Box Cutter: Atlas Refinement for Efficient Packing via Void Elimination (SIGGRAPH 2018)

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Supplemental Tables

1 Additional Experimental Results

This document contains a larger set of experimental results for our *Box Cutter* method. In addition to the parameterization / segmentation methods shown in the paper, we also show data sets for the *MIQ* method of Bommes et al., as well as for the *Isocharts* algorithm by Zhou et al. [BZK09, ZSGS04].

Table 1 shows the improvement in packing efficiency which could be achieved by our method, for different boundary length constraints. For all data sets that contained overlaps, Table 2 compares our overlap removal strategy to the standard method of Lévy et al. [LPRM02]. Finally, Table 3 shows runtime performance for optimization to different boundary length constraints.

Model [Method]	PE / BL Bijective	PE Improvement (PE / BL) BLen < 130%	BLen < 150%	BLen < 200%
armadillo [PTH+17]	55% / 11.3	**+33%** (73% / 14.4)	**+45%** (80% /15.9)	**+46%** (81% /19.3)
elk [PTH+17]	51% / 13.4	**+42%** (72% / 16.4)	**+58%** (80% /20.0)	**+58%** (80% /20.0)
girl [PTH+17]	44% / 14.8	**+75%** (77% / 18.7)	**+81%** (80% /21.5)	**+85%** (82% /22.8)
octo [PTH+17]	46% / 16.5	**+47%** (67% / 20.9)	**+57%** (72% /24.5)	**+57%** (72% /24.5)
beethoven [SH02]	59% / 16.2	**+31%** (77% / 20.1)	**+36%** (80% /22.1)	**+36%** (80% /22.1)
bull [SH02]	55% / 6.9	**+37%** (75% / 8.5)	**+37%** (75% /8.5)	**+58%** (87% /13.0)
bunny [SH02]	62% / 14.1	**+28%** (79% / 18.1)	**+30%** (81% /20.0)	**+31%** (81% /23.0)
camel [SH02]	36% / 9.9	**+54%** (56% / 11.4)	**+120%** (79% /13.9)	**+128%** (82% /14.9)
cat [SH02]	68% / 4.3	**0%** (68% / 4.3)	**+25%** (85% /6.1)	**+33%** (90% /6.5)
cow [SH02]	49% / 9.1	**+57%** (77% / 11.4)	**+66%** (82% /13.1)	**+66%** (82% /13.1)
dinosaur [SH02]	44% / 14.0	**+73%** (77% / 18.2)	**+76%** (78% /20.9)	**+83%** (81% /22.7)
eight [SH02]	53% / 5.8	**+43%** (76% / 7.2)	**+43%** (76% /7.2)	**+60%** (85% /9.6)
feline [SH02]	54% / 17.5	**+37%** (75% / 20.5)	**+41%** (77% /25.5)	**+41%** (77% /25.5)
fender [SH02]	55% / 13.8	**+46%** (81% / 17.9)	**+56%** (86% /20.2)	**+56%** (86% /20.2)
gargoyle [SH02]	55% / 11.0	**+33%** (73% / 12.9)	**+53%** (83% /16.4)	**+56%** (85% /18.1)
head [SH02]	46% / 11.9	**+69%** (77% / 15.1)	**+77%** (81% /17.2)	**+79%** (82% /18.1)
