

A MEASURING METHOD FOR 3D-ANALYSIS OF FOOTPOSITIONS IN FIGURE SKATING

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INTRODUCTION

For the complex analysis of jumping techniques in figure skating (especially the take-off (Knoll & Hildebrand, 1995)) the investigation into the whole body movement in connection with a precise assessment of the courses of angles and amplitudes of movements in the foot area as well as exact statements on the use of edges are of essential interest (Knoll & Witt, 1994).

But our experience up to now has shown that it is not possible to deduce sufficiently exact data on footpositions from video-recordings of the whole body - because of the limited resolution. Additionally reliably determined parameters in this field are essential for the development of take-off models. Thus for investigations like those there is the inevitable necessity to restrict the picture field to the interesting part of the body - lower leg and foot - which increases the resolution of pictures in the area of interest several times. We can now exactly identify important objectpoints (Figure 1).

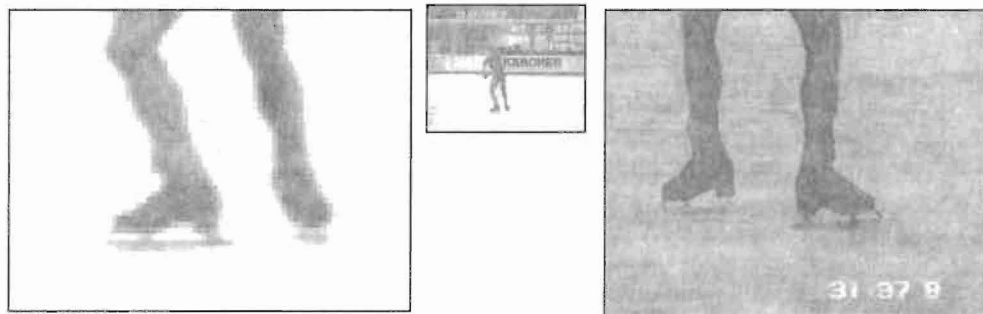


Figure 1: On the left hand side the foot area, enlarged on the basis of a whole body picture, on the right hand side the corresponding picture of the recorded details.

For such complicated recording set-ups the up to now usual evaluation strategies for quantitative analyses are insufficient. The reason is as follows:

- The space of movement is, as a rule, the whole icy surface. To track the figure skater the camera must be permanently panned, tilted as well as zoomed.
- The object-background of recorded details in figure skating has almost no additional information for conclusions concerning the actual position of optical axis and the change of focal length.

Consequently our aim was to develop approaches to evaluate such detail-recordings and to apply them in an initial application for the analysis of jumps during the 1995 European Championships in figure skating in Dortmund.

METHODS

For the determination of the courses of typical angles in the foot area using photogrammetric evaluations the spatial calibration of recording cameras is required. But the object-background of the recording area of the foot in figure skating is often only the icy surface (figure 1). In this case there are no usable informations for calibration available. Thus the determination of the current orientation of the detail-camera is only possible in that case the measuring object itself provides calibration information. This can be done using two pairs of cameras, synchronized with and to each other and a transfer of measurement cascadelly:

- The first camera-pair records, as usual, the figure skater with large format. The analysis of the whole body provides the typical biomechanical parameters (Knoll & Hildebrand, 1995) as well as the 3D-coordinates of clear-cut objectpoints in the area of the lower legs/feet.
- Now these clear-cut objectpoints serve as reference points for the photogrammetric evaluation of the camera-pair which is concentrated on recording feet. Both pairs of cameras are fixed on a tripod, panned, tilted and zoomed. Basis for the calibrations of the cameras is a calibration frame which is placed on several positions of the icy surface. The starting calibrations of all four cameras for the jump, which we will analyze, is done by photogrammetric evaluations of the recorded picture of the calibration frame being located nearby the centre of the jump.
- For the consecutive calculations we use the photogrammetric evaluation procedures presented by Drenk (1994).
- To enhance the reliability of monitored hidden points we insert the projection line of the other camera belonging to the actual point into the measurement picture. Because of the separation of the monitoring programme from the programme to calculate real co-ordinates this requires at present a multi-step procedure. Initially only the objectpoints which are well visible are digitised. As a next step the orientations for all pictures and the spatial co-ordinates of these well visible objects are calculated. Then the objectpoints which have been left out or which are badly visible are monitored. We can now insert an existing direction information of the other camera which serves as subsidiary monitoring means.
- The digitalisation and analysis is done with programmes which have been developed at the Institute for Applied Training Science Leipzig.

RESULTS

Several training sessions during the 1995 European Championship in Dortmund were recorded with this double-pair camera-configuration. The cameras stood in pairs - always one camera for the whole-recording and one for the detail-recording - at the corners at the shorter side of the ice stadium. The application of this measuring method was to be planned for complicate triple jumps which were performed during training and which we successfully had record in coordination. However, it turned out to be really complicated for us to hold the desired detailed range sharply and in large format when tracking the interested athlete, i. e. to record the pictures in such a way that the advantages of this measuring method can be used in their entirety.

For mathematical consideration of movements of the detail-cameras (pan, tilt, zoom) we introduced at least 2 clear-cut object points of the whole-recording. In

Figure 2 two such points are marked in a picture out of the recording sequence of the detailed-camera, an angle of interest and the corresponding projection line for a hidden point which was well visible for the other camera.

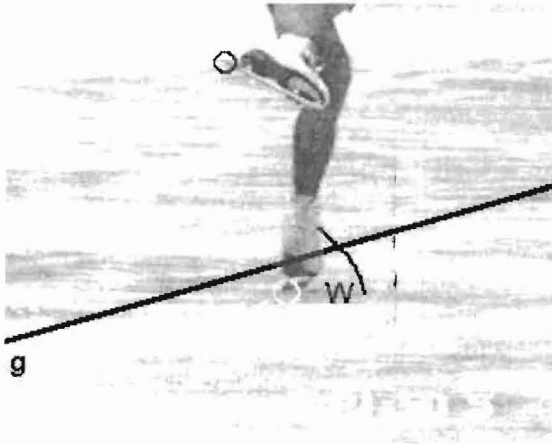


Figure 2: An example for a picture digitized from the detail-camera.

- o - reference points at whole - recording
- w - edge angle
- g - projection line of the other camera across the tiptoe which is hidden in this picture

CONCLUSION

In figure skating the assessment of footpositions is of great interest for several reasons, but when measuring them based on video recordings we were faced with considerable problems.

One of our two camera-pairs recorded the foot area. This pair was connected with a second pair of cameras that was synchronized with the first one and which recorded the usual large format. Using our methods which allows free rotation and zooming of the cameras we were able to develop a special measuring method. The exactness of these points' digitalisation which might be hidden from one camera perspective could be enhanced by inserting the direction information for that point from the other camera into the photogrammetric picture. This procedure to record and process information on complicated jumps was applied during the 1995 European Championship in Dortmund.

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