FIELD TRIAL OF THE LAVEG LASER DIODE SYSTEM FOR KINEMATIC ANALYSIS IN VARIOUS KINDS OF SPORTS

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INTRODUCTION

The newly developed laser diode system LAVEG (LAser VElocity Guard - JENOPTIK Technologie GmbH, Jena) opens up new prospects of carrying out kinematic analysis of one-dimensional acceleration phases in various kinds of sports. The distance-time and velocity-time functions of interest as well as individual kinematic parameters of a motion are recorded in ON-LINE mode and thus, they are immediately available to trainer and sportsman as instantaneous information. Contrary to ultrasonic techniques, it is not necessary to carry along a transmitterlreceivcr attached to the sportsman/device. The total amount of the metrological requirements involved is considerably reduced compared to video or film analyzing techniques.

The purpose of the present study was to verify the accuracy of this new measurement system and to carry out its life test.

The specific advantage of the LAVEG system consists in the fact that measurement accuracy does not depend on the distance between measurement object and measurement device. With respect to velocity measurement the accuracy of the technique can be indicated with 0.1 to 0.2 m/s in a range of up to 10 mls. Opposed to the ultra-precise pulsed light photogrammetry (the experiments were conducted at a frequency of 140 Hz) our LAVEG nicasurement results (50 Hz) showed a very high degree of correspondence (<2%). First extensive tests made in luge and bobsledge sport as well as in athletics for analyzing sprint and jump disciplines reveal the enlarged possibilities and capabilities of this measurement system.

METHODOLOGY

For detailed information on optical design and measurement principle of the laser diode system (laser semiconductor diode = 904 nm, beam diameter = 3 mrad) please refer to Schmalz/Türk-Noack 1993.

In principle, we distinguish between to basic measurement setups as regards the analysis of nicasured data (data interpretation):

a) measurements with fixed (non moving) sighting channel (sighting optics)
b) measurements of moving objects performed in the manual tracking mode of the sighting optics.

For checking the accuracy of the LAVEG measurement system it was necessary to lay the foundations allowing our measurement system to be compared with other techniques. Consequently we prefered measurements with fixed sighting channel. (Measurements of moving objects performed in the manual tracking mode of the sighting optics, as for instance in sprint disciplines, did not meet these requirements.) A specific training device used in luge sports complies with the conditions required, as on the one hand an exact translational motion is executed (roller sledge on rails) and on the other hand it is possible to sight and measure fixed reflectors attached to the above-mentioned training device.

To satisfy the requirements placed on comparative measurements, it was necessary to have available a measurement technique standing up to the accuracy test of the LAVEG. The high-precision pulsed light photogrammetry (IFG) (Gutewort/Blumentritt 1978) presents such a system which is appropriate for our purposes.

The test setup, as depicted in Fig. 1, shows both measurement techniques simultaneously utilized for velocity measurements. The laser beam is deflected by a reflector attached to the back of the sledge especially for this purpose, while at the same time a glow lamp (140 Hz) was mounted to the device in order to record the light pulses on a photoplate by means of a specific photogrammetric camera (UMK 10/1318 - CARL ZEISS JENA).

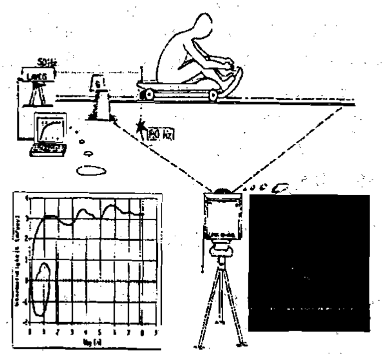

Fig.1: Test setup for testing the accuracy of the LAVEG measurement system

31 measurements were taken. The measured data were edited using mathematical-statistical procedures (smooting method: cubic spline functions). Both measurement techniques were compared at the first local maximum of the v-t function (Fig. 2).