horse [SH02]	51% / 7.8	**+34%** (69% / 9.7)	**+50%** (77% /11.1)	**+71%** (87% /13.9)
knot [SH02]	40% / 6.8	**+125%** (90% / 8.0)	**+125%** (90% /8.0)	**+125%** (90% /8.0)
pig [SH02]	60% / 5.3	**0%** (60% / 5.3)	**+34%** (81% /7.7)	**+43%** (87% /10.0)
rabbit [SH02]	71% / 9.7	**+13%** (81% / 12.0)	**+16%** (83% /13.9)	**+18%** (84% /15.4)
triceratops [SH02]	61% / 6.8	**+20%** (74% / 8.6)	**+35%** (83% /9.6)	**+40%** (86% /13.2)
aircraft [Lip12]	68% / 12.2	**+23%** (84% / 15.7)	**+23%** (84% /15.7)	**+23%** (84% /15.7)
cup [Lip12]	69% / 6.9	**+16%** (80% / 8.4)	**+24%** (85% /9.6)	**+30%** (89% /11.3)
aircraft [BCW17]	63% / 12.2	**+27%** (81% / 15.3)	**+30%** (82% /17.1)	**+30%** (82% /19.3)
armadillo [BCW17]	55% / 16.3	**+38%** (76% / 21.0)	**+38%** (76% /21.0)	**+38%** (76% /21.0)
armchair [BCW17]	63% / 8.9	**+14%** (72% / 11.1)	**+29%** (82% /13.2)	**+34%** (84% /14.4)
blade [BCW17]	55% / 13.7	**+43%** (78% / 17.6)	**+46%** (80% /18.9)	**+47%** (80% /20.9)
camel [BCW17]	66% / 24.7	**+12%** (75% / 29.5)	**+12%** (75% /29.5)	**+12%** (75% /29.5)
cow2 [BCW17]	64% / 12.6	**+17%** (74% / 15.2)	**+20%** (76% /16.9)	**+30%** (83% /24.2)
cup [BCW17]	52% / 8.7	**+46%** (76% / 11.1)	**+60%** (83% /13.1)	**+67%** (87% /14.9)
ramses [BCW17]	58% / 10.8	**+29%** (75% / 14.0)	**+32%** (77% /14.2)	**+38%** (80% /19.0)
aircraft [BCE+13]	68% / 11.6	**+20%** (82% / 14.5)	**+24%** (85% /17.3)	**+27%** (87% /21.2)
camel [BCE+13]	49% / 21.4	**+50%** (74% / 26.5)	**+50%** (74% /26.5)	**+50%** (74% /26.5)
cup [BCE+13]	69% / 7.0	**+13%** (78% / 8.4)	**+20%** (82% /9.1)	**+34%** (92% /13.5)
aircraft [BZK09]	63% / 12.2	**+25%** (79% / 14.6)	**+31%** (83% /18.2)	**+37%** (86% /19.2)
camel [BZK09]	53% / 23.6	**+44%** (76% / 29.4)	**+44%** (76% /32.6)	**+44%** (76% /32.6)
cup [BZK09]	68% / 10.2	**+21%** (83% / 13.1)	**+22%** (84% /13.6)	**+22%** (84% /13.6)
aircraft [MPZ14]	58% / 18.5	**+40%** (81% / 22.9)	**+50%** (87% /27.3)	**+51%** (88% /28.3)
camel [MPZ14]	54% / 26.7	**+39%** (75% / 31.6)	**+39%** (75% /31.6)	**+39%** (75% /31.6)
cup [MPZ14]	80% / 7.8	**+14%** (92% / 10.0)	**+14%** (92% /10.0)	**+17%** (94% /12.0)
mannequin [MPZ14]	59% / 15.1	**+23%** (73% / 17.6)	**+36%** (81% /21.3)	**+36%** (81% /21.3)
maxplanck [MPZ14]	53% / 23.0	**+46%** (77% / 27.8)	**+46%** (77% /27.8)	**+46%** (77% /27.8)
santa [MPZ14]	61% / 27.1	**+25%** (77% / 32.0)	**+25%** (77% /32.0)	**+25%** (77% /32.0)
