PERVASIVE COMPUTING TO ENHANCE SPORT PERFORMANCE

Arnold Baca and Philipp Kornfeind
Section of Biomechanics, Kinesiology and Applied Computer Science, Faculty of Sport Science, University of Vienna, Austria

The integration of modern sensor-, information- and communication technologies provides new means for developing systems to acquire data in training and competition. Various sensors and devices are incorporated into the sport equipment or attached to the athlete. Mobile computers acquire and present the data recorded, other systems use telemetric methods to transmit the data acquired to receiving stations, which then process and adequately present them. Portable devices, which are not bound to laboratory conditions are particularly useful. Systems of that kind have been developed for table tennis and rowing. In the example of table tennis a microcontroller based solution for analysing service techniques is presented. In the case of rowing the system was developed for giving feedback both during on water and ergometer rowing.

KEY WORDS: table tennis, rowing, feedback, knowledge of results, knowledge of performance

INTRODUCTION: Effective means to improve sport performance in elite sport are provided by the integrated application of modern information and communication technologies. Computer scientists and engineers cooperate with biomechanists, physiologists and sport psychologists and interdisciplinary develop systems, which provide coaches and athletes with innovative and most efficient support as they identify and analyze performance indicators (Broker and Crawley, 2001). Time for technique improvement can be reduced by appropriate feedback systems. Augmented feedback (Knowledge of Results – KR, Knowledge of Performance – KP) may improve sport performance significantly (Schmidt and Lee, 1999).
Tools and methods are required, which are specially oriented on the motion task to be performed (Liebermann et al., 2002). Powerful technology is applied to develop systems, which provide athletes objectively with supplementary information rapidly or immediately according to Farfel's principle (Farfel, 1977). One main issue of systems of that kind is to acquire and present data for judging, qualifying and quantifying sport techniques.
To be well accepted in practice the ease of application, the usability and the transportability of the devices applied is of specific importance. Systems are required, which may easily be made available in training, especially in non laboratory conditions. Products of that kind will become more and more pervasive in the training environment. This will be illustrated by the following examples from table tennis and rowing.

METHODS:
Table tennis: A system was developed for quantifying the speed of service techniques. The time interval between first and second impact of the ball on the table is determined and displayed immediately after service execution. In the case of short services, the device also computes and presents the time interval between the second and the third impact. Two microphones are used for recording the signals caused by the ball impact. Both are fixed in metallic boxes. The boxes are put onto both halves of the table. The signals captured by the microphones are electronically preprocessed and then fed to a low-cost microcontroller (PIC16F628), which is also connected to the serial port of a PC, laptop or PDA (Figure 1). A LabVIEW® 6.1 program acquires the data from the serial port and displays the results (Figure 1). The overall system is not bound to a specific table tennis table and can easily be transported to the environment (table, hall, etc.), where it is used.

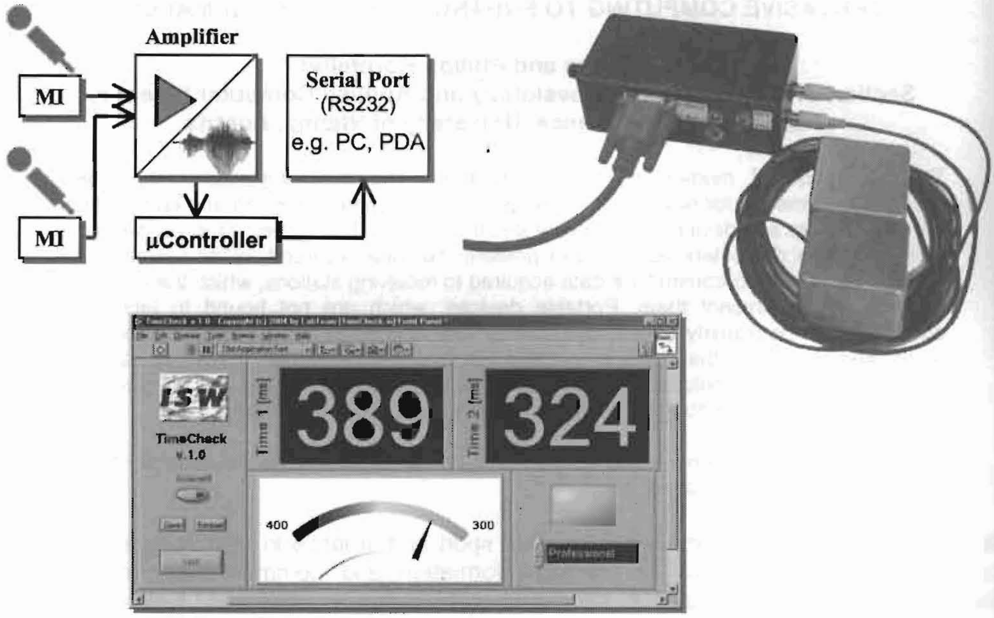

Figure 1 Ball impact time interval detection system. Upper left: Block diagram of the measuring system. Upper right: Photo of the system. Lower: Graphical user interface (times between first and second impact as well as between second and third impact are displayed after a short table tennis serve).

The system works fully automatic. No user intervention is required between successive serves. Surrounding noise is filtered electronically so that the impact signals are hardly distorted.

