SHORT-TIME MEASURE OF RELEASE VELOCITY AND RELEASE ANGLE OF TRACK AND FIELD THROWING DISCIPLINES

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In the throwing disciplines of track and field sports disciplines the release velocity and the release angle are crucial factors of the throwing distance. Based on a typical three dimensional video measuring unit a method has been developed to provide these parameters within short-time as feedback information during training. With a newly developed mix-unit two synchronous video signals are composed to one signal with a shift of one half frame. Data acquisition (including live-capturing) and processing of release parameters during the final phase of the throw are realized with a specific analysis program. Feedback information can be presented within ten to twenty seconds after the throw.

KEY WORDS: videogrammetry, 3D, track and field, throwing disciplines

INTRODUCTION: In the throwing disciplines of track and field disciplines the release velocity and the release angle are crucial factors for the calculation of the potential throwing distance and therewith for the prognosis of the performance in competition (Hildebrand, 2001). During training athletes aim at high release velocity and optimal release angles. To provide effective feedback these parameters must be acquired in short time. Several procedures for the measurement of the velocity of flying objects exist. Frequently used are photo sensors and radar systems. Benefits of these technologies are the instantaneous availability of the velocity measures, but normally information about the object's spatial characteristics are not obtained and parameters such as release angles cannot be calculated. Three dimensional video measurements allow to assign the spatial characteristics of the throwing object exactly and therefore release velocities as well as release angles can be determined. Normally, this procedures need much time.

For the effectiveness of feedback training it is very important that the results of the video analysis can be presented with less time delay. On the other hand, it would be of great advantage due to comprehensible reasons if standard video equipment could be used for the three dimensional kinematic analysis. A solution that meets both requirements is introduced here.

METHODS: The basic configuration is a standard 3D-video equipment with two dubbed video cameras. A newly developed interface mixes the video signals of both cameras as follows: Each video frame consists of one field of each camera which are closed in time (even field camera 1, odd field camera 2). Figure 1 shows an example of a mixed image. Due to this data reduction the video signal can be processed by a commercial (consumer) video card or a digital video input (firewire interface). The mixing interface requires accurate synchrony and therefore

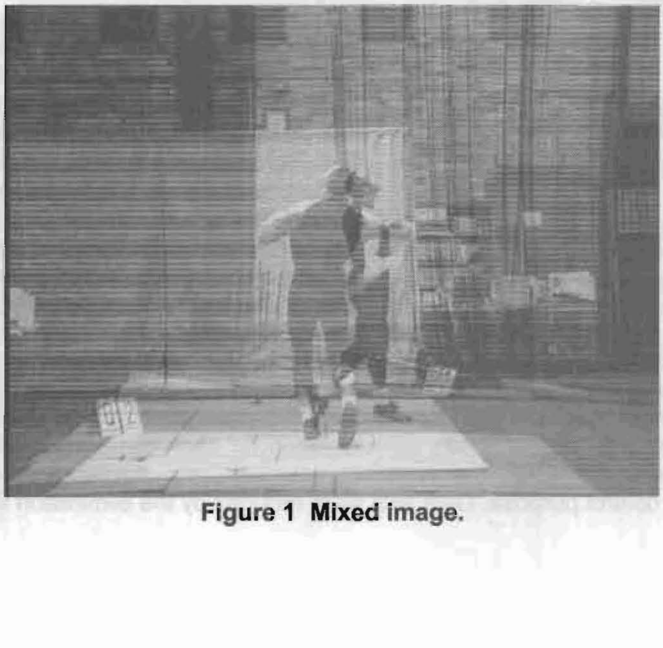

Figure 1 Mixed image.

the application of synchronizable cameras is necessary.
A specific and mostly expansive video card with two separate ports or 2 ports for digital input are not necessary. Further, all frames can be recorded separately for a complete 3D analysis. Only a few frames are required for the calculation of the release velocity and the release angle. A specific computer program has been developed, which optimizes the data processing. Main components of this program are:

- Live-capture
- 3D-calibration (DLT)
- Measure of coordinates in each field
- Inter- and extrapolation between the field rates of both cameras
- Calculation of the trajectory during the final phase of the throw and derivation of the release velocity and angle of release
- Display and storage of raw data and calculated parameters

The following aspects deserve separate considerations:

1) The video frames taken after release differ in their time shift to the accurate time of release. Time shift may be up to 2 fields (40 ms). Due to the linearity of the velocity curve, this can be neglected.
2) The real position of the measuring point is approximated by inter- and extrapolation between the coordinates acquired from the time shifted frames of both cameras. The estimated aberration should be in the range of the measurement error for video analysis (±1 pixel). This is further reasonable, because we assume a very good linear interpolation of the flight curve of the object during and after release.
3) For the full 3D-analysis velocities were calculated using a cubic spline function (Spaeth, 1973). A small weigthing factor was chosen to model the linear estimated flight curve following the release.

RESULTS AND DISCUSSION: Figure 2 and 3 show the mix-unit and a screenshot of the analysis program, respectively. The system was field-tested for discus throwing of elite athletes in Leipzig, Germany. While the discus was thrown into a net, no information of the throwing distance was available.

Figure 2 Mix-unit.

A common setup for 3D video analysis including two cameras at a rate of 50 Hz was chosen. Further, care was taken that a minimum of 4 fields after release were recorded. Spatial calibration was done before the recordings started. Video capture was started and stopped manually by the operator who acted with the support of an overlay live window. With a trackbar the field was chosen, that showed the release of the discus, and the middle of the discus was digitized in both fields. The calculated release velocity and the release angle were displayed immediately. For some trials, additional video recordings served for instantaneous visual control of the movement processing. Figure 4 shows athletes and trainer surveying the release parameters.
The accuracy of this measurement was evaluated by a detailed 3D video analysis of 6 trials. Up to 5 frames following the release of the discus were digitized for each camera. Frame coordinates, calculated space coordinates, the resultant velocities and the angles of projections were calculated for control purpose. Data sets were reduced by the elimination of

frame coordinates to achieve the same amount of information provided by the analysis of the mixed frames. The deviations between inter-, respectively extrapolated and measured coordinates didn't exceed ±1 pixel and therefore were in the range of the measurement errors for video analysis. The space coordinates resulting of measured and interpolated data, respectively, are compared in Table 1. The mean distance between space coordinates was less than 1 cm, the error of the release velo-city was less than 0.3m/s.

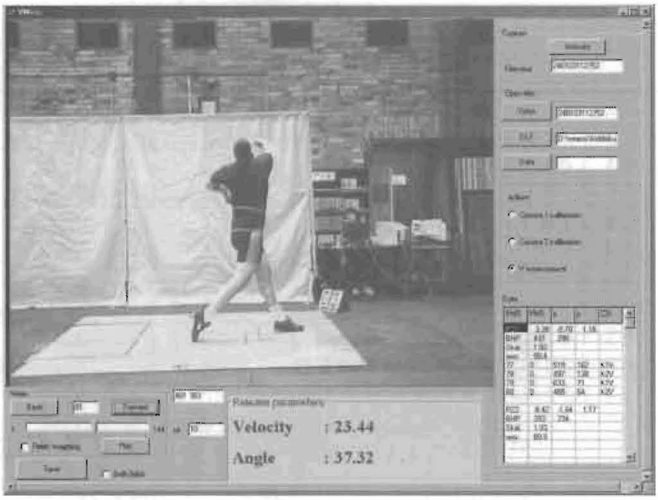

Figure 3 Screenshot of the analysis program.

Figure 4 Athletes and trainer surveying parameter.

To control the characteristics of the path velocity of the discus after release velocities at each sampling point were compared. For the complete analysis these values were approximately the same during the first 4-5 fields. Therefore we suppose that the selection of the frames as well as the frame frequency is not a critical factor. Table 1 confirms this suggestion. In Table 1, trials 1 to 3 are throws out of a standing position, whereas trials 4 to 6 were throws after full rotation. The angle between the path tangent and the ground remained constant as well during the first 4-5 fields. The differences of the angles shown in Table 1 result from slight differences of the flight curve coordinates. We consider that the mean deviations of the resultant velocities (< 0.2 m/s) and the release angles (< 0.4°) are acceptable for the purpose of feedback-training. Better results are expected if 3 instead of 2 fields are analyzed. This requires a widening of the field of view for the lateral camera. Considering time reason the additional digitizing do not seem to carry weight. The adjustment of the release frame requires most time.

Table 1 Test results.

	Trial	space coordinates of two points of the flight curve, time shift 0.4ms [m]						release Velocity [m/s]	angle of release [°]
		x	y	z	x	y	z		
full 3D	1	2.97	0.80	1.75	3.61	1.01	2.19	20.6	33.5
mix-unit		2.97	0.80	1.74	3.62	1.01	2.20	20.7	33.4
full 3D	2	2.79	0.63	1.88	3.44	0.88	2.35	21.0	33.8
mix-unit		2.80	0.63	1.88	3.45	0.88	2.36	21.1	34.5
full 3D	3	2.99	0.58	1.98	3.69	0.78	2.40	20.7	29.6
mix-unit		2.99	0.58	1.98	3.69	0.78	2.40	20.9	30.4
full 3D	4	2.22	0.56	1.72	2.91	0.78	2.28	22.9	37.0
mix-unit		2.22	0.56	1.72	2.91	0.78	2.27	22.9	37.0
full 3D	5	2.45	0.63	1.87	3.07	0.97	2.43	22.9	37.3
mix-unit		2.45	0.63	1.88	3.07	0.97	2.43	22.8	37.4
full 3D	6	2.71	0.25	2.02	3.45	0.32	2.52	22.3	33.4
mix-unit		2.71	0.25	2.02	3.44	0.32	2.51	22.0	33.8

CONCLUSION: In order to reaching great throwing distance in track and field throwing disciplines a high release velocity and an optimal release angle are required. To provide these parameters in short-time and efficiently for the use in training was the aim of the development present here. Video signals coming from a standard 3D-video technique were reduced with a special mix-unit. With a specific computer program two frames of each camera were analyzed. After at most 20 s the release parameters were provided as feedback information. In following studies feedback system will be applied on javelin throwing.

REFERENCES:

Hildebrand, F. (2001). Modelling of Discus Flight. In J. R. Blackwell (Ed.), *Proceedings of Oral Sessions of the ISBS Symposium* (p.371-374). San Francisco: Exercise & Sport Science Department.

Spaeth,Helmuth (1973). Algorithmen für elementare Ausgleichsmodelle. Verfahren der Datenverarbeitung. R.Oldenbourg Verlag München. Wien.