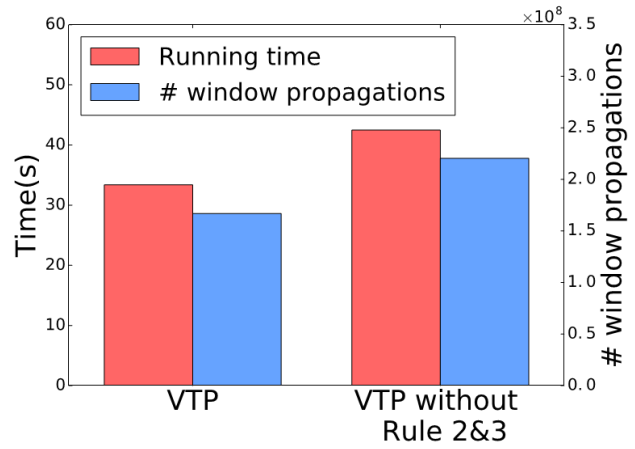
Rocker Arm (F: 482K)



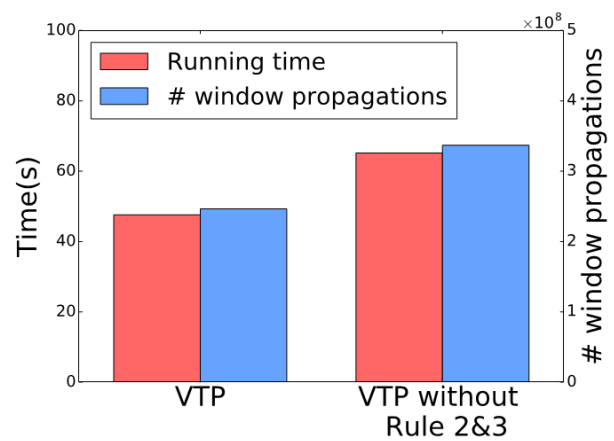
IsidoreHorse (F: 2M)



Happy Buddha (F: 2.6M)



Neptune (F: 4M)



References:

- [1] Xin, S. Q., & Wang, G. J. (2009). Improving Chen and Han's algorithm on the discrete geodesic problem. *ACM Transactions on Graphics (TOG)*, 28(4), 104.
- [2] Mitchell, J. S., Mount, D. M., & Papadimitriou, C. H. (1987). The discrete geodesic problem. *SIAM Journal on Computing*, 16(4), 647-668.
- [3] Surazhsky, V., Surazhsky, T., Kirsanov, D., Gortler, S. J., & Hoppe, H. (2005, July). Fast exact and approximate geodesics on meshes. In *ACM transactions on graphics (TOG)* (Vol. 24, No. 3, pp. 553-560). ACM.
- [4] Xu, C. X., Wang, T. Y., Liu, Y. J., Liu, L. G., & He, Y. (2015). Fast Wavefront Propagation (FWP) for Computing Exact Geodesic Distances on Meshes. *IEEE transactions on visualization and computer graphics*, 21(7), 822-834.