PHOTOGRAFMETRIC SYSTEM FOR MOVEMENT ANALYSIS IN TEAM SPORTS

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This work develops a system based on photogrammetric methodologies; such system enables us to analyse the movements of the player in team sports such as soccer, indoor soccer, handball, basketball, etc. It can also be used in individual sports such as tennis with the same aim of quantifying player’s movements. This system, called “RUNNER”, can quantify player movements, by obtaining several kinematic parameters useful for deducing the physical loads on the players in real conditions. In this work we present some results obtained from soccer and indoor soccer studies.

KEY WORDS: photogrammetry, team sports, methodology, kinematics, work load.

INTRODUCTION: This work develops a system based on photogrammetric methodologies; it enables us to analyse the movements of the player in team sports such as soccer, indoor soccer, handball, basketball, etc. It can also be used in individual sports such as tennis with the same aim of quantifying player’s movements. The work area of sport biomechanics researchers has traditionally been focused on those sport events in which kinematic parameters are specially relevant for performance and the prevention of risk factors which may cause injuries. As a result, other research lines focused on team sports are not usual, particularly since collective interaction is considered more important that kinematic factors in team sports. The difficulty in the biomechanical analysis of team sports is the traditional photogrammetric methodologies of sport biomechanics because are commonly used in reduced spaces, due to the problem of developing big reference systems and other problems associated to the usual algorithms of three-dimensional reconstruction. Another difficulty is the long time intervals that have to be analysed in these sports, making the usual frame by frame methodology in the digitising process, virtually impossible in these cases. In this sense, traditional photogrammetric methodologies cannot be used for analysing the movement of players in team sports over long intervals of time, and other methodologies are not commonly available at present. Similar methodologies have been made in other works (Riera & Aguado, 1989; Winkler, 1991; Hernández, 1991; Ohashi et al., 1993). The accurate quantification of a player’s movement in field conditions enables us to obtain knowledge relevant for deducing the physical loads to which the player is subject. This knowledge is particularly relevant to specialists involved in the training work area, since with this information they can programme training loads more precisely, using analysis of the player’s movements and velocity. The main aim of this work is the development of a photogrammetric system that allows us to analyse team sport movements in real conditions. This system, called “RUNNER”, can quantify the player’s movements, obtaining several kinematic parameters useful for deducing the physical loads on the players in real conditions. Individual sports such as tennis can also be analysed with this system.

METHODS: For the development of this work we have adapted the traditional 2D photogrammetric methodology, creating a software called “RUNNER” (version 1.0). It has been used to analyse some different team sports such as soccer and indoor soccer. The methodology is based on a sequential process in which different phases are applied, starting with the filming. We used video recording in S-VHS format (PANASONIC MS-5 cameras), locating one or two cameras from above the pitch, in positions as elevated as possible, to try to minimize the perspective deformation that would later be eliminated in the computerizing process. The filming area contained the field area that the researcher wanted to analyse. The reference system is defined from the dimensions of the playing area. For big spatial areas 2 cameras are recommended, each of them focused on different playing areas. After filming, the computerizing process in pc-platform running Microsoft Windows operating system begins, using different modules included in “RUNNER” software. Each player is digitised in real time using an specific module that works using the cursor of a digitising table (a mouse can also be used, but the digitising table is more accurate). The geometric centre of the
support base (mid-point between both feet) is used to follow the player’s movements. The
user of digitising module must be intensely trained to be able to achieve the necessary
precision in digitising. Periodically, the possibility of estimation errors in the digitising process
must be tested because of the difficulty of real time digitising; that is why we developed a
methodology to estimate errors in which the user must digitise a well-known indoor soccer
player movement of 1000 meters of displacement during an interval of 10 minutes. We can
validate the data comparing the real motion with the estimation obtained with the software
(differences lower than 2% should be enough accurate). The researcher can choose different
intervals of recording frequency with the cursor (between 50 Hz and 1 Hz). From our pilot
studies, we recommended 4 Hz for soccer and indoor soccer, since that provides enough
accuracy in the kinematic analysis of the player’s movements and greater frequencies do not
give more precision in those sports. Afterwards, the position of the player throughout the
match is smoothed using digital filters (Figure 1), reconstructed using trigonometrical
algorithms for removing perspective deformation, and in that cases we used two
simultaneous cameras, temporal synchronization being applied for the different views
recorded by each camera. The perspective error is removed using trigonometrical and
vectorial algorithms based on the detection of the four angles of each corner of the playing
area.

