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Automation of Real-time Target Scoring System Based on Image Processing Technique

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ABSTRACT

This paper describes how to design and develop a low cost, high accuracy, high speed target scoring system based on image processing. The proposed target scoring framework needs no extra hardware and relies just upon existing direct image preparing like edge detection, image enhancement, and object recognition. The work has been done in two phases, the first phase has been done using standard image located in database for testing the proposed target scoring system, and the second phase has been done using a real-time video recorded by using high resolution digital camera, therefore the proposed system algorithms has been modified in the second phase to be able to process the real-time video and giving accurate results. Exploratory outcomes show that the technique can get great scoring. The results that obtained automatically in compared with other ways such as the manual way it is proved that automatically is more accurate and faster in detection and scoring.

KEYWORDS

Automatic scoring, image processing, morphological operations, image enhancement, object recognition.

INTRODUCTION

Target scoring is an important task for many applications includes national and international shooting competitions, military and police training academic, etc. Target scores have been characterized by a blend of direct interpretation from distributed position desires and gauges dependent on factual model. The valuation of the scoring accuracy of the projectile-firing depends on the detection of the position of the hit on a target board and giving a score accordingly [1]. Target board consists of a set of concentric circles. Each pair of circles defines a specific region that gives a scoring ring. Smaller rings give larger scores; the sum of individual scores after a finite number of rounds are used to measure the performance of the player**,** Figure (1) shows an official International Shooting Union -10-type target.

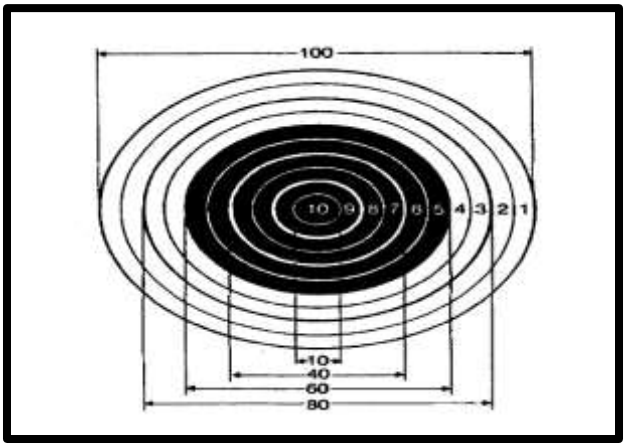

Figure 1. International Union official ten-ring target

There are two ways to calculate scores [2]: Manual target scoring and automatic target scoring. At present, in the major shooting competition, target-scoring is still mainly relied on manual observation by target scoring staff hiding in trenches below the target. However, there are many drawbacks of artificial target-scoring (manual). The

main drawback is the low efficiency because it takes a long time which is often one of the main factors limiting the efficiency of the sporting events, the error is big, and the risk is high. Whereas automatic scoring advantages are: High efficiency, it takes short time, and Error is less. Automatic target scoring systems depends on the way to detect the bullet hole and the center of the target accurately. There are number of previously published researches within the automatic target scoring systems.

In **2008**, **F. Ali, and A. B. Mansoor,** presented a cost effective and speedy Automatic Scoring system based on Computer Vision method for the shooting targets **[3]**. In **2012, J. Rudzinski, and M. Luckner** proposed low cost system for automatic shooting target scoring based on computer vision technique. The proposed framework needs no additional gear, and just relies upon direct image handling methods for instance the Prewitt edge identification and the Hough change **[4]**. In **2013,** T**. Thi Zin et al** proposed an automatic scoring system for archery targets on the basis of an image processing techniques. The proposed framework applying morphological procedure on the objective image to build the thickness of limits of the bolt hits and afterward use division cycle to fragment target region by utilizing shading and shape highlights **[5]**. In **2015, Y. Chi Lin et al** proposed a programmed rendition. With image preparing procedures, the area of a projectile opening and the sequential ID number on an objective sheet are distinguished, individually, to ascertain the score acquired by the shooter with that ID number **[6]**. In **2019**, **P. Widayaka et al** proposed a programmed shooting scoring framework dependent on image processing for live shooting meeting.