aircraft [LZ14]	61% / 13.1	**+26%** (76% / 15.7)	**+32%** (80% /18.9)	**+37%** (83% /20.0)
beetle [LZ14]	65% / 18.9	**+21%** (78% / 22.4)	**+21%** (78% /22.4)	**+21%** (78% /22.4)
bozbezbozzel [LZ14]	60% / 27.7	**+20%** (72% / 33.1)	**+20%** (72% /33.1)	**+20%** (72% /33.1)
camel [LZ14]	54% / 22.1	**+41%** (76% / 27.8)	**+41%** (76% /27.8)	**+41%** (76% /27.8)
cup [LZ14]	68% / 11.4	**+22%** (83% / 13.9)	**+25%** (85% /16.9)	**+25%** (85% /16.9)
bird [CZL+15]	30% / 9.4	**+131%** (70% / 11.5)	**+172%** (83% /13.7)	**+181%** (85% /18.4)
duck [CZL+15]	29% / 10.7	**+159%** (76% / 13.3)	**+160%** (76% /16.1)	**+169%** (79% /19.9)
excavator [CZL+15]	30% / 9.6	**+114%** (64% / 11.2)	**+167%** (80% /14.0)	**+181%** (84% /17.6)
jordan [CZL+15]	16% / 11.4	**+273%** (61% / 13.0)	**+370%** (76% /16.1)	**+388%** (79% /19.2)
tower [CZL+15]	38% / 10.6	**+40%** (54% / 12.5)	**+89%** (73% /13.9)	**+131%** (89% /19.3)
bunny [JKS05]	68% / 17.6	**+14%** (77% / 21.0)	**+14%** (77% /21.0)	**+14%** (77% /21.0)
fandisk [JKS05]	61% / 17.4	**+37%** (83% / 22.2)	**+39%** (84% /24.9)	**+39%** (84% /24.9)
feline [JKS05]	60% / 35.4	**+18%** (71% / 40.6)	**+18%** (71% /40.6)	**+18%** (71% /40.6)
gargoyle [JKS05]	61% / 18.4	**+30%** (79% / 23.1)	**+30%** (79% /23.1)	**+30%** (79% /23.1)
horse [JKS05]	62% / 20.2	**+24%** (77% / 25.1)	**+24%** (77% /25.1)	**+24%** (77% /25.1)
feline [ZSGS04]	67% / 26.1	**+10%** (73% / 28.6)	**+10%** (73% /28.6)	**+10%** (73% /28.6)
gargoyle [ZSGS04]	65% / 15.2	**+23%** (79% / 18.7)	**+26%** (81% /20.2)	**+26%** (81% /20.2)
horse [ZSGS04]	71% / 13.4	**+14%** (81% / 16.6)	**+14%** (81% /16.6)	**+14%** (81% /16.6)
dancer2 [JSP17]	31% / 11.0	**+141%** (75% / 14.0)	**+167%** (83% /16.1)	**+167%** (83% /16.1)
fertility [JSP17]	41% / 15.1	**+90%** (78% / 19.6)	**+99%** (81% /22.4)	**+99%** (81% /22.4)
fish [JSP17]	44% / 9.4	**+54%** (67% / 10.3)	**+54%** (67% /10.3)	**+88%** (82% /16.7)
moai [JSP17]	49% / 7.0	**+70%** (83% / 9.0)	**+70%** (83% /9.0)	**+81%** (88% /11.6)
rockerarm [JSP17]	42% / 12.4	**+75%** (74% / 15.3)	**+86%** (79% /18.4)	**+96%** (83% /22.6)
venus [JSP17]	59% / 5.4	**+25%** (73% / 6.4)	**+40%** (82% /7.8)	**+55%** (91% /10.7)
Min.	16% (4.3)	**0%**	**+10%**	**+10%**
Max.	80% (35.4)	**+273%**	**+370%**	**+388%**
Average	55% (13.8)	**+45%**	**+55%**	**+60%**
Median	58% (12.2)	**+33%**	**+39%**	**+41%**

