ABW Images: The Camera and Models

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The ABW range camera recovers depth from triangulation using structured light. A detailed description of the workings of the camera can be found in [2]. The following equations are taken from [1]. Each pixel in an ABW range image $r[i][j], 0 <= i, j <= 512$ is converted to Cartesian coordinates (in millimeters) as follows:

$$
\begin{aligned}
x[i,j] &= (j-255) * (r[i,j]/\mathbf{scal} + \mathbf{offset})/|\mathbf{f_k}| \\
y[i,j] &= (255-i)/\mathbf{c} * (r[i,j]/\mathbf{scal} + \mathbf{offset})/|\mathbf{f_k}| \\
z[i,j] &= (255 - r[i,j])/\mathbf{scal}
\end{aligned}
$$

The specific values of **offset**, **scal**, $\mathbf{f_k}$ and **c** are obtained through calibration before imaging. For the 40 images used in this project, there are two sets of calibration values:

$$
\begin{aligned}
&(1)\ \mathbf{offset} = 785.410786, \mathbf{scal} = 0.773545, \mathbf{f_k} = -1610.981722, \mathbf{c} = 1.4508 \\
&(2)\ \mathbf{offset} = 771.016866, \mathbf{scal} = 0.791686, \mathbf{f_k} = -1586.072821, \mathbf{c} = 1.4508
\end{aligned}
$$

Figure 1 shows the eight objects used in imaging. CAD descriptions of these objects, in the form of vertex and face lists, are included at the end of this write-up for the sake of completeness. Scale is in millimeters. Table 1 lists which objects appear in each of the 40 images, and specifies which calibration values apply for each image.

References

[1] Xiaoyi Jiang, "Range Images of Univ. of Bern", unpublished write-up, May 17, 1993.

[2] T. G. Stahs and F. M. Wahl, "Fast and Robust Range Data Acquisition in a Low-Cost Environment", in *SPIE #1395: Close-Range Photogrammetry Meets Mach. Vis.*, Zurich, 1990, 496-503.

