A Test Report of Calibration and Distance Measurement Tool on Three Data Sets

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This report shows the current performance of the Calibration and Distance measurement tool, which is tested on two data sets from Tavis, and one data set from Jay.

The three data sets are diverse with different kinds of slope (including flat). The camera angle is set close to the ones from the outside in the wild. It covers land from very far. This kind of data set is difficult because the farther it is, the harder it gets to distinguish marks as they are getting very closer on the camera image. Therefore it becomes more sensitive to human clicking error. The test result shows that even though the data sets are challenging with farther marks very close on image and two of them with slope, the measurement is in acceptable range.

1. Data

We have tested on three sets of data. The three data sets cover three common scenarios.

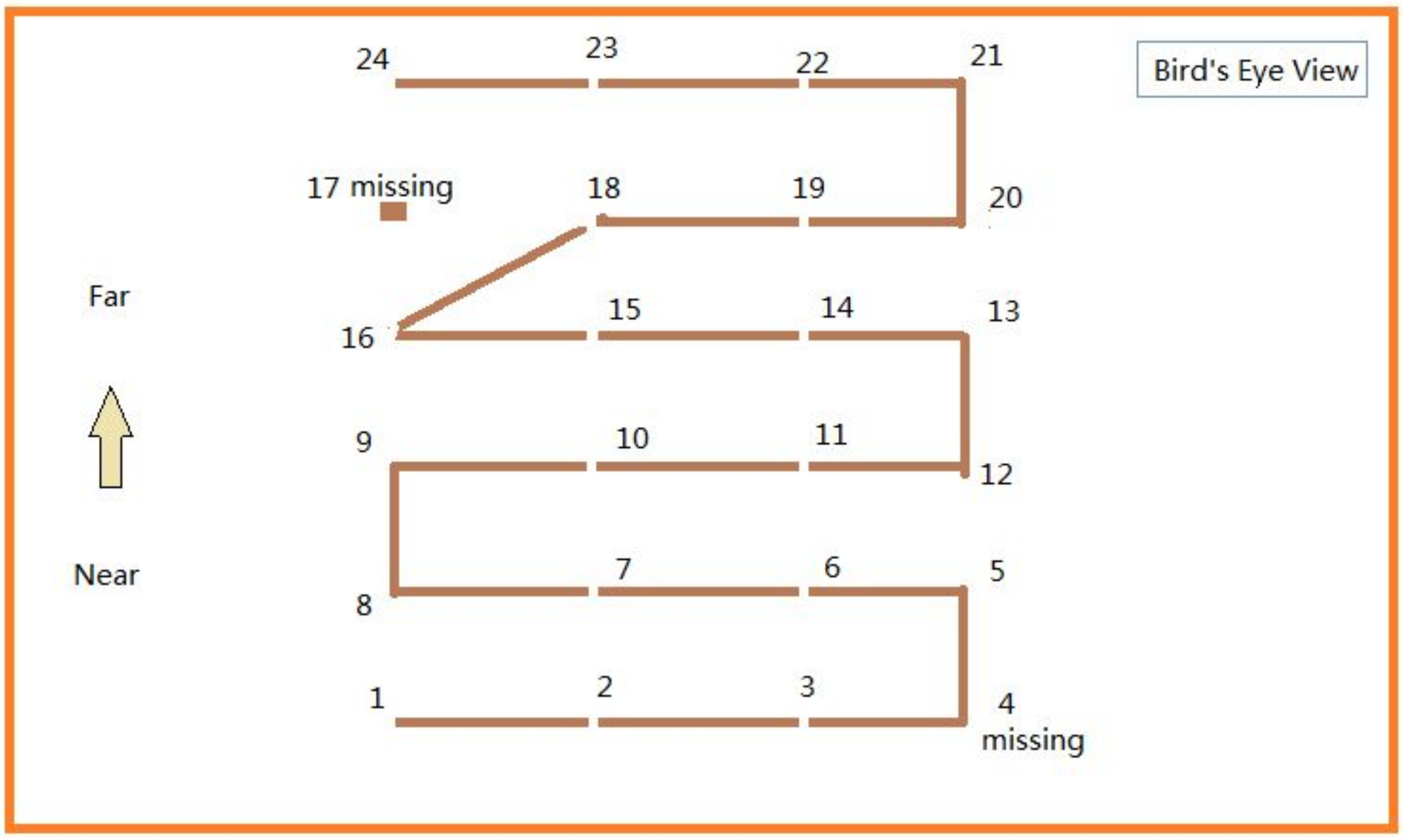
(1). Tavis's data 1:

The data can be downloaded from the link provided below:

https://www.dropbox.com/sh/1eddx3b23qcq73y/AAA2krtv4xdGuc9_qih_BiBPa?dl=0

This data set is on a comparatively flat ground. The figure below describes the data set one from Tavis.

The numbers indicate the places where a pole calibration picture is taken. The lines are where the distances are measured with the tool. We are measuring these distances because the grass is high and only with the corresponding pole picture, can we click on the right place of the ground.



(Fig. 1. Data set one description)

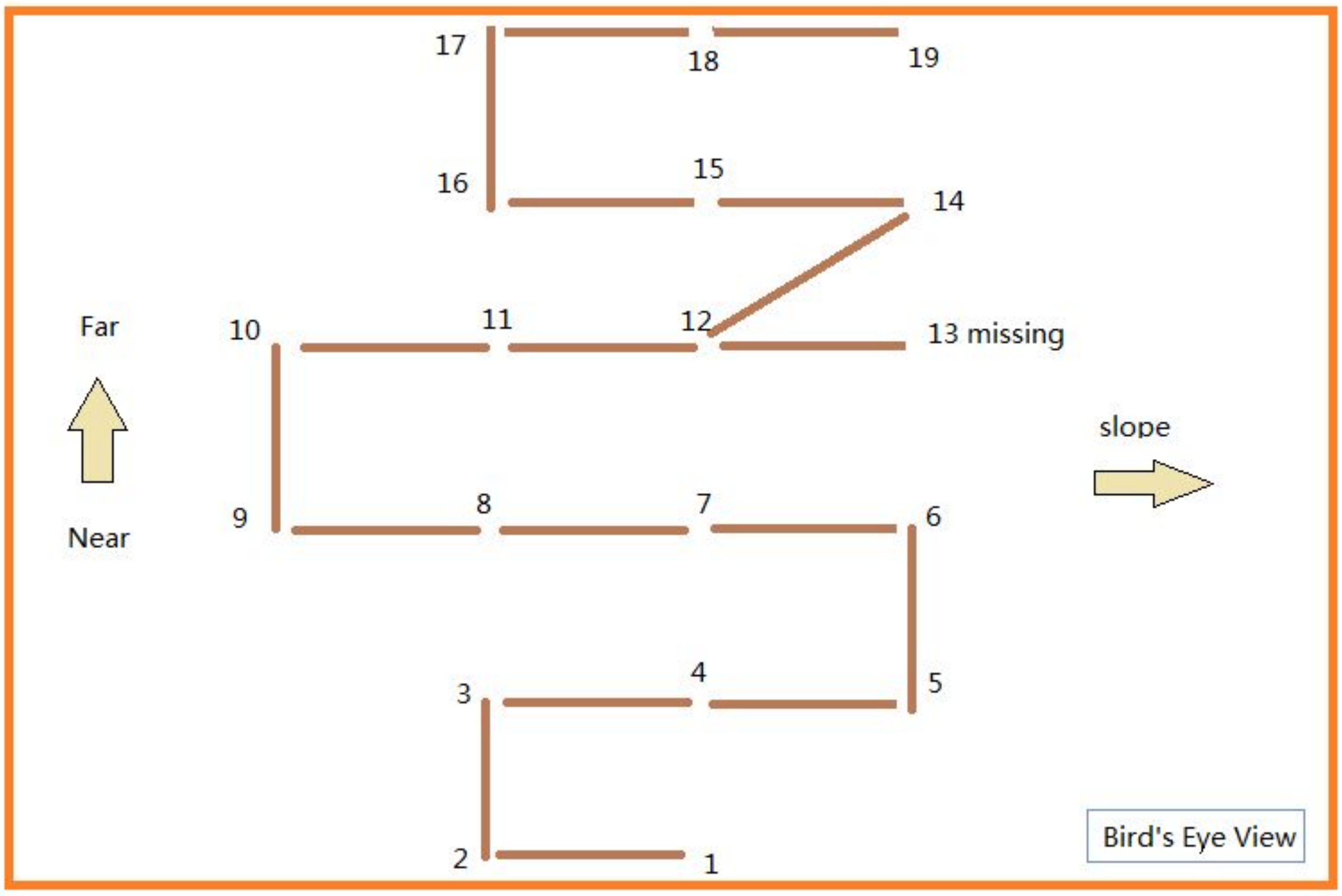
(2). Tavis's data 2:

The data can be downloaded from this link below:

https://www.dropbox.com/sh/y9zzvsi6ijaxlkv/AABZ3P0A22-DS79Ik1PMFHmXa?dl=0

This data set is on a slope. The slope is from left to right, where ground on the right side of the pole calibration pictures are higher.

The figure below describes the data set in a similar way from the first data set.



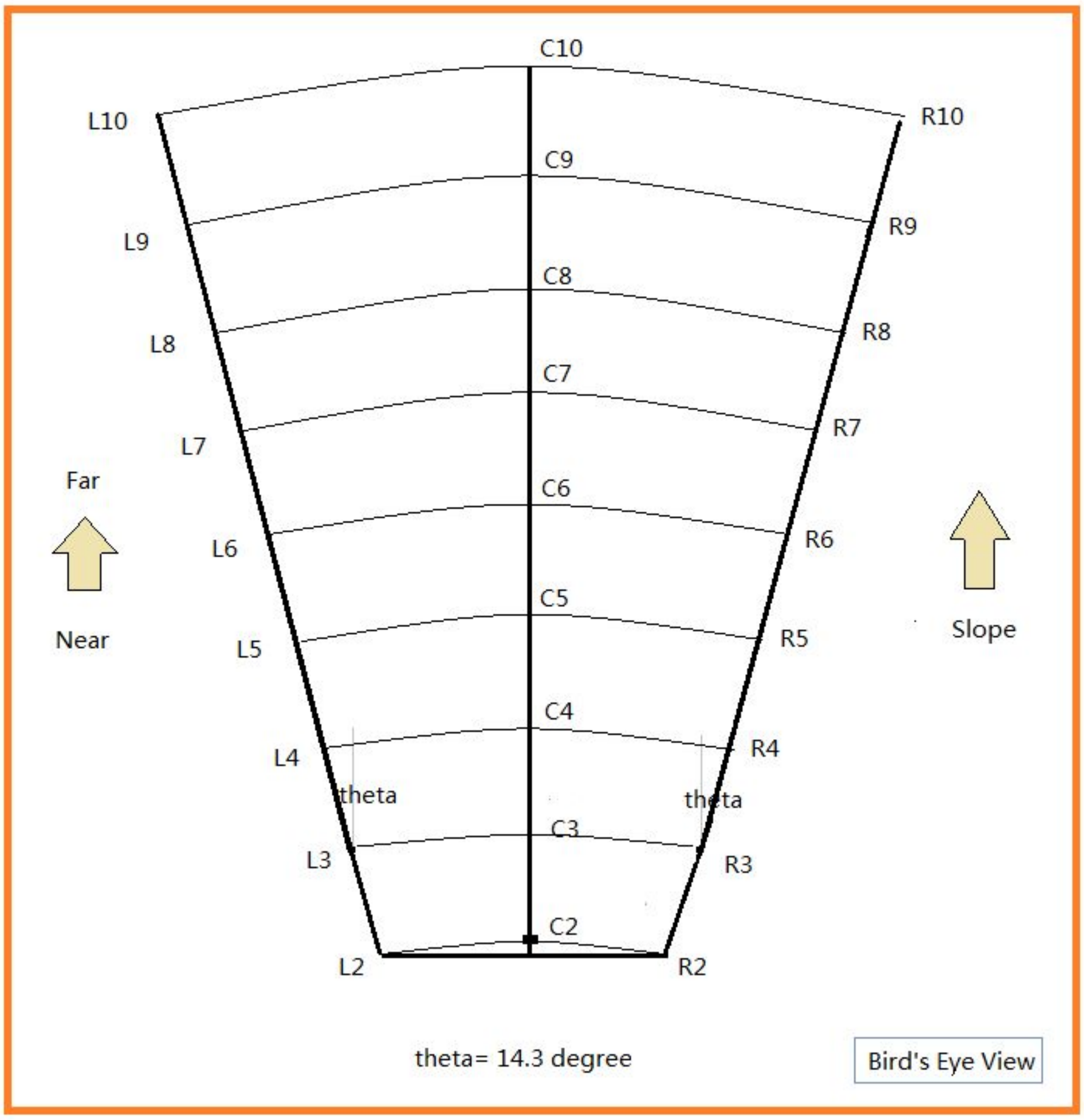
(Fig. 2. Data set two description)

(3). Jay's data outdoor:

Here is the link to Jay’s data.

https://www.dropbox.com/sh/cd32vkwvvdm5ogx/AABafxFcsAqWBJw4KhW8LYnEa?dl=0

This data set is also on a slope. Unlike the second set of data, this slope faces the camera. There are certain places with pit and pump, but generally speaking, the farther it is, the higher the ground gets. There is a slight slope from left to right as well.



(Fig. 3. Data set three description)

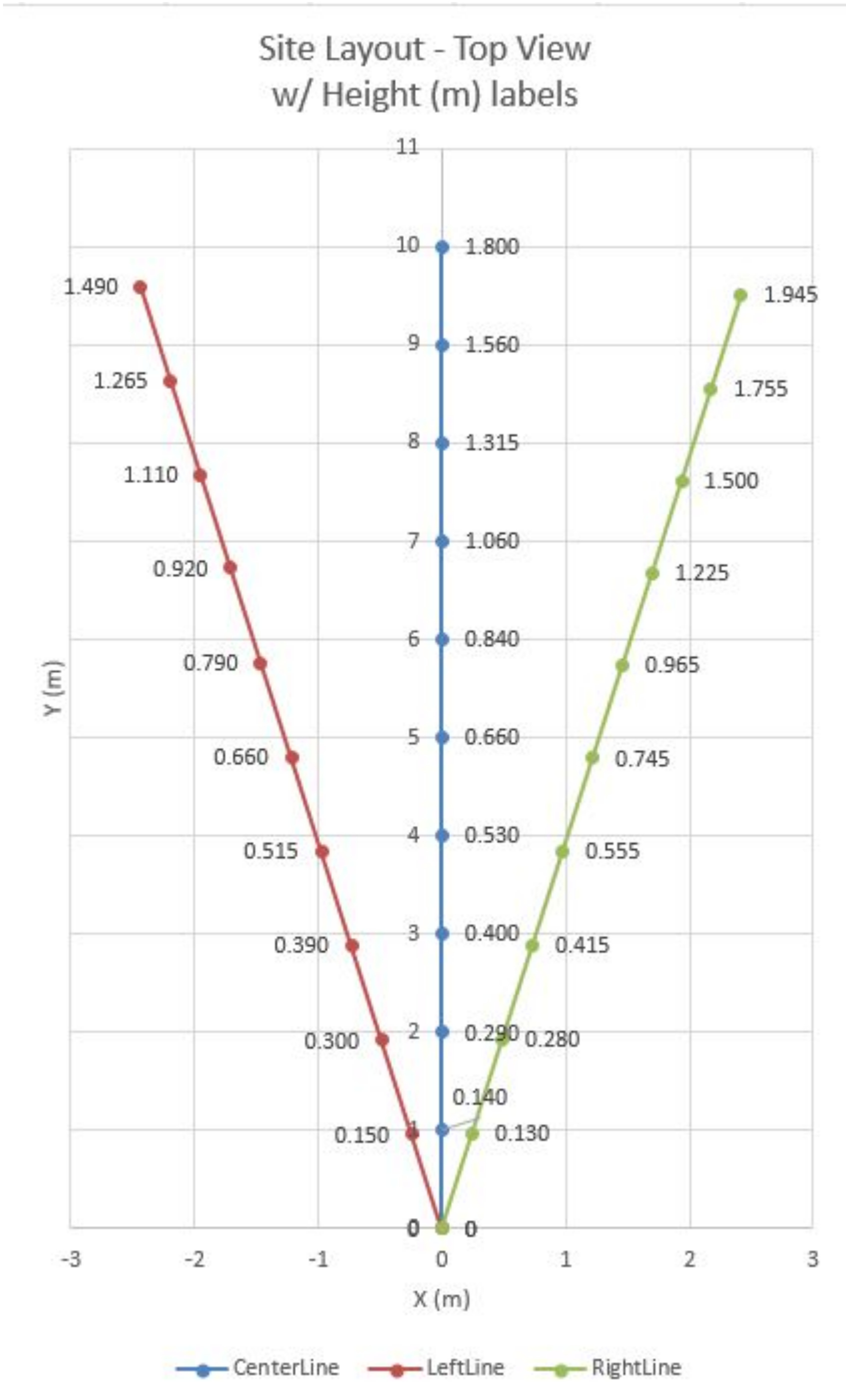
Below is some detailed description of the third data set.

(a). Line Parameters

Lines parameters:				Derived Line Parameters:		
Len	10	meters		Nm	10	
Mspace	1	meters		LCtheta	14.3	deg
LCspace	2.5	meters		RCtheta	14.3	deg
RCspace	2.5	meters		LRtheta	28.5	deg

(b). Site Parameters: Marker Heights

Site Parameters: Marker Heights						
	M to M Delta H (mm)			M to M Slope (deg)		
M#	Lline	Cline	Rline	Lline	Cline	Rline
0	0	0	0			
1	150	140	130	8.6	8.0	7.5
2	150	150	150	8.6	8.6	8.6
3	90	110	135	5.2	6.3	7.8
4	125	130	140	7.2	7.5	8.0
5	145	130	190	8.3	7.5	11.0
6	130	180	220	7.5	10.4	12.7
7	130	220	260	7.5	12.7	15.1
8	190	255	275	11.0	14.8	16.0
9	155	245	255	8.9	14.2	14.8
10	225	240	190	13.0	13.9	11.0
Totals:	1490	1800	1945	8.6	10.4	11.2



(c). Site Parameters: Marker Positions

Site Parameters: Marker positions										
		Left Line Marker Pos (m)			Center line Marker Pos (m)			Right line Marker Pos (m)		
M#	p (m)	X	Y	Z	X	Y	Z	X	Y	Z
0	0	0	0	0	0	0	0	0	0	0
1	1	-0.243	0.958	0.150	0.000	1.000	0.140	0.244	0.961	0.130
2	2	-0.487	1.917	0.300	0.000	2.000	0.290	0.487	1.919	0.280
3	3	-0.732	2.883	0.390	0.000	3.000	0.400	0.731	2.880	0.415
4	4	-0.976	3.845	0.515	0.000	4.000	0.530	0.975	3.839	0.555
5	5	-1.220	4.804	0.660	0.000	5.000	0.660	1.217	4.792	0.745
6	6	-1.464	5.765	0.790	0.000	6.000	0.840	1.458	5.740	0.965
7	7	-1.708	6.726	0.920	0.000	7.000	1.060	1.696	6.680	1.225
8	8	-1.950	7.679	1.110	0.000	8.000	1.315	1.934	7.616	1.500
9	9	-2.193	8.636	1.265	0.000	9.000	1.560	2.173	8.556	1.755
10	10	-2.434	9.584	1.490	0.000	10.000	1.800	2.415	9.507	1.945

2. The tool can be downloaded at:

https://www.dropbox.com/sh/i821lei6mz3db6v/AADw2jk60BmgGf9zbdaDXzEia?dl=0

3. Results

(1). Tavis's data 1:

Calibration Result:

(Fig. 4. Data set one: Calibration Result)

This figure shows the predicted pole-ground contact places. The measurement will depend on a model which takes in these data.

Test Result:

Mark/Mark	groundTruth	Measurement	latterMark_from_camera	precision
1->2	1	1.12	7.013842773	0.88
2->3	1	1.03	5.409844971	0.97
3->4	1	0.84	7.749002838	0.84
4->5	1	0.21	7.958898926	0.21
5->6	1	0.91	7.555519104	0.91
6->7	1	1.11	6.687877655	0.89
7->8	1	1.14	6.890026855	0.86
8->9	1	0.61	6.993170166	0.61
9->10	1	1.14	7.287013245	0.86
10->11	1	1.27	8.416197205	0.73
11->12	1	0.98	8.243412781	0.98
12->13	1	0.13	8.368347931	0.13
13->14	1	0.98	7.923286438	0.98
14->15	1	1.15	9.013425446	0.85
15->16	1	1.25	7.121828461	0.75
16->18	1.4	1.2	7.403921509	0.8571429
18->19	1	1.17	8.013188934	0.83
19->20	1	1.17	8.593236542	0.83
20->21	1	0.18	8.776661682	0.18
21->22	1	1.25	8.10089035	0.75
22->23	1	1.1	7.772958374	0.9
23->24	1	1.08	7.269561768	0.92

Average Precision
0.75987013

(Fig. 5. Data set one: Distance Measurement Result)

The Mark numbers in the above figure come from corresponding data set description figure.

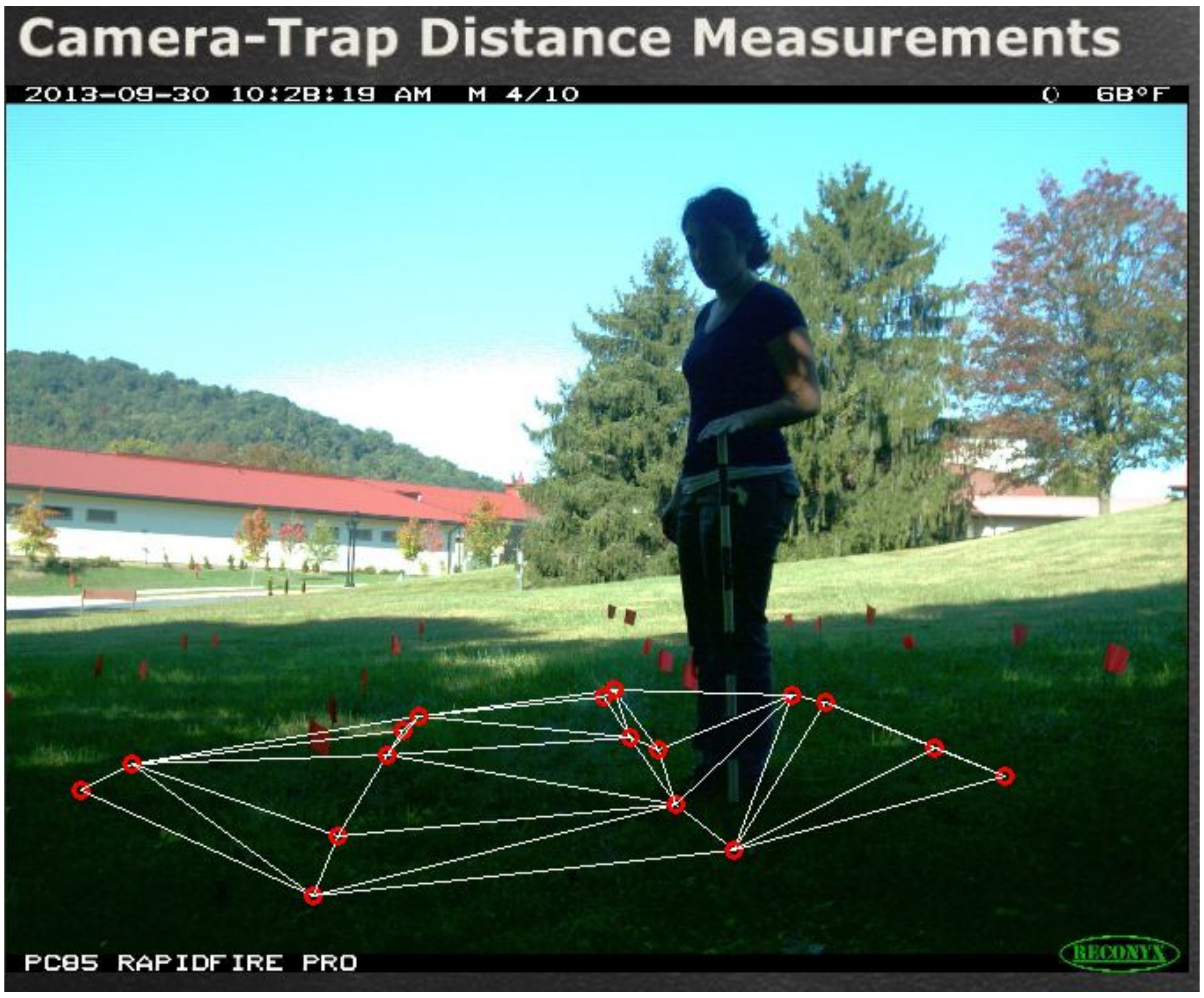
(Fig. 6. Data set one: Distance Measurement Result Corresponding Test Screen)

For the last distance measurement, I clicked the wrong place, so I did it again. This is a common mistake. We should click the pole-ground contact position(which usually cannot be seen because of the grass). We should NOT click the position shown on the above image Figure 6(The red circle). Instead, we should click on the position in the figure 7, which is almost a strip width lower.

(Fig. 7. Data set one: Distance Measurement Result Corresponding Test Screen, appendix)

(2). Tavis's data 2:

Calibration Result:



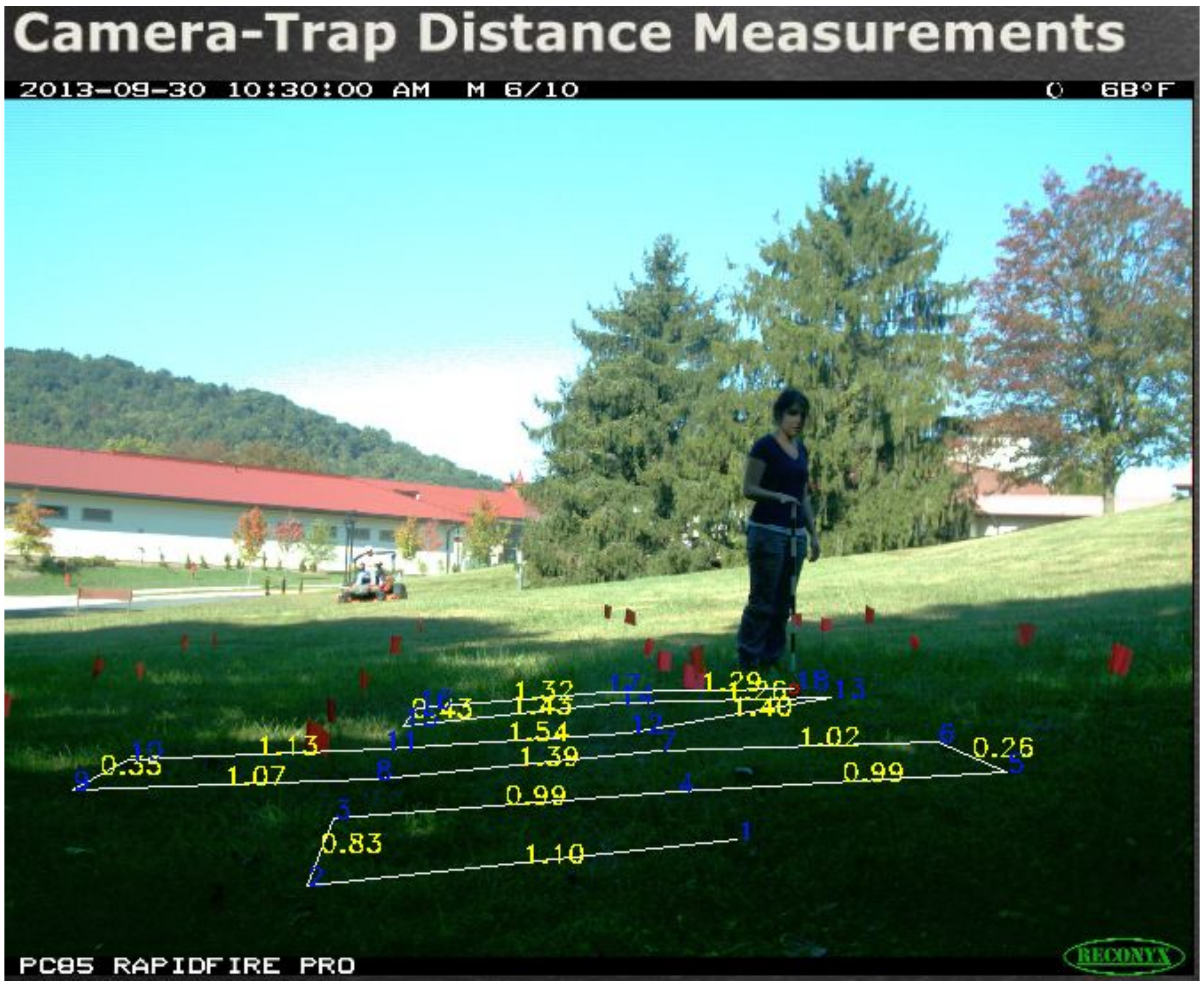
(Fig. 8. Data set two: Calibration Result)

Test Result:

1st test	Mark/Mark	groundTruth	Measurement	latterMark_from_camera	precision
	1->2	1	1.1	3.797152328	0.9
	2->3	1	0.83	4.60957222	0.83
	3->4	1	0.99	4.593574524	0.99
	4->5	1	0.99	5.463726807	0.99
	5->6	1	0.26	5.727426147	0.26
	6->7	1	1.02	5.58429718	0.98
	7->8	1	1.39	5.694352341	0.61
	8->9	1	1.07	5.675848007	0.93
	9->10	1	0.33	6.010137558	0.33
	10->11	1	1.13	5.763698959	0.87
	11->12	1	1.54	5.359372711	0.46
	12->14	1.4	1.4	6.517194366	1
	14->15	1	1.26	6.416533661	0.74
	15->16	1	1.43	7.423290253	0.57
	16->17	1	0.43	6.564744568	0.43
	17->18	1	1.32	6.795613098	0.68
	18->19	1	1.29	6.822749329	0.71

Average Precision
0.722352941

(Fig. 9. Data set two: Distance Measurement Result, First Test)

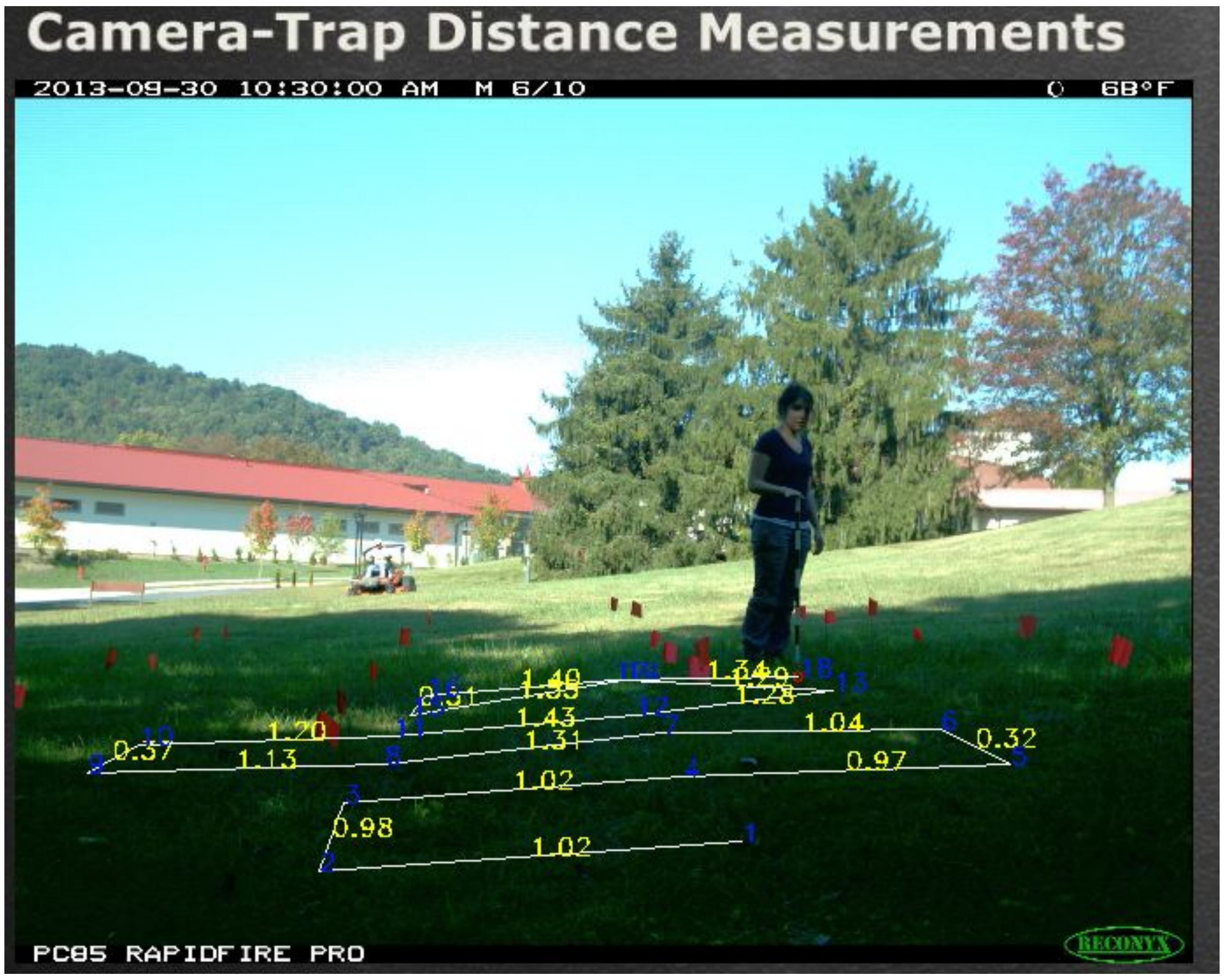


(Fig. 10. Data set two: Distance Measurement Result Corresponding Test Screen, First Test)

2nd test	Mark/Mark	groundTruth	Measurement	latterMark_from_camera	precision
	1->2	1	1.02	3.817580414	0.98
	2->3	1	0.98	4.777111435	0.98
	3->4	1	1.02	4.623274994	0.98
	4->5	1	0.97	5.450538254	0.97
	5->6	1	0.32	5.771052933	0.32
	6->7	1	1.04	5.682619095	0.96
	7->8	1	1.31	5.863501358	0.69
	8->9	1	1.13	5.75845108	0.87
	9->10	1	0.37	6.111820221	0.37
	10->11	1	1.2	5.81299057	0.8
	11->12	1	1.43	5.649344254	0.57
	12->14	1.4	1.28	6.466656494	0.9142857
	14->15	1	1.2	6.922052002	0.8
	15->16	1	1.55	6.176106262	0.45
	16->17	1	0.31	6.683161163	0.31
	17->18	1	1.4	6.937113953	0.6
	18->19	1	1.34	6.963222504	0.66