A camera is mounted before shooting objective casing to catch each and every shoot image. We utilize a few image handling calculations, for example, target ring identification, viewpoint change, image deduction, just as morphological picture preparing. Form discovery technique is utilized to play out a point of view change, acquiring circle width and focus hover position by utilizing jumping box work by removing distinguished shape and projectile opening position **[7]**. In **2019, Zhongwei Su et al** introduce and break down the edge data of the information picture, and afterward extricate the greatest correspondence region as veil to lessen the figuring's. Thirdly, we can get powerful objective extraction as per the component of focus on region's four sides. In the wake of utilizing the point of view change, the region can be changed over to a standard rectangular. At long last, the flood fill calculation can eliminate the impedance data that may exist on the objective territory **[8]**. Using image processing techniques thresholding, erosion, dilation, contour detection, and template matching, the position of bullet hole and serial ID number in target board are distinguished. The contents of this paper are divided into four sections: Section 1 Automatic target scoring based on image processing. Section 2 proposed system used for automatic scoring with simulation results. Section 3 Real time data.

IMAGE PROCESSING BASED AUTOMATIC TARGET SCORING

Target-scoring is an important part of a shooting competition for military shooting exercises and sports such as archery targets**.** A universally useful image obtaining and preparing framework normally comprises of four basic segments [9, 10]:

1. A image procurement framework, this could be a CCD camera, a flatbed scanner, or a video recorder.
2. A frame grabber which is a device used to change over the electrical sign (a simple video signal) comes from the image obtaining framework into a computerized image that can be put away.
3. A PC or a workstation that gives the preparing power.
4. Image preparing programming that gives the apparatuses to control and break down the images.

Figure (2) shows the basic component of an image processing system [11].

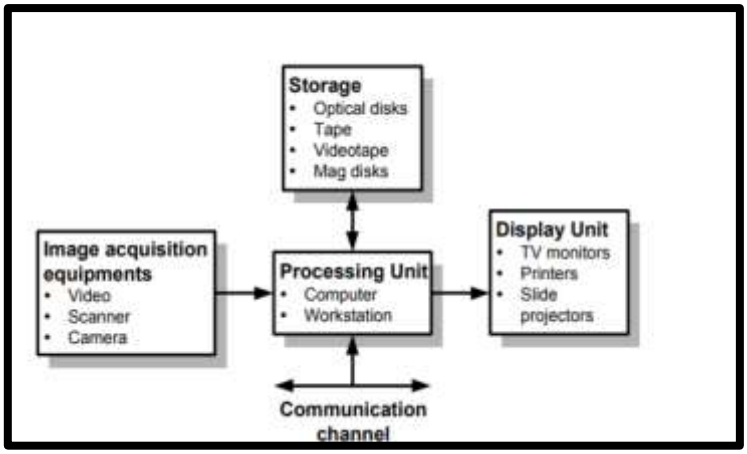

Figure 2. The basic component of an image processing system

PROPOSED SYSTEM USED FOR AUTOMATIC SCORING WITH SIMULATION RESULTS

An automatic target scoring system model is designed based on image processing using Matlab 2016b language as a programming language. The proposed design is outlined within takes image that is stored as inputs, at first the image of the target board with no hits is taken to determine the points that is important this image is the template image, then additional images with bullet hits are taken and processed to give an output that conclude the results of the scores. Figure (3) shows the block diagram of the proposed model, which involves the following steps:

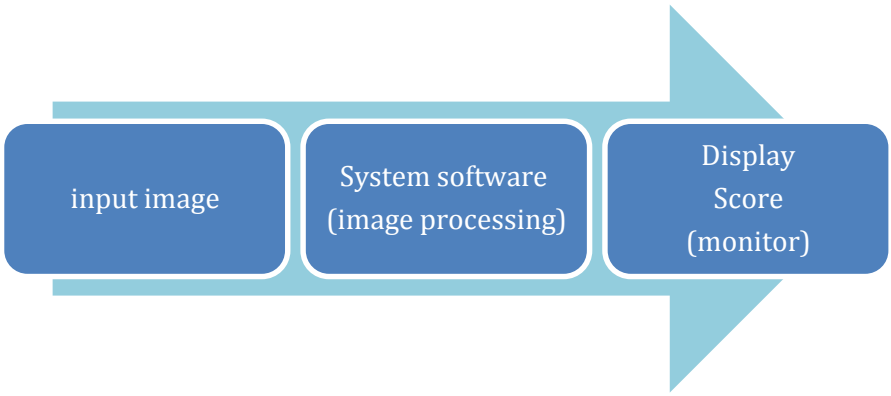

Figure 3. The block diagram of the proposed model

This part of the proposed model describes image processing used to process input image of a target; image processing is the essence of the proposed system. System software includes three main modules: - preprocessing, detection, and finally scoring.

Preprocessing modules

Preprocessing module involves the following image processing: - thresholding, Sobel edge operator and gradient image, and binarization. Preprocessing goal is enhancing the target image to make it more efficient and clear to measure the feature point. Figure (4) shows the standard target image and the resultant image after preprocessing (binary image).

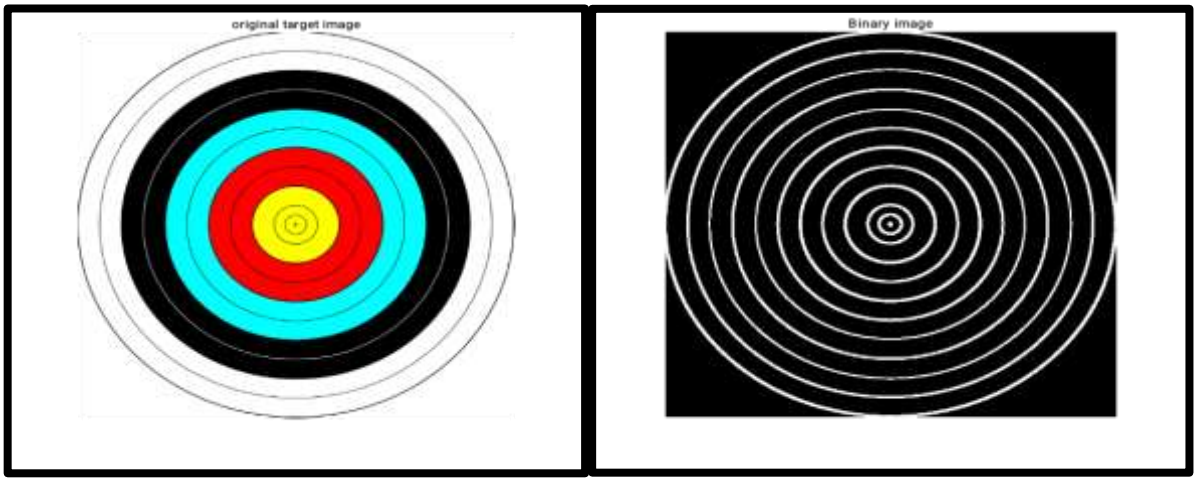

Figure 4. The block diagram of the proposed model

Detection module

Detection Modula involves three basic detection processes: detect target rings, detect the bull's eye (center of the target), and detect the bullet hole hit and its center. After calculation of the binary image version of the target image, now detection of target rings can easily have done by using geometrical features of the circular pattern of the target, so the rings are located. Figure (5) shows the chart of algorithm that used to detect target rings.

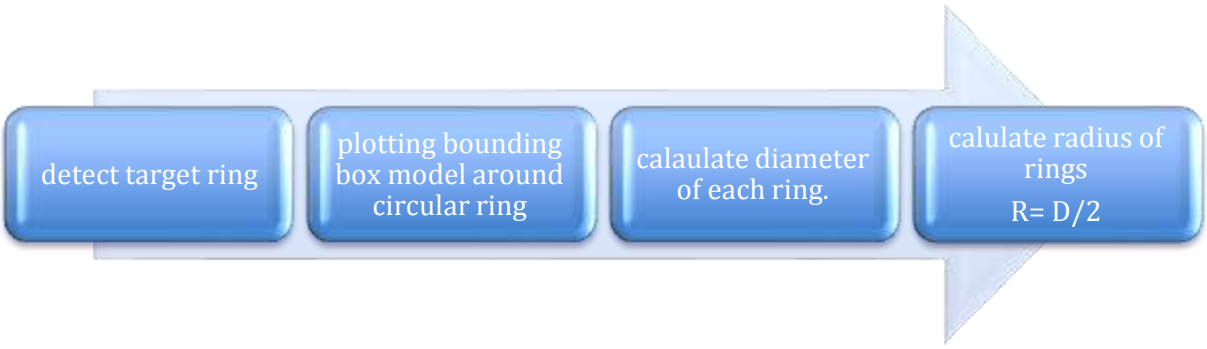

Figure 5. Algorithm for detection target ring

The algorithm to find the bull eye center of the target is as follow:

1- Read the original target image.
2- Convert the original target image to the gray scale.
3- Using region properties to find the properties of connected component, and here only specify the center of the object (circles) and as mentioned before the circular rings has the same center (concentric circles). Figure (6) shows the target image after detection the center of target.

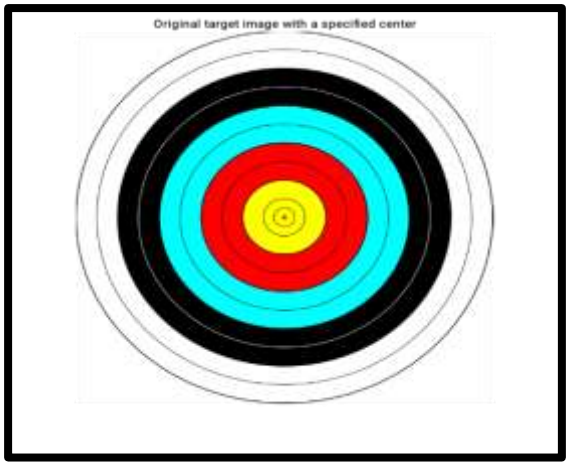

Figure 6. Detection the bull eye (center of the target)

Detection the bullet hole, Bullet hole segmentation is an important key in automatic target scoring systems. Image subtraction method is the kernel in techniques that employed for such purpose.

Using image subtraction method to segment bullet hole has many advantages**:**

1- Image subtraction reduces the bullet hole segmentation algorithm.
2- It simplifies the process of extraction and detection of a bullet hole.
3- It increased the total efficiency of a system.
4- It reduces the times of target changing.

In image subtraction, the old hit spot is filtered relative to the new one therefore only the new bullet spot and a background are remaining. Figure (7) shows the bullet hole detection using image subtraction.

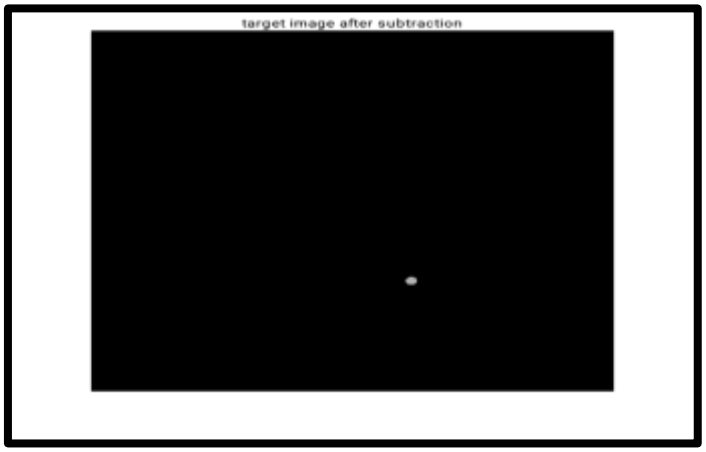

Figure 7. Target image after subtraction

The center of the bullet hole is located by using the following algorithm shown in Figure (8).

Figure 8. The chart of algorithm to detect bullet center

Scoring

The calculation of the score for each hit is done by comparing the distance between the center of the target (center of the bull eye) and center of bullet hole with the radius of circular rings and gives it a score accordingly.

TARGET SCORING SYSTEM USING REAL-TIME VIDEO PROCESSING

Ordinarily, programmed scoring arrangement of shooting objective is finished by costly equipment part, for example, shooting targets scanners, optical assessment framework, electronic shooting targets, or acoustics frameworks. A less expensive option of an objective scoring framework can be made by utilizing the accompanying equipment:

1- Digital camera.
2- Interface cable.
3- Computer.

Design Implementation of Target Scoring System Using Real-Time Video processing software

Image processing is the core of the system software; the program is done using Matlab 2016b language to implement the function of the proposed system software. Target scoring system software consists of three basic modules: -

1- Preprocessing module.
2- Detection module.
3- Scoring module.

The flow of the whole program that is used to process the input data (real-time video) is at the beginning of the program defines the constant that needed**,** as long as the video is large, the video is divided into duration to read it and process it as a frame. The next step is read video frame from the specified portion of the video file, and then saved these video frames as a set of images. Image of the set is considered the standard original image with no hit, after getting the original target image template; the next step is taken out the region of interest (ROI) from the image by using the built function Target points. The output of this function gives the dimension of the box which surrounds the (ROI). The resultant image can be considered as the template image of the target plane. The template image is used to detect the target circular rings and find its center and radiuses. Figure (9) show the template image of the target plane.

Figure 9. The template image of the target plane

In the next step apply the gray scale of the template image of the target plane to the second function Circular Hough transform based on the gradient field. Circular Hough change dependent on the angle field of an image is utilized to identify roundabout shapes in a gray scale format image, resolve their middle positions and span. Compare images to detect difference pixels so as decide depending on the result whether there is a hit or not. Finally, to calculate the score of the hit, at first calculate the Euclidean distance between the center of the target plane and the center of the bullet hole by equation:

$$dis = \sqrt[2]{((X1 - x)^2 + (Y1 - y)^2)} \quad (1)$$

Where:

dis is the distance between the two centers, (X1, Y1) is the center of target plane and (x, y) is the center of the bullet hole hit. After calculate distance between the two centers, compare the distance with the radius of the circular rings to specify the score. Finally display the result calculated on the monitor including bullet score, the total score, the number of hit, hit time, video time, Figures (10), and (11) and show some of final resultant image of the system program with displaying information about the shots.

Figure 10. The first hitting of the target

Figure 11. The second hitting of the target

CONCLUSION

This paper presented a design of image processing based target scoring system which has applications in sports shooting game and military shooting training. The proposed design is denoted by using image processing and was formed by two main phases. The first one the proposed design takes standard input image as input data for the system, in which all circumstances are relatively ideal such as illumination, and then applies some of image processing techniques such as thresholding, binarization, edge detection, etc. in order to process the input images and calculating the score. The second phase of the proposed design takes a real-time video as input data, which is recorded by a stationary digital camera. The results show high accuracy of the proposed system to calculate scores with low-cost equipment (no additional equipment is used) depending on image processing techniques and algorithms.

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