3-D VIDEO TECHNIQUE FOR ANALYSIS OF ROWING IN A NATURAL ENVIRONMENT

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INTRODUCTION: The dominant methods for biomechanical analyses of rowing are the use of a) measuring vessels to determine the forces on the oar and the board on which the feet are supported and b) video analysis to deduce split times for a race. Using theses procedures it is not possible to gain information on body movements which are of special interest in team boats. There is a paucity of research literature related to this problem. The purpose of this study was to develop video procedures and equipment which make possible the full-format recording of spacious rowing cycles by solving complicated calibration problems.

METHODS AND PROCEDURES: Two new approaches were used to solve the problem of acquiring 3D kinematic information on rowing in a natural environment. Both solutions focus on the large scale monitoring of several stroke cycles and consequently on carrying along the cameras onboard.
The first solution was focused on recording during competitions. Two video cameras with freely chosen positions on the banks were panned, tilted and zoomed when recording the boat. The positions of representative buoys and the camera positions were measured. (We used the electronic total station GTS 213 by Topcon.) From a picture similar to Figure 1 the camera orientations were calculated employing the known camera positions. The further calculations were carried out with the algorithms described by Drenk (1994). The buoys in the measuring picture were employed as additional control points.

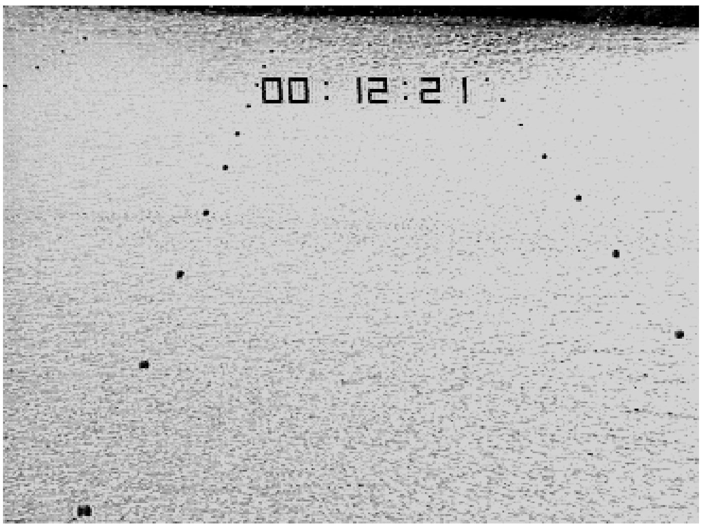


Fig. 1: View of the regatta course Duisburg shot with the mea-suring camera

This solution presupposes:

1. A symmetric frame of buoys positions to reduce the measuring effort. Only selected buoys on the edge are measured, the remaining positions are interpolated.
2. A stable position of the buoys during the recordings to guarantee exact measurements. Evaluation 3 and more buoy positions adjust inevitable errors caused by buoy movements in any frame.

The advantage of this solution is the absolute spatial relation, making the calculation of the course of the vessel's speed possible.

Disadvantages are:

1. The required geodetic measurements. To disclaim these measurements would only be possible if the buoys frame exactly followed by cm the race regulations. Our experience is still insufficient in this respect. This would allow us to calculate camera orientation based on two panned recordings of the plain frame of control points (buoys frame).
2. The camera positions have to simultaneously fulfill several conditions:
   - good angle of intersection of the optical axes
   - full-format recording of the boat and several buoys despite zooming.

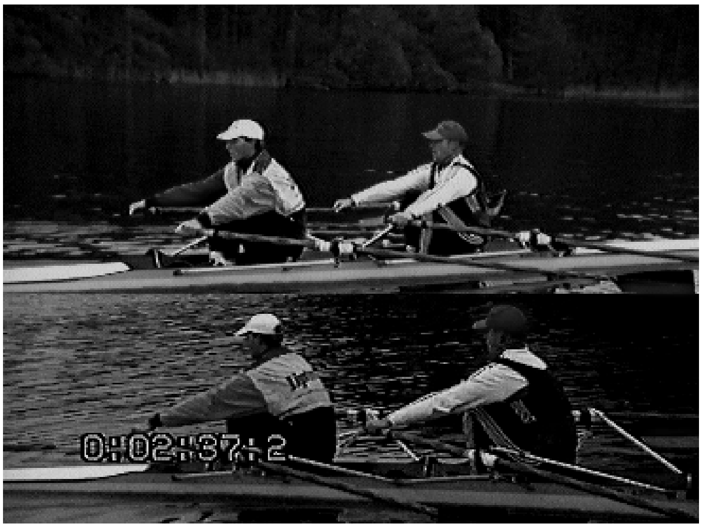
To fulfill these conditions requires good preparation of the recordings.

