Aryu_Proceeding_2013-1.pdf

by

2013 3rd International Conference on Instrumentation Control and Automation (ICA)
Bali, Indonesia, August 28-30, 2013

Camera-Based Shooting Simulator using Color Thresholding Techniques

Aryuanto Soetedjo
Department of Electrical Engineering
National Institute of Technology (ITN)
Malang, Indonesia
aryuanto@gmail.com

Ali Mahmudi
Department of Informatics Engineering
National Institute of Technology (ITN)
Malang, Indonesia

M. Ibrahim Ashari
Department of Electrical Engineering
National Institute of Technology (ITN)
Malang, Indonesia

Yusuf Ismail Nakhoda
Department of Electrical Engineering
National Institute of Technology (ITN)
Malang, Indonesia

Abstract—**This paper presents the camera-based shooting simulator, where the shooter shots the target using a laser pointer attached on the weapon. A camera is attached on the weapon to capture the image of laser shot and circular target. The red color thresholding techniques are employed for detecting the laser spot on the target. From the experiments, it is obtained that the proposed system could detect both circular target and laser spot under different background environments. Further the proposed algorithm is able to compute the shooting score properly.**

Keywords-shooting simulator; camera system; color thresholding; laser pointer

I. INTRODUCTION

Recently, the camera-based application systems increases significantly, due the rapid development in the image processing techniques and machine vision technology. One of them is the application of camera systems to detect the presence of laser pointer for several applications such as: home automation systems [1]-[2], presentation systems [3]-[6], shooting simulator [7]-[9]. In those systems, a camera is used to detect the laser spot directed or fired to the target/screen. In the shooting simulator, a laser pointer is attached to the weapon for replacing the bullets. When a shooter shots the laser pointer to the target, a camera system detects the presence of laser spot on the target and calculates the shooting score.

The laser shooting simulator in [7] used a projector to project the virtual scene of aquarium to the screen, a CCD camera is used to capture the image from the screen, and a personal computer is used to control the overall system. Before starting the program, user selects four points on the target for calibrating the system. The laser detection algorithm is based on the comparison of the normal RGB average value (the starting time) and the RGB value of each frame. When the difference is greater than a threshold, the laser spot is detected.

A single stationary camera and multiple moving cameras were proposed in [8]. In the single stationary camera, a camera is installed in a fixed position in front of the target screen. Since the position of camera is not perpendicular to the screen, a homography should be calculated at first. To detect the laser spot, three features are used: a) the laser spot is brighter than the background; b) the size and aspect ratio of the laser pointer; c) the intensity of laser pointer decreases from the center toward the outer in a Gaussian manner. The single stationary camera system could not be used when there are multiple shooters shoot the single target. To overcome the limitation, they proposed the multiple moving camera system, where a camera is attached on the weapon. In this approach, there is no laser pointer on the weapon. Therefore, it is assumed that the hit point is in the center of camera frame. Since the camera is moving, then the homography should be recomputed every time.

The challenging problem of laser detection system is to overcome the varying illuminations. The shutter rate, gain, exposure of camera should be adjusted to ensure the brighter laser pointer [5]. They proposed a single thresholding technique to detect the laser spot. To deal with varying illuminations, the threshold is generated after a background removal process. The simple thresholding technique which considering two steps: a) selection of an appropriate color space; b) selection of an appropriate threshold, were proposed in [3].

Our previous work [9] proposed a simple thresholding technique to detect the laser spot. Instead of installing the camera in front of the target, the camera is installed behind the target inside a non-transparent box. Using the approach, the lighting is controlled and the simple threshold works effectively.

In this paper, we extend our previous work by proposing a moving camera system and a movable target. In the system, the camera is attached on the gun, while the conventional circular pattern target printed on a paper could be posted on the wall or other objects. The simple color thresholding technique based

978-1-4673-5798-2/13/$31.00 ©2013 IEEE

on the normalized RGB chromaticity is employed to detect both laser spot and circular target pattern.

The rest of paper is organized as follows. Section 2 presents the proposed system. Section 3 discusses the experimental results. Conclusion is covered in section 4.

II. PROPOSED SYSTEM

A. System Configuration

Fig. 1 shows the configuration of the camera-based shooting simulator. As shown in the figure, the weapon or gun is equipped with a laser pointer and camera. The camera is connected to a computer for perfoming the image processing tasks. In this work, the shooting target is the circular pattern which is printed on a piece of paper then posted on the wall or any other places. The target could also be generated and displayed on the computer monitor.

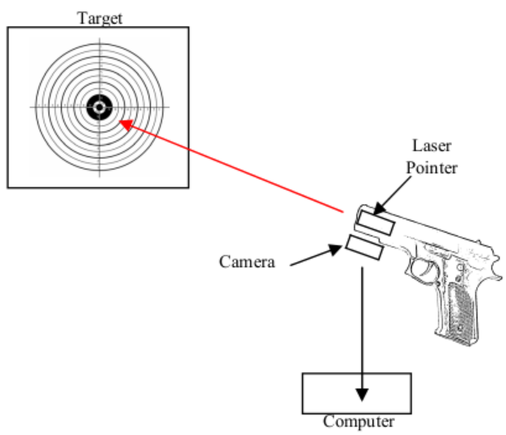

Figure 1. System configuration.

An electronic circuit, called one-shot pulse generator is adopted to provide the fire mechanism of laser pointer attached on the weapon. Using this circuit, when the shooter pushes a fire button, the laser pointer is ON for a short pulse only. The camera on the weapon captures the images continously, frame by frame. The computer analyzes the captured image for detecting the circular target and laser spot. Once the laser spot is detected, the shooting score is calculated based-on the position of detected laser spot and the target.

B. Detection Algorithm

The detection algorithm is shown in Fig. 2. The input of algorithm is the RGB image captured from a video camera. Since the camera is attached on the weapon, the captured image moves according to the shooter's aiming. Therefore the first task is to find the circular target pattern on the image. To provide the simplicity and robustness of the algorithm, the circular target pattern should be prepared as shown in Fig. 3. The diameters of circular target and outer red ring, called as the guided ring, are 10 cm and 15 cm, respectively. The important feature of the target is that the guided ring should be in red color. The red color is chosen, due to the fact that the color will be detected easily by the proposed red color thresholding technique as described in the next section. The space between circular pattern and outer red ring is used to distuingish the red color of guided ring and laser spot on the target.

After the circular target pattern is found, the bounding box of the target is identified. Then the algoritm finds the laser spot inside the bounding box. This approach assumes that the laser spot of the shooter hits inside the target, unless it will not be detected by the system. The fusing of two red color thresholding techniques is employed to detect the laser spot as decribed in the next section.

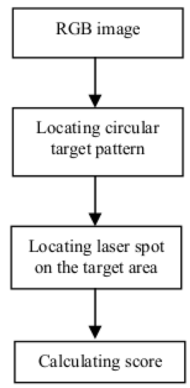

Figure 2. Detection algorithm.

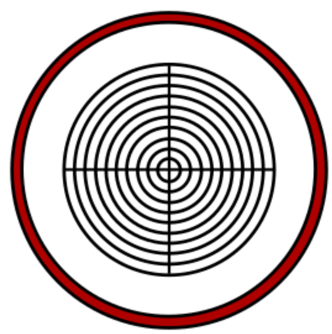

Figure 3. Circular target pattern.

C. Red Color Thresholding

Our previous works proposed a red color thresholding technique that works effectively for traffic sign detection [10], and lip detection [11]. The proposed red color thresholding utilizes the normalized RGB chromaticity diagram as shown in Fig. 4. The chromaticity coordinates r and g are defined as

$$r=R/(R+G+B) \quad (1)$$

$$g=G/(R+G+B) \quad (2)$$

From the figure, it is clear that the diagonal line might be used to separate the red colors from the other ones. Therefore the red color thresholding is expressed as [10], [11]:

If g-$r < TR1$, then assign pixels as RED (3)

where $TR1$ is a threshold.

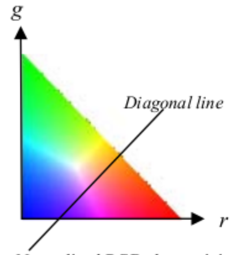

Figure 4. Normalized RGB chromaticity diagram.

The threshold of $TR1$ could be interpreted as the crossing point of the diagonal line with g-axis. By examining the figure, the more negative of $TR1$ will separate the more reddish color. From a few experiments, the value of -0.025 is the most effective threshold's value for detecting the red guided ring shown in Fig. 3. It is noted here that since the normalized RGB color space is adopted, it reduces the effect of lighting changes.

The red color thresholding defined by (3) extracts all reddish objects, including the laser spot. Due to the characteristic of laser spot which scatters the red color as shown in Fig. 5(a), the detected laser will produce the large blob as shown in Fig. 5(b). It will reduce the accuray of laser spot detection and yields the wrong shooting score. To overcome the problem, the fusion color detection technique as described below is proposed.

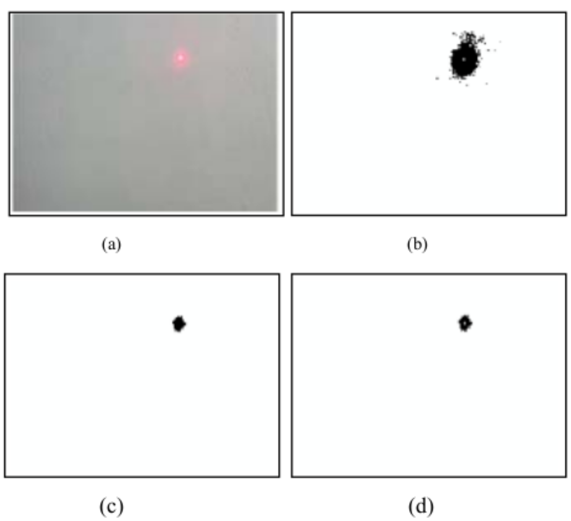

Figure 5. Laser spot detection: (a) Laser spot; (b) Detected blob using (3); Detected blob using (4); Detected blob using (5).

Our previous work in [9] employed the simple red color thresholding to detect the laser spot which is expressed as

If $R > TR2$, then assign pixels as RED (4)

where $TR2$ is a threshold. This technique detects the solid red color of laser spot, not the scattered red color, as shown in Fig. 5(c). However, the thresholding technique defined by (4) also detects the white/brighter objects. Therefore to detect the laser spot, the new color thresholding is expressed as

If (g-$r < TR1$) AND ($R > TR2$), then assign pixels as RED (5)

From a few experiments, the most effective value of $TR2$ is 0.9. Using the fusion thresholding technique defined by (5), the detected laser spot is shown in Fig. 5(d).

D. Locating Target Pattern

When a shooter aims the weapon to the target, then the circular target will be captured by the camera on the weapon. Since the guided ring of target is in red color, the circular target will be the largest red object in the image. Therefore it might be detected easily by the color thresholding technique defined by (3). However in the complex backgrounds, some false objects are also detected by this color thresholding. Fortunately, the detected red guided ring could be distuingished from other objects by utilizing the solidity of detected blob. In this experiment, the blob is considered as the guided ring when the solidity is lower than 0.25.

The detected blob is used to calculate the shooting score. To provide the accuracy, the centroid's coordinates of the blob are taken into consideration for calculating the score as described in next session.

E. Shooting Score Calculation

After the bounding boxes of circular target and laser spot are obtained, the shooting score (S) is calculated using the following formula [9]:

$$S = 11 - ceil\left(\left(15\sqrt{(cx_2 - cx_1)^2 + (cy_2 - cy_1)^2}\right)/r\right) \qquad (6)$$

where,
cx_1 is the x-coordinate of the center of the circular target;
cy_1 is the y-coordinate of the center of the circular target;
cx_2 is the x-coordinate of the center of laser spot;
cy_2 is the y-coordinate of the center of laser spot;
r is the radius of the outermost circle;
$ceil(A)$ rounds to the nearest integer greater than or equal to A.

III. EXPERIMENTAL RESULTS

To verify the proposed system, several experiments are conducted. In the experiments, the algorithm is implemented using MATLAB running on a PC Intel Core i-5, 4 GB RAM. The camera used for capturing image is Logitech Webcam, 800 x 600 pixels. The laser pointer is the red laser pointer commonly used in the airgun.

Fig. 6 shows the experimental results for target printed on a piece of paper and posted on the wall. The thresholded image obtained using (3) is shown in Fig. 6(b), where the bounding box denotes the detected target pattern. Fig. 6(c) shows the thresholded image using (4). In this case, both laser spot and some right parts of the background are extracted. It is caused by the fact that the lighting is non-uniform as shown in Fig. 6(a) and yields the brighter color which is extracted by (4). The detected laser spot using proposed fusion thresholding is shown in Fig. 6(d). In this case, only laser spot is detected, while the red guided ring is not detected.

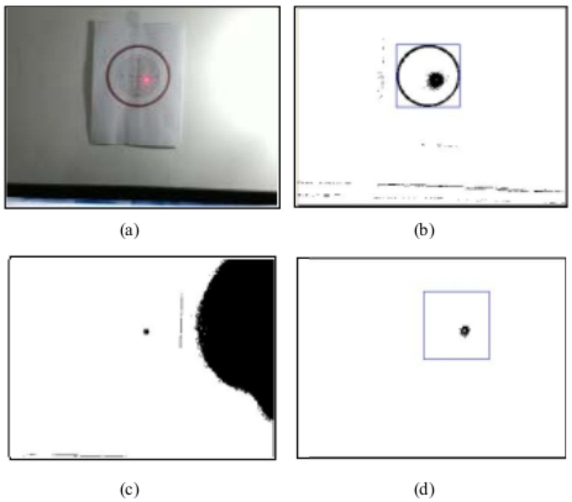

Figure 6. Detection result for target posted on the wall : (a) Captured image; (b) Thresholding result using (3); (c) Threshoding result using (4); (d) Thresholding result using (5).

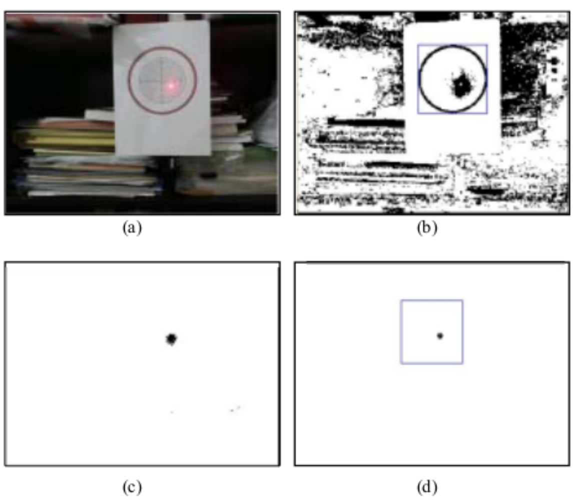

Figure 7. Detection result for target posted on colorful background: (a) Captured image; (b) Thresholding result using (3); (c) Threshoding result using (4); (d) Thresholding result using (5).

Fig. 7 shows the experimental results for the target which is posted on the colorful background. It is shown in Fig. 7(b) that the thresholding result of (3) also contains the other parts of the background. However, since the algorithm only considers the connected objects/blobs with the solidity below than 0.25 as discussed in previous secion, the circular target is detected as indicated by the bounding box on it. The thresholding result of (4) only contains the laser spot as shown in Fig. 7(c). The thresholding method in (5) is able to extract the main part of laser spot as shown in Fig. 7(d). The scattered laser spot detected in Fig. 7(b) is avoided.

