THE DEVELOPMENT OF CCD RANGE FINDER

Jiaying Zhou, and Jianlong Guo
Department of Physical Education, Xi'an Physical Education Institute, Xi'an, China

Application of a range finder in both indoor and outdoor settings shows that distance and subject information can be performed accurately. The range finder can measure the distance, show the performance and do the management task at the same time. It is adapted to any climate and can work in different conditions. It has the characteristics of being cheap, convenient, quick and accurate.

KEY WORDS: CCD, distance measuring, apparatus

INTRODUCTION: Objects travelling through the field of vision of CCD will cause the output signs to jump. As CCD output signs are even analog signs or TTL level digital signs, they can be easily recognized by computers. Besides, the attached computers can also work out the distance between the snap and the center of the field of vision. Computers can also calculate the vertical bias between objects and the marked center of the field with the ratio relationship of objects.

The CCD range finder is made up of two systems. The hardware system consists of a computer, two TCD 1206UD linear video cameras (including special lens), and a double input 8-digit A/D data collecting base. The technical indexes are as follows: the lens object focus is 37 mm; the range of response is bigger than 40°; The lens resolution ratio must not only match to the pixel resolution ratio of TCD 1206UD linear CCD but also be superior to 501p/mm. The A/D data collecting base is 8-digit synchronism, the data ratio is faster than 1 MHZ, 8KD interior data space. The software system consists of C language software package (including using , demonstrating and testing),which also support A/D data collecting base. The management software package of the CCD range finder includes: (1) Initial surface storage: concerned events selection (ranging from standing jump, long-jump, triple long-jump, shot, javelin, discus and hammer), testing groups and rounds, sexes, numbers of athletes tested , and additional value of each event. (2) Database: names of referees, time of competition, personal information of candidates (number, name, province, etc. This information may be stored in advance. When needed, it will be shown after numbers are entered . After the match, the personal performances and the performances of the group can be arranged in certain number, printed and stored. CCD range finder's testing software package includes: (1) The data processing contains the showing of CCD stored curves (dynamic, automatic pursuing), erasion of the background noise in the testing field, capture and identification of sign impulses, and the calculation of impulse pixel; (2) Distance calculation includes formula for different events, mathematical models, calibration coefficient and fit coefficient. Add up the result and the additional values of each event, the distance will be worked out and shown on the screen.

METHODS AND RESULTS:

Indoor experiment:

(1) The design and production of CCD lens shell and horizontal stand. They must be rain-, dust- and shock-proof which must be easily adjusted to level.
(2) Leveling experiment of CCD lens leveled using a spirit level.
(3) Justifying the range of response of CCD lens.
(4) Determining the range of indoor bi-lens horizontal measurement.
(5) Interior labeling.

The object is to make clear the real focus of lens, correct the non-linear variation of lens, and establish correct corresponding relationship between the range of response of lens and the number of CCD central pixel. The procedure is as follows:

a. Setting up the measurement platform
b. Adjusting one CCD linear camera so that the primary optical axis focuses on the central

point of the base line. (On the screen, the impulse pixel shown is1100)

c. Deciding the field of vision of the lens.

d. Placing the tiny light sources in turns at an interval of 100mm, and then test the impulse index value corresponding to each point.

The findings are shown in Table 1:

Table 1 Findings

Right Camera			Left Camera	
X M	N Central pixel	tga	X M	N Central pixel
-0.7	2 125	-0.3861	-0.7	2 108
-0.6	1 973	-0.3309	-0.6	1 965
-0.5	1 827	-0.2758	-0.5	1 821
-0.4	1 682	-0.2206	-0.4	1 676
-0.3	1 536	-0.1655	-0.3	1 532
-0.2	1 390	-0.1103	-0.2	1 389
-0.1	1 241	-0.0552	-0.1	1 243
0	1 100	0	0	1 100
+0.1	954	0.0552	+0.1	957
+0.2	810	0.1103	+0.2	813
+0.3	668	0.1655	+0.3	672
+0.4	530	0.2206	+0.4	529
+0.5	392	0.2758	+0.5	389
+0.6	251	0.3909	+0.6	246
+0.7	115	0.3861	+0.7	107

(The order of impulse pixel is from left to right, and the lens distance is 1.813m.)

As $tga=a+bN+cN^2+dN^3$, we can get the following figures:

Right Camera: $\alpha=0.43306$; $b=-4.1924^{e-4}$; $c=1.68203^{e-8}$; $d=-2.64140^{e-12}$

Left Camera: $\alpha=0.42841$; $b=-3.9671^{e-4}$; $c=8.5556^{e-9}$; $d=-1.71512^{e-12}$

Bring the above figures into the distance calculating formula for correction.

(6) Indoor distance measurement and verification experiment.

Make the experiment in both a fan landing section (i.e. shot) and a rectangular section (for example, stand-long jump) ,first, adjust the central pixel of 2 cameras to the field rod at the marked point. Suppose the central pixel number is 1100. Using the central pixel as the cardinal point, testers will see whether the central pixel will fall to the left or right of the central point. Assume that the pixel of the landing presentation is n_1, n_2 (n_1 for left CCD, n_2 for the right CCD), and the pixel number is, corresponding to the central pixel 1110, n_1-1100, n_2-1100,

$$tag\alpha = \frac{(n - 1100) \times 0.014}{37}$$

$$\alpha = \text{arctg} \frac{(n_1 - 1100) \times 0.014}{37}$$

$$\therefore \beta = \text{arctg} \frac{(n_2 - 1100) \times 0.014}{37}$$

(In testing, α, β should be verified.)

Table 2 Indoor experiment results vs steel ruler measuring results.

Steel Ruler (Distance) m	CCD Finder Distance	Notes
1.5	1.4998	
1.7	1.7013	
2.0	2.0016	
2.1(marked point)	2.1000	
2.5	2.5011	Marked point
2.6	2.5962	
2.8	2.8064	Eccentric point(to the lefts)
3.0	3.0078	Edge/brim

Table 2 shows that the results obtained by these two means are quite close to each other and the differences just lie on millimeter. The differences fall within the accuracy requirements for track and field measurement. Indoor experiment results are ideal; therefore, outdoor experiment is also possible.

Outdoor Experiment:

Measuring Accessories

To prevent the ultra-strong beam from saturating the CCD impulse curves, polarizing filter lens are added. And CCD lens sometimes may fail to capture the signals, especially those 50 meters away; thus, the signal spot is also designed that it can be moved up and down and the brightness can be adjusted. The test proves that it works well.

Setting the scaling values for different items

According to the landing distance and range of different events, through theoretical calculation and factual testing verification, we set the scaling values for each event so as to facilitate the installation of instrument before testing. Each scaling value is: stand long-jumpα=2.1 m; long jump and triple long jump, α=3 m; shot α=9 m; javelin;α=28 m; discus and hammer α=33 m.

Setting the Scaling Values in Outdoor Experiment

The scaling values for outdoor experiment are set on the basis of outdoor experiment and verification of errors in exact testing. All these errors are caused by the following factors (1) The two lens are not at the same level in the field; (2) In setting the scaling values, researchers may make errors in deciding the signal spot.(3)The testing ground is not flat; (4) Steel rulers are not ideal calibration scale, because of uneven ground and in different temperatures the numerical reading differs from the real measure, we took some measures, which proved effective from the findings obtained. Testing results after fixing the scale show that: In long-jump, triple jump, and stand long jump and other short-distance events, there are almost no errors, although sometimes an error of 0.5 cm was recorded which is indeterminate. This kind of error is indeterminate. Different researchers may read the scale differently, so the errors appear randomly. Other long-distance events, such as javelin, discus and hammer, in the margin of effective testing range, there is an error of about 2 cm. From the absolute value, 2 to 4 cm, can't be neglected. But compared to a distance of 40-50 meters, this error is still small.

Measure concerning increasing the accuracy and minimizing errors

At present, all the parts used for this CCD ranger finder are cheap. To improve the accuracy, we can use parts with higher accuracy, such as high-fitness CCD and specialized distortion-free optical lens. One more possible way is to use laser range finder to verify CCD range finding system, because steel rulers are easily affected by topography, temperature, misreading and other artificial factors.

CONCLUSION: The CCD range finder can be applied in sports testing and in field refereeing. It has very high practical, popularizing and promotional values. If superior equipment is used and use more advanced verifying tool, the accuracy of the CCD range finder will also improve.

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