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Different shape and color targets detection using auto indexing images in computer vision system

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Different shape and color targets detection using auto indexing images in computer vision system

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Abstract One of the main challenges in computer vision is to determine the number of different types, shapes, locations and color targets within the image plane for use in computer control systems. In this study, an algorithm introduced to detect the number of targets (one or two), their shapes (square or circle) and colors (red, green or blue). A new technique presented as a digital indexing code table to present the studied color targets images. The indexing table technique depends on decimal and binary numbers. In this study, there were 42 different cases represents all the input images. There is a special case considered for the similarity of input images in case it has the same shape and color, but a change in rotation and space between two image targets. This solved using referencing to indicate the same target in each case. Thus, the classification results were 100% for the presented algorithm for all input cases.

Keywords: shapes and color recognition, area calculation, object indexing, image processing, computer vision classification system.

1. Introduction

Humans use their eyes and their brains to see and sense the world around them. Everyone can classify objects using his senses, but computers cannot. To enable a computer to detect and recognize a target, computer vision field used to deal with objects as human eye to give a similar objective. Computer vision plays an important role in industry and manufacturing application [1], that estimates geometric primitives and other features from the image [2]. Detection of geometric shapes such as circle, square and rectangle in images has important application in computer vision such as automatic inspection [3], and auto monitoring systems for the agriculture fields like conveyer belt. Targets in a video frame or an image depend on matching the target with a reference image or reference video frame image, and a decision is made based on the degree of match between them [4]. The Hough Transform (HT) algorithm used for shape detection that has been used extensively [5] to extract analytic features, such as straight lines, and circles, because of its robustness against noise, clutter, object defect, and shape distortion etc. [6]. A color target is obtained by discretizing image color bands and counting how many pixels belong to each level color value [7] and consider an important feature detection which has been successfully used [8]. The center location of an object within an image is described and used to specify xy coordinate [9].

There are many methods and algorithms deals with shape and color target detection, which is developed by researchers. Object shape recognition method proposed where circle, square and triangle objects are detected. This method utilizes intensity value from the input image then threshold it by Otsu's method to obtain the binary image. They obtain detection accuracy reached about 85%[1]. In 2013, a suggested method discussed using 180 images with shapes squares, circles, rectangles, and

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triangles and recognize it using 2D geometry with accuracy reach 99% [4]. In 2014, it proposed a geometric shapes recognition algorithm that can select the desired shape individually even if there are different shapes in the image (multi-shapes image). Unfortunately, it needs to repeat the algorithm many times to get the good results [10]. In 2016, an approach presented to detect and recognize of regular 2D shapes in low noise environments. This algorithm based on locating the edges then calculating the area of the object to help in the identification of a specified shape, and it is time efficient as it requires just 0.6seconds on an average for executing the program and predicting the result [11]. In 2017, a shape recognition system implemented which based on edge detection algorithms namely Canny, Laplacian and Sobel. They approved that Canny is the best algorithm compared to Sobel and Laplacian [12]. While in 2018, contours, shapes and colors of various geometrical figures detected in the sample using Python 2.7, Open Source Computer Vision Library (OpenCV) well known code and Numpy. The algorithm was not implemented on real images [13].

This study presents new suggested algorithm to detect target shape (circle, and square), color (red, green, and blue), and location with a fixed background. This algorithm coded using MATLAB software and designed carefully to solve similar cases that presented within this paper. Thus, indexing table idea used to get perfect matching to detect different target images. Moreover, there is a case that the same target within image plane rotated and the distance may change between the two objects which means it has similarity to the same input images. This case is solved by updating the proposed algorithm to generate 100% accurate results.

2. The Introduced System

In this study, the proposed system developed to detect and recognize different targets setting cases in the image depending on targets that differed in shape, color, and location. The system scheme for capturing the different cases of color targets shown in figure 1. This project was done in a room of 4.62m length, 3m width, and 2.70 m height. The lighting system is normal fluorescent lighting (FL) lamps. The distance between the camera (iPh7) and targets is 1m. One of the challenges that face this project is lighting condition because it affects image lighting quality. The effect of lighting on the color of a captured image for the color targets cannot be neglected in processing steps. Therefore, the environment lightening was 109 Lux measured in Luxmeter device. The tools and software that used in this work are:

- 12-megapixel wide-angle iPhone 7s plus camera, with a (f/1.8) aperture for wide range lens and (f/2.8) aperture for a telephoto lens.
- Two types of geometric shape (square and circle) made of cardboard with three colors (red, green, and blue) for each shape i.e. 12 geometric shape color targets.
- MATLAB R2017a software running on Windows 10, core i7, RAM 16 GB.

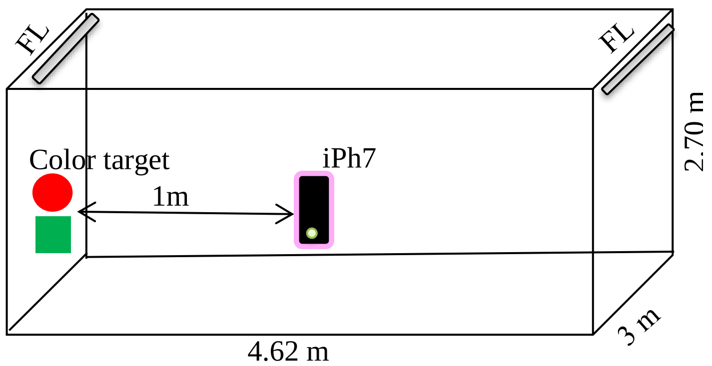

Figure 1. (color online) Sketch of the studied imaging system.

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3. Image Indexing Algorithm

The proposed algorithm focus on detecting 2D geometric shapes, color, and the location of the targets in the input image. This done by extracting red, green, and blue bands from input RGB-image and applied a median filter to eliminate image noise. A threshold process method [14] applied to separate target from background then transforming the bands into binary to detect the number of targets in input image. The total cases studied are 42 cases but the total images are 261 because there are occurrences for each target. From the 42 cases, there are 36 images with two targets cases and 6 images for one target cases. The new idea within this paper is based on using indexing to these cases.

The block diagram of the introduced algorithm shown in figure 2 where the *regionprops* function used to determine the number of objects. The note is mentioned below earlier to explain the symbols used in the block diagram of the algorithm.

Notes: I_i : one band colored image . *regionprops*: is matlab function.
C_r, C_g, C_b: Y-coordinate center. $C(2)$: Y-coordinate center of second target.
$L(D)$: length of D-vector (maybe 0, or 1, or 2) i.e. number of circle in image.
thy: represent threshold point y-values separated between first and second color target.
r-code=[0 0], g-code=[0 1], b-code= [1 0].
De= [32 16 8 4 2 1] decimal vector code for the utilized 6-binary digits.

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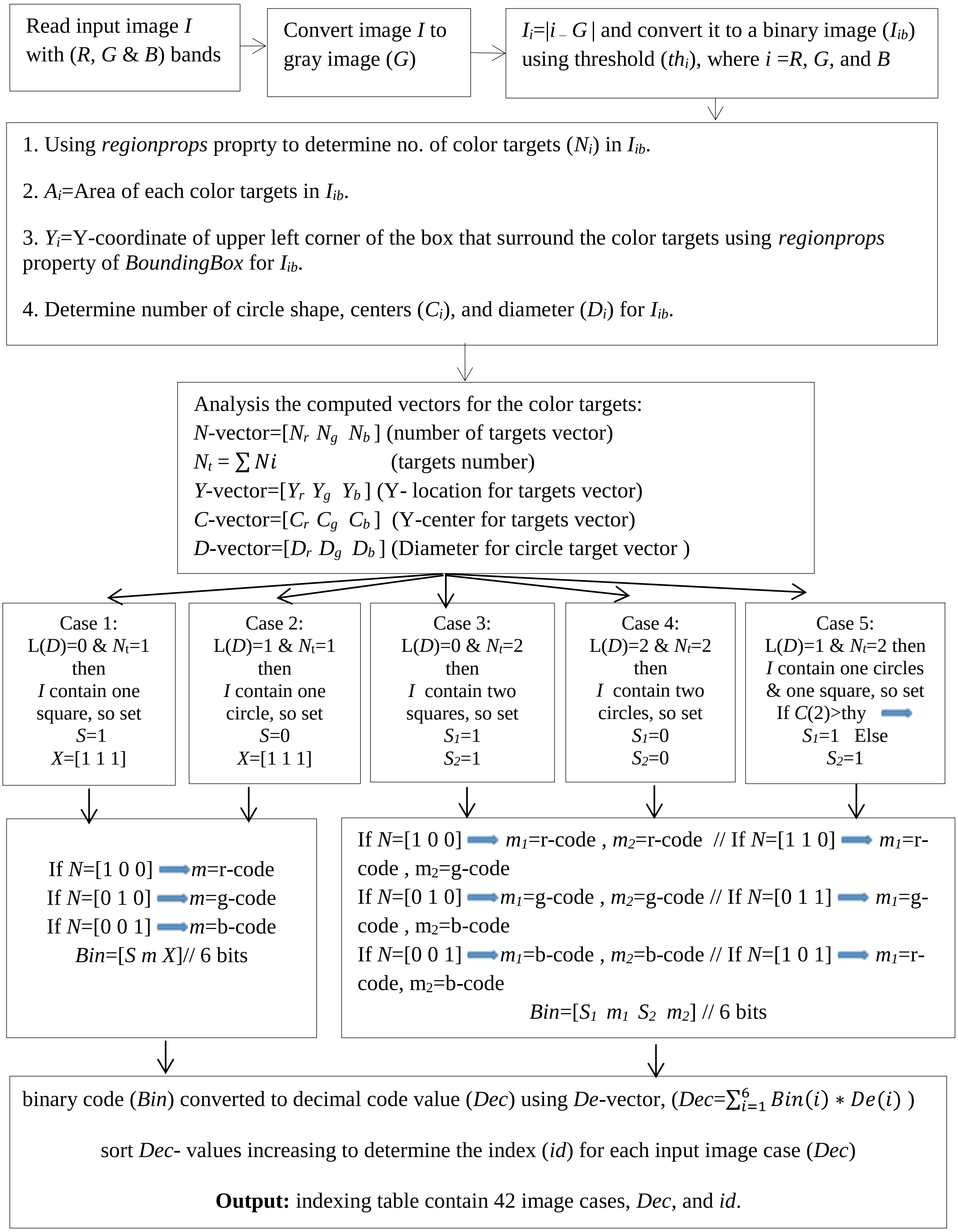


Figure 2. Block Diagram of Image Indexing Algorithm.

4. Binary Code Indexing Technique

This section discusses the novelty of the introduced algorithm to use an indexing method. A new systematic method introduced to code each case of an input image. The suggested systematic method designed to address the target shape with one-bit code and a two-bit code to the target color as shown in the table 1. There are two target shapes used within this study and coded as 0 and 1 for circle and square respectively. Moreover, three colors are used namely red, green, and blue coded as 00, 01, and

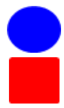
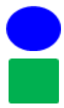
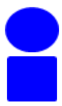
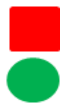
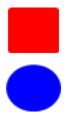
10 respectively. For instance, the red square shape can be coded as 100, and for red circle shape written as 000.

Table 1. The Suggested Codes for Representing Target Shape and Color.

	Color			Shape	
colors and shape / codes	R	G	B		
Binary codes	00	01	10	0	1

An ascending index number (id) used to code each input image simultaneously with the binary number. There are two situations in the input image, the first with one target, and the second with two targets. The two targets case the targets are aligned vertically as shown in table (2), represented by a code consisting of a 6bit binary number (*Bin*). The first 3bits of the first target will be added to the second 3bits of the second target. For the single target, the same code technique used but a fixed 3 bits (111) added to avoid the similarity when it converted to the decimal numbers (Dec). The resulted column *Dec* sorted ascendingly for each *Bin* code, but for the two targets, the *Dec* has a new start and sorts ascendingly, as shown in the table 2. Column (Occ) presents the number of the occurrence to the same input image case (IC) but it is different in position and rotation. The suggested algorithm considered all possibility of the occurrence and feedback the same resulted index case to the same input images.

Table 2. (color online) Index table for Input Images with all Cases.

Id	Bin	Dec	IC	Occ	id	Bin	Dec	IC	Occ
1	000-111	7		5	22	010-100	20		6
2	001-111	15		4	23	010-101	21		7
3	010-111	23		4	24	010-110	22		5
4	100-111	39		5	25	100-000	32		5
5	101-111	47		5	26	100-001	33		9
6	110-111	55		4	27	100-010	34		8

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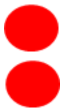
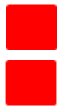
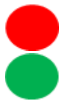
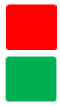
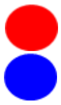
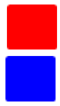
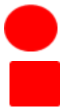
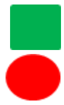
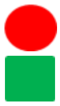
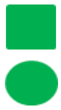
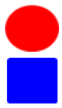
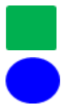
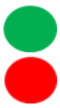
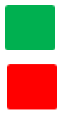
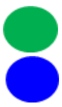
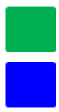
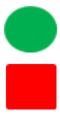
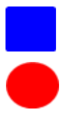
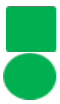
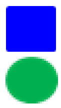
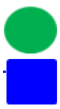
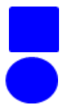
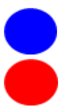
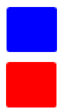
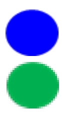
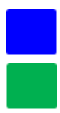
7	000-000	0		5	28	100-100	36		5
8	000-001	1		6	29	100-101	37		9
9	000-010	2		5	30	100-110	38		8
10	000-100	4		5	31	101-000	40		7
11	000-101	5		8	32	101-001	41		5
12	000-110	6		8	33	101-010	42		7
13	001-000	8		5	34	101-100	44		9
14	001-001	9		4	35	101-101	45		9
15	001-010	10		4	36	101-110	46		7
16	001-100	12		9	37	110-000	48		7
17	001-101	13		5	38	110-001	49		6
18	001-110	14		7	39	110-010	50		5
19	010-000	16		5	40	110-100	52		9
20	010-001	17		6	41	110-101	53		8

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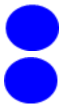
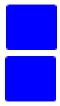
21	010-010	18		4	42	110-110	54		7

5. Estimate Optimal Threshold Value

The input image cases used in this study are contained either two color regions (background and target) or contain three regions (background and two separated target). The background color is approximately white color, while the color target has red (R), green (G), and blue (B). The statistical properties of the input image which are mean, standard deviation, and histogram calculated within un-presented designed algorithm as shown in the table 3 and figure 3 respectively. The highest values of the mean (μ) are highlighted using the circle to be used in determining threshold values later with the benefit of histogram data. The goal of applying threshold is crucial to determine optimal threshold values to extract red, green, and blue color targets.

The characteristics of the colored target and background regions must be extracted by computing mean (μ), standard deviation (σ) [15], and histogram [16]. Then determining threshold values for the separated color targets from the background in input color image. This can be achieved by extracting a block from each color region (background and targets). The red block, for instance, is not pure red, therefore a combination of green and blue appear in mean values. The resulted mean (μ) and standard deviation (σ) are listed in the table 3, while the histograms for these regions shown in figure 3.

Table 3. Mean (μ) and standard deviation (σ) for the red, green, blue, and white target.

Target color	Mean			Standard deviation		
	R	**G**	**B**	**R**	**G**	**B**
Red	**131**	26	22	3	3	3
Green	19	**82**	31	2	3	3
Blue	9	70	**147**	6	4	5
White (background)	**189**	**179**	**169**	3	3	3

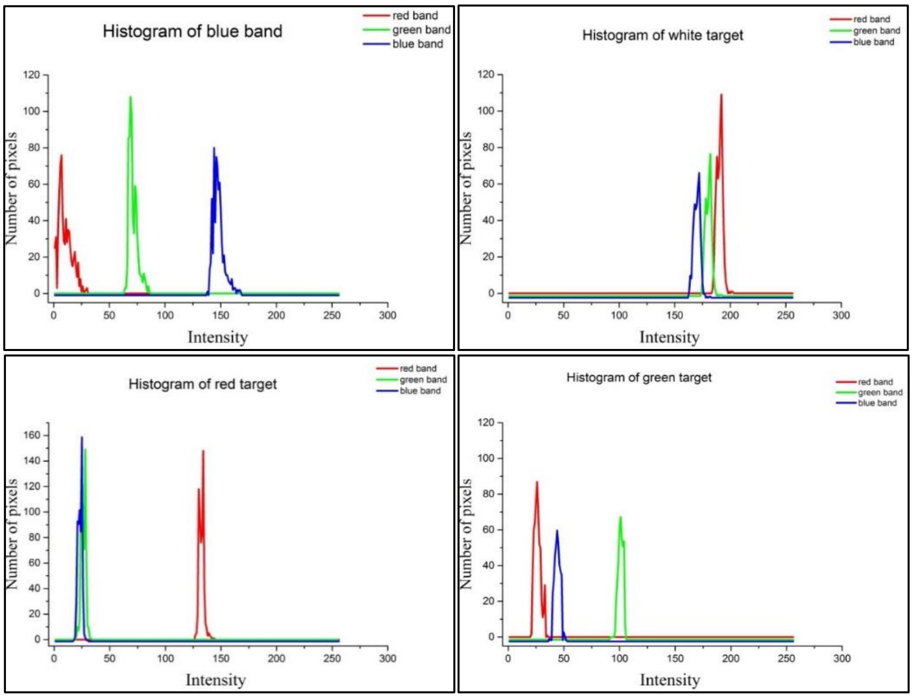


Figure 3. (color online) Histogram of red, green, blue, and white (background) target.

A new efficient way used to estimate threshold value by choosing the highest value for the mean from the table 3 and the range of the associated color in figure 3. The associated range peak in figure 3 for the red, green, and blue targets are (0.15-0.55), (0.06-0.24), and (0.12-0.52), respectively, where the range determines by considering the high and low value of each band within its histogram and dividing this range by 255. However, the optimal threshold values are within this range but need to investigate more. Therefore, a set of testing values are used in the introduced algorithm then the optimal threshold values are presented in figure 4. The values with accuracy 1 show that with this value the selected color can be shown, otherwise, the color target cannot be shown. The resulted optimal threshold values to detect color targets are (0.15-0.35), (0.06-0.1), and (0.12-0.37) for the red, green, and blue, respectively.

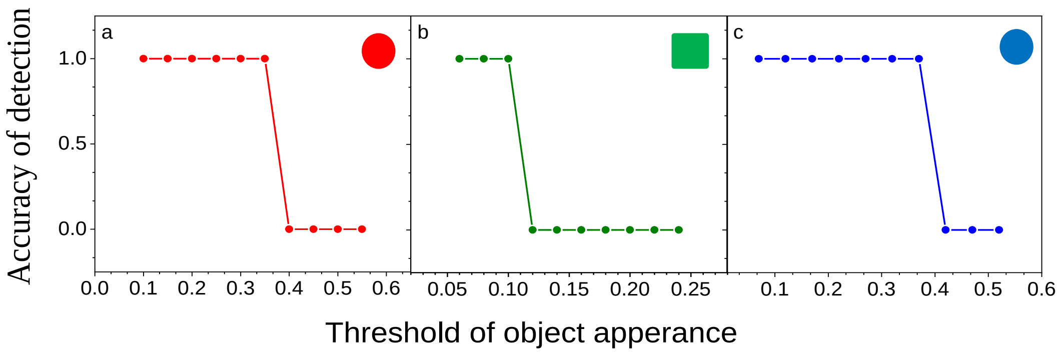


Figure 4. (color online) Optimal threshold values to detect red, green, and blue color targets.

6. Suggested Algorithm Results

The first step is uploading colored image and convert the RGB input image to grey image to have a binary image, because there is no direct way to get it. In this stage the median filter is applied to remove noise. The binary image separated to three bands of color namely red, green, and blue. These

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three bands resulted using optimal threshold method that described earlier. Figure 5 shows some input RGB image cases, gray image and color discriminated for each case.

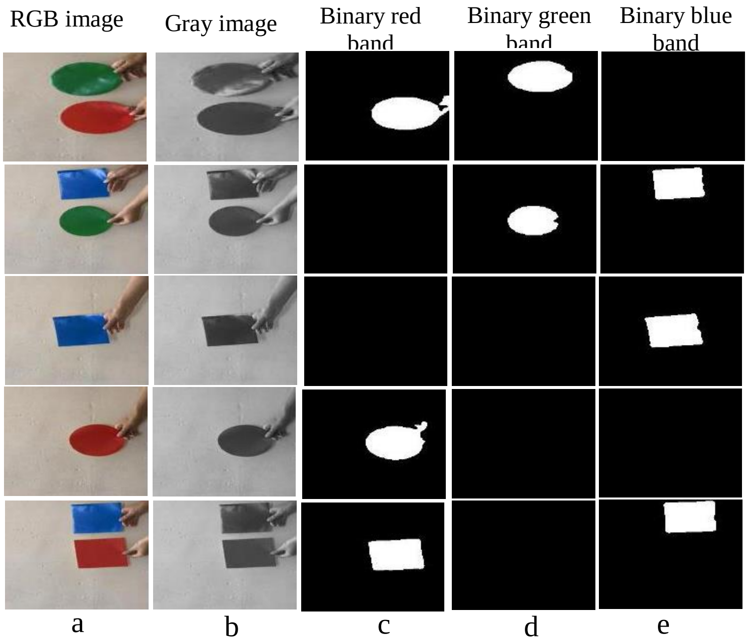

Figure 5. (color online) The process of applying the introduced algorithm steps (a) RGB input image, (b) gray image, (c) binary image (red-band) (d) binary image (green-band) and (e) binary image (blue-band).

The next step of the suggested alogorithm is tested 261 input images individualy where the similarity of the input image (same input images differing in target orientation and location in image plane) indicates the same *id* parameter for the 42 cases listed in table 2. Figure 6 shows the occurrence of some results of input image cases for one target where the target either changed in dimension (rotated or flipped) or location. All these images refer to the same *id* within the suggested algorithm.

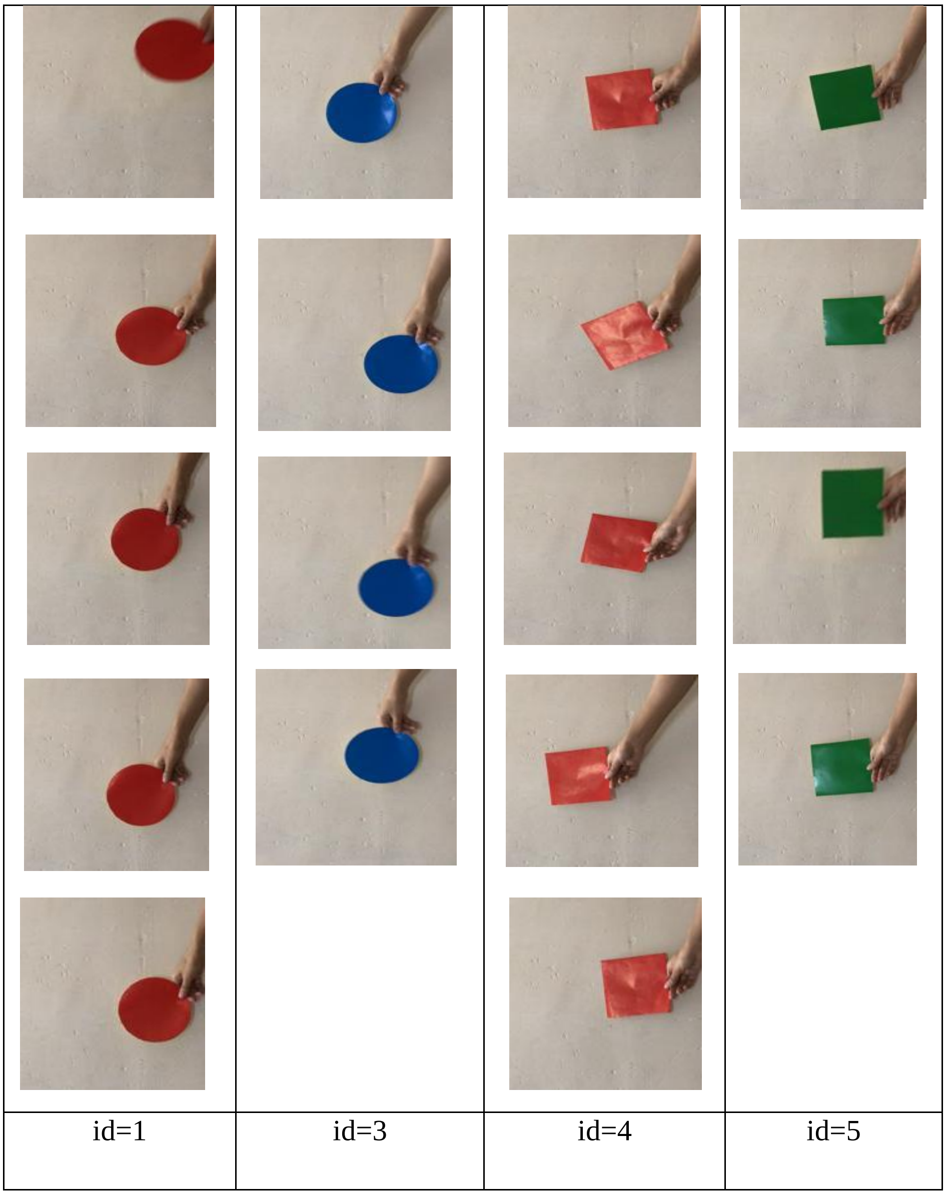

Figure 6. (color online) The input image and output indices for one target image cases.

The challenging case is with two targets where both of them are changing in dimension (rotated or flipped) or location (like space between targets). The suggested algorithm solved this issue and feedback with the same *id* value to the same group of occurrences. Figure 7 shows two targets in the plane of input images with different location, space between targets, and orientation.

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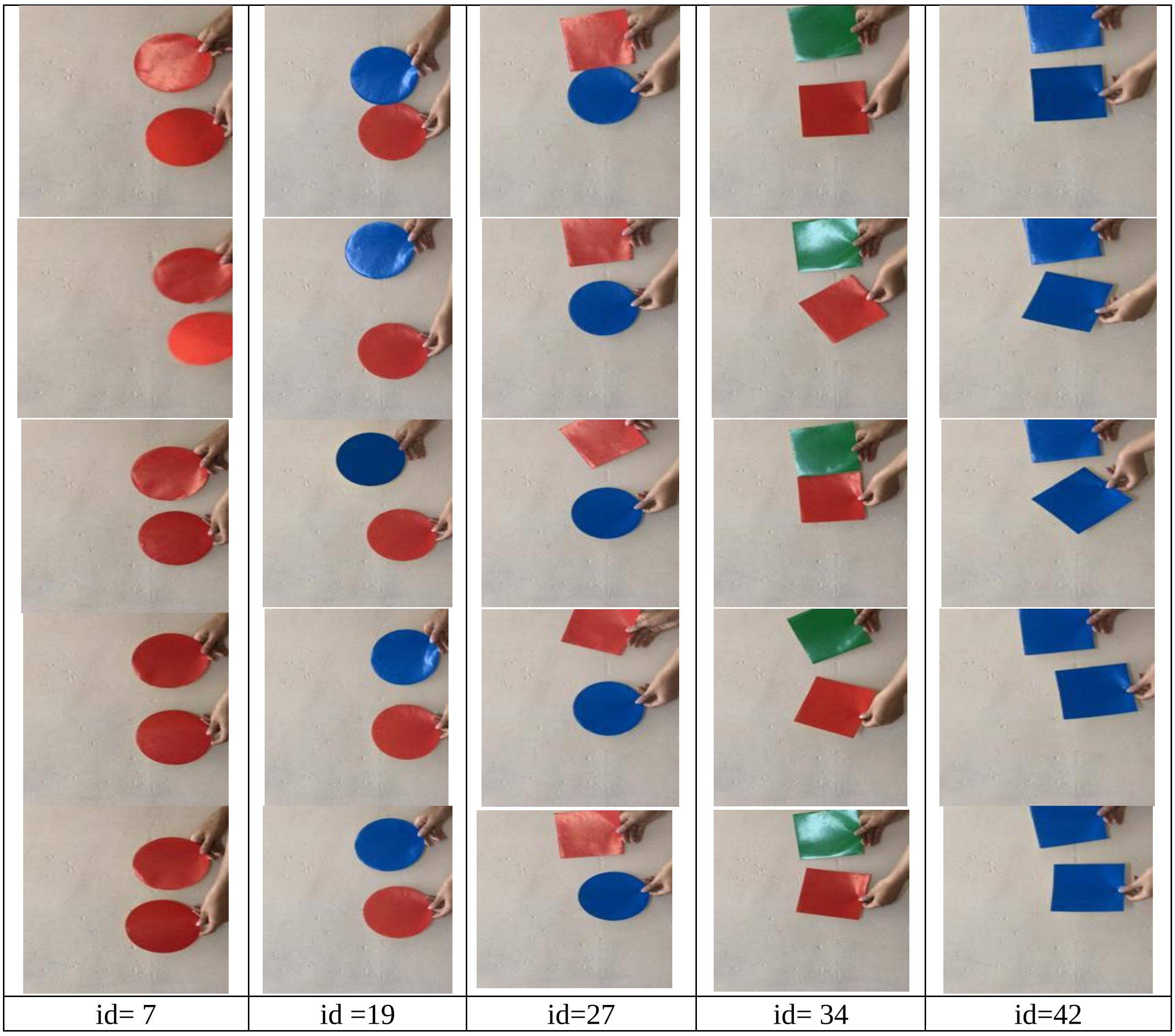

Figure 7. (color online) The input image and output indices for the two target image cases.

7. Conclusions

The suggested method, based on specially designed code for this task, used to recognize and detect multi objects that have different colors. This code concentrates first on estimating optimal threshold values for utilizing color targets. The lighting conditions play significant role to estimate threshold values in the introduced imaging system to separate the color targets (red, green, and blue) from a white background in the input images. The extracted optimal threshold values for the red, green and blue were (0.15-0.35), (0.06-0.1), and (0.12-0.37), respectively.

It is necessary to consider the similarity of the input images in case it has one. Thus, the introduced algorithm tested with different cases by changing object position, rotation or flipping to the same input object. Therefore, the idea of occurrence (Occ) presented in this work to check the recognition results and feedback to the same binary number. The binary number is coded to describe the input image in case it has one object or two, circle or square, and different color (red, green, or blue). So, this work extends to test 261 images that have 42 different cases. The resulted classification accuracy obtained from the suggested algorithm is 100%.

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