ISSN : 0974 - 7435 Volume 10 Issue 13

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(13), 2014 [7153-7159]

Effects and corrections of video camera's high angle shot to the analytical results of motion image analysis

Lin Li, Zhongqiu Ji*

College of PE and Sports, Beijing Normal University, Beijing, 100875, (CHINA)

E-mail : jizhongqiu@126.com

ABSTRACT

The analysis towards sports competition is an important part of technical motion analysis. With the features of being able to measure at a distance and non-contact, motion video analysis system becomes the first choice of data collection and analysis in sports competition. However, due to some objective reasons, there is often a certain depression angle when shooting competitions. Through theoretical analysis and experimental verification, this paper analyzes the effects of video camera's high angle shot to two-dimensional and three-dimensional analytical results and proposes correction methods.

KEYWORDS

Sports competition; High angle shot; Motion image analysis.

INTRODUCTION

With strong competitive and confrontational features, sports competition is a way to assess, compare or show the athletic performance. On the field, in order to defeat the match, athletes not only show their usual training results, but also continue to improve the existed skills, tactics and create new technologies, new tactics. They are often able to show physical and technical actions which are beyond the limits[1]. Therefore, the analysis towards sports competition is an important part of technical motion analysis. Motion video analysis system can collect and analyze the competition situation from a technical point of view. The primary means of analysis is through measuring the kinematic parameters of athletes when they are exercising, and making diagnosis and evaluation of sports technology, which provide a theoretical basis to improve the techniques and performance of athletes. With the features of being able to measure at a distance and non-contact, motion video analysis system becomes the first choice of data collection and analysis in sports competition. However, there are some practical problems in shooting videos of sports competition. When shooting large sports competitions, such as the National Games, National Championships, it is difficult for researchers to enter the competition terrain. They can only set up video cameras to shoot the scene from stands. Even though they enter the competition terrain, due to space constraints of the competition site, they may also need to shoot with a certain depression angle. Moreover, there are some events, such as diving, gymnastics, boxing, their competition terrains are high. They need to be shot from a lower angle[2]. Since low angle shot and high angle shot take similar processing methods, this paper only analyzes the latter one. Through theoretical analysis and experimental verification, this paper analyzes the effects of video camera's high angle shot to two-dimensional and three-dimensional analytical results and proposes correction methods.

EXPERIMENTAL SECTION

Research content

Effects and corrections of video camera's high angle shot to the two-dimensional analytical results

Theoretical analysis

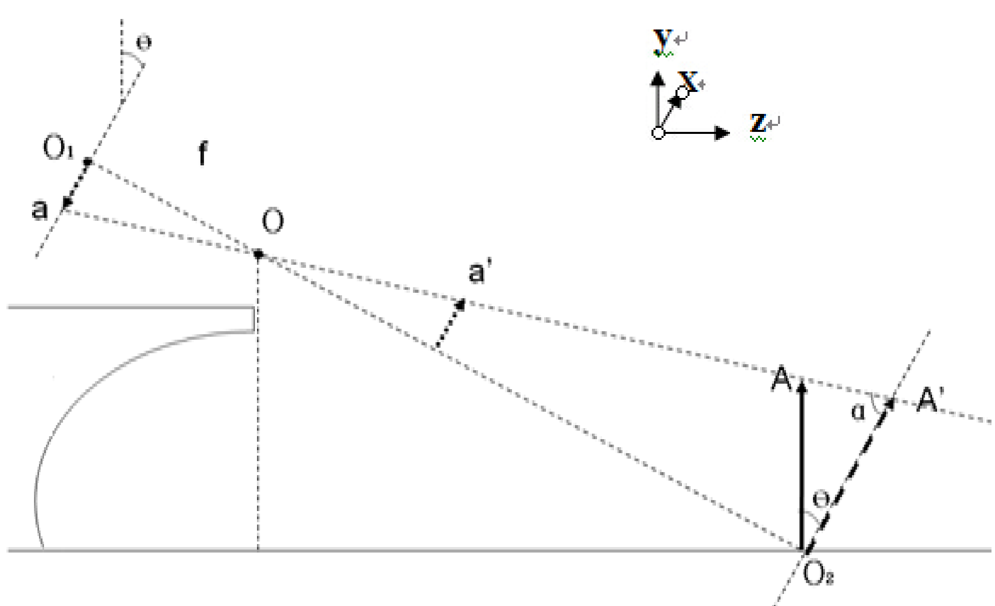

Figure 1 : Schematic diagram of video camera shooting at angle *θ*

O — The origin of the camera coordinate system, i.e. the optical center of the camera

O_1 —The origin of the image coordinate system

O_2 — The origin of the actual coordinate system

OO_1 — The focal length f of the camera

O_1O_2 —The main optical axis

In Figure 1, perpendicular to the y-axis, z-axis and inside them is the positive direction of the x-axis. The video camera shoots point A at angle ɵ from a high angle.

