ACCURACY OF 3D POSITION PREDICTION OVER A LARGE OBJECT SPACE VOLUME USING PAN AND TILT CAMERAS

Reid Robert¹, Tjørhom Håvard¹, Moger Tron¹, Haugen Per¹, Kipp Ronald², Smith Gerald¹
(Norwegian School of Sport Sciences ¹, Norway, University of Utah ², USA)

Introduction: The study of alpine skiing kinematics in the field using the methods of close-range photogrammetry requires a large volume to be calibrated in order to capture the athlete’s motion. The purpose of this study was to assess the accuracy of a DLT-based method that allows panning, tilting, and zooming of the cameras. Based on the method described by Nachbauer et al. (1996), this method in essence consists of calibrating each image from each camera individually. To determine the types of research questions that are appropriate to examine with this method, it is essential to assess its accuracy.

Methods: Measurements were taken during a Norwegian national team slalom training session. 208 control points were placed on the slope to create a calibrated object space volume of approximately 40m x 10m x 2m, thus allowing 2 complete slalom turns to be studied. Additionally, 15 non-control points to be used for accuracy assessment (and not for calibration) were placed close to the skier’s path. Marker positions in a 3d, right-handed, orthogonal coordinate system were determined using a theodolite. The object space X, Y, and Z axes were defined to be directed across the slope, vertically, and parallel to the slope fall line, respectively. Four cameras recording at 50 Hz were positioned so as to surround the object space. Each image from each camera was calibrated individually using a minimum of 14, and an average of 29, control points. The 11 DLT constants were fit with interpolating cubic spline functions which were used in synchronizing the cameras using an adaptation of the software genlock method of Pourcelot et al. (2000). Two methods were used to assess measurement accuracy. First, position prediction of the non-control points reflects accuracy in the image calibrations as well as the manual digitization error of relatively well-marked points. However, it does not reflect error associated with manually digitizing difficult points, such as body joint centers. Nor does it reflect errors in camera synchronization since the non-control points are fixed. To assess these sources of error, predictions of forearm segment length were compared to actual measurements taken with a tape measure.

Results: Root mean square error (RMSE) for position prediction of non-control points was 10.2 mm, 5.00 mm, and 11.2 mm for the X, Y, and Z dimensions, respectively (n = 1617 predictions from 6 trials). The RMSE in predicting the forearm segment length was 14.4 mm (n = 445 predictions for 4 athletes).

Conclusions: Considering the substantial size of the calibration volume, the method is sufficiently accurate for determination of ski and skier dynamic positions for technique analysis. A disadvantage of this method is the large volume of manual digitizing that is necessary.

References:

Keywords: 3D Analysis, Accuracy/Consistency, Skiing