Rowing: Technique analysis in rowing involves the consideration of fine details of the movement of the rower with regard to the boat. In addition to kinematic analyses the study of the kinetics of the boat-rower system provides valuable insights into strengths and weaknesses (e.g. peculiarities in motion coupling) of the rowers investigated (Spinks and Smith, 1994; Baudouin and Hawkins, 2004). Feedback systems incorporated directly in the boat are used in elite rowing (Smith and Loschner, 2002). Developments towards an integrated application of information and communication technologies can be observed. Broker and Crawley (2001), for example, report on a system that measures oar bending and oar position of four rowers simultaneously as well as boat velocity. Data are processed on-board and transmitted to a receiver located on the coach's launch. Particularly useful in this area are systems based on standard mobile electronic devices, such as that proposed by Collins and Anderson (2004), who couple a PDA with inbuilt Wi-Fi capabilities and a data acquisition card within an expansion box. The PDA captures the data from sensors mounted on the rowing boat and transmits it to a laptop, which processes and displays it.

Analyses of the rowing technique in the boat are difficult to realize and are very demanding in time and instrumentation. In many cases analyses are therefore based on rowing simulators (rowing ergometers) on land (e. g. Page and Hawkins, 2003). In order not to draw wrong conclusions from the training sessions on land it is essential to compare the rowers' technique in the boat to that on the ergometer.

A specific setup has been developed for this purpose. Units for measuring reaction forces in the foot stretcher (Figure 2) in two dimensions have been constructed. They record reaction forces at both feet separately and may be used in the boat as well as on the rowing ergometer (Concept II®) with or without slides (a construction that is attached to the legs of the ergometer, allowing the ergometer to roll back and forth during the rowing stroke). The construction is based on load cells (HBM, type HLC220) and strain gauges (HBM, type 6/120XY91). The (portable) units may easily be attached to the foot stretcher of the boat or of the ergometer (Figure 2). Their accuracy has been shown by putting the ergometer on two (Kistler, type 9281C) force plates and comparing the horizontal reaction forces measured or determined with both systems.

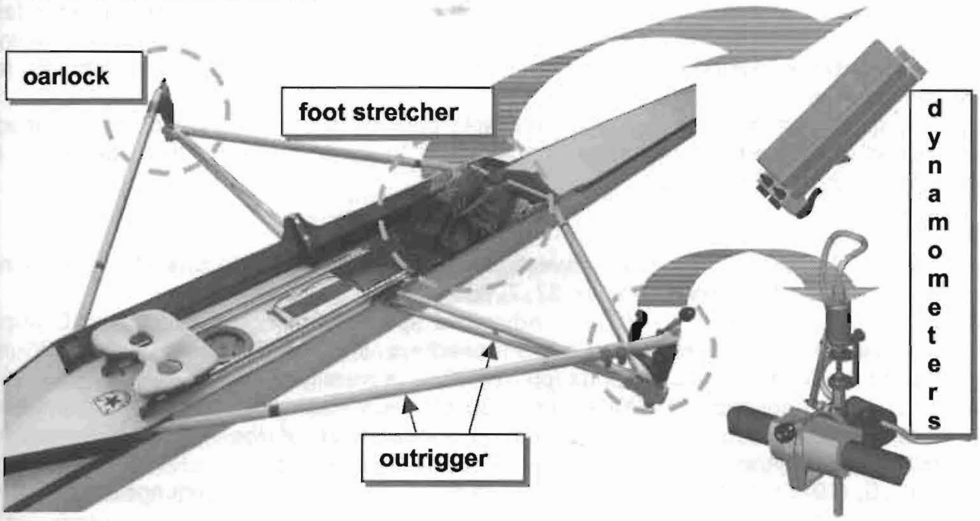

Figure 2 Measuring the dynamics in rowing. The dynamometer for measuring reaction forces may either be attached to the foot stretcher in the boat (depicted here) or to that of the ergometer. To measure pulling forces, a pair of dynamometric oarlocks is attached to the outriggers.

In addition to the reaction forces the pulling forces also allow to draw conclusions on the rowing technique. In the case of ergometer measurements we connect a force transducer (HBM, U9B) to the chain attached at the handle. In the boat, dynamometric oarlocks are used for this purpose. Data measured in the boat are recorded using a data logger (Weba Sport, RowExpert).

RESULTS AND DISCUSSION: Both systems were successfully applied to give feedback to coaches and athletes.
The system developed for table tennis is used to give feedback on the quality of different service techniques. Because of its transportability it can easily be set up at different locations. One typical task to be performed by the players is to serve long and diagonal and to achieve impact time intervals, which are as short as possible, thus reducing the time for the opponent to react properly. It is obvious that this time interval is strongly affected by the degree of spin of the serviced ball. A kind of competition situation can be observed when youth table tennis players use the system for training.
In the case of ergometer rowing knowledge-of-performance feedback is given to the athletes on the quality of their technique. For this purpose, the time histories of the relevant kinetic parameters are displayed on a monitor in view of the rowers during motion execution. The rowers are thereby able to discover how changes in the movement pattern altered the shape of the curves. In addition, a series of successive strokes can be evaluated. In this case the results are presented in the form of summative feedback. A variant of the feedback system for use in the boat is under development. We intend to integrate wireless technologies following the proposal of Collins and Anderson (2004) allowing to transmit the data recorded to the coach offering the possibility to view the information in real time.

CONCLUSION: Real time and rapid feedback systems as well as sophisticated systems for collecting and analysing sports-specific data provide innovative and effective support to coaches and athletes. Powerful IT-tools and wireless technology facilitate the development of user-friendly systems, which are specifically oriented towards their needs. It is of central importance for the success of systems of that kind that the characteristics to be improved are measured exactly and that the results can be made available to coaches and athletes fast and comprehensible. The latter aspect implies that special care has to be taken in the design of the presentation component of the system. A graphical visualisation form should, for example, be preferred.

If these aspects are considered, novel and rapid performance measurement and feedback tools based on modern information technology will become more and more pervasive in everyday training.

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