Automatic Score in Archery Target Using Simple Image Processing Method

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Abstract: In this paper we present our developing tool in archery for judging system, which is workable for outdoor and indoor archery competition. The system used in this tool uses a camera to capture archery targets then the frames obtained from the camera will be processed using the opencv library to get the score. We do a test simulation program using opencv and python with video input as an experimental object. We have successfully collected data from 4 subjects with different brightness settings. The results obtained using this system for score detection accuracy is 96.55%. This paper introduces a new judging system with high accuracy and displays the results.

1 INTRODUCTION

Archery is a sport with a long history that train focus and composure. According to worldarchery.sport, the first archery competition took place in Finsbury, England in 1583 which was attended by around 3.000 participants. Furthermore, this sport was officially included in the Olympics in 1900 for men and 1904 for women. In archery competition, the distance between the archer and the target board is 70 meters with the target board tilted 75 degrees to the ground and the center height of the target board is 1.3 meters from the ground. On the target there are 10 circles is the same, from the center yellow, red, blue, black and white. The determination of the score in the current archery professional competition uses the Falco Eye System, which is a laser scanning system to determine the point of hitting the arrow on the target. This system is an electronic target using lasers mounted on the sides. This system is quite accurate, but unfortunately quite expensive and not easy to move because it weighs up to 86 kilograms. In amateur and junior level archery competition, judges and trainers manually determine the points earned by archers by either using binoculars or by approaching the target board to observe and validate the position of the arrow (Humaid, et al., 2021).

In this paper, we would like to implement an archery score detection system with low memory usage and simpler method as in, in order to obtain the most suitable to mount the installation and capture the whole archer base target. Recently, the computer vision is a new technology, which can provide more convenient applications for users. Imaging recognition is the key technology in vision for various applications (Hsia, Wang, Cheng, & Chang, 2021). Many researchers are interested in developing this system because of its simplicity in determining archery scores. Most of the papers and journals published on the internet still detect scores using images or videos that are processed to get the score data. In journal published by Thi thi zin, Ikuo oka, Takuya Sasayama and Shingo ata, the arrow detection using image approach and the score calculation not real time. The low computational complexity and the easiness of implementation are the key advantages of proposed method in the journal (Zin, et al., 2013). Another journal discussing the topic of score detection is published by Raymond Parag. The journal discusses score detection in archery with a video approach. The frame processed continuously to predict the position of the arrow on the archery target board based its color (Parag, 2017).Various methods and techniques using OpenCV are discussed and applied to detect and score the arrows. The target is

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detected by a color-based approach. The perspective of the target is corrected by a homographic transformation matrix and arrows are detected and scored using the Hough lines Transform in combination with a point in contour test.

2 IMAGE PROCESSING TECHNIQUE

This paper provide research about score detection in archery using image processing technique that programmed by python language. The method used in this paper divided in many process, there are Background Subtraction, Morphological Operation, Arrow Detection, Target Detection, and Scoring Calculation. Detailed information about how we calculate the score in archery using image processing explained in Figure 1.

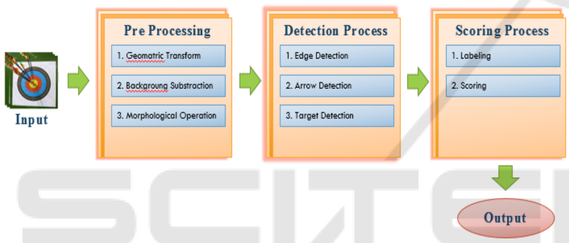

Figure 1: Method Proposed for Automatic Scoring System.

2.1 Background Subtraction

Background subtraction is an approach used to detect moving objects in a sequence of frames from static cameras. The base in this approach is that of detecting moving objects from the difference between the current frame and reference frame, which is often called 'Background Image' or 'Background Model'. This task is the fundamental step in many visual surveillance applications for which background subtraction is a suitable solution which provide a good compromise in terms of quality of detection and computation time (Bouwmans & Garcia, 2019). Frame difference is used to estimate the background image by comparing the previous frame with the current frame. This approach can be used when segment motion-based objects such as arrow movement, cars, pedestrians etc. And it is very sensitive to threshold value settings. Therefore there are limitation usage depending on object structure, frame rate and global threshold. Figure 2 is some cases of this approach based on threshold values.

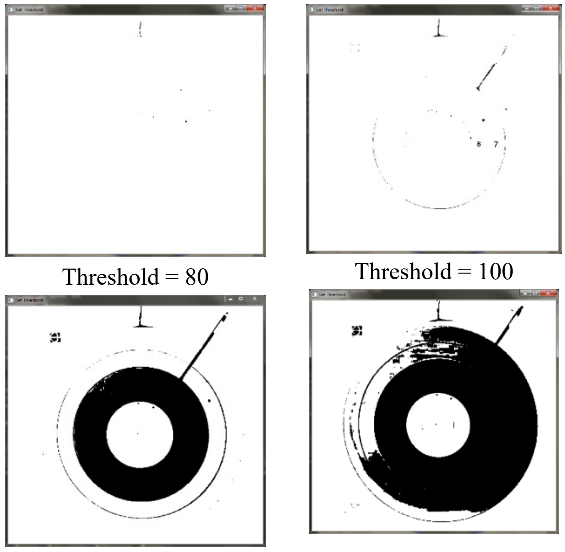

Figure 2: Approach based on threshold value.

