High-Performance Elliptical Cone Tracing Supplemental

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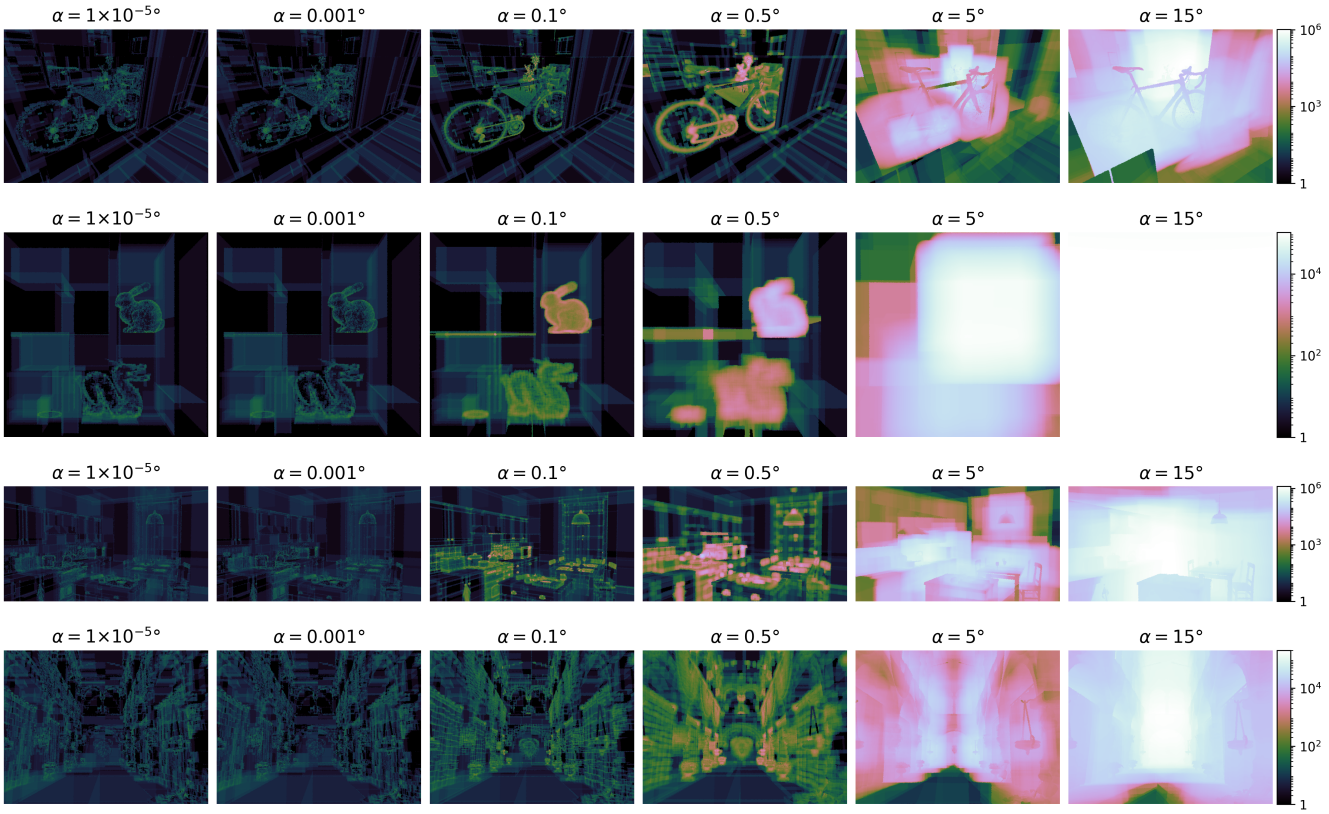
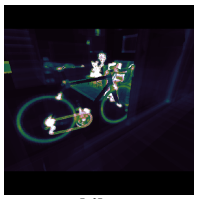
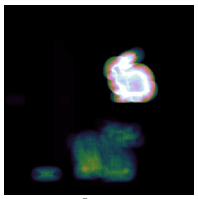
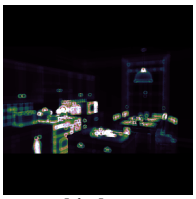
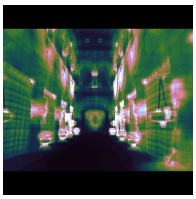
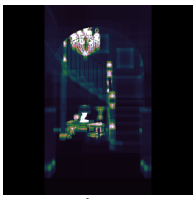


Figure 1: *Heatmaps of count of revisited triangles in a K-d tree traversal for cones of varying sizes. Revisited triangles constitute a considerable wasted effort in K-d tree traversal. From top to bottom scenes are bike, box, kitchen and sponza.*

primary cones

		bike			box			kitchen			sponza			staircase		
	cone α	µs	nodes	tris	µs	nodes	tris	µs	nodes	tris	µs	nodes	tris	µs	nodes	tris
kdtree	ray	3.22	44.0	25.3	1.48	15.4	10.6	2.98	34.0	24.8	3.99	51.5	31.3	2.80	36.8	22.7
	10^{-5}°	12.5	47.2	31.0	5.81	19.5	11.9	11.5	39.4	29.4	13.5	54.1	34.2	9.36	39.7	22.9
	0.1°	19.5	50.2	47.5	15.8	28.9	38.2	33.9	50.3	88.4	19.2	57.9	46.7	14.5	43.6	35.7
	0.5°	77.8	70.9	198	129	122	349	276	152	795	55.1	80.1	129	63.8	75.2	167
	5°	6.04K	1.36K	12.1K	13.7K	6.12K	22.6K	24.7K	6.14K	46.7K	2.31K	1.06K	4.51K	3.65K	1.79K	8.28K
	15°	80.8K	11.6K	109K	57.2K	21.9K	81.7K	243K	46.0K	354K	20.9K	6.94K	31.3K	31.8K	9.99K	47.7K
bvh	ray	4.66	25.2	11.7	1.72	9.17	2.48	3.32	20.4	3.58	5.95	39.0	3.95	4.21	23.3	10.5
	10^{-5}°	13.6	33.5	18.4	4.15	11.0	3.24	10.5	29.5	10.6	20.7	63.1	16.8	12.3	31.4	16.8
	0.1°	18.3	37.4	25.2	10.1	20.1	12.7	22.0	43.2	28.3	25.7	68.0	21.7	16.0	34.6	23.3
	0.5°	42.1	59.6	62.6	42.1	71.3	59.7	84.1	114	113	49.0	95.1	51.9	33.4	52.0	56.9
	5°	1.08K	445	628	1.38K	637	543	2.18K	956	1.07K	714	650	636	568	284	458
	15°	13.4K	1.67K	2.23K	5.55K	316	277	17.7K	2.86K	3.26K	4.12K	1.94K	1.96K	3.64K	670	1.10K
bvh8w	ray	1.37	10.0	11.1	.477	3.37	2.49	.701	7.61	3.58	1.04	15.6	5.10	1.21	8.32	10.3
	10^{-5}°	3.16	9.06	13.5	1.22	3.91	3.24	1.69	7.80	5.26	2.05	13.8	5.35	2.54	8.10	11.3
	0.1°	6.45	11.0	24.0	4.49	7.45	14.7	11.2	15.1	38.2	4.24	15.9	11.5	5.01	9.49	20.0
	0.5°	33.4	27.7	126	33.3	34.7	118	112	91.8	456	19.9	29.4	61.1	23.0	21.1	96.8
	5°	2.49K	1.30K	8.52K	2.81K	1.59K	7.90K	7.63K	5.72K	34.9K	945	632	2.99K	1.08K	648	4.71K
	15°	26.4K	11.2K	72.7K	4.47K	738	3.85K	62.0K	41.0K	258K	7.13K	4.06K	21.6K	7.79K	4.27K	30.1K

