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Shooting parameters measuring from videostream during sports competitions

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Abstract. This paper proposes the method for determining the time and coordinates of hits on targets on the video stream during sports competition. Proposed method allows reduce the number of false alarms of the detector associated with such negative factors at video stream as environment conditions changing, occlusion, video compression artifacts, etc.

1 Task definition

When conducting sports competitions in outdoor shooting, the task of determining the coordinates and time of hits on targets is actual. In cases when the target is located at a significant distance from the shooting site, it is impossible to evaluate the results of shooting in the immediate proximity. Especially it is actual when conducting military games (for example, tank biathlon, etc.), because it is also dangerous for life.

It is necessary to do the following to solve the task: place the camera next to the target and determine the coordinates and time of hits by analyzing the video stream received from this camera. The analysis of the video stream raises questions about the variability of environmental conditions during the video shooting: the appearance and disappearance of sunlight or shadows from clouds, flying small objects (birds, pieces of dirt or dust, etc.). The appearance of video compression artifacts also reduces the detection accuracy. All these factors lead to false operations of the hit detector, and to decreasing in the detection accuracy.

Thereby, the actual task is to improve the accuracy of determining the time and coordinates of hits on sports targets on the video stream.

2 Method of solving the task

The method of detecting the coordinates and time of hits on sports targets on a video sequence is proposed. A block diagram of its operation algorithm is shown in Fig. 1.

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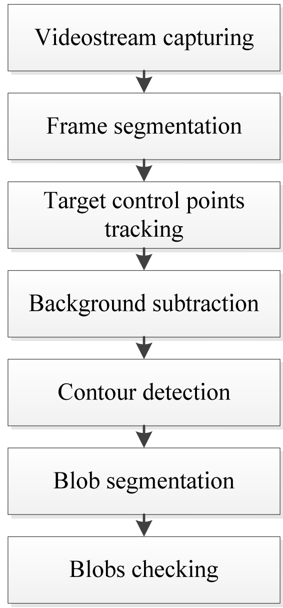
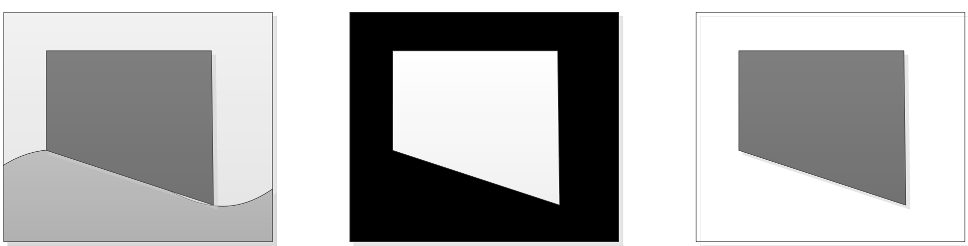


Fig. 1. Algorithm of the method for detecting hits on targets

At the first stage, in the semi-automatic mode, using the watershred segmentation algorithm [1, 2], the selection and construction of the target mask on the video sequence are made. When the position of the target is changed, the mask is recalculated in the frame.



(a) (b) (c)

Fig.2. (a) source frame, (b) constructed mask, (c) image in mask region.

After that, the target is memorized during the start time, which is set manually, depending on the shooting conditions. Choosing the first frame as the base image is impractical because of possible artifacts or small moving objects (rain, snow, dust, birds, etc.). In the future, the resulting base image will be used to find hits in the target.

With the course of time, shooting conditions can change, namely, shadows or sun rays appear and disappear, the illumination changes, which tend to occur smoothly and affect most of the image. Therefore, minor changes in the color component should lead to a correction of the base image, for excluding the possibility of determining the side effects (taking the sun beam for getting into the target).

Suppose that the color of the trace from the hit is significantly different from the color of the target. Then, to find the hits, you need to subtract the base image $B(x,y)$ from the current frame $I(x,y)$ (equation 1) and convert result to binary mask $M(x,y)$ using threshold [3] (equation 2).

$$S(x,y) = I(x,y) - B(x,y); \quad (1)$$

$$M(x,y) = \begin{cases} 0, & S(x,y) \leq threshold\_level \\ 1, & S(x,y) > threshold\_level \end{cases} \tag{2}$$

The result of these operations is a set of areas - possible hits. An example is shown in Figure 3.

Fig. 3. Clearing the image from the background.

A hit in a point can change adjacent areas, leading one hit on the image by several if they are treated as separate areas, as shown in Figure 4 (a).