From Figure 2 when threshold value is set to 30, the circle is not visible compared to when threshold value at 100, the circle look clearer and easier to detect.

The common method used for background subtraction is Mixture of Gaussians. The Mixture of Gaussians is a mixture of k Gaussians distribution models for each background pixel with values for k within 3 and 5. The inventor assumes that different distributions each represent the different background colors and foreground colors. The weight of each one of those used distributions on the model is proportional to the amount of time each color stays on pixel. Therefore when the weight of pixel distribution is low, the pixel is classified as a foreground pixel.

2.2 Morphological Operations

Morphology is a vast extent of image processing operations that modifies the images based on shapes. It is considered to be one of the data processing methods useful in image processing (Priya & Kadhar, 2017). Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image. The rule used to process the pixels defines the operation as a dilation or an erosion. Table 1 is lists of the rules for both dilation and erosion (Priya & Kadhar, 2017).

Table 1: Rules of dilation an erosion.

Operation	Rules
Dilation	The value of the output pixel is the maximum value of all pixels in the neighborhood. In a binary image, a pixel is set to ‘1’ if any of the neighboring pixels have the value ‘1’. Morphological dilation makes objects more visible and fills in small holes in objects. The lines appear thicker, and filled shapes appear larger.
Erosion	The value of the output pixel is the minimum value of all pixels in the neighborhood. In a binary image, a pixel is set to ‘0’ if any of the neighboring pixels have the value ‘0’. Morphological erosion remove floating pixels and thin lines so that only substantive objects remain. The remaining lines appear thinner and shapes appear smaller.

2.3 Arrow Detection

Arrow detection in this paper using data obtained from background subtraction and hough line method. When another object enters the frame, that object will be considered as an arrow that sticks to the target of the archery. From the detection of arrows using the hough line method, two coordinates will be obtained which are the coordinates of the start of the line (assume as “a” coordinate) and the end of the line (assume as “b” coordinate). After we get the data, the next step is to look for the contours of the arrows as parameters to capture images or only 1 frame is processed, this is to minimize the use of cpu so that it is not too big. Early approaches to contour detection aim at quantifying the presence of a boundary at a given image location through local measurements (Arbelaez, Maire, Fowlkes, & Malik, 2011).

To determine the end of the arrowhead, the approximation of the coordinates of center circle is used. If coordinate "a" is closer to the center of the target than coordinate "b", then point "a" is the arrowhead and point b is the arrow's tail, and vice versa. The center of the archery target is obtained based on the target detection method described in section 2.4. This arrow detection test is very crucial in determining the score in this scoring process. The accuracy of the arrowhead tip detection will affect the accuracy of the score detection obtained.

Figure 3: Arrow head detection using approximation of the coordinates of center circle.

2.4 Target Detection and Scoring Calculation

After the arrow head point is found or detected, the system need to find in which ring this point is located (Danielescu, 2021). Archery target testing aims to detect score circles which will be used as an important component in detecting archery scores. The method used in detecting circles on archery targets is the hough circle method. From this method, the radius and coordinates of the center point of the circle will be obtained. To get more accurate results, it is necessary to first set the threshold of the frame. The score circles obtained from detection using the hough circle method will later be compared with the position of the tip of the arrow obtained previously and then the score for the arrow will be obtained.

Calculating the archery score is obtained by comparing the results of the previous steps. That is by measuring the radius from the arrowhead to the coordinates of the center of the circle compared to the radius of each circle.

3 EXPERIMENTS AND SIMULATIONS RESULT

In this experiment and simulation, video input is used to detect scores on the archery target board. There are 4 arrows that are the object of the experiment in determining the accuracy from the method proposed in this paper. Then experiment by giving different light conditions to see the difference in accuracy obtained.

3.1 Score Detection

Score detection is the final process in this paper. The calculation used in determining the score in this paper uses data obtained from the previous process. The score calculation is carried out by comparing coordinates of the arrowheads in the radius of rings. The results are shown in Figure 4 until Figure 7.

Figure 4: Score detection on the first arrow by calculate the radius from the arrowhead to the center of circle.

Figure 5: Score detection on the second arrow by calculate the radius from the arrowhead to the center of circle.