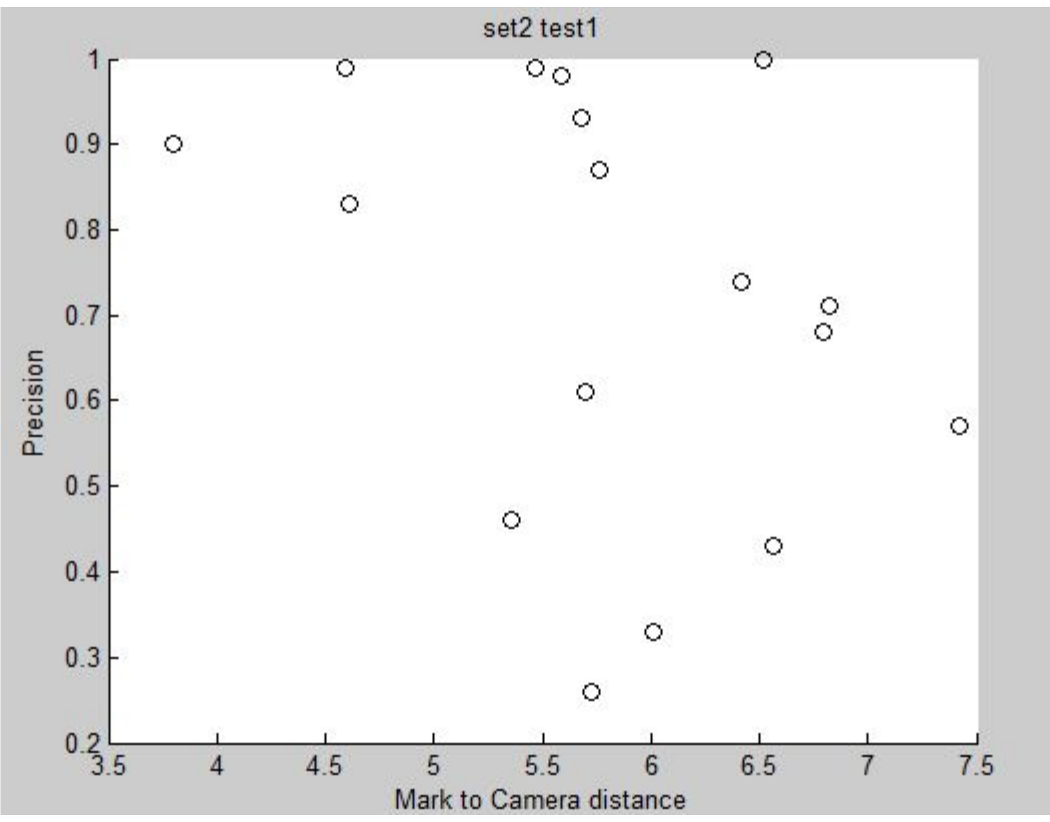
Average Precision
0.71907563

(Fig. 11. Data set two: Distance Measurement Result, Second Test)

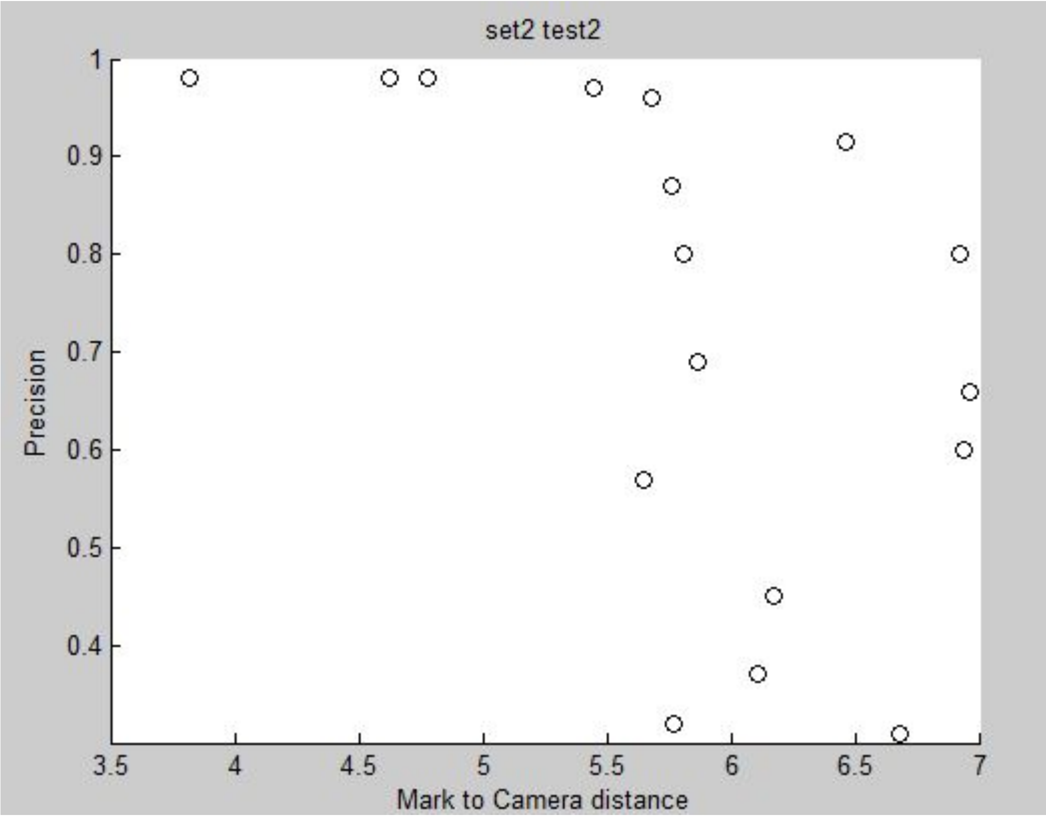


(Fig. 12. Data set two: Distance Measurement Result Corresponding Test Screen, Second Test)

Looking at the relationship between the precision and the distance from the Mark to the camera, we found for this data set, the farther it is, the more sensitive it becomes for the user to do the test. Because the small distance on the image mean larger errors. The two figures show that as the mark-to-camera distance gets greater, the precision could jump up and down quickly, which means it becomes more sensitive.



(Fig. 13. Data set two: precision and distance relationship, First Test)



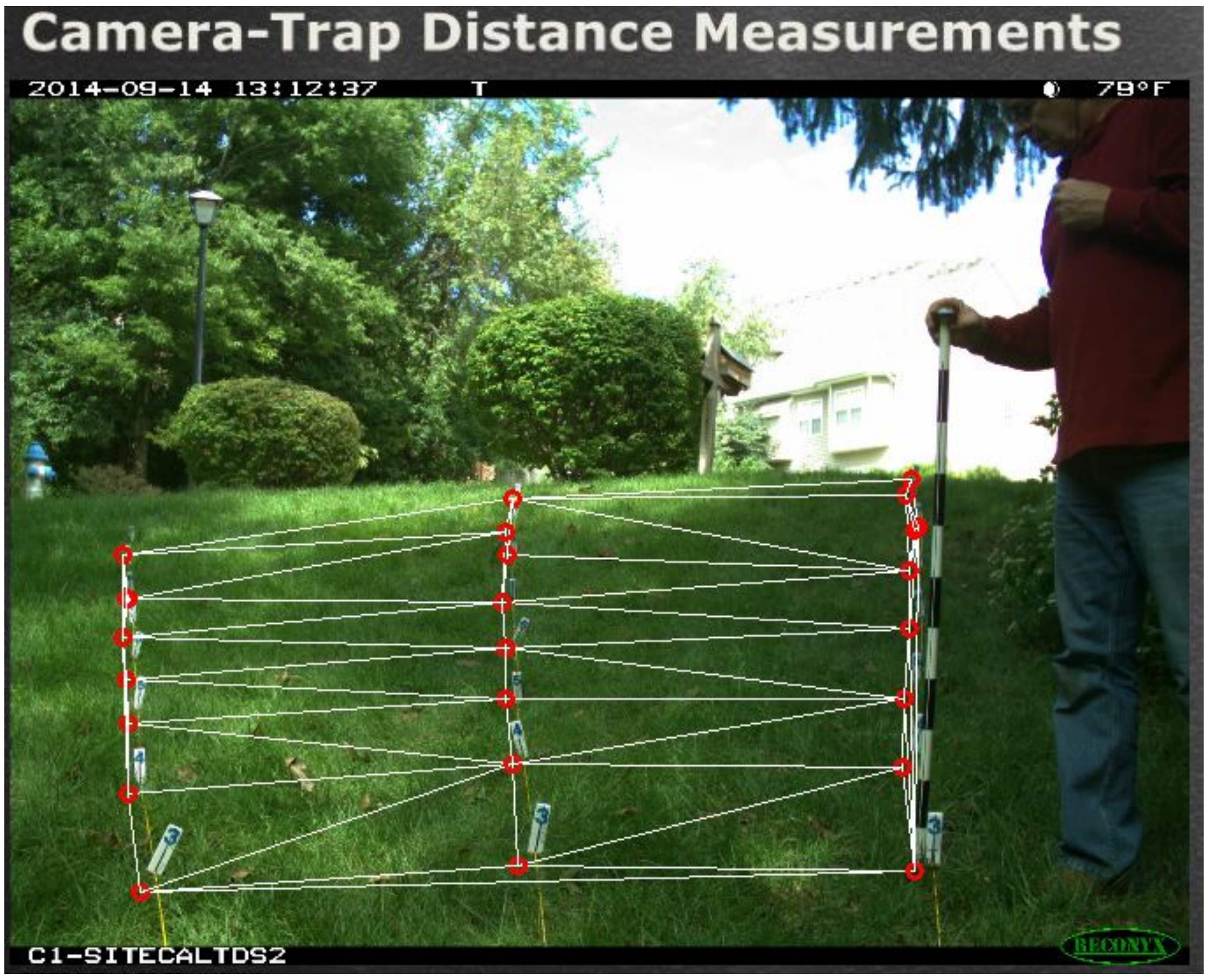
(Fig. 14. Data set two: precision and distance relationship, Second Test)

(3). Jay's data outdoor:

The previous two data sets come with comparatively less pole calibration images. With similar pole calibration images, the second data set is of average precision 0.72, lower than the first data set, whose average precision is 0.76. This shows that the slope seems to make a test harder.

However, the test on data set 3 shows that, with more pole calibration images, we can better calibrate the scene, which will more precisely render the measurement distances. The data set 3 is with a slope as well, mainly from near to far, and slightly from left to right. In this data set, we measure very far distances, and we measure much more distances than the previous two data sets. The average precision of this data set however, is 0.82, higher than both data set 1 and data set 2.

Calibration Result:



(Fig. 15. Data set three: Calibration Result)

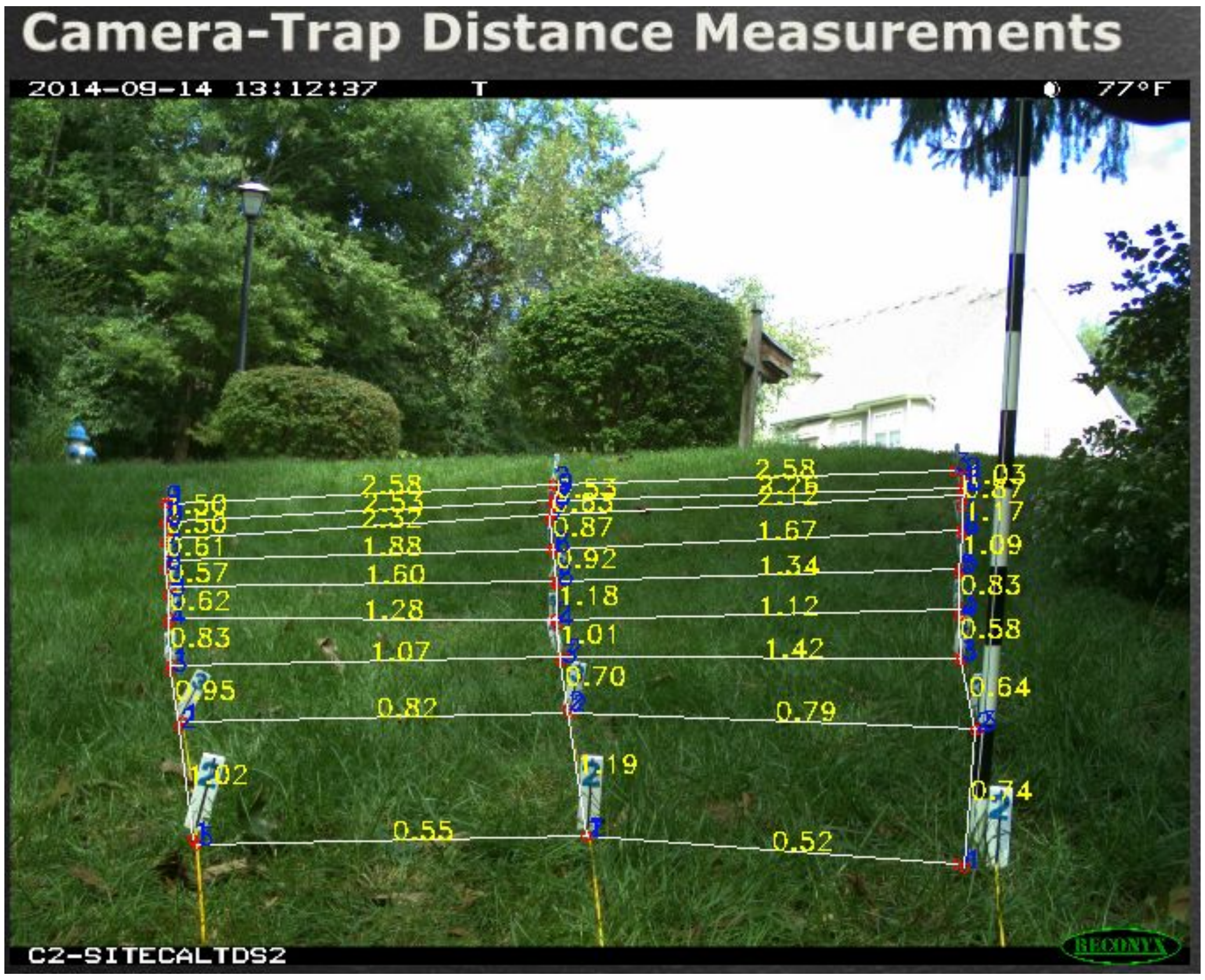
Test Result:

First test:

1st test	Mark/Mark	groundTruth	Measurement	latterMark_from_camera	precision
	L2->L3	1	1.02	3.172350883	0.98
	L3->L4	1	0.95	4.110481644	0.95
	L4->L5	1	0.83	4.925909042	0.83
	L5->L6	1	0.62	5.532034683	0.62
	L6->L7	1	0.57	6.09380722	0.57
	L7->L8	1	0.61	6.695894623	0.61
	L8->L9	1	0.5	7.19090271	0.5
	L9->L10	1	1.5	9.64573822	0.5
	L2->C2	0.5	0.55	2.126365471	0.9
	L3->C3	0.75	0.82	3.29521904	0.906666667
	L4->C4	1	1.07	4.176511383	0.93
	L5->C5	1.25	1.28	5.190348053	0.976
	L6->C6	1.5	1.5	6.306352615	1
	L7->C7	1.75	1.88	7.163916779	0.925714286
	L8->C8	2	2.32	8.142480469	0.84
	L9->C9	2.25	2.53	8.746795654	0.875555556
	L10->C10	2.5	2.58	9.539661407	0.968
	C2->C3	1	1.19	3.345619583	0.81
	C3->C4	1	0.7	4.042306137	0.7
	C4->C5	1	1.01	5.041750717	0.99
	C5->C6	1	1.18	6.210573578	0.82
	C6->C7	1	0.92	7.114239502	0.92
	C7->C8	1	0.87	7.974604034	0.87
	C8->C9	1	0.63	8.594482422	0.63
	C9->C10	1	0.53	9.118460846	0.53
	C2->R2	0.5	0.52	2.174076462	0.96
	C3->R3	0.75	0.79	2.969639015	0.946666667
	C4->R4	1	1.42	4.976673508	0.58
	C5->R5	1.25	1.12	4.265645218	0.896
	C6->R6	1.5	1.34	5.055747604	0.893333333
	C7->R7	1.75	1.67	6.176927567	0.954285714
	C8->R8	2	2.12	7.778590393	0.94
	C9->R9	2.25	2.26	8.201848602	0.995555556
	C10->R10	2.5	2.58	9.571733093	0.968
	R2->R3	1	0.74	2.955888748	0.74
	R3->R4	1	0.64	3.582045364	0.64
	R4->R5	1	0.58	4.155737686	0.58
	R5->R6	1	0.83	4.975926971	0.83
	R6->R7	1	1.09	6.054861832	0.91
	R7->R8	1	1.17	7.222046661	0.83
	R8->R9	1	0.87	8.08950119	0.87
	R9->R10	1	1.03	9.112580872	0.97

Average Precision
0.825137566

(Fig. 16. Data set three: Distance Measurement Result, First Test)



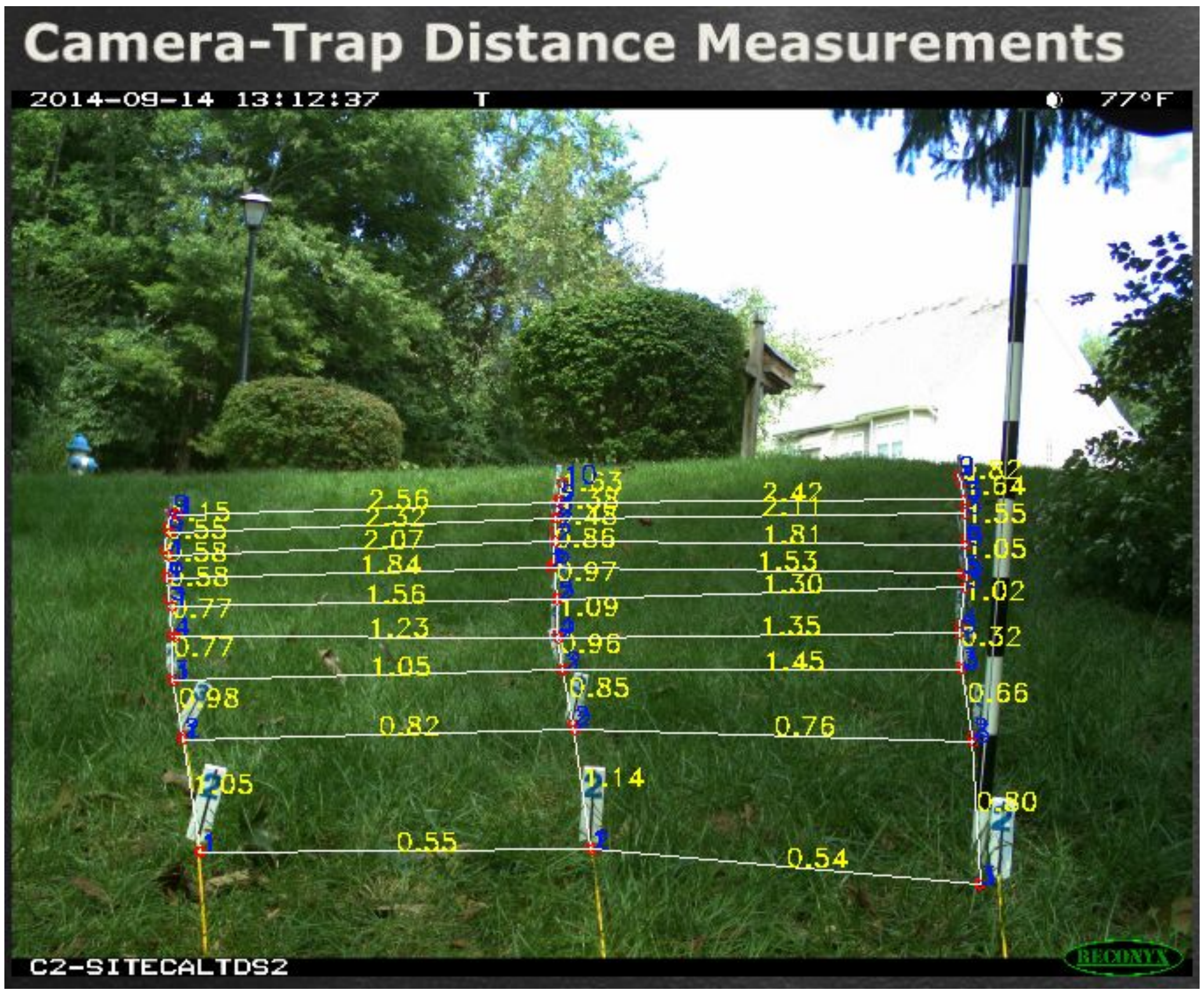
(Fig. 17. Data set three: Distance Measurement Result Corresponding Test Screen, First Test)

The second test.

2nd test	Mark/Mark	groundTruth	Measurement	latterMark_from_camera	precision
	L2->L3	1	1.05	3.199154472	0.95
	L3->L4	1	0.98	4.170011139	0.98
	L4->L5	1	0.77	4.926049423	0.77
	L5->L6	1	0.77	5.681075287	0.77
	L6->L7	1	0.58	6.257109451	0.58
	L7->L8	1	0.58	6.825852966	0.58
	L8->L9	1	0.55	7.365867615	0.55
	L9->L10	1	1.15	9.778975677	0.85
	L2->C2	0.5	0.55	2.159020615	0.9
	L3->C3	0.75	0.82	3.220557022	0.906666667
	L4->C4	1	1.05	4.133639526	0.95
	L5->C5	1.25	1.23	4.995026779	0.984
	L6->C6	1.5	1.56	6.125189209	0.96
	L7->C7	1.75	1.84	6.984240723	0.948571429
	L8->C8	2	2.07	7.672971344	0.965
	L9->C9	2.25	2.32	8.437556458	0.968888889
	L10->C10	2.5	2.56	8.876985931	0.976
	C2->C3	1	1.14	3.29521904	0.86
	C3->C4	1	0.85	4.13552475	0.85
	C4->C5	1	0.96	5.090395737	0.96
	C5->C6	1	1.09	6.167417908	0.91
	C6->C7	1	0.97	7.117399597	0.97
	C7->C8	1	0.86	7.968276978	0.86
	C8->C9	1	1.48	8.442211914	0.52
	C9->C10	1	1.33	9.164710236	0.67
	C2->R2	0.5	0.54	2.228081894	0.92
	C3->R3	0.75	0.76	2.955064583	0.986666667
	C4->R4	1	1.45	4.976673508	0.55
	C5->R5	1.25	1.35	5.223369598	0.92
	C6->R6	1.5	1.3	4.898574066	0.866666667
	C7->R7	1.75	1.53	5.238762283	0.874285714
	C8->R8	2	1.81	6.054272079	0.905
	C9->R9	2.25	2.11	7.398168945	0.937777778
	C10->R10	2.5	2.42	8.201848602	0.968
	R2->R3	1	0.8	2.99678688	0.8
	R3->R4	1	0.66	3.640505981	0.66
	R4->R5	1	0.32	5.360480118	0.32
	R5->R6	1	1.02	5.194842911	0.98
	R6->R7	1	1.05	6.238891602	0.95
	R7->R8	1	1.55	7.778590393	0.45
	R8->R9	1	1.64	9.409664917	0.36
	R9->R10	1	0.82	10.22625961	0.82

Average Precision
0.820417234

(Fig. 18. Data set three: Distance Measurement Result, Second Test)



(Fig. 19. Data set three: Distance Measurement Result Corresponding Test Screen, Second Test)

In conclusion, the calibration and distance measurement tool provides acceptable result to diverse data sets. It can deal with slight slopes. In order to gain better results, it is very important to use more poles for calibration. As the mark goes farther from the camera, the measurement error becomes more sensitive to the deviation of human input.