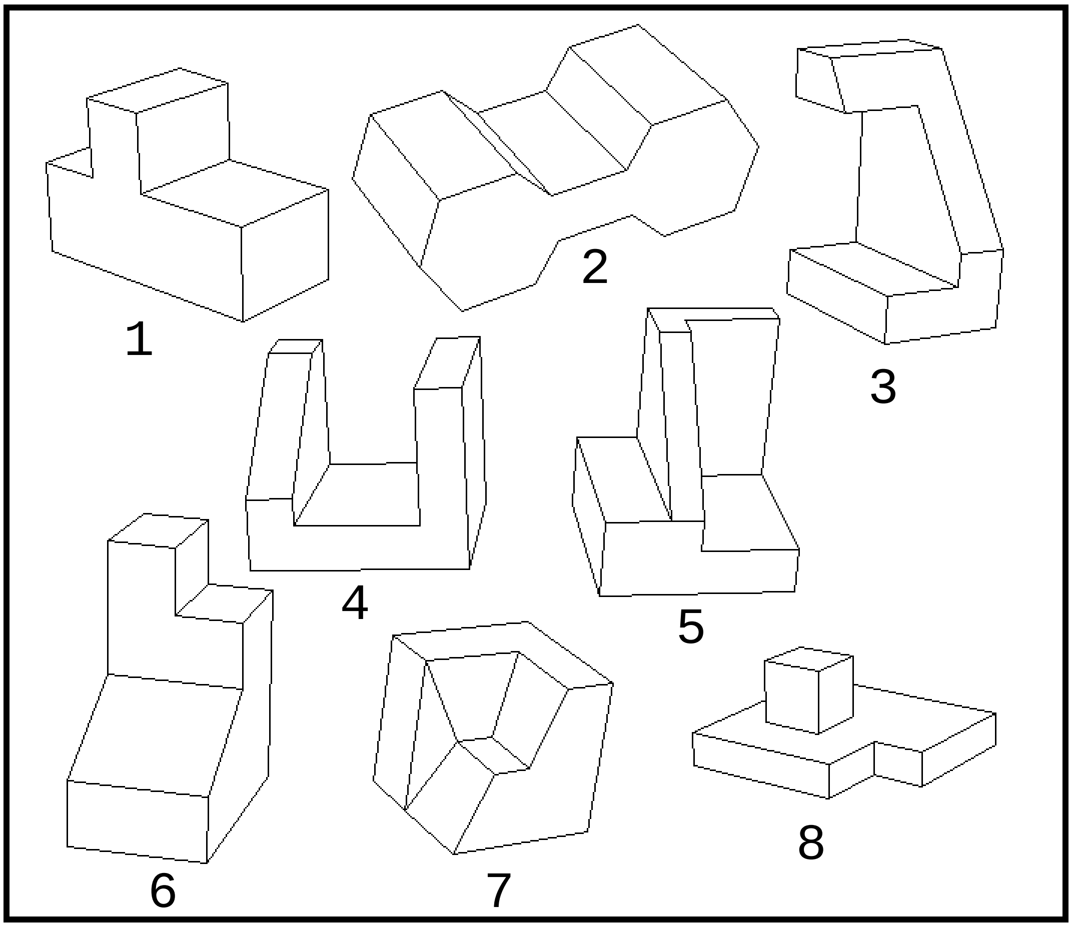

Figure 1: Models of objects used in imaging.

image name	objects	cal.		image name	objects	cal.
abw.train.0	1,2,3,4,6	1		abw.test.10	1	2
abw.train.1	1,3,6	2		abw.test.11	1	2
abw.train.2	1,4,7	2		abw.test.12	3,4,7	2
abw.train.3	1,6	2		abw.test.13	3,4	2
abw.train.4	3,4,6	2		abw.test.14	3,5	2
abw.train.5	3,6	2		abw.test.15	3,7	2
abw.train.6	4,5,6	1		abw.test.16	3	2
abw.train.7	4,7	2		abw.test.17	3	2
abw.train.8	5,6	2		abw.test.18	4,5	2
abw.train.9	6,7	2		abw.test.19	4,6,7	1
abw.test.0	1,3,4,6	1		abw.test.20	4,6	2
abw.test.1	1,3,4	2		abw.test.21	4	1
abw.test.2	1,3,5	2		abw.test.22	4	2
abw.test.3	1,3	2		abw.test.23	5,6,7	2
abw.test.4	1,4,5	2		abw.test.24	5,7	2
abw.test.5	1,4,6	2		abw.test.25	5	1
abw.test.6	1,4	2		abw.test.26	5	2
abw.test.7	1,5	2		abw.test.27	6	1
abw.test.8	1,6,7	2		abw.test.28	6	1
abw.test.9	1,7	2		abw.test.29	7	1

Table 1: Which objects appear in each image, and appropriate calibration data.

x	y	z		faces
0.0000216	-0.0000128	39.9998400		1 2 3 4
0.0000216	-0.0000128	-0.0001460		4 3 5 6
79.9999900	0.0000471	-0.0001460		6 5 7 8
79.9999900	0.0000471	39.9998400		8 7 9 10
79.9999700	30.0000400	-0.0001460		10 9 11 12
79.9999700	30.0000400	39.9998400		12 11 13 14
59.9999900	30.0000200	-0.0001460		14 13 15 16
59.9999900	30.0000200	39.9998400		16 15 2 1
59.9999600	55.0000100	-0.0001460		6 8 10 12 14 16 1 4
59.9999600	55.0000100	39.9998400		2 15 13 11 9 7 5 3
39.9999700	54.9999900	-0.0001460		
39.9999700	54.9999900	39.9998400		
39.9999800	30.0000900	-0.0001460		
39.9999800	30.0000900	39.9998400		
0.0000296	30.0000500	-0.0001460		
0.0000296	30.0000500	39.9998400		

Table 2: CAD description of Object 1: 16 vertices, 10 faces.