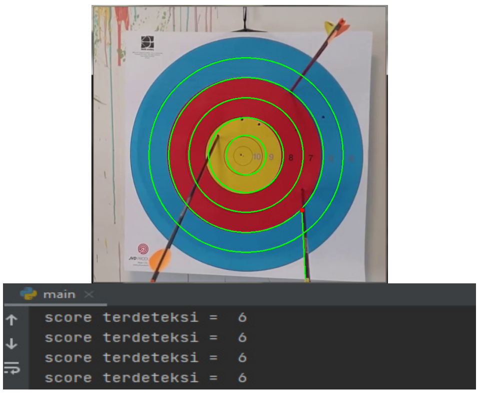

Figure 6: Score detection on the third arrow by calculate the radius from the arrowhead to the center of circle.

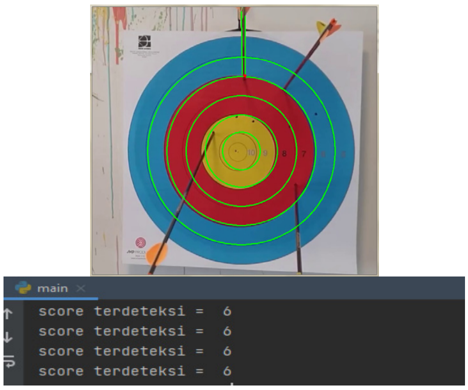

Figure 7: Score detection on the fourth arrow by calculate the radius from the arrowhead to the center of circle.

Table 2: Score detection accuracy.

Arrow Number	Score Actual	Score Detected
1	7	7
2	9	9
3	7	6
4	7	6
Total	30	28
Accuracy	93.33%	

3.2 Various Brightness

This experiment aims to see whether the intensity of the light given affects the accuracy of detecting scores on archery targets. There are 2 experimental objects with different light intensity, among others, by increasing the brightness of +10, and +40. From this experiment, the following results were obtained.

Figure 8: Brightness increasing by +10.

Table 3: Score detection accuracy with brightness increasing by +10.

Arrow Number	Score Actual	Score Detected
1	7	7
2	9	9
3	7	6
4	7	7
Total	30	28
Accuracy	96.66%	

Figure 9: Brightness increasing by +40.

Table 4: Score detection accuracy with brightness increasing by +40.

Arrow Number	Score Actual	Score Detected
1	7	7
2	9	8
3	7	6
4	7	4
Total	30	25
Accuracy	83.33%	

4 CONCLUSIONS

In this paper, we have proposed score detection in archery target using simple image processing method. The experimental results show that in terms of performance, the program for score detection is running well. However, the light conditions need to be adjusted to get higher accuracy. This research will be very well implemented in stable lighting conditions. This paper can help referees determine scores in archery so that the time spent in judging can be more effective. In future, the automatic lightning calibration will be included to increase the accuracy of the system.

REFERENCES

Arbelaez, P., Maire, M., Fowlkes, C., & Malik, J. (2011). Contour Detection and Hierarchical Image Segmentation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, (pp. 898-916). doi:10.1109/TPAMI.2010.161

Bouwmans, T., & Garcia, B. (2019). Background Substraction in reak Applications: Challenges, Current Models and Future Directions. Cornell University. doi:https://doi.org/10.48550/arXiv.1901.03577

Chudasama, D., Patel, T., & Joshi, S. (2015). Image Segmentation using Morphological Operations. *International Journal of Computer Applications*, *117*, pp. 16-19. Bharuch. doi:10.5120/20654-3197

Danielescu, L. A. (2021). OnTarget: An Electronic Archery Scoring System. *Cornell University.* doi:https://doi.org/10.48550/arXiv.2104.01622

Hsia, S.-C., Wang, S.-H., Cheng, W.-C., & Chang, C.-Y. (2021). Intelligent Blowgun Game Scoring Recognition System Based on Computer Vision. *IEEE Access*, *9*, pp. 73703-73712. doi:https://doi.org/10.1109/ACCESS.2021.3081457

Humaid, H., Pelana, R., Wendy, C.-S., Winata, B., Yulianti, E., Wattimena, F. Y., & Artono, E. (2021). Validity of the Scoring System Technology for Detecting Points in Archery. *Journal of Physical Education and Sport, 21*(3), 1520-1524. doi:10.7752/jpes.2021.03193

Parag, R. (2017). Sequential Recognition and Scoring of Archery Shots. *Leiden University*. Retrieved from https://theses.liacs.nl/pdf/RaymondParag.pdf

Priya, M. S., & Kadhar, N. (2017). Effective Morphological Image Processing Techniques and Image Reconstruction. *National Conference on "Digital Transformation-Challenges and Outcomes" (ASAT in CS'17).* Bangalore.

Zin, T. T., Oka, I., Sasayama, T., Ata, S., Watanabe, H., & Sasano, H. (2013). Image processing Approach to automatic Scoring System for Archery Targets. *In 2013 Ninth International Conference on Intelligent Information Hiding and Multimedia Signal Processing* (pp. 259-262). IEEE. doi:https://doi.org/10.1109/IIH-MSP.2013.73