

A New Rank Constraint on Multi-view Fundamental Matrices, and its Application to Camera Location Recovery

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1. Supplementary Material

1.1. Results on camera location error

In Table 1 we compare Our, LUD, ShapeKick and 1DSfM on 14 different scenes for $N = 50, 100$ and 150 images. For each scene and each choice of N we report the average of the median camera location error for 5 different trials. In Table 3-16, each table compares four competing algorithms on 5 different trials for 50, 100 and 150 images.

1.2. Results on essential matrix error

In Table 2 we compare Our, LUD, ShapeKick and 1DSfM on 14 different scenes for $N = 50, 100$ and 150 images. For each scene and each choice of N we report the average of the median essential error for 5 different trials. Essential matrix error between two cameras is computed as the norm of their difference after they are normalized to unit norm. We multiply the essential matrix error by 100 and report it for convenience. In Table 17-30, each table compares four competing algorithms on 5 different trials for 50, 100 and 150 images.

Table 1: Average of median camera location error for 5 trials for each scene and each choice of N

Scene	50 images				100 images				150 images			
	Our	LUD	ShapeKick	1DSfM	Our	LUD	ShapeKick	1DSfM	Our	LUD	ShapeKick	1DSfM
Alamo	0.43	0.44	0.39	1.85	0.47	0.48	0.49	1.49	0.45	0.46	0.44	1.16
Ellis Island	8.03	22.72	26.42	4.4	13.8	21.87	26.61	3.96	16.45	20.68	26.41	3.37
Madrid Metropolis	3.44	3.59	9.45	13.26	3.38	3.60	20.62	10.43	3.01	3.11	14.50	9.06
Montreal Notre Dame	0.42	0.53	2.41	2.55	0.50	0.54	2.78	1.80	0.51	0.54	2.53	1.50
Notre Dame	0.33	0.39	0.29	2.42	0.27	0.30	0.39	1.91	0.26	0.29	0.23	1.42
NYC Library	1.66	2.76	10.89	2.81	2.11	2.58	14.37	2.12	1.58	2.02	13.85	2.33
Piazza Del Popolo	0.79	1.07	1.00	3.37	1.21	1.46	9.73	2.48	1.64	1.72	7.91	2.76
Piccadilly	1.47	2.07	2.94	6.36	1.85	2.20	8.47	4.57	2.21	2.40	6.56	4.76
Roman Forum	5.65	5.84	4.50	40.20	4.05	4.10	21.35	26.71	4.50	4.32	36.09	20.61
Tower of London	3.46	4.57	17.46	48.34	6.99	7.35	39.69	22.44	4.21	4.42	49.73	17.49
Union Square	3.13	3.54	4.46	4.73	4.46	4.52	5.37	11.16	7.58	8.66	12.06	10.64
Vienna Cathedral	3.61	4.42	15.79	18.30	3.89	5.57	25.82	5.17	5.17	5.89	24.59	4.72
Yorkminster	1.79	2.31	20.34	5.09	2.20	2.55	18.67	6.86	2.51	2.68	18.77	6.44
Gendermenmarkt	19.29	19.90	24.63	37.15	15.54	16.34	20.79	35.18	17.20	17.46	21.63	36.70

Table 2: Average of median essential matrix error for 5 trials for each scene and each choice of N

Scene	50 images			100 images			150 images		
	Our	LUD	ShapeKick	Our	LUD	ShapeKick	Our	LUD	ShapeKick
Alamo	3.96	3.90	3.74	4.77	4.86	5.19	4.52	4.57	4.64
Ellis Island	30.34	72.05	82.64	41.66	69.42	81.31	48.87	66.58	78.28
Madrid Metropolis	11.69	12.18	10.48	12.68	13.09	10.72	13.11	13.48	16.30
Montreal Notre Dame	17.95	19.67	17.34	5.21	5.53	5.86	4.92	5.14	5.69
Notre Dame	4.90	5.07	4.37	3.86	4.18	4.44	3.71	3.89	3.52
NYC Library	19.63	24.84	21.73	20.37	24.32	29.68	19.21	21.28	34.84
Piazza Del Popolo	4.65	5.78	5.68	6.88	8.06	7.59	9.36	9.44	9.74
Piccadilly	32.34	35.67	39.17	28.86	33.62	35.55	17.56	18.51	22.66
Roman Forum	13.68	16.03	9.77	8.34	9.58	12.57	8.23	8.55	25.42
Tower of London	5.93	7.47	11.52	10.56	11.07	13.05	7.39	7.59	6.06
Union Square	40.46	49.98	46.65	59.31	62.78	68.45	51.03	50.70	57.01
Vienna Cathedral	9.27	25.18	22.28	9.62	13.27	23.16	12.43	14.93	24.90
Yorkminster	6.34	7.82	9.45	8.60	9.68	6.94	8.94	9.46	10.71
Gendermenmarkt	74.03	76.43	78.62	61.64	66.09	65.30	55.42	56.24	59.60

