INNOVATIVE VIDEO CALIBRATION PROCEDURE USED AT ATLANTA OLYMPICS

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INTRODUCTION

The objective of this study was to develop a procedure using field dimensions and anatomical landmarks from the discus event at 1996 Atlanta Olympic Games to obtain calibration information necessary for accurate three dimensional direct linear transformation (DLT) of the video records.

METHODS

Biomechanical analysis was performed on the discus event at the Atlanta Olympics in 1996. Video cameras were placed in key positions in order to record the particular event. Video records were recorded by three video cameras of the preliminary and final Men's Discus performances at the Atlanta Olympics. Camera 1 was ldcated approximately 50 m behind the discus circle, camera 2 was 60 m from the right side of the circle, and camera 3 was situated 80 m away at a 45 deg to the left front of the circle in order to record the throwing scoreboard (see Figures 1 & 2).

All three video cameras recorded all the throws at 60 fields per second. The video pictures were grabbed from each view with Intel Smart Video Recorder Plus frame grabber and the files were stored in Audio Video Interlace format (AVI). The longest throws completed by the top four performers were selected for analysis purposes. The dimension of the circle and various other objects in the field, were used as stationary objects for the calibration points.

VIDEOGRAPHIC CALIBRATION PROCEDURES FOR DISCUS THROW

From the rear camera view, a fixed point on the end of the left hash line, the circle diameters adjacent to each of the dividing line hash marks were digitized as control points and a scaling factor was determined using the multiplier module. Then the ends of the hash marks, circle diameter, and latitudinal mid-line of the athlete were digitized. The data coordinate endpoints were then smoothed using a second order low-pass Butterworth digital filter with a 10 Hz cutoff frequency and converted to real life

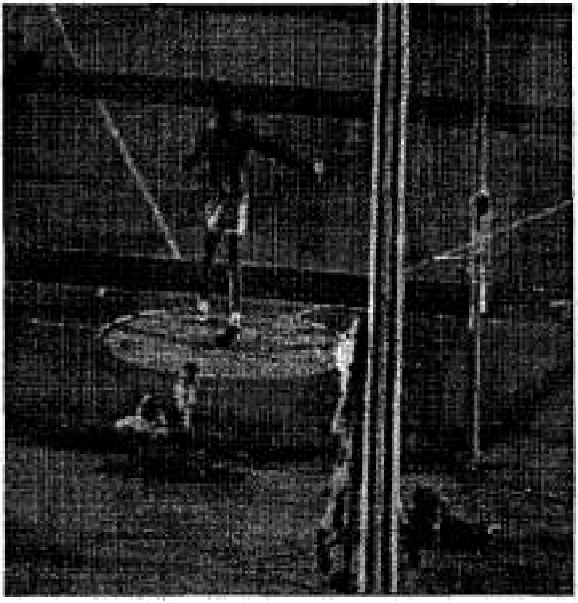

Figure 1. Camera view of discus thrower from rear position

Figure 2. Camera view of discus thrower from side position

displacements using a scaling or multiplier technique. A root mean square (RMS) error:of 2.1 cm (.8%) was found for the 250 cm latitudinal diameter dimension as determined from the rear view position using the multiplier technique.

From the side camera perspective, a fixed point on the end of the left hash line, the circle diameters at the back and front of the circle were digitized as control points, and a scaling factor was determined using the multiplier module. Then the ends of the hash marks, circle diameter, and the longitudinal mid-line of the athlete were digitized. The data coordinate endpoints were then smoothed using a second order low-pass Butterworth digital filter with a 10 Hz cutoff frequency and converted to real life displacements using a multiplier technique. The RMS error in the longitudinal circle diameter was 3.1cm (1.2%) from a distance over 90 m. The multi-staged scaling or multiplier techniques had to beutilized to obtain thex, y coordinates for the athlete's mid-line because too many of the known field measurements were coplanar which made it impossible for the 3-D direct linear transformation (DLT) algorithm to accurately determine the coordinates (Allard, Blanchi, & Aissaoui, 1995).

RESULTS

Next the athlete's standing height which was obtained from the Official Olympic Track and Field Guide (Watman, 1996) was entered into the calibration data with the x, y, coordinates of the athletes' mid-line determined from the previously discussed multiplier techniques. The inputted standing heights were: 199, 193, 197, and 188 cm for Riedel, Dubrovschchik,

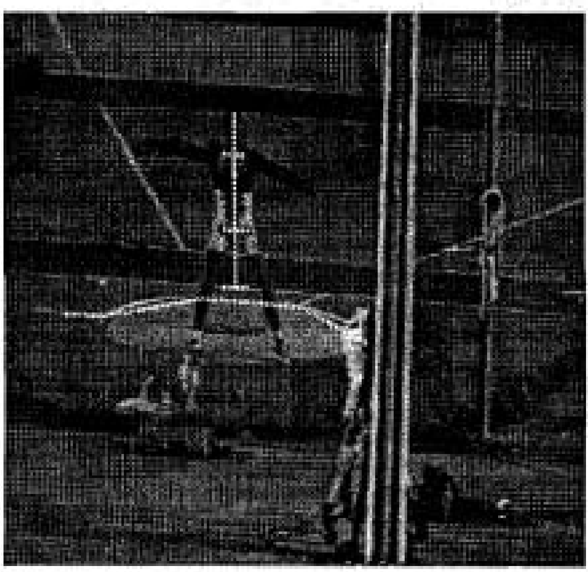

Figure 3. Composite calibration cube including field measurements and anatomical land-marks.

Kaptyukh, and Washington, respectively. When the athlete's height was multiplied by the segmental limb length ratios reported by Dempster (1955), a height for the athlete's shoulder, hip, and knee was determined. The body parameter height percentages inputted were: Head (1.00 x HT), Shoulder (.791 x HT), Hip (.487 x HT), and Knee (.253 x HT). These heights were used to create a 3-D control cube incorporating five data points on the circle (left hash, left and right circle diameter, left and right sector hash) and four mid-line body control points from the athlete (top of head, shoulder, hip, and knee) (see Figure 3).

Then 21 data points consisting of 18 anatomical data points, the disc, the right and left circle hash marks were digitized. The 18 anatomical data points inputted were: left foot (fifth metatarsal), ankle, knee, and hip; right, hip, knee, and ankle; left wrist, elbow, and shoulder; right shoulder, elbow, wrist, and hand; discus, base of the neck, mastoid process, top of the head. This composite control cube consisting of 9 points and 21 data points were digitized and entered into the three dimensional DLT module using procedures described by Abdel-Aziz & Karara (1971) and Walton (1981) to convert the image coordinates to real displacements. The real coordinate endpoints were smoothed using a 10 Hz cutoff frequency in a low-pass digital filter. The 3-D displacements of the circle diameter were compared to the actual 250 cm displacement.

This measurement procedure using the DLT algorithm was repeated 10 times for the top four discus performers in the Atlanta Olympics and the RMS error in the 250 cm diameter dimension determined for these 40 measurements was 2.8 cm (1.1%) with errors ranging from 1.6 to 3.6 cm with a subject to camera distance of over 90 m.

CONCLUSIONS

This multi-staged procedure using the multiplier technique created a 3-D cube of control points consisting of field measurements and human anthropometric measures which was non-ooplanar and nonlinear. After obtaining these calibration displacements, the DLT algorithm could be accurately utilized. This made it possible to overcome the limitation of not having a pre-determined calibration cube set in the field of view and yet, obtain accurate 3-D track and field data from the Olympics.

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