Table 1: Results of packing efficiency optimization on a large test data set.

Model [Method]	BLen Increase (Pack. Eff.)		
	[Lévy et al. 02]	Overl. Cut	Welded
beethoven [SH02]	**+76%** (62%)	**+13%** (59%)	**+13%** (59%)
bunny [SH02]	**+47%** (57%)	**+17%** (62%)	**+17%** (62%)
dinosaur [SH02]	**+28%** (45%)	**+18%** (44%)	**+18%** (44%)
feline [SH02]	**+58%** (48%)	**+14%** (54%)	**+14%** (54%)
fender [SH02]	**+40%** (51%)	**+29%** (55%)	**+29%** (55%)
gargoyle [SH02]	**+30%** (54%)	**+15%** (55%)	**+15%** (55%)
head [SH02]	**+39%** (45%)	**+16%** (46%)	**+16%** (46%)
rabbit [SH02]	**+88%** (67%)	**+27%** (71%)	**+27%** (71%)
aircraft [Lip12]	**+70%** (71%)	**+25%** (68%)	**+7%** (68%)
cup [Lip12]	**+37%** (81%)	**+42%** (71%)	**−13%** (69%)
aircraft [BCW17]	**+76%** (62%)	**+17%** (66%)	**+4%** (63%)
armadillo [BCW17]	**+55%** (64%)	**+26%** (64%)	**+13%** (55%)
armchair [BCW17]	**+29%** (63%)	**+12%** (63%)	**+12%** (63%)
blade [BCW17]	**+35%** (43%)	**+22%** (60%)	**+16%** (55%)
camel [BCW17]	**+95%** (58%)	**+27%** (67%)	**+22%** (66%)
cow2 [BCW17]	**+70%** (56%)	**+23%** (65%)	**+16%** (64%)
cup [BCW17]	**+33%** (77%)	**+63%** (59%)	**+9%** (52%)
ramses [BCW17]	**+35%** (58%)	**+18%** (56%)	**+18%** (58%)
aircraft [BCE$^+$13]	**+71%** (70%)	**+25%** (69%)	**+2%** (68%)
camel [BCE$^+$13]	**+92%** (61%)	**+26%** (57%)	**+8%** (49%)
cup [BCE$^+$13]	**+37%** (81%)	**+42%** (71%)	**−13%** (69%)
aircraft [BZK09]	**+72%** (68%)	**+23%** (64%)	**+7%** (63%)
camel [BZK09]	**+89%** (57%)	**+26%** (56%)	**+19%** (53%)
cup [BZK09]	**+36%** (81%)	**+64%** (68%)	**+28%** (68%)
aircraft [MPZ14]	**+57%** (64%)	**+12%** (66%)	**+1%** (58%)
camel [MPZ14]	**+74%** (70%)	**+12%** (64%)	**−1%** (54%)
cup [MPZ14]	**+21%** (76%)	**+25%** (81%)	**+25%** (80%)
mannequin [MPZ14]	**+81%** (64%)	**+14%** (66%)	**−4%** (59%)
maxplanck [MPZ14]	**+71%** (47%)	**+18%** (58%)	**+4%** (53%)
santa [MPZ14]	**+58%** (60%)	**+15%** (66%)	**−1%** (61%)
aircraft [LZ14]	**+75%** (63%)	**+19%** (65%)	**+9%** (61%)
beetle [LZ14]	**+66%** (40%)	**+24%** (66%)	**+14%** (65%)
bozbezbozzel [LZ14]	**+92%** (64%)	**+29%** (65%)	**+15%** (60%)
camel [LZ14]	**+93%** (64%)	**+26%** (63%)	**+12%** (54%)
cup [LZ14]	**+37%** (81%)	**+68%** (68%)	**+42%** (68%)
feline [JKS05]	**+4%** (59%)	**+2%** (60%)	**+2%** (60%)
Min.	**+4%** (40%)	**+2%** (44%)	**−13%** (44%)
Max.	**+95%** (81%)	**+68%** (81%)	**+42%** (80%)
Average	**+57%** (62%)	**+25%** (63%)	**+12%** (60%)
Median	**+58%** (62%)	**+23%** (64%)	**+13%** (60%)

Table 2: Our overlap removal strategy compared to the standard method of Lévy et al.[LPRM02]. Numbers show boundary length increase (smaller is better) and packing efficiency (higher is better). Data sets in the second vertical section of the table are using globally continuous parameterizations, hence their seams can be welded together to reduce the boundary length, in some cases even below the original one.