Table 1: *Mean time, nodes visited count and triangles intersected per traversed primary cone or ray for different ADSs for several scenes.*

secondary cones

		bike			box			kitchen			sponza			staircase		
	cone α	µs	nodes	tris	µs	nodes	tris	µs	nodes	tris	µs	nodes	tris	µs	nodes	tris
kdtree	ray	2.39	27.6	13.1	1.70	16.4	12.4	2.05	18.6	11.4	3.07	33.5	19.8	2.70	25.9	16.0
	10^{-5}°	8.27	29.6	15.1	6.05	20.0	11.8	6.67	20.4	12.4	11.0	35.6	23.5	8.29	27.0	15.3
	0.1°	12.2	31.1	23.0	7.00	20.7	13.6	10.9	22.1	20.9	13.0	36.9	27.5	9.59	27.9	18.2
	0.5°	63.8	44.5	125	14.5	25.7	28.4	50.5	34.9	106	26.2	44.5	53.8	24.0	34.9	45.7
	5°	4.27K	735	6.23K	399	222	710	2.72K	659	4.78K	618	314	1.14K	849	313	1.38K
	15°	36.6K	4.97K	44.7K	3.11K	1.35K	4.77K	22.9K	4.58K	34.6K	4.80K	1.79K	7.23K	6.97K	1.96K	9.59K
bvh	ray	3.33	17.0	4.44	1.67	8.70	2.50	2.36	11.2	2.85	5.57	32.3	3.47	3.52	15.8	7.45
	10^{-5}°	13.5	26.2	11.1	5.50	10.8	4.65	8.77	16.5	6.64	24.7	53.2	15.7	12.6	22.4	13.2
	0.1°	15.7	28.1	13.8	6.06	11.4	5.20	10.5	18.0	8.58	26.4	54.7	17.3	13.6	23.2	14.6
	0.5°	28.6	39.5	29.3	8.93	14.8	8.82	19.1	26.3	19.1	34.6	62.6	26.0	18.7	26.9	21.6
	5°	568	227	263	58.4	67.4	57.0	228	133	146	195	208	187	126	79.5	115
	15°	5.70K	776	928	248	180	155	1.52K	425	487	903	604	620	742	211	351
bvh8w	ray	1.00	6.70	4.72	.478	3.79	2.60	.714	4.18	2.99	1.10	12.7	4.79	1.25	5.53	7.58
	10^{-5}°	1.92	6.54	4.96	1.25	4.15	3.18	1.52	4.27	3.46	1.94	11.7	4.42	2.35	5.33	7.74
	0.1°	7.37	10.1	24.5	1.82	4.61	4.88	4.10	5.87	11.7	3.23	12.8	7.99	3.84	6.02	12.3
	0.5°	55.2	38.2	196	6.65	8.39	21.5	37.7	27.6	140	14.4	21.8	48.5	15.3	12.2	53.8
	5°	2.64K	1.46K	9.15K	234	162	802	1.92K	1.30K	8.08K	445	340	1.73K	537	297	2.04K
	15°	15.2K	7.00K	44.7K	1.13K	722	3.72K	10.9K	7.65K	47.8K	2.44K	1.76K	9.61K	2.88K	1.50K	10.5K

Table 2: *Mean time, nodes visited and triangles intersected per traversed secondary cone or ray for different ADSs for several scenes.*

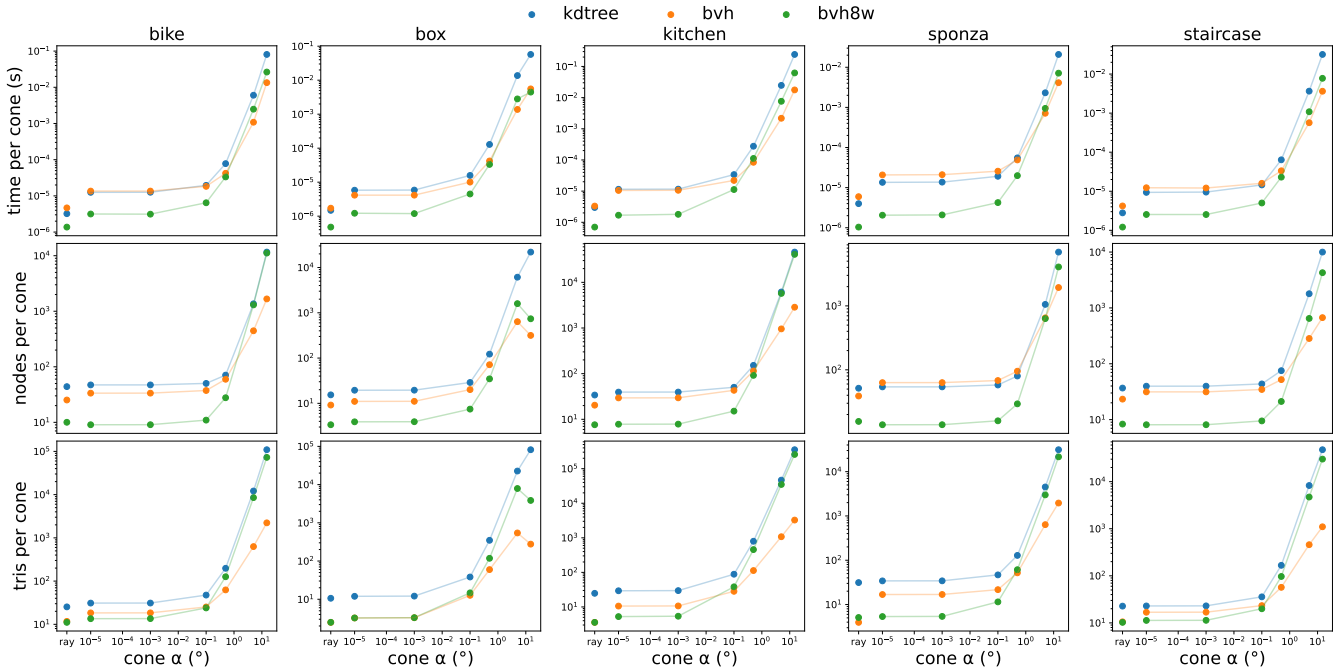


Figure 2: *Mean time, nodes visited and triangles intersected per traversed primary cone or ray for different ADSs for several scenes visualized from Table 1. Smaller cones ($< 5^\circ$ cone α) favour our implementation of the 8-wide BVH, while larger cones ($\geq 5^\circ$ cone α) favour our implementation of the BVH.*

