Lidar Line Selection with Spatially-Aware Shapley Value for Cost-Efficient Depth Completion

Appendix

I Shapley Value Normative Criteria

Shapley value (φ) is an attribution method, i.e., a method that assesses the value of different agents / players / members on the final outcome of their common action. Let ν be a characteristic function. Shapley value is the only attribution method that satisfies the following four criteria,

1. The total gain is distributed among the players (Efficiency).
2. If i and j are players such that $\nu(\mathcal{K} \cup i) = \nu(\mathcal{K} \cup j)$ for each coalition $\mathcal{K}$ of a set of all players, $\mathcal{N}$, then $\varphi_i = \varphi_j$ (Symmetry).
3. A player who contributes nothing to every coalition obtains zero individual payoff (Dummy).
4. For two characteristic functions ν_1 and ν_2 and a player n, $\nu(\mathcal{K}) = \nu_1(\mathcal{K}) + \nu_2(\mathcal{K})$ for every coalition implies $\varphi_n^{\nu_1} + \varphi_n^{\nu_2} = \varphi_n^{\nu}$ (Additivity).

II Line Configurations

The exact line configurations obtained by SaS flexible, global as presented in Fig. 2.

Lines	RMSE	Configuration
4	3436	42-52-56-64
8	2147	39-46-51-55-57-62-63-64
16	1178	35-36-39-44-47-48-49-52-54-55-56-58-59-61-62-64
32	888	27-28-29-30-33-34-35-36-37-39-41-43-44-45-46-47-48-50-51-52-53-54-55-56-57-58-59-60-61-62-63-64

III Line-Distance Correspondence for Different Lidar Placement Heights

We consider the lidar range to be 200 meters (the ranges vary between 100 and 300 meters) with vertical angle 32 (vertical angles usually vary between 25 and 40 meters). For 64 lines, the lines are distributed at equidistant intervals of 0.5 degrees.

Assume the height of the car to be 2m. Then $\arctan(2/200) = 0.5$ degrees, which means that the beam that reaches from the top of the car is at the 89.5 degrees (almost horizontal). The sum of angles is 180=90+89.5+0.5.

We provide below the information about the distance that each scanning line reaches given different heights of lidar placements. For a customized sensor, it would be desirable to make angle adjustments for selected lines based on the lidar height.

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Line	Angle from Earth surface			Distances (m)				
	Deg	Rad	Tan angle	$h = 1$	$h = 1.5$	$h = 2$	$h = 2.5$	$h = 3$
64	0.5	0.01	0.01	115	172	229	286	344
63	1	0.02	0.02	57.3	85.9	115	143	172
62	1.5	0.03	0.03	38.2	57.3	76.4	95.5	115
61	2	0.03	0.03	28.6	43	57.3	71.6	85.9
60	2.5	0.04	0.04	22.9	34.4	45.8	57.3	69
59	3	0.05	0.05	19.1	28.6	38.2	47.7	57.2
58	3.5	0.06	0.06	16.3	24.5	32.7	40.9	49
57	4	0.07	0.07	14.3	21	28.6	35.8	43
56	4.5	0.08	0.08	13	19.1	25.4	31.8	38.1
55	5	0.09	0.09	11.4	17.1	23	28.6	34.3
54	5.5	0.1	0.1	10	16	20.8	26	31.2
53	6	0.1	0.11	9.51	14.3	19	23.8	28.5
52	6.5	0.11	0.11	8.78	13.2	17.6	21.9	26.3
51	7	0.12	0.12	8.14	12.2	16.3	20.4	24.4
50	7.5	0.13	0.13	7.6	11.4	15.2	19	22.8
49	8	0.14	0.14	7.1	10.7	14.2	17.8	21.3
48	8.5	0.15	0.15	6.69	10	13.4	16.7	20.1
47	9	0.16	0.16	6.31	9.47	13	15.8	18.9
46	9.5	0.17	0.17	5.98	8.96	12	14.9	17.9
45	10	0.17	0.18	5.67	8.51	11.3	14	17
44	10.5	0.18	0.19	5.4	8.09	10.8	13.5	16.2
43	11	0.19	0.19	5.14	7.72	10.3	12.9	15.4
42	11.5	0.2	0.2	4.92	7.37	9.83	12.3	14.7
41	12	0.21	0.21	4.7	7.06	9.4	11.8	14.1
40	12.5	0.22	0.22	4.51	6.77	9.02	11.3	13.5
39	13	0.23	0.23	4.33	6.5	8.66	10.8	13
38	13.5	0.24	0.24	4	6.2	8	10.4	12
37	14	0.24	0.25	4.01	6.02	8.02	10	12
36	14.5	0.25	0.26	3.87	5.8	7.73	9.67	11.6
35	15	0.26	0.27	3.73	5.6	7.46	9.33	11.2
34	15.5	0.27	0.28	3.61	5.41	7.21	9.01	10.8
33	16	0.28	0.29	3.49	5.23	6.97	8.72	10.5
32	16.5	0.29	0.3	3.38	5.06	6.75	8.44	10.1
31	17	0.3	0.31	3.27	4.91	6.54	8.18	9.81
30	17.5	0.31	0.32	3.17	4.76	6.3	7.93	9.51
29	18	0.31	0.32	3.08	4.62	6.16	7.69	9.23
28	18.5	0.32	0.33	2.99	4.48	6	7.47	8.97
27	19	0.33	0.34	2.9	4.36	5.81	7.26	8.71
26	19.5	0.34	0.35	2.82	4.24	5.65	7.06	8.47
25	20	0.35	0.36	2.75	4.12	5.49	6.87	8.24

Table 1: Height (h) and scanning line distance reach correspondence for different lidar placement heights.