x	y	z	faces
0.0000216	-0.0000128	59.9998400	1 2 3 4
0.0000216	-0.0000128	-0.0001408	4 3 5 6
10.0000300	-19.9999800	-0.0001408	6 5 7 8
10.0000300	-19.9999800	59.9998400	8 7 9 10
35.0000200	-19.9999600	-0.0001408	10 9 11 12
35.0000200	-19.9999600	59.9998400	12 11 13 14
45.0000000	-7.9999640	-0.0001408	14 13 15 16
45.0000000	-7.9999640	59.9998400	16 15 17 18
70.0000000	-7.9999450	-0.0001408	18 17 19 20
70.0000000	-7.9999450	59.9998400	20 19 21 22
80.0000100	-19.9999200	-0.0001408	22 21 23 24
80.0000100	-19.9999200	59.9998400	24 23 25 26
105.0000000	-19.9999000	-0.0001408	26 25 27 28
105.0000000	-19.9999000	59.9998400	28 27 2 1
115.0000000	0.0000886	-0.0001408	6 8 10 12 14 16 18 20 22 24 26 28 1 4
115.0000000	0.0000886	59.9998400	2 27 25 23 21 19 17 15 13 11 9 7 5 3
105.0000000	20.0000700	-0.0001408	
105.0000000	20.0000700	59.9998400	
79.9999900	20.0000500	-0.0001408	
79.9999900	20.0000500	59.9998400	
70.0000000	8.0000510	-0.0001408	
70.0000000	8.0000510	59.9998400	
45.0000200	8.0000320	-0.0001408	
45.0000200	8.0000320	59.9998400	
35.0000200	20.0000200	-0.0001408	
35.0000200	20.0000200	59.9998400	
10.0000300	20.0000000	-0.0001408	
10.0000300	20.0000000	59.9998400	

Table 3: CAD description of Object 2: 28 vertices, 16 faces.

x	y	z		faces
30.9090700	64.9999600	39.9998500		1 2 3 4 5 6
30.9090600	64.9999700	14.9996100		6 5 7 8
59.9999900	25.0000200	14.9996100		9 10 8 7 11 12 13 14
59.9999900	25.0000200	-0.0001366		12 11 15 16
19.9999500	79.9999700	-0.0001366		17 18 16 15 4 3
19.9999500	79.9999700	39.9998500		10 1 6 8
-0.0000383	79.9999500	-0.0001366		18 13 12 16
-0.0000383	79.9999500	39.9998500		4 15 11 7 5
-0.0000275	64.9999600	14.9996100		2 1 10 9
-0.0000271	64.9999400	39.9998500		14 13 18 17
0.0000216	-0.0000128	-0.0001366		3 2 9 14 17
0.0000216	-0.0000128	39.9998500		
0.0000103	14.9999800	39.9998500		
0.0000096	14.9999800	14.9996100		
60.0000000	0.0000321	-0.0001366		
60.0000000	0.0000321	39.9998500		
60.0000000	15.0000200	14.9996100		
60.0000000	15.0000200	39.9998500		

Table 4: CAD description of Object 3: 18 vertices, 11 faces.

x	y	z		faces
0.0000151	69.9998600	0.0000206		1 2 3 4
0.0000151	-0.0000720	0.0000206		4 3 5 6
0.0000430	-0.0000720	60.0000000		6 5 7 8
0.0000430	69.9998600	60.0000000		8 7 9 10
15.0000400	-0.0000720	59.9999900		11 12 10 9 13
15.0000400	69.9998600	59.9999900		14 11 13 15
15.0000200	-0.0000720	15.0000100		16 14 15 17 18
15.0000200	69.9998600	15.0000100		18 17 2 1
55.0000100	-0.0000720	14.9999900		12 16 18 1 4 6 8 10
55.0000100	69.9998600	14.9999900		2 17 15 13 9 7 5 3
55.0000400	20.0002700	59.9997700		12 11 14 16
55.0000200	69.9998600	24.0000900		
55.0000300	-0.0000720	59.9997600		
70.0000200	20.0002900	59.9997600		
70.0000200	-0.0000720	59.9997600		
70.0000200	69.9998600	24.0000900		
70.0000200	-0.0000720	0.0000490		
70.0000200	69.9998600	0.0000490		

Table 5: CAD description of Object 4: 18 vertices, 11 faces.