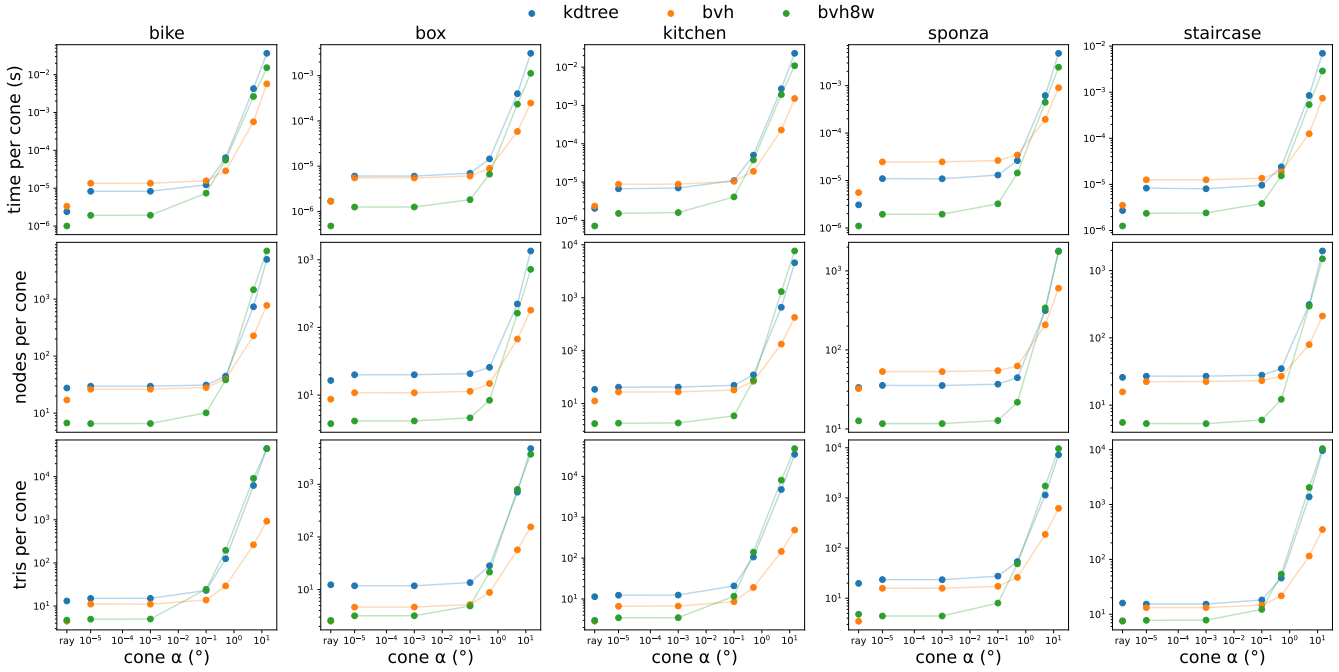


Figure 3: *Same as Fig. 2 but with secondary cones and rays, using data from Table 2. Relative performance between the ADSs is similar between primary and secondary cones and rays.*

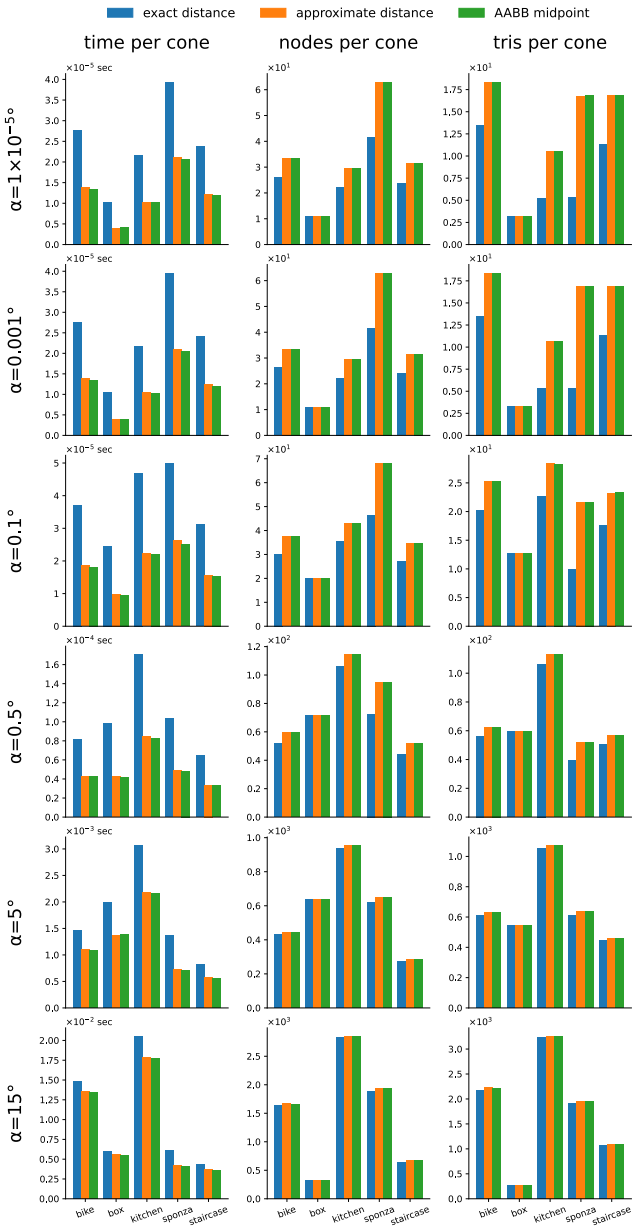


Figure 4: *Average time, count of nodes visited, and triangles tested per primary cone traversal with a binary BVH. Compared is the exact cone-to-child node distance (blue) against two approximations: ray (cone directrix)-to-node distance (orange), and origin-to-midpoint distance (green). The exact distance heuristic enables traversing less nodes and triangles, but is not worth the significant additional cost of a full cone–AABB intersection test.*

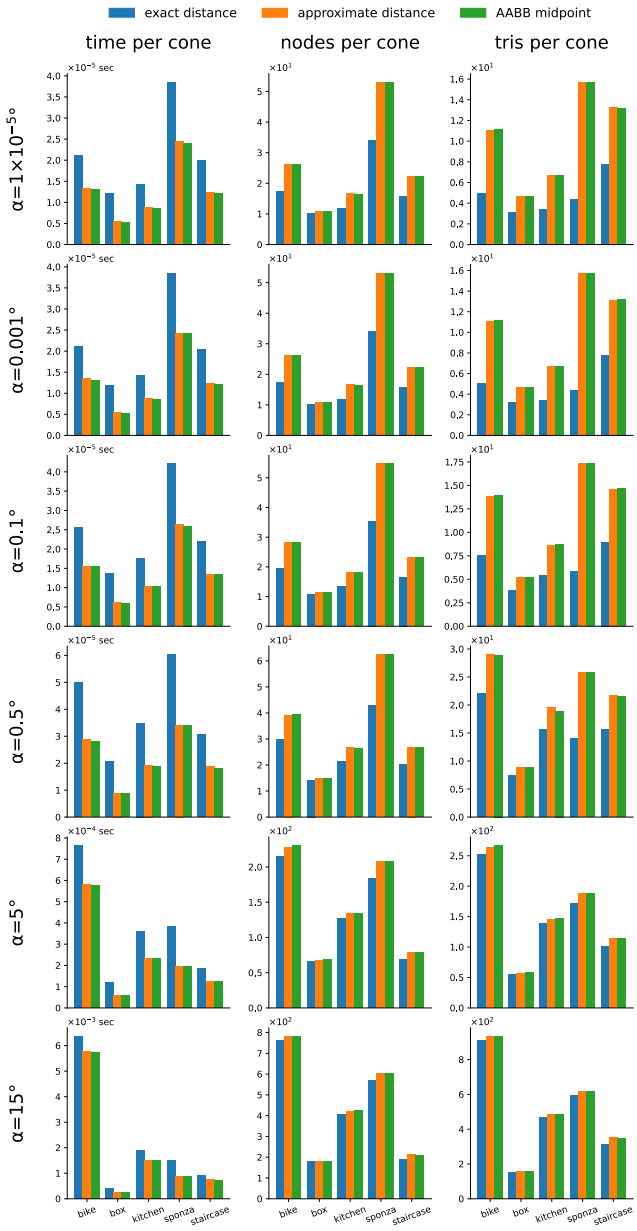


Figure 5: *Same as Fig. 4 but with secondary cones. The trend in the data is similar between primary and secondary cones*

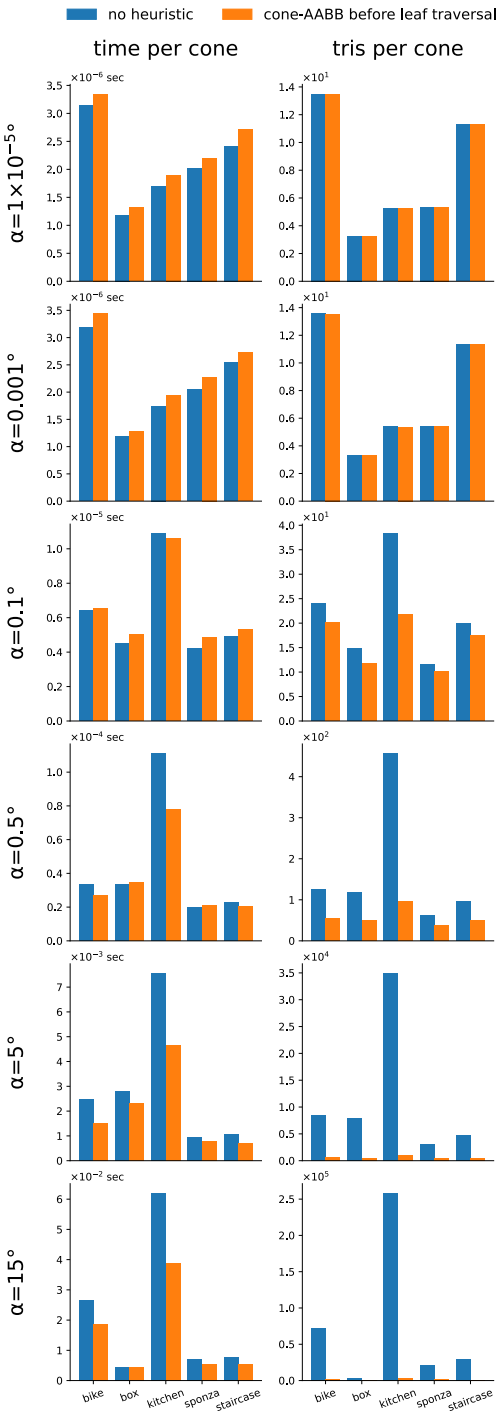


Figure 6: *Comparison of doing a cone-AABB test before traversing leafs in the 8-wide BVH (orange) and without the extra cone-AABB test (blue) on primary cones. For larger cones this heuristic avoids doing a significant number of cone-triangle intersections, which gives a performance benefit in some scenes. However, the overhead of a cone-AABB test per leaf makes this a performance loss in most cases.*

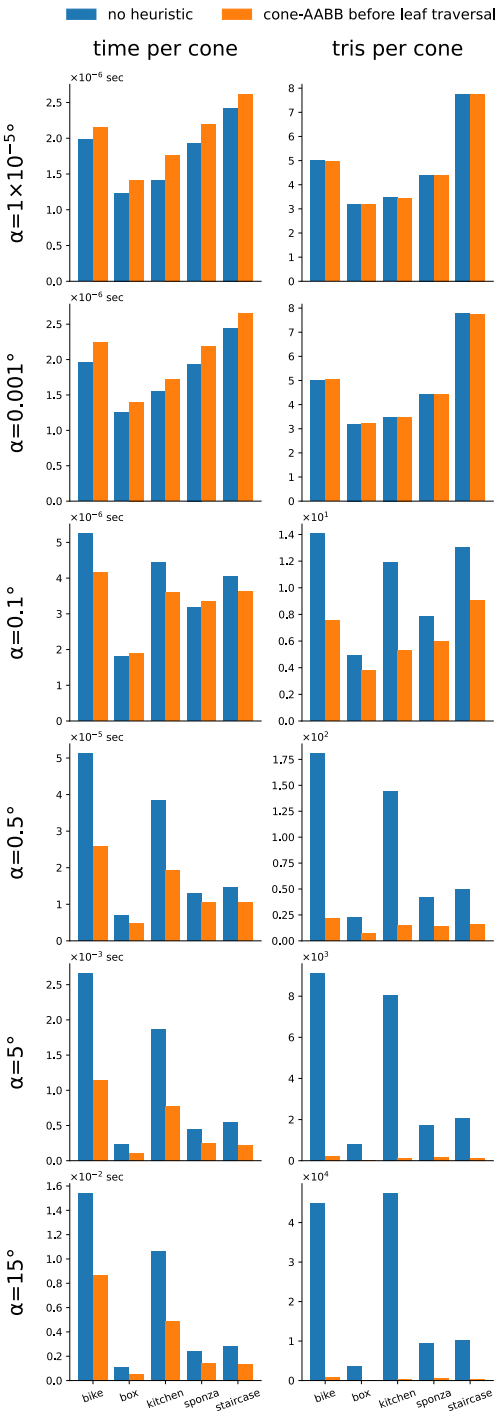


Figure 7: *Same as Fig. 6 but with secondary cones. The trend in the data is similar between primary and secondary cones.*