Table 3: Median translation error on ‘Alamo’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	0.43	0.56	0.39	0.42	0.33	0.45	0.40	0.39	0.36	0.75	0.43	0.37	0.39	0.39	0.64
LUD	0.41	0.50	0.45	0.50	0.32	0.46	0.41	0.39	0.38	0.76	0.43	0.38	0.40	0.41	0.69
ShapeKick	0.41	0.49	0.41	0.34	0.32	0.43	0.41	0.43	0.36	0.82	0.42	0.38	0.40	0.39	0.63
1DSfM	1.26	2.28	0.65	3.67	1.39	1.09	1.12	0.82	0.74	3.68	1.04	0.80	0.62	0.82	2.53

Table 4: Median translation error on ‘Ellis Island’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	5.28	11.54	4.19	12.31	6.84	12.19	17.20	12.87	16.53	10.20	18.22	16.20	15.03	17.24	15.56
LUD	19.62	27.20	20.70	24.40	21.66	18.00	24.81	20.36	27.02	19.17	21.89	21.48	17.55	23.49	18.98
ShapeKick	24.72	28.15	27.06	25.02	27.18	26.09	26.85	26.40	27.22	26.50	26.93	26.76	25.75	26.46	26.13
1DSfM	3.57	3.48	5.07	4.47	5.39	3.33	4.17	3.94	3.89	4.47	3.26	3.20	3.94	2.84	3.60

Table 5: Median translation error on ‘Madrid Metropolis’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	5.01	2.53	2.56	2.60	4.50	6.19	1.42	2.12	1.33	5.81	2.71	3.07	4.19	1.54	3.54
LUD	5.40	1.90	3.39	3.37	3.89	6.69	1.67	2.05	1.51	6.08	2.96	3.09	4.21	1.63	3.66
ShapeKick	5.07	1.97	16.22	2.22	21.78	5.07	29.63	16.90	29.38	22.13	6.56	2.88	16.91	28.57	17.57
1DSfM	24.79	7.15	7.64	9.73	17.00	20.38	6.38	6.99	6.31	12.07	12.69	9.74	6.71	6.71	9.43

Table 6: Median translation error on ‘Montreal Notre Dame’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	0.28	0.29	0.28	0.58	0.67	0.44	0.36	0.62	0.47	0.57	0.45	0.40	0.72	0.47	0.53
LUD	0.39	0.39	0.42	0.72	0.75	0.45	0.39	0.70	0.55	0.61	0.47	0.41	0.74	0.51	0.56
ShapeKick	0.42	0.36	0.41	10.14	0.72	0.46	0.41	1.50	10.88	0.64	0.45	10.22	0.77	0.61	0.58
1DSfM	0.79	1.59	4.32	2.79	3.28	1.67	2.42	2.19	1.12	1.58	1.45	1.65	2.43	1.20	0.75

Table 7: Median translation error on ‘Notre Dame’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	0.36	0.28	0.29	0.27	0.47	0.29	0.23	0.27	0.29	0.26	0.26	0.23	0.27	0.31	0.25
LUD	0.38	0.31	0.37	0.34	0.56	0.31	0.27	0.27	0.32	0.32	0.26	0.25	0.29	0.33	0.30
ShapeKick	0.26	0.23	0.31	0.30	0.36	0.24	0.48	0.33	0.33	0.58	0.21	0.20	0.24	0.28	0.20
1DSfM	2.42	1.87	2.64	1.81	3.38	2.24	1.50	1.17	2.58	2.06	2.70	1.12	0.80	0.79	1.67

Table 8: Median translation error on ‘NYC Library’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	0.73	1.79	1.21	0.99	3.58	1.28	1.45	3.03	1.49	3.29	1.34	1.24	2.26	1.19	1.88
LUD	1.49	4.30	2.34	1.34	4.33	1.95	2.23	3.23	1.99	3.50	1.86	1.80	2.57	1.61	2.26
ShapeKick	12.73	14.38	9.29	1.00	17.04	14.20	15.10	13.76	14.30	14.50	13.19	14.26	13.61	14.24	13.93
1DSfM	1.59	3.91	1.56	1.48	5.51	1.64	1.41	2.62	1.78	3.12	2.73	1.58	2.67	1.55	3.13

