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MEASUREMENT OF DISTANCE COVERED ON A BASKETBALL COURT USING A VIDEO-BASED SYSTEM WITH MULTIPLE CAMERAS

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INTRODUCTION

One of the important kinematic variables related to activity profile during a game is the concept of distance covered. Video-based methods allow for the analysis of the player movements during a game, and for different sports [4,5,6]. Due to the size of the field or court, it becomes necessary to use two or more cameras for tracking the player's movement. Thus, the studies reported in the literature have used from 2 to 16 cameras. Calibration is an other key step. The difficulties and sources of error might be associated with: a) measuring the points in the field (known points) to be used for calibration, b) correct identification of known points in the image, and c) the minimum amount of points required. Thus, the aim of this study was the tracking and measurement of distance covered using multiple cameras in basketball. The analysis comprises: a) determination of the cutoff frequency, and b) obtaining the absolute errors in the determination of the distance covered.

METHODS

This study was authorized by the Research Ethics Committee of UNICAMP (CEP n° 1008/2010). The study was performed in a controlled setting to verify the error in the determination of the distance covered. The circuit was defined by a path (54.77 m) using a polypropylene (PP) braided rope (2mm) attached to the surface of the court and control points P_k (k=1, ..,7). For the calibration process, the points (C_j : j=1, .., 26) were used to determine the coordinate system. Point C_1 is the origin of the coordinate system. All points are white objects (15 cm height x 5 cm diameter) placed on the court and the known 2D coordinate is the center of each object (figure 1). All points were measured using a laser measures (Leica® DISTO D5). A volunteer jogged around the circuit five times. The participant was instructed to follow the marked course and changed the direction of motion exactly at the control points. The DVideo kinematical analysis system (Barros et al, 1999, Figueroa, 2003) was used to obtain 2D coordinates of the markers on the images. The three cameras (JVC, model GZHD10, 30 Hz) were statically positioned on the gymnasium corners, at 12m height from the ground. The 2D data were smoothed with a zero-phase forward and a reverse Butterworth digital filter. The cut-off frequency was determined considering the control points P_k (k=1, ..,7) and the circuit distance. The distance covered was calculated as the cumulative sum of player displacement between two successive frames.

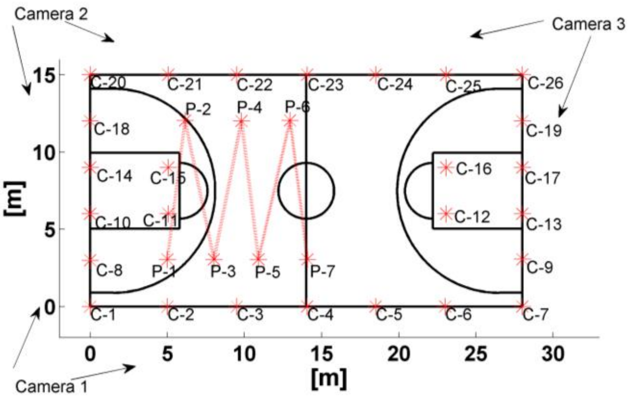

Figure 1: The experimental setup of camera placement and objects distribution in the court with control points P_n (n=1..7). The points C_j (j=1,..,26) are used as the point of reference for the calibration. The distance of the circuit (P_1, .., P_7) has 54.77m of length. At least 21 points are visible to each camera.

RESULTS AND DISCUSSION

Each camera was properly positioned (figure 1,2a) to visualize at least 21 calibration points. The 2D data were smoothed with the cut-off frequency of 0.45 Hz determined by considering the control points P_k (k=1, ..,7) and the circuit distance (54.77 m).

The trajectory performed by the volunteer was smoothed and superimposed (Figure 2b,2c,2d). Each of the smoothed trajectories adequately represented the circuit since each trajectory passes through the control points P_k(k = 1, ..7), as well as the path defined by the PP braided rope attached to the surface of the court. However, some parts of the trajectory obtained from the camera 3 show effects not observed in the other cameras. This effect may be due to the greater distance of the camera 3 compared with the other cameras.