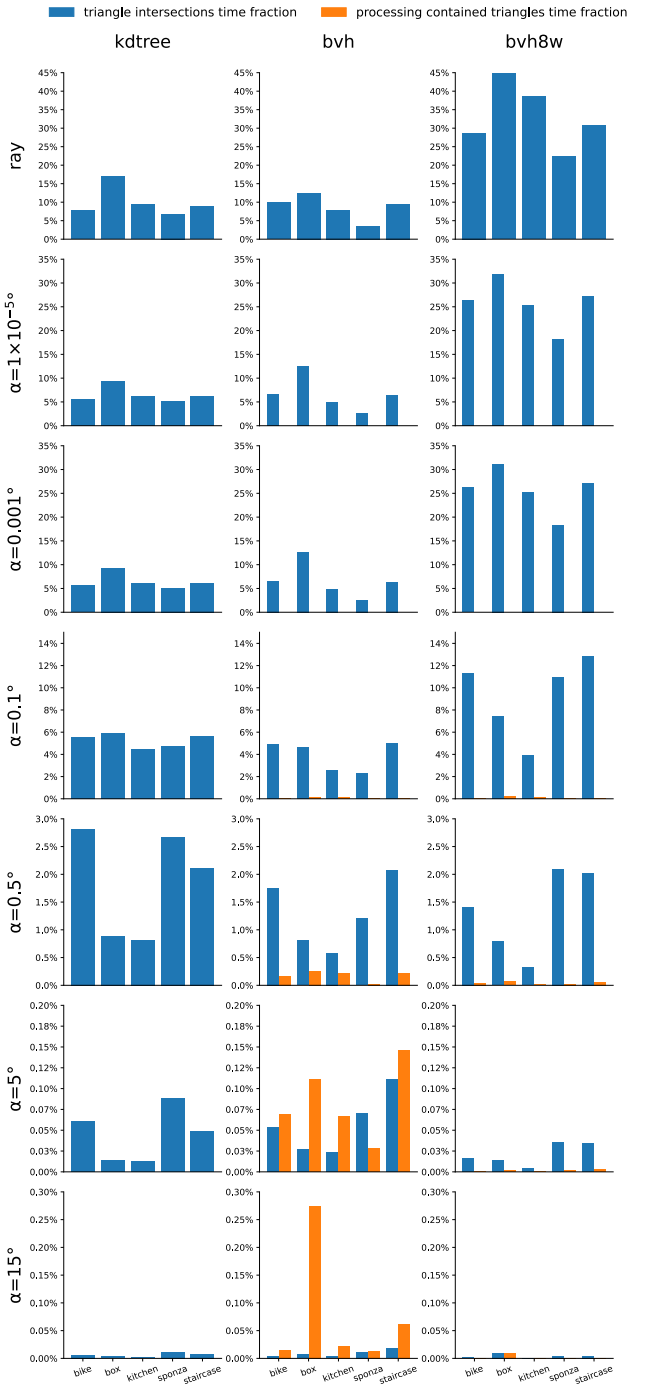


Figure 8: *Relative time spent doing triangle intersections tests or determining intersection range for triangles in the case of contained subtree traversals when traversing an ADS with primary cones and rays. The 8-wide BVH is considerably faster at traversing internal ADS nodes, and often spends less time doing so for rays and small cones. However, for large cones 8-wide BVH traversal visits significantly more nodes which explains why it spends less relative time on triangles during traversal.*

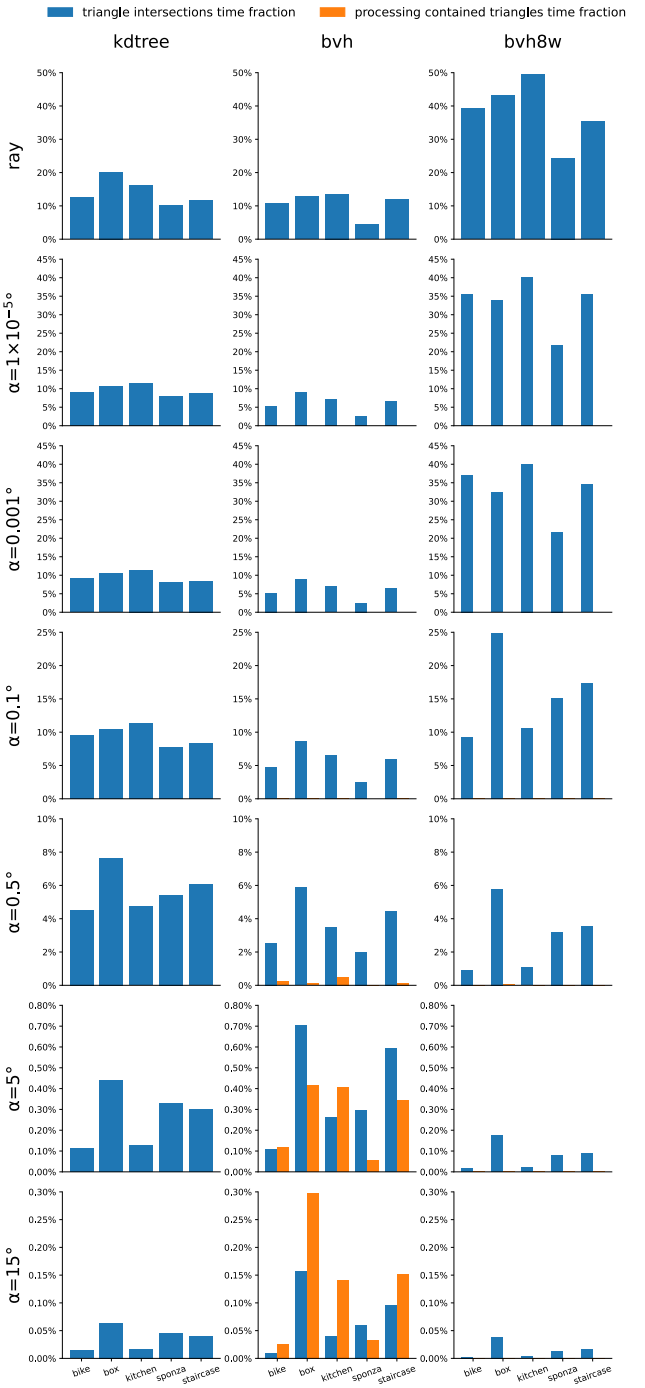


Figure 9: *Same as Fig. 8 but with secondary cones and rays. The trend in the data is similar between primary and secondary cones.*

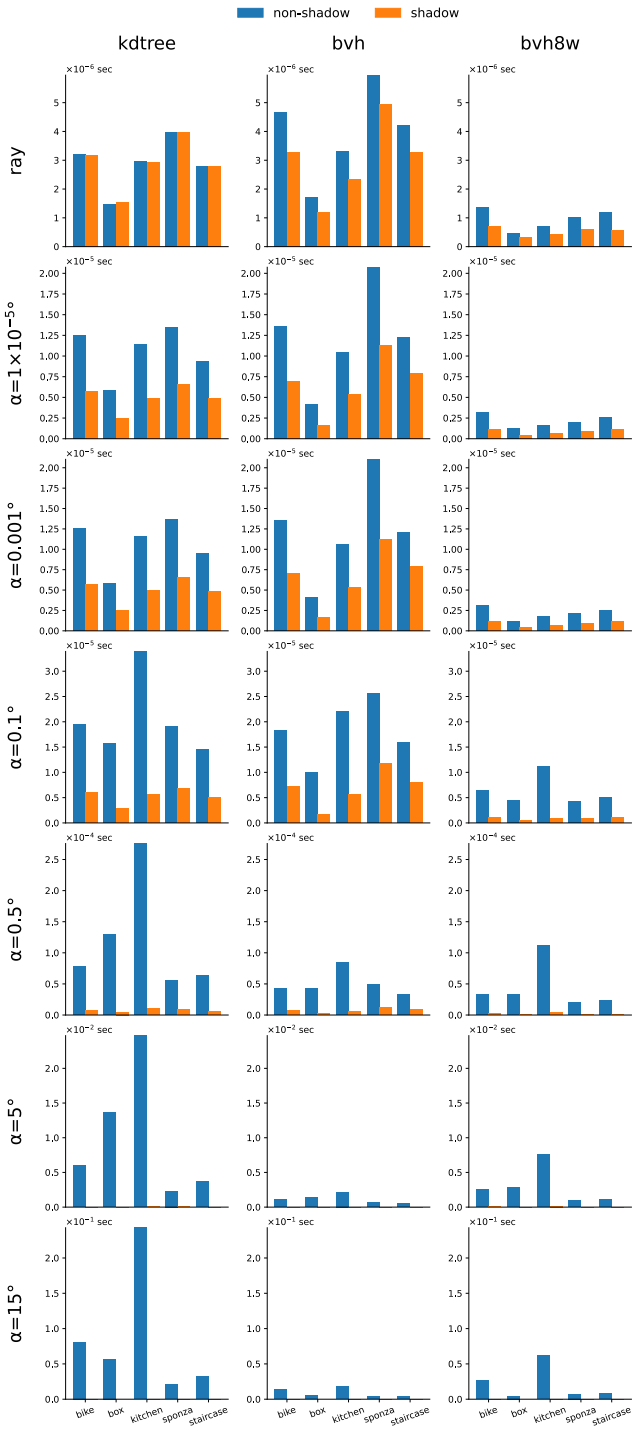


Figure 10: *Shadow cone queries compared with full cone queries. As expected, with greater cone apertures shadow queries get comparatively faster as they can terminate earlier while the full queries become more expensive; and, ADSs that are able to spend less time on traversal (K-d tree, 8-wide BVH) benefit more, compared to ADSs that are more bound by traversal costs (BVH).*