Table 9: Piazza Del Popolo

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	0.99	0.95	0.55	0.75	0.72	1.39	1.11	0.72	1.11	1.74	1.67	1.57	1.58	1.49	1.89
LUD	1.12	1.23	1.04	1.03	0.96	1.41	1.28	0.92	1.68	2.00	1.80	1.62	1.64	1.59	1.97
ShapeKick	1.00	1.30	0.67	1.14	0.87	1.27	13.35	0.85	14.64	18.54	16.79	18.36	1.23	1.44	1.72
1DSfM	2.72	2.74	2.90	3.64	4.85	2.77	1.77	1.26	2.85	3.77	3.97	2.62	1.85	3.33	2.05

Table 10: Median translation error on ‘Piccadilly’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	0.87	2.78	1.56	1.98	0.16	2.17	1.71	2.81	2.35	0.22	1.73	1.82	1.97	2.45	3.08
LUD	1.08	2.97	3.22	2.93	0.16	2.18	2.26	3.27	3.03	0.28	1.90	1.88	2.21	2.83	3.18
ShapeKick	1.10	5.07	6.38	1.99	0.16	9.28	10.28	13.09	9.37	0.31	9.52	11.18	1.73	9.80	0.59
1DSfM	8.83	10.40	4.37	7.26	0.94	5.56	7.57	3.69	5.49	0.53	4.92	5.39	3.58	6.10	3.79

Table 11: Median translation error on ‘Roman Forum’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	5.53	2.33	1.68	17.53	1.19	1.07	3.38	4.33	9.79	1.71	3.72	3.84	2.44	10.02	2.48
LUD	5.08	2.11	1.63	18.80	1.60	0.87	3.29	4.61	9.76	1.99	3.72	3.98	2.94	8.43	2.52
ShapeKick	4.36	1.65	1.62	13.57	1.30	0.98	3.49	37.63	44.24	20.43	31.57	40.08	26.75	44.48	37.56
1DSfM	69.33	56.74	8.56	62.09	4.31	28.53	29.28	23.06	41.96	10.73	16.21	6.86	37.05	38.59	4.34

Table 12: Median translation error on ‘Tower of London’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	1.57	7.55	2.19	3.81	2.16	15.43	4.29	7.18	6.01	2.01	6.15	4.40	3.88	4.10	2.52
LUD	1.85	9.75	2.74	6.13	2.36	15.91	4.37	7.70	6.44	2.34	6.28	4.61	4.01	4.41	2.80
ShapeKick	1.29	28.58	2.44	52.95	2.02	62.18	2.92	3.55	61.53	68.28	59.57	2.53	67.39	55.23	63.94
1DSfM	127.25	38.86	61.06	7.51	7.05	44.91	21.32	25.77	15.51	4.70	48.37	13.50	9.83	7.82	7.92

Table 13: Median translation error on ‘Union Square’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	2.42	2.08	4.95	2.03	4.19	7.46	3.79	1.19	4.14	5.72	8.03	10.76	6.53	5.27	7.29
LUD	2.54	3.58	5.34	2.58	3.65	7.96	4.53	1.46	4.08	4.59	7.62	11.56	6.41	9.91	7.78
ShapeKick	4.10	6.29	7.79	2.02	2.11	8.15	6.18	1.44	2.59	8.48	11.21	14.64	6.96	15.48	12.04
1DSfM	4.01	6.58	4.76	4.01	4.31	10.34	15.75	3.60	15.12	11.03	5.67	9.83	15.24	17.63	4.85

Table 14: Median translation error on ‘Vienna Cathedral’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	3.09	0.67	4.88	7.35	2.04	6.23	0.99	4.23	3.33	4.67	8.77	1.49	5.00	4.43	6.14
LUD	4.36	1.31	5.01	9.75	1.66	8.57	1.52	5.47	5.91	6.37	8.94	2.01	5.93	5.47	7.10
ShapeKick	3.45	14.81	31.26	23.21	6.20	25.26	19.73	23.83	32.15	28.11	24.27	19.34	30.71	22.89	25.72
1DSfM	67.82	3.20	5.15	10.74	4.60	6.27	4.54	4.11	6.41	4.49	4.83	2.37	5.41	4.12	6.89