x	y	z		faces
40.0000100	60.0000000	25.0000000		1 2 3 4
29.9999500	60.0000000	25.0000000		5 6 7 8
29.9999800	20.0001100	69.9998300		3 2 9 8 7
40.0000300	20.0000900	69.9998400		9 10 5 8
-0.0000016	9.9999920	14.9998800		11 12 13 14
-0.0000012	9.9999940	69.9998400		1 11 14 15 10 9 2
29.9999900	10.0000100	69.9998300		5 10 15 16 17 6
29.9999900	10.0000100	14.9998800		18 19 17 16 13 12
29.9999500	59.9999900	14.9998800		4 3 7 6 17 19
-0.0000386	59.9999700	14.9998900		13 16 15 14
59.9999500	60.0000300	24.9999900		1 4 19 18
59.9999900	0.0000390	24.9999900		11 1 18 12
59.9999900	0.0000390	-0.0001286		
59.9999400	60.0000100	-0.0001286		
-0.0000386	59.9999700	-0.0001286		
0.0000063	-0.0000059	-0.0001286		
0.0000063	-0.0000059	69.9998400		
40.0000100	0.0000223	25.0000000		
40.0000300	0.0000241	69.9998400		

Table 6: CAD description of Object 5: 19 vertices, 12 faces.

x	y	z		faces
0.0000374	40.0000500	60.0000100		1 2 3 4
0.0000362	19.9999800	60.0000000		2 5 6 3
30.0001100	19.9999800	60.0000100		2 1 7 8 9 5
30.0001100	40.0000600	60.0000300		10 11 12 9 8 13
0.0000371	19.9999800	79.9998300		14 10 13 15
30.0001100	19.9999800	79.9998300		1 4 16 14 15 7
0.0000374	40.0000500	-0.0001387		6 5 9 12
0.0000368	0.0000548	-0.0001387		7 15 13 8
0.0000368	0.0000548	79.9998300		11 10 14 16
60.0000300	0.0000998	19.9998500		4 3 6 12 11 16
30.0000900	0.0000773	39.9998300		
30.0001100	0.0000773	79.9998300		
60.0000300	0.0000998	-0.0001387		
60.0000000	40.0001000	19.9998600		
60.0000000	40.0001000	-0.0001387		
30.0001000	40.0000600	39.9998400		

Table 7: CAD description of Object 6: 16 vertices, 10 faces.

x	y	z		faces
59.9999400	60.0000000	25.0000000		1 2 3 4
59.9999600	0.0000267	25.0000000		5 1 4 6 7
59.9999900	0.0000313	-0.0001341		7 6 8 9
59.9999400	60.0000000	-0.0001341		2 10 11 9 8 3
59.9999400	60.0000000	59.9998400		12 5 7 9 11 13
-0.0000386	59.9999600	-0.0001341		3 8 6 4
-0.0000386	59.9999600	59.9998400		1 5 12 14
0.0000063	-0.0000137	-0.0001341		12 13 15 14
0.0000063	-0.0000137	59.9998400		11 10 15 13
20.0000100	0.0000003	25.0000000		2 1 14
20.0000200	0.0000013	59.9998400		10 2 14 15
46.9999700	30.0000000	59.9998400		
31.9999700	29.9999900	59.9998400		
47.0000200	29.9999800	32.9999900		
31.9999600	29.9999900	32.9999900		

Table 8: CAD description of Object 7: 15 vertices, 11 faces.

x	y	z		faces
0.0000020	0.0000016	12.9998800		1 2 3 4
0.0000020	0.0000016	-0.0001096		4 3 5 6
59.9998900	-0.0000024	-0.0001096		6 5 7 8
59.9998900	-0.0000024	12.9998800		8 7 9 10
59.9998900	29.9999700	-0.0001096		10 9 11 12
59.9998900	29.9999700	12.9998800		12 11 2 1
79.9999900	29.9999700	-0.0001096		6 8 10 12 1 4
79.9999900	29.9999700	12.9998800		2 11 9 7 5 3
79.9999900	84.9999600	-0.0001096		13 14 15 16
79.9999900	84.9999600	12.9998800		17 13 16 18
0.0000840	84.9999800	-0.0001096		19 17 18 20
0.0000840	84.9999800	12.9998800		14 19 20 15
38.9999900	25.9999800	36.9998600		17 19 14 13
15.0000000	25.9999900	36.9998600		
15.0000000	25.9999900	12.9998800		
38.9999900	25.9999900	12.9998800		
38.9999900	49.9999800	36.9998600		
38.9999900	50.0000000	12.9998800		
15.0000800	50.0000000	36.9998600		
15.0000800	50.0000000	12.9998800		

Table 9: CAD description of Object 8: 20 vertices, 13 faces.