A second solution focused on the training environment using recordings of two video cameras on a catamaran. On the vessel the cameras have positions as far as possible from each other (to have a good angle of intersection of the optical axes) and are firmly attached to the vessel - and even constant in their adjustment (Fig. 2).

Fig. 2: Catamaran for 3D measurements

The optical axes of the cameras are chosen in such a way that both perspectives can be mixed horizontally (Figure 3). This makes the recordings and measurements much easier. The boatsman on the catamaran chooses the distance to the rowing boats to obtain a predetermined ideal position. This requires a certain routine and is supported by a control screen for the boatsman.

Fig.3: Photogrammetric picture - recordings of both cameras mixed



Calibration for this procedures is only done once, using a solid calibration frame on the bank with the same arrangement of the cameras.

Figure 4 shows the functional block diagram of the measuring devices.

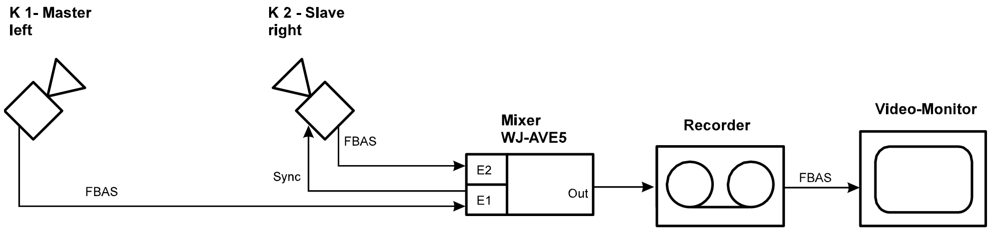


Fig. 4: Functional block diagram of the measuring system

The advantages of the solution are the standardized recording conditions and, compared with the first solution, the easier data analysis.
The disadvantage is that no results on absolute movements can be gained.

RESULTS AND DISCUSSION: Data analysis is done with a Screen Machine or AV-Master (FAST AG) and a simultaneous evaluation of both perspectives with the updated programs - the ones which were quoted by Drenk (1996). Simulation calculations showed that the catamaran with a length of 10 m and a beam of 2 m does not start to vibrate with the waves' movements. Tests on Ratzeburg Lake confirmed this finding. But the drive motor caused vibrations of the superstructures of about 5 Hz, which again caused interfered vibrations of the real co-ordinates. The vibrations were digitally filtered from the original data. The analyzing programs employed have been developed by us. They made it possible to evaluate the synchronization of body movements for team boats in natural environments.

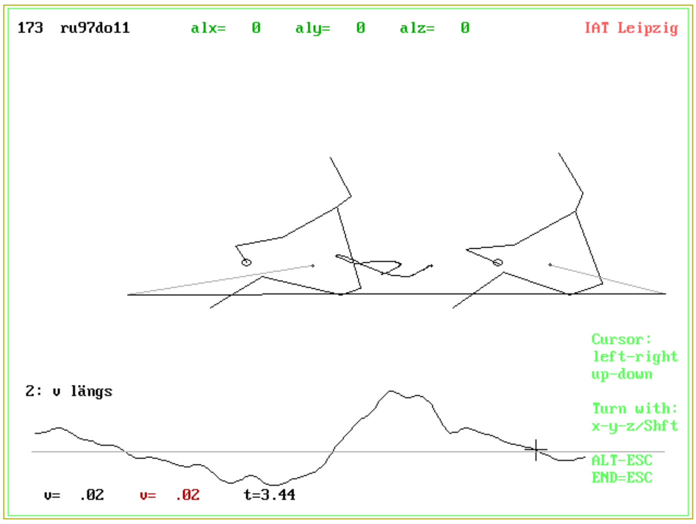


Fig. 5: Presentation of computer animation with the spatial course of the common center of gravity (center of image) and its speed variations (lower part)

Sometimes unexpected distinct transverse movements of the boat during the rowing cycle were monitored. As usual, body angles and their temporal course, as well as the impulse transformation onto the boat, could be calculated.

CONCLUSIONS: Movement analyses in rowing in a natural environment could be performed successfully using new calibration and recording procedures. The analysis of video recordings became much simpler, since the recordings of both cameras could be analyzed simultaneously. We developed 2 solutions. The first solution was focused on cameras on the banks, which panned, tilted and zoomed when recording the boat. This solution is going through a test phase. For the second solution - cameras on a catamaran - we have first results of interest. Inclinations of the boat line up to 16° relative to the direct line were found. These were caused by minimal asymmetrical rowing motions.

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