Table 15: Median translation error on ‘Yorkminster’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	2.82	1.83	0.79	1.04	2.45	1.46	1.88	3.17	1.65	2.83	2.54	2.22	3.17	1.66	2.98
LUD	2.71	3.44	1.02	1.38	3.02	1.82	2.36	3.41	2.04	3.14	2.64	2.33	3.30	1.83	3.30
ShapeKick	24.83	20.61	24.68	12.51	19.05	17.15	15.19	23.57	15.94	21.51	17.32	16.95	23.01	14.93	21.61
1DSfM	8.17	3.76	6.25	3.66	3.59	8.32	6.39	7.07	5.94	6.58	8.87	6.52	6.89	5.86	4.05

Table 16: Median translation error on ‘Gendarmenmarkt’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	21.81	29.08	25.47	9.00	11.09	30.80	19.18	19.63	7.40	0.69	4.16	3.23	19.86	31.45	27.31
LUD	22.08	29.18	26.05	10.79	11.40	31.23	20.51	19.10	9.90	0.97	6.09	4.30	19.69	31.38	25.82
ShapeKick	22.08	29.24	28.65	29.94	13.23	30.13	33.03	12.88	26.88	1.00	4.62	3.82	28.96	32.16	38.57
1DSfM	60.17	38.88	35.73	21.35	29.61	45.94	36.53	21.24	17.12	55.09	43.35	36.71	27.86	49.52	26.09

Table 17: Median essential matrix error on ‘Alamo’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	3.45	4.37	3.88	4.98	3.09	4.37	4.13	4.29	5.36	5.69	4.45	3.75	3.95	4.31	6.14
LUD	3.43	4.20	3.85	5.06	2.98	4.46	4.23	4.46	5.38	5.74	4.50	3.80	4.01	4.35	6.20
ShapeKick	3.46	4.10	3.74	4.42	3.00	4.34	4.27	4.56	4.84	7.92	4.43	3.80	4.00	4.16	6.80

Table 18: Median essential matrix error on ‘Ellis Island’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	21.31	37.73	21.78	38.26	32.61	37.81	43.05	44.16	47.02	36.27	51.19	48.04	47.57	51.98	45.57
LUD	61.47	78.99	73.37	80.39	66.01	67.30	68.53	71.99	74.29	64.99	67.83	66.15	64.62	70.77	63.50
ShapeKick	71.34	86.47	87.20	91.98	76.20	79.84	79.59	84.43	87.27	75.39	78.52	77.83	77.06	83.39	74.61

Table 19: Median essential matrix error on ‘Madrid Metropolis’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	15.71	6.36	18.10	6.08	12.20	17.65	6.76	7.99	5.47	25.54	11.32	8.13	23.05	6.95	16.08
LUD	17.11	6.35	19.33	5.41	12.71	17.78	6.87	8.52	5.59	26.67	11.52	8.39	23.62	7.11	16.79
ShapeKick	12.59	5.79	17.46	4.84	11.71	10.22	6.09	8.66	5.79	22.83	17.87	7.20	32.42	6.76	17.25

Table 20: Median essential matrix error on ‘Montreal Notre Dame’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	3.94	2.63	69.88	5.51	7.79	3.99	3.06	8.86	4.35	5.80	3.78	3.91	7.28	4.26	5.35
LUD	4.33	3.17	75.90	6.34	8.63	4.25	3.31	9.40	4.65	6.04	3.96	4.04	7.79	4.44	5.49
ShapeKick	4.19	3.12	63.02	6.55	9.79	5.05	3.53	8.95	4.91	6.85	4.28	4.17	8.66	5.23	6.12

Table 21: Median essential matrix error on ‘Notre Dame’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	5.09	5.79	4.13	3.41	6.06	4.38	3.92	3.15	4.16	3.69	3.82	3.63	3.67	4.16	3.28
LUD	5.84	5.58	4.50	3.64	5.78	4.89	4.19	3.36	4.43	4.06	4.02	3.79	3.81	4.33	3.48
ShapeKick	4.24	4.57	4.05	3.88	5.10	3.69	4.82	3.82	4.90	4.96	3.28	3.56	3.64	4.04	3.08

Table 22: Median essential matrix error on ‘NYC Library’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	9.42	32.89	20.85	9.32	25.68	15.42	18.87	24.60	18.52	24.46	15.99	19.24	25.74	15.37	19.69
LUD	15.44	40.88	23.54	12.73	31.60	19.28	23.16	28.34	22.82	28.02	18.42	21.53	27.52	17.56	21.36
ShapeKick	8.97	38.38	19.24	10.03	32.05	29.24	30.29	22.11	30.71	36.04	48.04	31.21	33.81	25.90	35.22