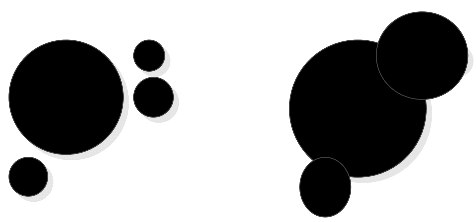


Fig. 4. (a) a binary mask for one hit, (b) a dilatation result

In order to exclude such an error, it is necessary to apply the morphological dilatation operator, connecting the four regions into one using equation 3 [4].

$$A \oplus B = \bigcup_{b \in B} A_b \tag{3}$$

The result of the previous steps is a set of areas that can potentially be considered as hits, as shown in Figure 5.

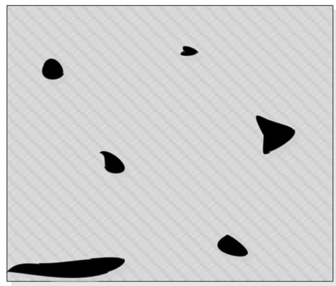


Fig. 5. A set of potential hits.

A priori information about the shape, color and maximum size of the bullet holes allows to filter out some areas (for example, the lower left corner of Figure 5) as erroneous, by that reducing the probability of false detector triggering.

For each area found, a weight coefficient is set that grows with time, because unlike flying objects, the bullet hole should remain in place for a long time. An example of the difference between a hit from a flying object is shown in Figure 6.

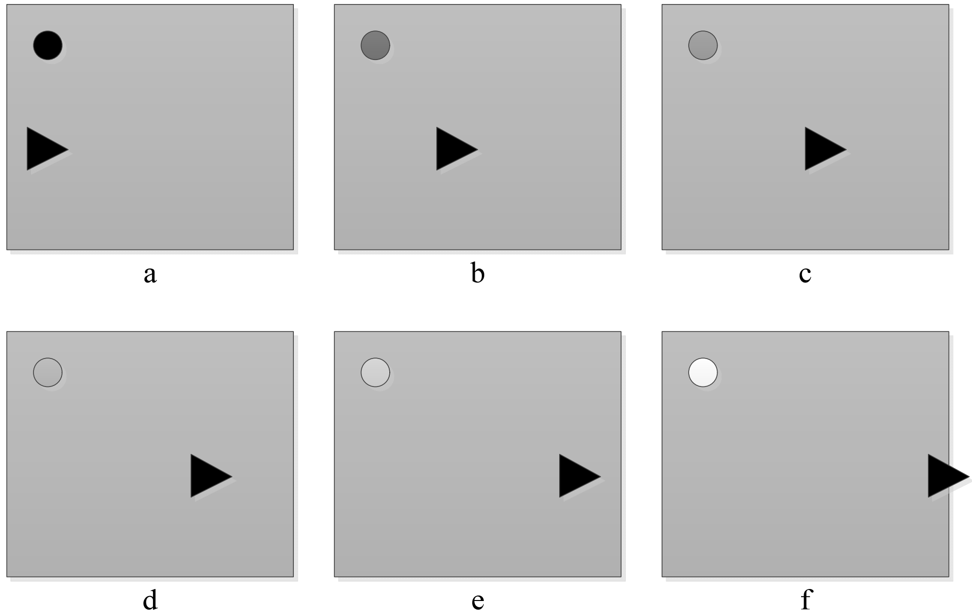


Fig. 6. Schematic frame-by-frame image of the target.

Figure 6 schematically shows several frames (a-f) of a video sequence with two objects on the target: the hit point (circle) and the flying object (triangle). The brightness of objects denotes the weight coefficient: the lighter the object, the higher its value. The trace of the hit with the passage of time remains in place, so its weight coefficient grows, and the flying object constantly changes its coordinates, so its weight coefficient is close to zero.

When the weight coefficient of areas reaches the maximum values they are considered as hits, for them the coordinates and time of appearance are remembered. Because of the need to calculate the weight coefficient, the detection of the hit is done with a slight delay relative to its appearance on the video sequence.

3 Results

To research the accuracy of the work, five videos of shooting on the target were recorded, and processed by the proposed method. The results are summarized in Table 1.

Table 1. Accuracy of the detection of hits on video sequences.

Video file index	1	2	3	4	5	Sum
Actual number of hits	4	7	3	12	5	31
Number of detected hits	4	9	4	10	5	32
Number of errors	0	2	1	2	0	5
Accuracy						84%

The probability of correctly detecting a target hit is 84%, in order to more accurately calculate the probability, it is necessary to increase the test sample.

Finding more hits than there is in fact, is due to the hit on the target of foreign objects. Detection of a smaller amount is due to the weak distinctness of the trace from the target itself.

Conclusion

The method of determining the time and coordinates of hits on sports targets on a video stream is proposed. This method allows to significantly reducing the number of false detectors triggered. The probability of determining the hit is 84%.

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