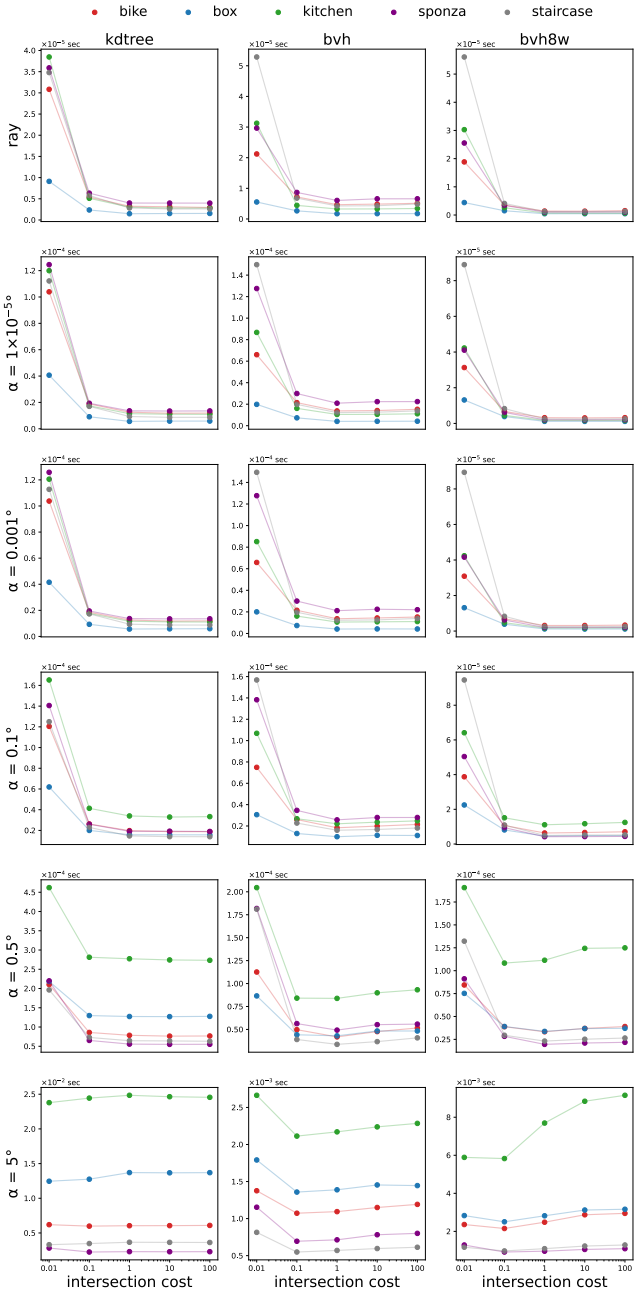


Figure 11: *Average time to trace a cone as function of the primitive intersection-to-traversal cost ratio parameter. Larger cone apertures perform better with shallower ADSs.*

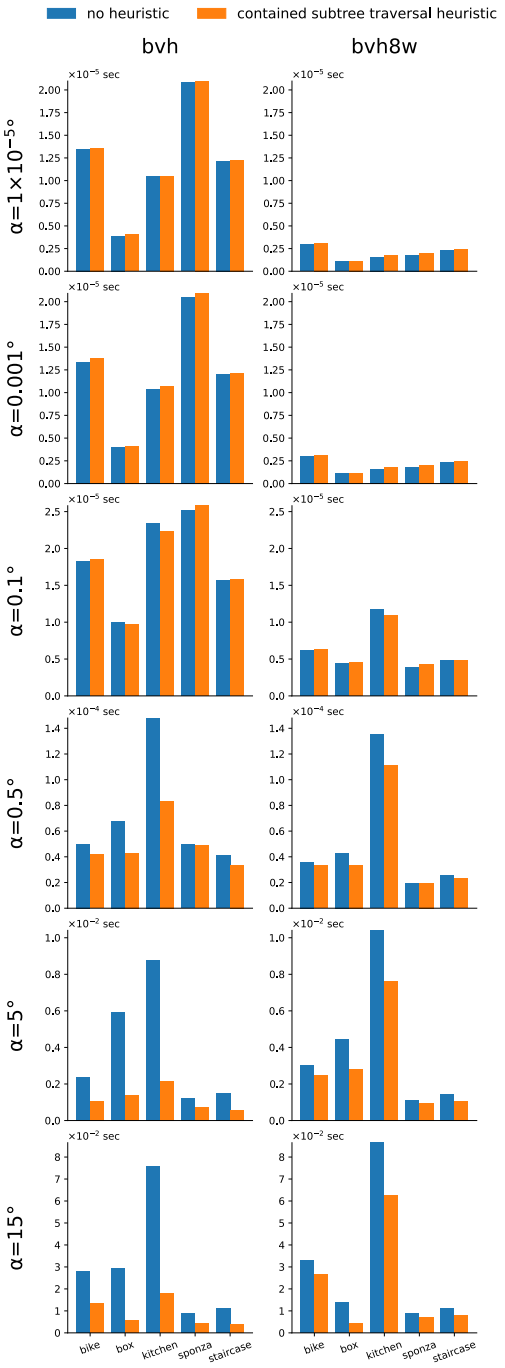


Figure 12: *Average time per primary cone traversal in a binary BVH and 8-wide BVH. Comparison is made for time spent with (orange) and without (blue) the contained subtree traversal heuristic. Checking if each node is fully contained adds a small overhead that can slow cone traversal down for very tiny cones, but for larger cones where many nodes are contained there is a significant speedup from avoiding intersection tests.*

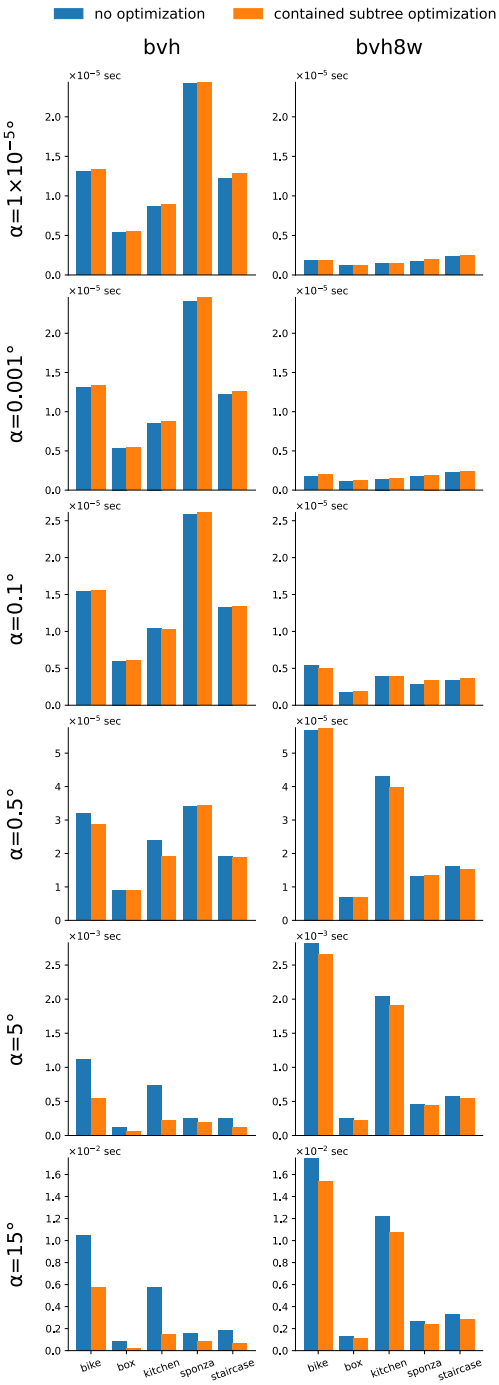


Figure 13: *Same as Fig. 12 but with secondary cones. The benefit seen from this heuristic for secondary cones is comparable to that seen for primary cones.*

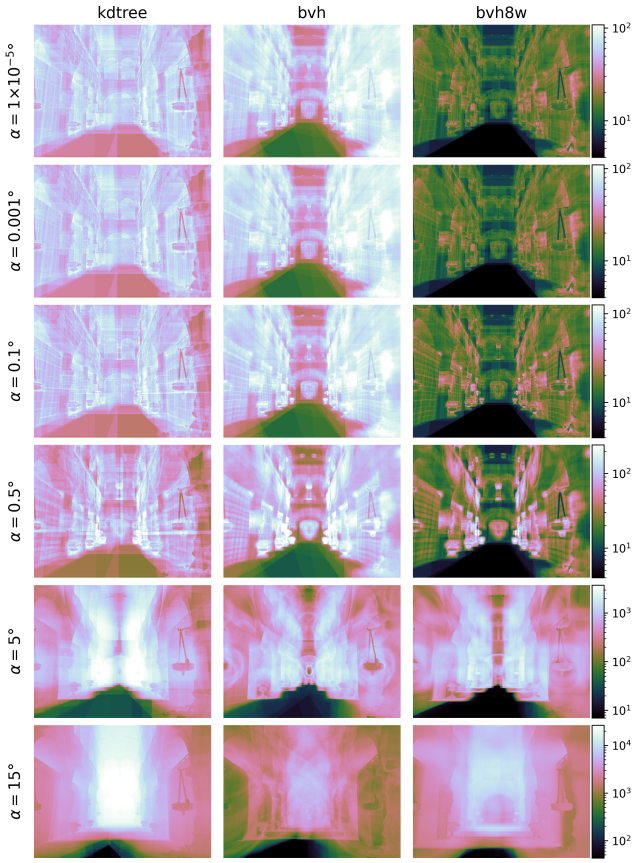


Figure 14: *Heatmaps of count of internal nodes visited during traversal of sponza with each ADS for cones of varying aperture.*

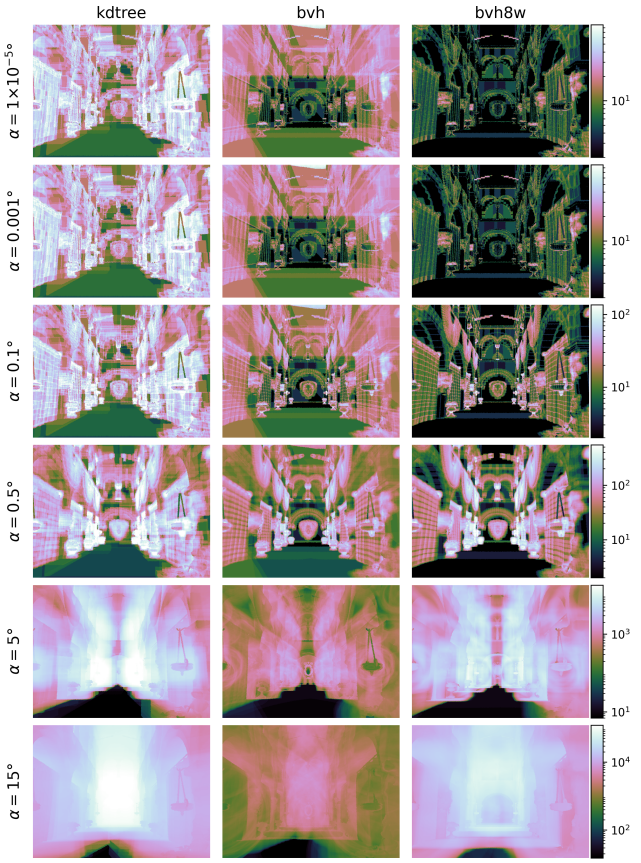


Figure 15: *Heatmaps of count of triangles intersected during traversal of sponza with each ADS for cones of varying aperture.*

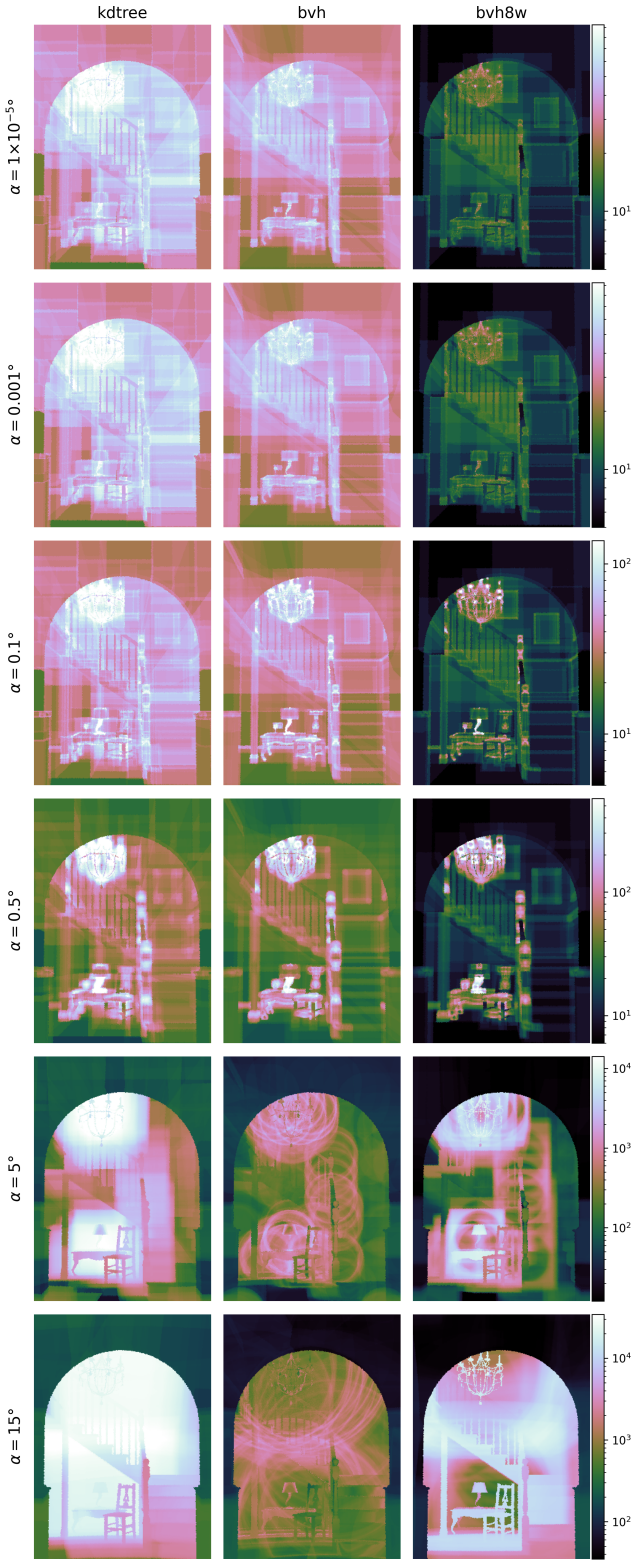


Figure 16: *Heatmaps of count of internal nodes visited during traversal of the staircase scene with each ADS for cones of varying aperture.*