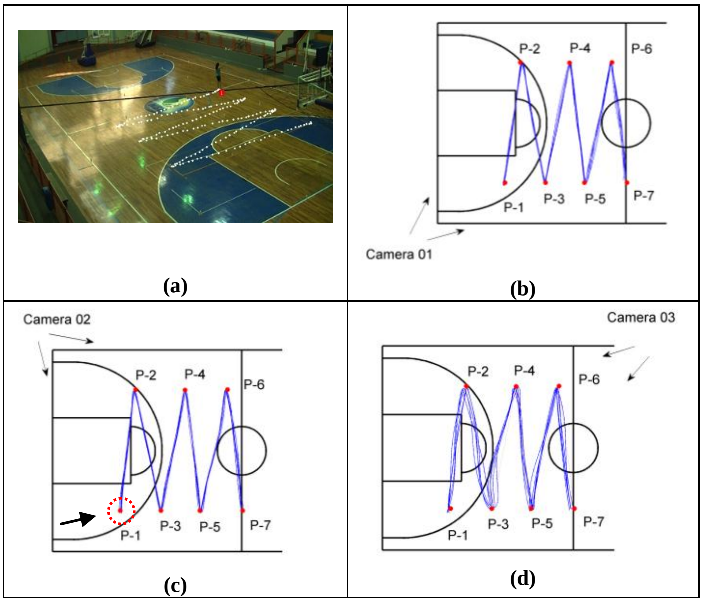

Figure 1: An image with camera 2 tracked points (a); the five smoothed trajectories of camera 1 (b), camera 2 (c), and camera 3 (d). The markers (*) in red indicate the points with known measures P_n (n=1..7).

The distance covered for each camera (mean ± std; C1: 54.4 ± 0.15 m, C2: 54.9 ± 0.3 m, C3: 54.7 ± 0.28 m) and the circuit distance (54.77 m) gives, respectively, the differences of 0.39 m, 0.25 m, and 0.19 m (mean absolute error of 0.7%, 0.46%, 0.34%). The smallest and largest values of distance covered were: a) camera C1 was 54.18 m and 54.57 m (absolute error of 1.06% and 0.36%), b) C2 camera was 54.76 m and 55.18 m (absolute error of 0.01% and 0.75%), c) camera C3 54.69 m was 55.24 m (absolute error of 0.14% and 0.86%).

The video-based methods use different principles to detect the position of the player on the court or the pitch, and these methods allow the analysis of the player movements during a game, since the players don't need to carry any sensor or device and the experimental setup doesn't interfere in the results [1,3,4,6]. In the study [2], the authors assessed the validity of several GPS devices for measuring distance, the study presented accuracy level less than 5% to three models of GPS devices for measuring of distance covered. Due to the importance of examining the accuracy of the method, the results obtained in this study (less than 1%) indicate the quality of the data and are comparable to the results presented in [1].

CONCLUSIONS

The results show the feasibility of using a set of cameras to obtain kinematic variables on the court. For this, the use of a set of calibration points coincident between the cameras allowed obtaining the trajectory representing the circuit appropriately. Thus, the analysis of a basketball game can be performed considering the mean absolute errors in the determination of distance covered for each camera that ranged from 0.34% to 0.7%.

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Table 1: Values of distance covered, the difference between the distance covered and the distance of the circuit (54.77 m), and the absolute error in each of the cameras (C1, C2 and C3) and for each jogging. The negative sign indicates that the distance covered was less than the distance of circuit.

Camera	Jogging 1 (m)	Jogging 2 (m)	Jogging 3 (m)	Jogging 4 (m)	Jogging 5 (m)	Mean
C1	54.27 (-0.50)	54.40 (-0.37)	54.18 (-0.59)	54.57 (-0.20)	54.47 (-0.30)	54.4 (0.39)
	-0.91%	-0.67%	-1.06%	-0.36%	-0.53%	0.70%
C2	54.81 (0.04)	54.76 (-0.01)	54.38(-0.39)	55.18 (0.41)	54.66(-0.11)	54.9 (0.19)
	0.08%	-0.01%	-0.71%	0.75%	-0.18%	0.34%
C3	54.69 (-0.08)	54.90 (0.13)	54.46 (-0.31)	55.24 (0.47)	55.04 (0.27)	54.7 (0.25)
	-0.14%	0.25%	-0.56%	0.86%	0.51%	0.46%