

3-D Reconstruction of 2-D Video Data

For many sport-biomechanical analyses, e.g. in Alpine skiing, the athletes have to be recorded over a **large area**. To digitize body landmarks a sufficiently large image of the athlete is necessary. Thus, one has to **follow the athlete** with the cameras and to **zoom the lenses**.

The photo on the right side shows a typical situation. The given setup was used to record data during the flight and the landing phase of ski racers in the downhill event of the 1994 Winter Olympic Games in Lillehammer. Our recordings were done **during the competition**, and hence, no markers could be put on the athletes. The calibration volume was about 8 by 6 m in the best case. Our DLT method proved to be suitable to obtain 3-D data with **reasonable accuracy**, which was **sufficient for inverse dynamics**. We used the recordings to get estimates for the ACL forces and moments during the landing phase.



Control points

(carpet stripes and tennis balls) were distributed over the slope and their coordinates determined by geodetical surveying techniques. The cameras were positioned to ensure angles between the optical axes of 30° to 150° . The movement of the skier was recorded by two high speed video cameras at a sampling rate of 180 Hz.

The method of reconstruction requires at least 6 control points visible in each frame, but the use of 10

or more control points is recommended. On the left a photo of a digitization screen, with the racer in the recovery phase of the landing, is shown. The 23 digitized landmarks as well as 8 control points are marked.

REFERENCES

- [1] W. Nachbauer, P. Kaps, B. Nigg, F. Brunner, A. Lutz, G. Obkircher, and M. Mössner, *A Video Technique for Obtaining 3-D Coordinates on Alpine Skiing*, J. Appl. Biomech. **11** 1996.
- [2] M. Mössner, P. Kaps, and W. Nachbauer, *A method for obtaining 3D data in Alpine skiing using pan and tilt cameras with zoom lenses*, Skiing Trauma and Safety: 10th Int. Symp., ASTM STP 1266 (Philadelphia) 1996.
- [3] M. Mössner, P. Kaps, and W. Nachbauer, *Smoothing the DLT-parameters for moved cameras*, XVth Congress of the Int. Soc. of Biomechanics (Jyväskylä, Finland), 1995.

The F3D Software Package

F3D is a package for **3-D reconstruction** of **2-D video data**.

Basic Features:

- Output of common used digitization systems is accepted (Motion Analysis, Peak).
- The reconstruction technique is given by the **direct linear transformation (DLT)**. In addition one may force a constraint, which should be fulfilled from physical reasons.
- Since the cameras are calibrated for every set of synchronized frames, the **cameras** may be **panned** and **tilted** and the **lenses** may be **zoomed**. Even the **locations** of the cameras may **vary** during the recording.
- The control points for calibration may change from frame to frame and may be different for each camera. This enables **large scale** reconstructions. The object and the control points for calibration may be **zoomed in** as much as possible.
- The user may apply **smoothing** to internal data, such as **calibration parameters** and **image coordinates** of the landmarks, and/or to the **3-D reconstruction**. For smoothing we offer **smoothing splines** and **wavelets**.
- **Sophisticated numerical algorithms** for error reduction and reconstruction stability are used.

Limitations:

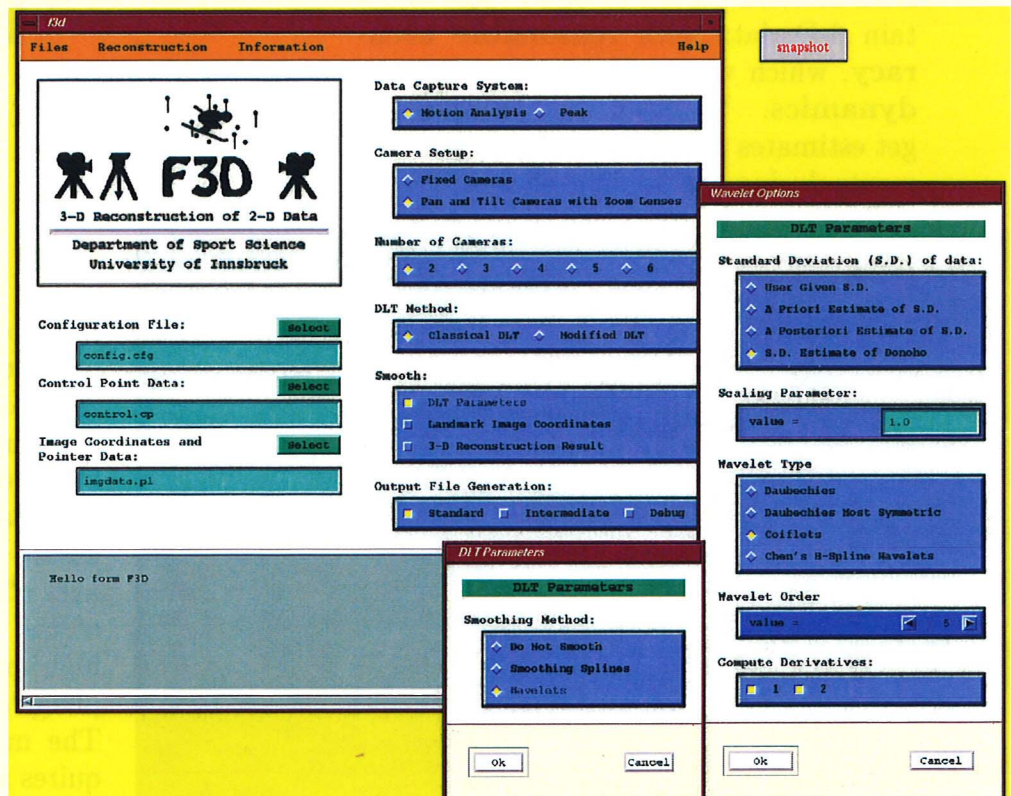
- Up to 6 cameras.
- Up to 120 control points.
- Up to 500 frames per reconstruction.
- Up to 20 control points per calibrated frame.
- Up to 40 landmarks per reconstruction.

If required, this limits may be enlarged considerably.

Package contents:

The delivery includes **binaries** for the SGI R4000 with Irix 5.2 and for the HP 9000/715 with HP-UX A.09.05. Furthermore, it contains the **documentation**, **examples**, and some useful MATLAB programs.

A **demonstration version** with full functionality, but restricted limits, is available from the authors. Further releases will probably contain versions for other Workstations and the PC. The package is distributed by ftp or as a **preinstalled version** on **CD**.



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- [1] M. Mössner, P. Kaps, and W. Nachbauer, *Instruction Manual for F3D, ver. 3.02*, Department of Sport Science, University of Innsbruck, Austria, 1995.