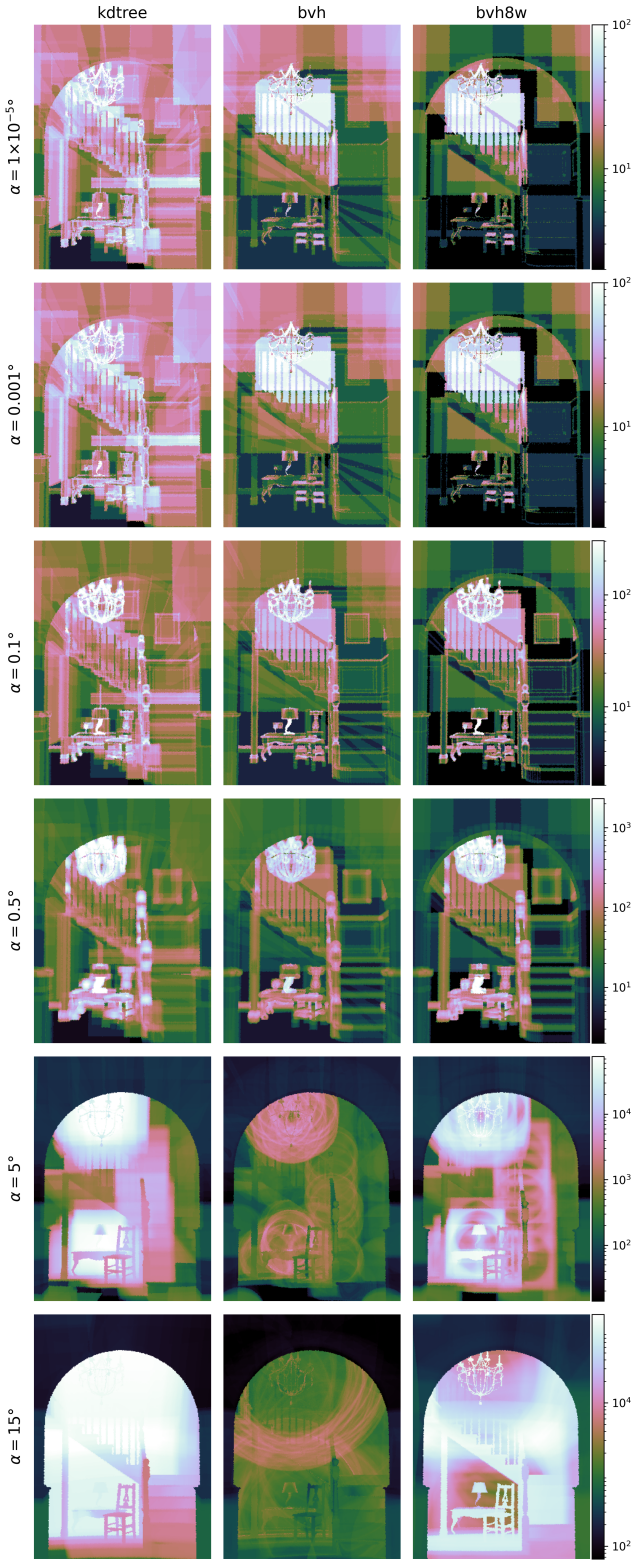


Figure 17: *Heatmaps of count of triangles intersected during traversal of the staircase scene with each ADS for cones of varying aperture.*

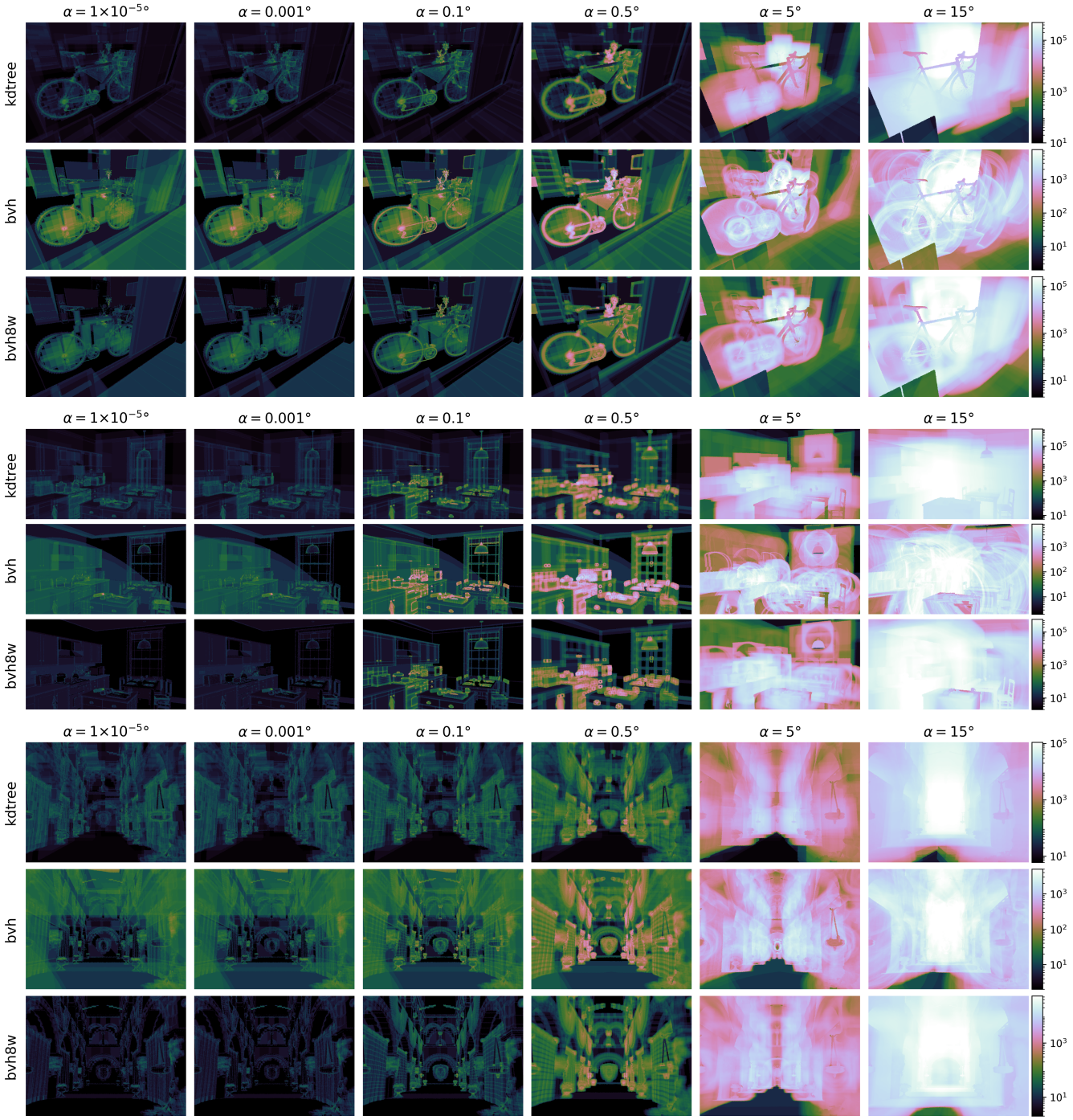


Figure 18: *Heatmaps of count of intersected triangles in traversals of different ADSs with cones of varying alpha. From top to bottom scenes are bike, kitchen and sponza.*