Model [Method]	#Triangles	Runtime (seconds)		
		BL < 130%	BL < 150%	BL < 200%
armadillo [PTH+17]	5,000	61.4	115.4	267.2
elk [PTH+17]	10,387	69.7	221.4	404.7
girl [PTH+17]	19,735	169.8	422.4	793.4
octo [PTH+17]	4,181	80.7	182.3	244.8
beethoven [SH02]	4,429	90.7	239.7	376.3
bull [SH02]	34,504	70.4	70.4	449.1
bunny [SH02]	15,201	188.6	408.1	590.5
camel [SH02]	4,884	19.0	118.9	332.6
cat [SH02]	671	0.0	20.2	55.0
cow [SH02]	5,804	53.7	328.3	328.3
dinosaur [SH02]	28,136	186.3	466.3	890.7
eight [SH02]	1,536	18.5	18.5	145.9
feline [SH02]	99,732	640.4	1350.1	1419.6
fender [SH02]	122,510	195.9	964.2	1409.2
gargoyle [SH02]	20,000	28.6	90.9	466.7
head [SH02]	7,232	88.9	221.1	440.8
horse [SH02]	96,966	108.5	208.1	1264.4
knot [SH02]	1,350	16.8	28.9	61.8
pig [SH02]	3,560	0.0	25.5	121.6
rabbit [SH02]	902	50.1	75.9	205.4
triceratops [SH02]	5,660	13.2	43.0	168.9
aircraft [Lip12]	4,656	259.3	259.3	259.3
cup [Lip12]	11,340	15.2	51.6	205.4
aircraft [BCW17]	4,656	101.9	179.8	287.6
armadillo [BCW17]	43,160	520.9	659.5	659.5
armchair [BCW17]	100,000	74.2	389.9	1172.4
blade [BCW17]	58,546	386.9	547.8	845.0
camel [BCW17]	69,092	968.4	968.4	968.4
cow2 [BCW17]	8,626	52.7	112.5	455.9
cup [BCW17]	11,340	34.5	143.5	342.4
ramses [BCW17]	100,000	165.8	247.8	1242.5
aircraft [BCE+13]	4,656	68.6	146.1	285.3
camel [BCE+13]	69,092	1080.6	1080.6	1080.6
cup [BCE+13]	11,340	15.7	34.6	201.8
aircraft [BZK09]	4,656	88.7	190.0	487.4
camel [BZK09]	69,092	999.1	1349.8	1349.8
cup [BZK09]	11,340	70.4	222.6	222.6
aircraft [MPZ14]	11,277	186.4	448.5	533.3
camel [MPZ14]	110,656	1141.2	1141.2	1141.2
cup [MPZ14]	16,758	142.6	142.6	343.7
mannequin [MPZ14]	130,625	362.1	1285.0	1285.0
maxplanck [MPZ14]	142,309	1854.2	1854.2	1854.2
santa [MPZ14]	200,892	1827.2	1827.2	1827.2
aircraft [LZ14]	4,656	82.6	144.8	386.6
beetle [LZ14]	38,726	831.1	883.7	883.7
bozbezbozzel [LZ14]	50,000	846.0	846.0	846.0
camel [LZ14]	69,092	798.4	798.4	798.4
cup [LZ14]	11,340	67.4	214.4	285.6
bird [CZL+15]	171	27.2	60.8	286.8
duck [CZL+15]	154	34.8	87.0	307.0
excavator [CZL+15]	55	22.2	54.1	275.2
jordan [CZL+15]	159	71.6	166.7	359.7
tower [CZL+15]	94	12.5	30.7	367.1
bunny [JKS05]	69,451	992.6	992.6	992.6
fandisk [JKS05]	9,926	189.6	295.5	295.5
feline [JKS05]	41,262	1340.3	1340.3	1340.3
gargoyle [JKS05]	20,000	577.6	741.8	741.8
horse [JKS05]	19,996	456.4	585.8	585.8
feline [ZSGS04]	41,262	719.6	719.6	719.6
gargoyle [ZSGS04]	20,000	244.9	511.3	511.3
horse [ZSGS04]	19,996	258.6	258.6	258.6
dancer2 [JSP17]	18,292	64.1	255.2	393.7
fertility [JSP17]	27,954	106.7	471.0	471.0
fish [JSP17]	13,465	21.1	21.1	260.2
moai [JSP17]	20,000	54.3	54.3	358.8
rockerarm [JSP17]	20,088	168.4	354.9	726.6
venus [JSP17]	1,396	9.7	20.8	98.0
Min.		0.0	18.5	55.0
Max.		1854.2	1854.2	1854.2
Average		306.9	430.0	597.6
Median		90.7	239.7	440.8

Table 3: Runtime performance, in seconds, for packing efficiency optimization.

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