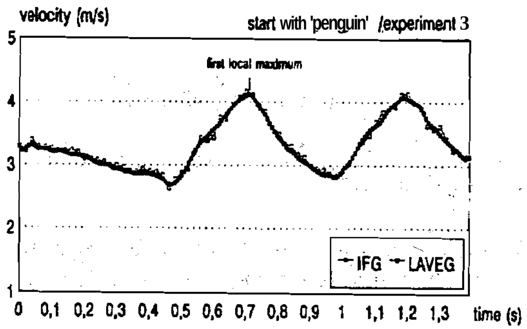

Fig.2: Comparison of measurement series obtained with LAVEG and IFG

The kinematic velocity-time functions of the drawing were plotted on the basis of both measurement techniques and characterize the accelerative impact on both sides during the start phase, the so-called "penguin".

RESULTS AND DISCUSSION

The results of the investigation demonstrate the high degree of correspondence of both measurement techniques (Fig. 2). Table 1 presents an example for the comparative results obtained with both systems, the LAVEG and the IFG.

	LAVEG	IFG	DifferenceLAVEG / IFG deviation (%)
$v_{MAX/31}$ (m/s)	3.89	3.88	1.59**
min/max_{31} (m/s)	3.5514.22	3.5714.16	

Table 1: Characteristic values of the analyzed motion, registered with LAVEG and IFG $v_{MAX/31}$: mean value of the first local maximum of the horizontal velocity (31 experiments); **min/max31:** minimum and maximum value of the first local maximum of the horizontal velocity; **: significance p=0.01)

In the velocity range from 3.55 m/s to 4.22 m/s the measured values show an average percental'deviation of < 2 %. Significant differences of the test series were not identified. Under standardized condition an average velocity error of < 2% should be taaken into account when using a fixed sighting optics.

The comparison of LAVEG measurements performed with the sighting optics in a manual tracking mode (Fig. 3), to normal light barrier systems shows identical values in a small tolerance range measured during the long jump take-off phase on standard distances of 11m - 6m and 6m - 1m away from the take-off board. As a result of 116 comparative measurements a linear correlation coefficient off 0.99 was determined concerning the time scale measured in a velocity range from 6.4 m/s to 9.1 m/s. A significant difference of both measurement series was not observed (significance p=0.05).

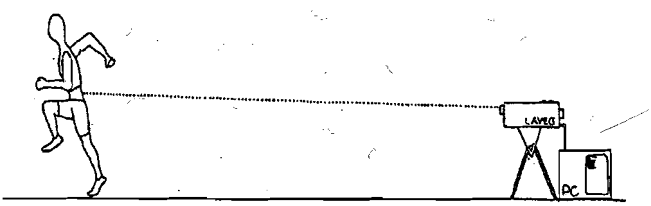

Fig.3: LAVEG velocity measurement carried out during the run-up phase to execute a horizontal athletic jump (measurement with sighting optics operated in a tracking mode)

Similar measurements were performed during the start phase in bobsledge sports where in a velocity range above 10 m/s the results obtained were on a level to those which were achieved with light barrier systems (deviation between both measurement series < 1 %).

Existing systems which can be also classified as kinematic ones (ultrasonic systems and others more, Liebscher 1987) and give evidence of their velocity characteristic (behaviour) do not always convince us in their technical parameters, especially as regards accuracy performance. In practical application this is aggravated by the fact that the reliability of ultrasonic systems falls off as much as the distance to be measured increases (Sanderson et al. 1991, Pratt et al. 1991). In comparison with ultrasonic measurements it can be assumed that the deviations of LAVEG measurements remain controllable even for higher velocities.

Above 10 m/s the scanning time of 50 Hz imposes a limit, especially in that case when high accelerations appear. With continious v-t functions accuracy performance is quite sufficent even for higher velocity levels.

Summing up this study one can point out that the LAVEG laser diode system provides substantially enlarged possibilities for motion analysis during sports events. while allowing a more differentiated approach to all types of movement which may be an integral part of any program. Training support can thus be claimed as one of the key benefits offered by LAVEG. This measurement system featuring the following aspects:

- instantaneous training-supporting information available at the training site
- uncomplicated technical handling of the measurement device
- practise-relevant application software exactly tailored to costomer requirements.

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