Figure 1. Smoothing process using RUNNER v.1.0 analysing indoor soccer.

At the end of the computerizing process, different numerical (kinematic parameters) and
graphic results are obtained. "RUNNER" software calculates and evaluates in depth the
movements of the players using different possibilities as shown in detail in the results
section. Basically, these results are based on different temporal analyses, calculation of
distances, instantaneous velocity and acceleration in each position, work loads deduced from
the time acceleration curve, analysis of spatial areas most used during the game, trajectories, etc. At the present time, in our laboratory, different projects using this
methodology are being developed, one in soccer and the other in indoor soccer. The latter
develops the analysis of players in professional teams of the Spanish league at different
moments of the competitive season (3 matches, analysing all the players). The soccer
project is focused on semi-professional players in the Spanish league, analysing some
specific positions. In both cases players are filmed in real conditions during official matches,
with the main aim of deducing the real kinematic behaviour of players during competition. For
better understanding of the movements, the curve of the velocity during the time is analysed,
deducing from it different types of behaviour (figure 2):

- Rest: interval of time without movement (player on the bench, or in static position).
- Walking: interval of time or effort where peak of velocity is less than 1 m/s.
- Slow running: interval of time or effort where peak of velocity is less than 3 m/s
- Medium running: interval of time or effort where peak of velocity is less than 5 m/s.
- Fast running: interval of time or effort where peak of velocity is less than 7 m/s.
- Sprinting: interval of time or effort where peak of velocity is higher than 7 m/s.

Using this classification we developed all the statistic processes for analysing movements.

RESULTS: in order to validate our results we applied the methodology (previously exposed
in Method chapter), at the beginning and ending of digitising the estimation errors were of
1.89% and 1.92%. In the following figures some of the kinematical and graphic results obtained using our methodology in the two projects (soccer and indoor soccer) are set out. In both cases the analysis obtained in one half of the match is given. More detailed analysis can be obtained by contacting the author using e-mail.

**Figure 2.** Analysis of the velocity of indoor soccer player during two minutes. In black: static-walking-slow running, yellow: medium running, pink: fast running, red: sprinting. Horizontal axis represents time (minutes). Vertical axis represents velocity (m/s).

Figures 3, 4, 5, 6 and 7 show some calculations made during one half of a match in indoor soccer. Figure 3 gives the interval of time used by each player. The analysis of the velocity of one player throughout the time is set out in figure 4, different kind of efforts made by the player in different colours are exposed. Figure 5 and 6 present the descriptive statistics of the temporal and spatial analysis of all the players. Figure 7 summarises the efforts made by the players, describing the work loads in training terms. Figure 8 draws areas most frequently used by all the players during the match, and by one individual player.

**Figure 3.** Temporal analysis of 7 players in one indoor soccer match (half).

**Figure 4.** Analysis of the velocity of one indoor soccer player during a half match.

**DISCUSSION:** The methodology proposed in this work, using RUNNER v.1.0, enables the movements of team sport players in real playing conditions to be quantified and described, using non-invasive indirect techniques, without affecting the normal behaviour of players during competition. For an accurate estimation of the calculations, the process of digitising must be developed by experts with enough training in this skill, using accurate
methodologies for controlling the possible errors introduced in this phase of the process. We consider this system very useful in any kind of team sport and individual sport.

In order to improve the possibilities of this system and make it more useful it would be interesting to synchronise this methodology with other parameters such as heart frequency (using cardiometers). In future work lines for improving the system, real time digitisation technologies that can substitute the manual process, should be developed. At this present moment some technological developments exist, but they are expensive or useful only in laboratory. Algorithms of artificial recognition will help more than the use of sensors in the player’s body.

REFERENCES: