Filming fast sports movements and problems associated with it

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Abstract

Objective of the study was to justify the possibilities and problems of using modern light-recording equipment for recording fast sports movements.

Methods and structure of the study. Recommendations for the appropriate use of the wide technical capabilities of modern light-recording equipment in solving current pedagogical problems of sports are considered.

Results and conclusions. The most difficult to distinguish and poorly eliminated geometric distortions of images of fast sports movements require special control and subsequent correction due to a possible decrease in the quality of assessment of motor actions during the judging process. Such distortions, which are a technical defect in filming, can be assessed by a coach or athlete as an imperfection in motor action. A possible violation of the geometry and shapes of the images negatively affects the work of the coach, who, guided by «distorted» factual information when analyzing the video recording, cannot objectively evaluate either the aesthetics or the sports technique of performing a fast motor action, which interferes with the formation of pedagogical recommendations. A possible sequence of practical actions is shown to obtain high-quality visual information of sporting events using equipment of various classes.

Keywords: *minimization of geometric distortions, optimization of the trainer's work, light registration, fast process.*

Introduction. One of the modern trends in many sports is to increase the speed of performing various motor actions. The information obtained during speed control is sometimes invaluable for coaches and allows them to significantly increase the effectiveness of athletes training.

When shooting fast movements, a special place is occupied by the so-called spatio-temporal distortions, i.e. violation of geometric similarity (homothy) [1, 2]. This is due to serious contradictions that are generated by the fantastic technical capabilities of modern light recording equipment, on the one hand, and the lack of objective criteria for assessing the resulting geometric distortions of the resulting images, on the other. The correct selection of shooting modes, ensuring the minimization of geometric distortions, is necessary to optimize coaching work and objectify refereeing.

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Results of the study and discussion. The desire of manufacturers of modern electronic equipment to «saturate» it as much as possible with all possible "brands" is obvious, therefore all photo and video equipment, including the advanced option of most smartphones, has high-speed shooting modes. On the other hand, high frequency of shooting, in addition to great advantages for solving a wide range of sports problems, also creates serious problems [1, 2].

Any sensory system operates on the principle of feedback based on deviation from a conditional reference value. Thus, vision, following this principle, forms a visual image based on the same law. It is possible to assess the quality of visual information by the degree of sharpness of the boundaries of a moving object (the so-called blurring) or to determine the degree of detail and usefulness (information content) of images even without the presence of special skills. On the other hand, a person cannot estimate the amount of distortion of the geometric shapes of bodies when filming fast movements due to the lack of information about the «reference» shape in his consciousness. These distortions depend on the speed and direction of movement, so they have an unpredictable, bizarre shape, and under certain conditions they bring the image to "unrecognizability", which leads to the impossibility of establishing whether this is caused by errors in sports equipment or is associated with imperfections in the production process itself. - toregistration.

This contradiction has no formal solution; only recommendations based on a speculative analysis of the results of filming fast sports movements are possible. To analyze geometric distortions, an object of «reference» shape was used - a symmetrical three-blade propeller of a household fan, the choice of rotation speed of which was associated with the known limiting values of the speed characteristics of the movements of highly qualified athletes, regardless of the type of sport (impact movements in acyclic or cyclic sprint sports: such as running, cycling, skating, etc.). In particular, the maximum values of the speed characteristics of human movements in terms of angular ones are no more than 3-5 revolutions per second (hereinafter referred to as rps), which determines the propeller rotation frequency chosen with some margin for the experiment - 6-8 r/s.

When using traditional line scanning, which is used today in all light detection systems, the image frame is formed line by line from top to bottom. To operate any light recording system, you also need a device that will regulate the exposure (shooting) time of each frame (individual image), the so-called shutter, which today comes in two types: global (shutter) and horizontal (electronic). rolling shutter) [1, 4].

The global shutter is an attribute of professional and very expensive equip-ment; it allows you to expose the entire area of the frame at once, which eliminates the occurrence of geometric distortions. The method of limiting the exposure time can be different: from optical-mechanical and electro-optical to magneto-optical (such as a Kerr cell or Faraday gate) operating principles [2, 3, 4, 5].

In amateur and semi-professional equipment (for example, the CASIO line of devices [6]), as well as in smartphones, a simplified electronic rolling shutter is used. The operating principle of this shutter is that exposure (shooting) of individual lines of the image is carried out in a sequential manner, that is, there is a significant time delay between the lines of one frame [1, 2, 4], which leads to the appearance of geometric distortions.

The time for forming a full frame, determined by the shooting frequency, must be commensurate with the time intervals of the shortest phases of the ana-lyzed sports movement, therefore the time interval between the upper (initial) and lower (final) lines of the frame is also commensurate with the time of the move-ment phase for which There is a significant movement of the object being photo-graphed, which leads to the appearance of geometric distortions in the form of changes in the shape and size of moving bodies.

To illustrate possible distortions, the well-known effect of a rotating propel-ler was used (test mode): the multi-directional movement of the propeller blades imitates the counter-directional movement of the limbs of a runner or the hands of a player. Figure 1 shows three single images

Figure 1. Images (still frames) of rotating blades of a symmetrical fan at different shooting frequencies and standard (automatic) mode settings

(freeze frames) of a symmetrical three-blade propeller rotating at the same speed (6-8 rps), shot at different frame rates and standard (automatic) shooting modes.

At a frequency of 30 fps, a strong «smear» is observed, which masks geo-metric distortions. However, in the presented freeze frame, it is easy to notice the difference in the degrees of «blur» for all three blades.

At a frequency of 120 fps, blurring becomes less, but geometric distortions in the form of curvature of the shape and linear dimensions of the blades increase noticeably, which, unfortunately, is quite expected during sports photography. Such distortions are a technical defect in filming, and can be assessed by a coach or athlete as an imperfection in motor action. A judge may find himself in a similar situation when he makes an erroneous decision.

At 240 fps, blur and distortion are visually reduced.

Typically, the ratio of horizontal and vertical scanning times are interrelat-ed, so increasing the frame rate has a positive effect on both the sharpness of single images and the reduction of their geometric distortions, as demonstrated in Figure 1.

Increasing the frame rate, as studies show [1, 2], is advisable up to a certain limit (in particular, up to 300-500 fps for most sports movements). In addition, in practice, increasing the frame rate leads to difficulties associated with increasing the volume of analyzed material, although there is no need to obtain additional visual information - it already becomes redundant.

Thus, as a result of using line scanning in amateur equipment and smartphones, the image will consist of sharp and high-quality individual lines, but, taking into account the relatively larger time interval between them, the resulting image of a fast moving object will have significant geometric distortions (Figure 2).

Figure 3 presents summary comparative information in the form of single images of a symmetrical three-blade propeller rotating at the same speed during burst and video shooting performed with a CASIO camera [6]. Qualitative analysis of the resulting images and their geometric distortions (Figure 3) allows us to draw attention to obvious features:

1. Geometric distortions depend on the mutual direction of the velocity vectors of the object being photographed and the frame scan. In our case, the device was positioned horizontally, the frame scan forms the frame from top to bottom, the propeller rotates clockwise. Under these conditions, the following is obvious: the blade located to the left of the axis of rotation moves upward, i.e. against the direction of the frame scan, which leads to «flattening» of the latter; the blade - to the right of the axis of rotation, on the contrary, «stretches», as a result, the geometry of the object being photographed is disrupted. With other positions of the blades, a more complex curvature of their geometry occurs, which fundamentally deprives the information of objectivity.

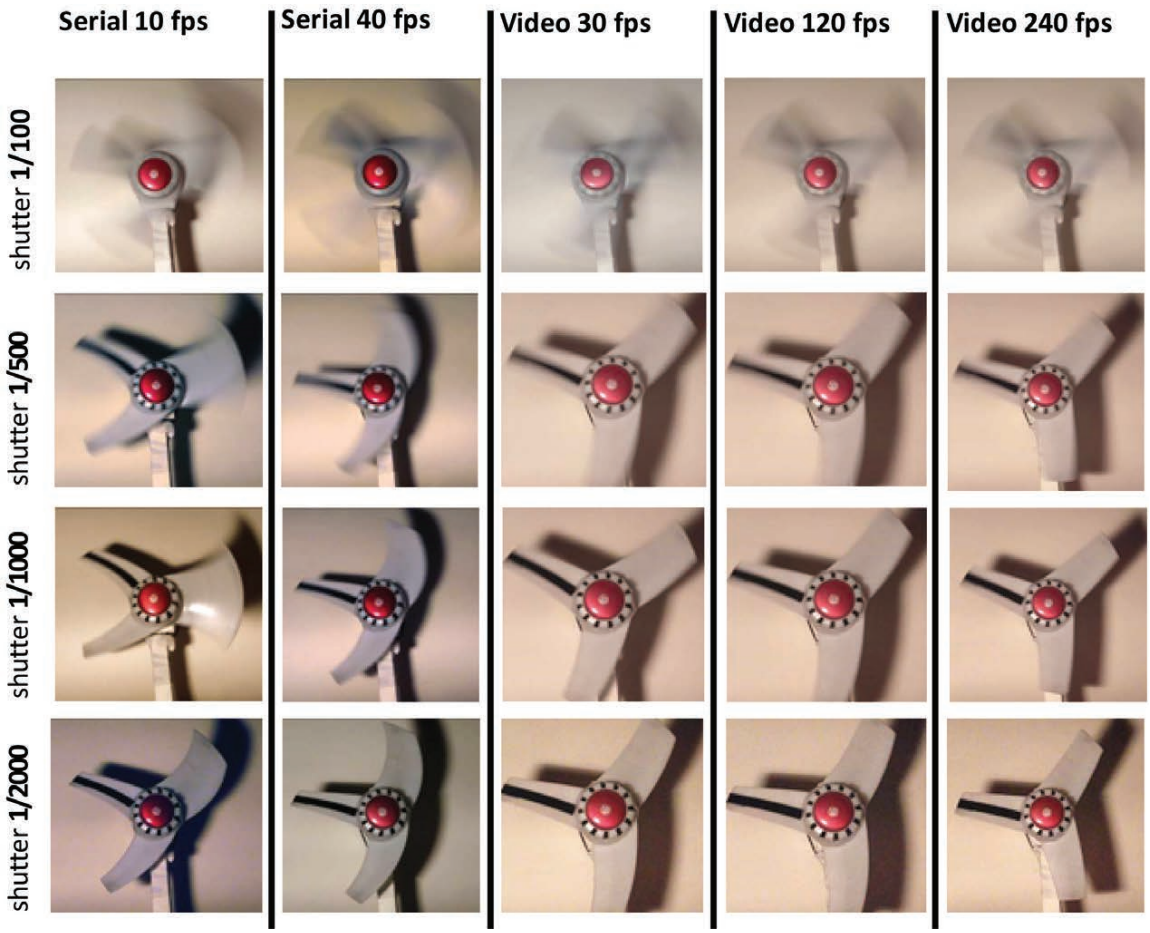
Figure 3. Influence of burst and video shooting parameters on shape distortion: horizontal rows – influence of shooting frequency; vertical columns – influence of exposure durations (shutter)

1. Geometric distortions are almost unnoticeable (fan rotation speed is constant, equal to 6-8 rps) only for video recording mode at frequencies above 200 fps.

2. With the same (close) parameters for the serial and video shooting modes, the geometric distortions of single video frames are much smaller compared to burst shooting images. This is due to the time it takes to form single frames, which is an order of magnitude longer for serial shooting, since high quality single frames are required (volume in MB) [3, 5], but, unfortunately, it creates conditions for the appearance of noticeable geometric distortions.

To analyze the training and competitive processes in modern sports, approaches are needed that allow coaches and judges to obtain detailed «prepared» in-formation about the various movements and actions of athletes. Such operational control over the high-speed actions of athletes, which sometimes last a fraction of a second, in conditions of tough competition can only be ensured by modern methods and non-standard approaches. Video recording equipment today has the widest capabilities and is suitable for implementing the mentioned tasks, but informed decisions are required on the optimality of its use [1].

Figure 2. Examples of deformation of symmetrical images three-blade propeller rotating at a speed of 6-8 rps (shooting was done with a short shutter speed of 1/2000 s)



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Conclusions. The experience of using high-speed shooting modes within the framework of current and operational control, in particular in basketball, presented in the above material, allows us to draw a number of practical con-clusions:

When filming fast sports movements, high-speed cameras are necessary; however, it is recommended to choose the minimum possible shooting frequency that ensures the necessary completeness and reliability of the visual information received. In this case, undistorted visual information is ensured by minimizing geometric distortions, which can be achieved already at a shooting frequency of 200-250 fps, regardless of the shutter type.

In case of noticeable geometric distortions when using an electronic rolling shutter, which can be established during the test mode of light detection with previously known body shapes, it is recommended to increase the shooting frequency.

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