In fact, the image plane should be behind the optical center O of the camera. And the image of the object in the image coordinate system is inverted (O_1a). For ease of use, the image plane is often moved to the front of the optical center, and the resulting image is upright ($O_2'a'$).

The image position of any point A in space on the diagram can be approximately expressed by needle control model. It means that the projection position of point A on the diagram is a which is the intersection of the image plane and OA. And OA is the connection of the optical center O and point A.

From the proportional relations, we can get the following formula: $y=\lambda Y_C$ (λ is proportional coefficient, and its size is the ratio of the length of image coordinate and the length of actual coordinate of benchmark). (X, Y) is the image coordinate of point a; (X_C, Y_C) is the coordinate of point A in camera coordinate system.[3]

Above all, if the video camera shoots point A at angle θ from a high angle, the calculated coordinate of point A is in fact the camera coordinate $A'(X_C, Y_C)$ not the actual coordinate of point A, i.e. A (X,Y).

Through the geometrical characteristics of Figure 1, we can get

$$Y=f\, Y_C/(f*\cos\theta+y*\sin\theta) \quad \textbf{(1)}$$

Since the shooting distance (OO_2) is much larger than the length of O_2A', it can be approximately considered that α is a right angle, then formula 1 can be simplified as follows:

$$Y= Y_C/\cos\theta \quad \textbf{(2)}$$

To sum up, when conducting two-dimensional shooting, we know that the calculated coordinate at Y-axis is related to angle θ which is the depression angle that the video camera takes to shoot. It is proportional to the cosine of angle θ, i.e., the larger the angle is, the smaller the calculated coordinate is at Y-axis direction.

This paper presents two correction methods to calculate the coordinates at Y-axis direction.

First, use the goniometer or Pythagorean theorem to get the depression angle θ that the video camera takes.

1. Use the equation (2) and make all the calculated coordinates at Y-axis direction be divided by the cosine of angle θ to obtain the actual coordinates at Y-axis direction.[4]

2. When shooting the benchmark, we need to place it vertically. And when entering its coordinates, we should enter the calculated value which is reached by using the actual coordinates to multiply the cosine of angle θ.

Similarly, we can get the formula:

$$X= X_C/\cos\theta \quad \textbf{(3)}$$

Because OX is parallel to O_CX_C and θ=0, we can get

$$X= X_C \quad \textbf{(4)}$$

This shows that video camera’s high angle shot has no effects to the coordinates at X-axis direction. Therefore, there is no need to make corrections.

Experimental analysis

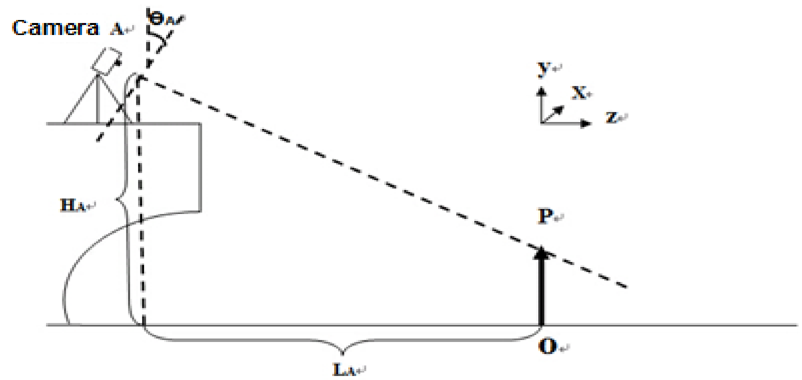

Figure 2 : Test schematic diagram of video camera shooting at θ angle

As shown in Figure 2, the height of *camera A* from the ground level is H_A, and its horizontal distance to benchmark is L_A. *Camera A* takes 14.9 °, 18.2 ° and 26.6 ° three different depression angles to shoot the benchmark. The shooting data and experimental data are shown in TABLE 1.

TABLE 1 : Shooting data and experimental data

No.	H_A（m）	L_A（m）	$θ_A$（°）	Y（m）	Y_C（m）	$Y_C/\cos θ$（m）	ΔY（m）	ΔY/Y（%）
1	4.27	8.54	26.57	0.9900	0.8823	0.9864	-0.0036	0.36
2	4.27	13.00	18.19	0.9900	0.9369	0.9862	-0.0038	0.38
3	4.27	16.00	14.94	0.9900	0.9496	0.9828	-0.0072	0.72

Y_C in the table are coordinates at Y-axis direction in the camera coordinate system. $Y_C/\cos θ$ is the revised coordinates at Y-axis direction. In the formula $ΔY = Y-Y_C/\cos θ$, ΔY reflects the differences between the actual coordinates at Y-axis direction and the calculated and adjusted coordinates at Y-axis direction. The average value of the three shooting numbers of ΔY/Y is only 0.49%, which proves the correctness of the above theoretical derivation about the effects and corrections of video camera's high angle shot to the two-dimensional analytical results.

Effects of video camera's high angle shot to the three-dimensional analytical results

Theoretical analysis

Direct linear transformation (DLT) algorithm is an algorithm to establish direct relationship between the coordinatograph coordinates and the object space coordinates[5]. In the calculation process, direct linear transformation algorithm establishes the positional relationship between the camera coordinate system and the world coordinate system. It uses the rotation matrix *R* and the translation vector *t* to describe[6]. If the homogeneous coordinates of a certain point *P* in space are respectively ($X_W, Y_W, Z_W, 1$) *T* and ($X_C, Y_C, Z_C, 1$) *T* in the world coordinate system and the camera coordinate system, then they have the following relationship:

$$\begin{bmatrix} X_C \\ Y_C \\ Z_C \\ 1 \end{bmatrix} = \begin{bmatrix} \mathbf{R} & \mathbf{t} \\ \mathbf{0}^T & \mathbf{1} \end{bmatrix} \begin{bmatrix} X_W \\ Y_W \\ Z_W \\ 1 \end{bmatrix}$$

Among them, R is 3 × 3 orthogonal unit matrix; t is a three-dimensional translation vector; 0 = (0, 0, 0) ^{T}.[7]

In summary, during the process of applying DLT method to conduct a video camera three-dimensional space calibration, the coordinate system has already been rotated and adjusted. Therefore, the angle changes caused by video camera's high angle shot and low angle shot have been adjusted in the process of the three-dimensional space calibration. So there is no need to make corrections.

Experimental analysis

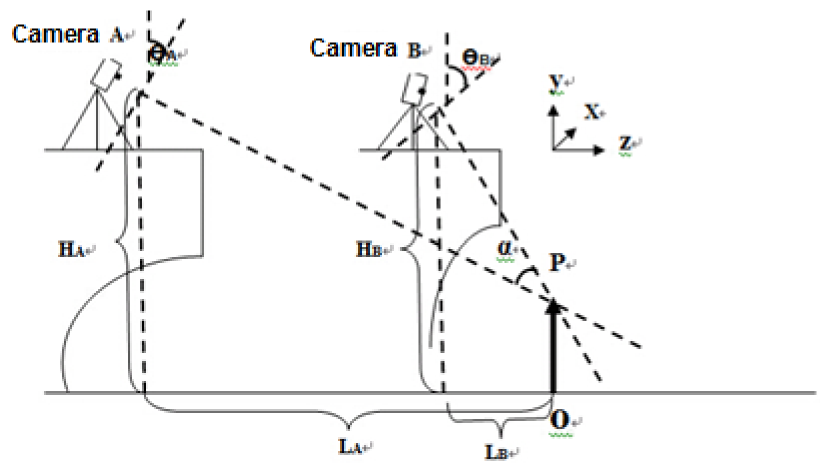

Figure 3 : Schematic diagram of video camera shooting at angle θ

The height of *camera A* from the ground level is H_A, and its horizontal distance to benchmark is L_A. The height of *camera B* from the ground level is H_B, and its horizontal distance to benchmark is L_B. *Camera A* and *camera B* takes four different depression angles to shoot the benchmark. The shooting data and experimental data are shown in TABLE 2 and TABLE 3.

TABLE 2 : Shooting data

No.	H_A (m)	L_A (m)	$θ_A$ (°)	H_B (m)	L_B (m)	$θ_B$ (°)
1	4.48	16.2	15.46	4.48	16.5	15.19
2	4.48	11.0	22.16	4.48	11.5	21.28
3	4.48	20.0	12.63	4.48	20.0	12.63
4	1.1	20.0	0	1.1	20.0	0

TABLE 3 : Experimental data

No.	X (m)	Y (m)	Z (m)	X_C (m)	Y_C (m)	Z_C (m)	ΔX (m)	ΔY (m)	ΔZ (m)	ΔX/X (%)	ΔY/Y (%)	ΔZ/Z (%)
1	0.74	0.75	0.62	0.71	0.72	0.59	-0.03	-0.03	-0.03	4.05	4.00	4.84
2	1.19	0.75	0.62	1.200	0.73	0.61	0.01	-0.02	-0.01	0.84	2.67	1.61
3	1.19	0.75	1.19	1.17	0.73	1.20	-0.016	-0.02	0.01	1.34	2.67	0.84
4	1.19	0.94	0.62	1.213	0.948	0.65	0.023	0.008	0.03	1.93	0.85	4.84

Shoot benchmark from four different angles which are shown in TABLE 2. Among the experimental data in TABLE 3, (X, Y, Z) is the actual coordinate of benchmark; (Xc, Yc, Zc) is the camera coordinate of benchmark; Among the formula ΔX = Xc- X, ΔY = Yc- Y, ΔZ = Zc- Z, ΔX, ΔY, ΔZ reflect the differences between the actual coordinates and the calculated coordinates computed by direct linear transformation algorithm (DLT)[8]. The experimental data shows that through shooting the benchmark from four different depression angles, the resulting error at the three axes are less than 5%, which proves that dual video camera's high angle shot has little effect on the three-dimensional analytical results.

CONCLUSION

Through theoretical analysis and experimental verification, this paper analyzes the effects of video camera's high angle shot to two-dimensional and three-dimensional analytical results and proposes correction methods.

Effects and corrections of video camera's high angle shot to the two-dimensional analytical results

When conducting two-dimensional shooting, we know that the calculated coordinate at Y-axis is related to angle θ which is the depression angle that the video camera takes to shoot. It is proportional to the cosine of angle θ, i.e., the larger the angle is, the smaller the calculated coordinate is at Y-axis direction.

There are two correction methods:

First, use the goniometer or Pythagorean theorem to get the depression angle θ that the video camera takes.

1. Use the equation (2) and make all the calculated coordinates at Y-axis direction be divided by the cosine of angle θ to obtain the actual coordinates at Y-axis direction.

2. When shooting the benchmark, we need to place it vertically. And when entering its coordinates, we should enter the calculated value which is reached by using the actual coordinates to multiply the cosine of angle θ.

The video camera's high angle shot has no effect to the coordinates at X-axis direction. Therefore, there is no need to make corrections.

Effects and corrections of video camera's high angle shot to the three-dimensional analytical results

During the process of applying DLT method to conduct a video camera three-dimensional space calibration, the coordinate system has already been rotated and adjusted. Through theoretical derivation and experimental verification, dual video camera's high angle shot has no effect to the three-dimensional space calibration, so there is no need to make corrections.

ACKNOWLEDGMENTS

This work was funded by the Ministry of Education of Humanities and Social Science project (11YJA88003).

REFERENCES

[1] Wang Xiaoxia, Zhu Jie, Yan Hong; On How to Appreciate Sports [J], Sichuan Sports Science, **3(1)**, 17-18 **(2006)**.

[2] Xia Nan; DLT Camera Calibration Method Based on Least Square Method [J], Information Technology, **3(5)**, 98-100 **(2006)**.

[3] Ai Kangwei, Wang Bowei, Peng Leihua; 3D Image Analysis with Pan /Tilt /Zoom and Its Assessment of Accuracy [J], China Sport Science and Technology, 03 **(2011)**.

[4] Song Peng, Qin Zhihui, Huang Chengjia, Yang Xiaozhu; The Accuracy Study about Three-Dimensional Motion Analysis System Framework in Changing the Shooting Angle of Vidicon [J], Journal of Southwest China Normal University (Natural Science Edition), 01 **(2011)**.

[5] Li Hanjun, Tong Liping, Zhou Xinglong, Qu Feng; Comparison of Kinematic Data of Lower Extremity between Image Analysis and Real Time Motion Capture System [J], Journal of Beijing Sport University, 01

(2011).
[6] Jing Longjun, Wang Peng, Yuan Tinggang, Li Aidong, Feng Shuyong; Technique Analysis on the Elite 20km Race Walkers of China and Foreign Countries [J]. China Sport Science and Technology, 01 **(2011)**.
[7] Wang Feng, You Jiangbo; Research on the Key Technology of Chinese Elite Male Race Walkers [J], Journal of Beijing Sport University, 09 **(2009)**.
[8] Wang Junde; Camera Calibration with the Radial Distortion [J], Science & Technology Information, 25 **(2009)**.