For both situations, the shooting scores generated by the algorithm are matched with the manual inspection.

IV. CONCLUSION

The moving camera system is developed for shooting simulator, where both the camera and laser pointer are attached on the weapon. To detect the laser spot and target, the simple and efficient red color thresholding techniques are employed. Experimental results show that the proposed system could detect both target and laser spot properly. However, using MATLAB the execution time is slow (about 2 fps). Therefore to be implemented in realtime, the algorithm should be implemented using C++ languange.

In future, the system will be extended to handle the different targets and multi shooters. Further the real implementation using artificial weapon will be carried out.

ACKNOWLEDGMENT

This work is supported by the "National Strategic Research Grant 2013" from Directorate General of Higher Education, Ministry of National Education and Culture, Republic of Indonesia.

REFERENCES

[1] F.Chavez, et al. "Hybrid laser pointer detection algorithm based on template matching and fuzzy rule-based systems for domotic control in real home environments," Applied Intelligence, Vol. 36, Issue 2, pp. 407-423, March 2012.

[2] A. Pavlovych, W. Stuerzlinger, "Laser pointers as interaction devices for collaborative pervasive computing," Advances in Pervasive Computing, pp. 315-320, 2004.

[3] A. Chowdhary, V. Agrawal, S. Karmakar, S. Sankar, "Web camera based laser actuated presentation system," Proceedings of 3rd International Conference on Human Computer Interaction, Bangalore, India, 2011.

[4] D.R. Olsen, T. Nielsen, "Laser pointer interaction," Proceedings of SIGCHI Conference on Human Factors in Computing Systems, pp. 17-22, Washington, USA, April 2001.

[5] B.A. Ahlborn, D. Thompson, O. Kreylos, B. Hamann, O.G. Staadt, "A practical system for laser pointer interaction on large displays," Proceedings of the ACM Symposium on Virtual Reality Software and Technology, pp. 106-109, California, USA, November 2005.

[6] J.G. Lim, F. Sharifi, D.S. Kwon, "Fast and reliable camera-tracked laser pointer system designed for audience," Proceedings of the 5th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI 2008), pp. 529-534, Seoul, Korea, November 2008.

[7] S.J. Kim, M.S. Jang, H.S. Kim, T.Y. Kuc, "An interactive user interface for computer-based education: The laser shot system," Proceedings

of World Conference on Educational Multimedia, Hypermedia and Telecommunications, pp. 4174-4178, 2004.

[8] S. Ladha, S. Chandran, K.T. Miles, “Vision assited safety enhanced shooting range simulator,” Proceedings of National Cpnference on Computer Vision, Pattern Recognition, Image Processing and Graphics (NCVPRIPG), Jaipur, India, January 2010.

[9] A. Soetedjo, E. Nurcahyo, “Developing of Low Cost Vision-Based Shooting Range Simulator, International Journal of Computer Science and Network Security, Vol. 11, No. 2, February 2011.

[10] A Soetedjo, K. Yamada, “A new approach on red color thresholding for traffic sign recognition system,” Journal of Japan Society for Fuzzy Theory and Intelligent Informatics, Vol. 19, No. 5, pp. 457-465, 2007.

[11] A. Soetedjo, K. Yamada, F. Y. Limpraptono, “Lip detection based on normalized RGB chromaticity diagram,” Proceedings of the 6th International Conference on Information & Communication Technology and System (ICTS 2010) , ITS Surabaya, Indonesia , 2010.

Aryu_Proceeding_2013-1.pdf

ORIGINALITY REPORT

11%	14%	10%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	doi.org Internet Source	6%
2	eprints.itn.ac.id Internet Source	3%
3	docplayer.net Internet Source	3%

Exclude quotes	On	Exclude matches	< 2%
Exclude bibliography	On		