Table 23: Median essential matrix error on ‘Piazza Del Popolo’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	6.14	5.02	2.82	5.11	4.15	7.55	4.87	3.74	6.34	11.90	9.64	8.31	10.25	8.45	10.16
LUD	7.43	5.28	4.59	6.78	4.85	8.48	5.47	4.20	8.00	14.17	10.20	8.92	11.06	8.79	10.72
ShapeKick	7.26	5.02	3.47	7.65	5.00	7.48	5.30	3.78	7.81	13.57	10.38	8.41	9.32	8.42	12.16

Table 24: Median essential matrix error on ‘Piccadilly’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	10.32	16.57	17.33	24.44	93.02	16.47	13.24	19.12	14.33	81.16	11.83	11.82	12.58	15.36	36.19
LUD	10.58	16.80	25.16	30.89	94.92	17.76	14.38	20.07	17.95	97.95	12.49	12.29	13.15	18.08	36.54
ShapeKick	10.77	19.83	37.34	33.28	94.62	26.25	18.12	31.36	13.43	88.60	17.96	18.86	12.28	35.14	29.06

Table 25: Median essential matrix error on ‘Roman Forum’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	11.90	7.15	6.17	37.92	5.26	3.00	7.87	12.43	11.22	7.16	7.34	10.07	7.19	9.65	6.89
LUD	16.52	8.22	5.38	43.48	6.56	5.51	9.31	13.57	12.18	7.34	7.58	10.34	7.57	10.15	7.12
ShapeKick	6.91	5.14	5.38	25.74	5.68	4.81	11.20	15.75	20.56	10.54	19.81	33.18	27.84	29.38	16.91

Table 26: Median essential matrix error on ‘Tower of London’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	3.24	11.29	4.79	6.90	3.44	21.79	8.05	10.02	8.12	4.82	8.36	8.25	7.32	7.08	5.92
LUD	3.42	12.20	6.86	10.70	4.17	22.81	8.34	10.40	8.60	5.22	8.51	8.46	7.58	7.24	6.14
ShapeKick	3.28	29.92	7.93	12.61	3.86	38.72	6.99	6.99	7.95	4.62	5.24	6.36	6.63	5.82	6.27

Table 27: Median essential matrix error on ‘Union Square’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	49.93	27.40	43.18	59.10	22.71	71.82	41.19	64.60	29.68	89.24	53.41	49.30	75.15	28.71	48.59
LUD	51.32	55.97	45.01	74.52	23.07	68.85	53.87	82.60	30.11	78.49	53.75	51.07	56.75	40.30	51.62
ShapeKick	44.06	55.31	48.19	69.74	15.92	77.33	60.16	76.59	29.35	98.79	67.21	53.69	56.32	51.96	55.89

Table 28: Median essential matrix error on ‘Vienna Cathedral’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	12.77	4.07	6.96	12.10	10.46	11.72	5.60	9.57	11.14	10.04	15.07	7.30	12.94	13.67	13.19
LUD	25.75	6.50	9.36	20.53	63.74	15.53	7.87	14.78	16.00	12.16	17.74	9.08	15.52	17.65	14.68
ShapeKick	18.56	11.20	20.03	31.25	30.35	31.21	10.05	34.17	22.96	17.39	33.10	17.62	21.93	25.49	26.37

Table 29: Median essential matrix error on ‘Yorkminster’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	6.68	7.33	3.68	5.98	8.01	6.34	8.71	9.46	8.55	9.94	6.66	8.86	11.63	7.87	9.69
LUD	7.45	9.91	4.33	7.43	9.97	6.83	10.12	10.17	9.85	11.43	7.02	9.54	12.19	8.33	10.21
ShapeKick	13.44	13.51	4.71	7.88	7.69	5.55	7.61	6.95	8.09	6.49	9.57	7.59	18.80	7.69	9.88

Table 30: Median essential matrix error on ‘Gendermenmarkt’

trials	50 images					100 images					150 images				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Our	125.45	120.76	60.34	33.90	29.67	121.74	55.02	85.01	37.03	9.37	9.31	12.19	67.80	90.62	97.17
LUD	127.45	122.34	61.55	39.83	30.98	119.72	55.65	86.67	43.07	25.31	10.52	11.92	68.12	91.04	99.63
ShapeKick	127.58	122.21	61.70	47.07	34.53	119.16	57.64	79.77	47.80	22.11	10.51	12.14	76.90	91.11	107.33