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Design and sorting of an object identification on machine vision by using line scan camera

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Abstract:This paper illustrates the design of a system to identify objects on a conveyor belt using machine vision. In the present study, a machine vision based on one line scan sorting was developed, the purpose being to sort objects based on various stages of maturity. Many different methods are available for object identification. But we made design a system that separates and counting them. Different objects placed on the conveyor belt moves along, a camera placed above the belt takes real-time video and feeds it to the MATLAB software for processing the object to compare with the basic template object. The vision camera understands an object based on its physical attributes, such as shape and size for effectively controlling the hardware, which will use in this work. Besides, the number of objects of a particular section that cross the conveyor to demonstrate the identification of moving objects is counted and displayed. A low-speed conveyor belt is manufactured with various test objects that pass through it. For identifying a good object, the wavelength data is used, determining the way to match the geometric patterns and to identify the dimensions, and edge detection is applied. The ability to count specific attributes objects is testing different test paths. The sorting of objects using machine vision was performed using an algorithm of pattern matching of machine vision. A pattern image template was built and stored in a computer's memory. When the object is sorting the application run, the camera receives the image of the object into MATLAB. The vision application investigates the image and transfers it to the classifier if the received image matches the model image or not matches.
Keywords:Machine vision, Sorting Object, Line scan camera, Design, MATLAB Software

1. Introduction

Machine vision gives the computer eyes and ears. The eyes are the most critical organs of the human body, and our abilities depend mainly on our ability to see, distinguish, and separate objects. Most professions depend on our vision. Machine vision does not mean design and sketch; indeed, it identified with the innovation of view; it made sense. Cameras offer PCs or devices the ability to see and distinguish and recognize elements or circumstances and decide the right options in the same way. Study progress of strategies and methods that allow the machines to translate digital images into m / c vision [1]. Over the past 15 years, machine vision in innovation has improved rapidly, becoming essential and, more often than not, a necessary device for robot assembly. Machine vision systems are now available in a wide range of commercial businesses, including semiconductors, pharmaceuticals, packaging, gadgets, car, and products for the shopper [2].

Machine vision is not a new phenomenon when it comes to object separation. The detection of objects in transport is a widespread industrial problem. When all objects are the same or have few variations, model-based recognition methods may be used. Plants for recycling, bottles, plastics, and other products must be classified. Inspect the objects of the fixed chamber mounted on the transport system used [3]. One has to decide if a pixel belongs to an object or a background. Line-scan cameras, as two-dimensional imaging instruments, have high resolution and fast frame rates [4]. These features open up new possibilities for more accurate measurement of continuously moving objects at high speed. As a result, line-scan cameras have largely replaced matrix cameras in vision measurement, especially in real-time applications [5].

Our idea for this paper is to use one line-scan camera to scan the object horizontally to the axis of motion of the objects. The object is scanned as they pass on the conveyor belt of the cameras and we can calculate the inspection time needed by an object. We may expect better accuracy than current solutions because the line rate of this camera is very high (up to 100 lines/sec). We'll start by setting out the fundamentals of our latest line-scan approach and demonstrating its viability. Following a summary of the experiments, a section discusses the image processing software that was used to retrieve all of the data from the line sequences. The process's results are then discussed and presented.

2. Literature review

Many articles and papers on the use of vision systems in object recognition and sorting operations in the industry are available in the open literature. Here's a look at some of the literature on the topic. Pourdarbani et al[6]. Research on an automated sorting system for date fruits based on different steps of its ability to satisfy customer requests was displayed. The system materialized a conveyor belt on which dates passed and a camera to capture the image of the dates. The sorting framework was a suitable engine-driven actuator.Hanmei et al[7].Using machine vision, demonstrated a method for classifying and sorting aquatic products.The visual quality of fish, fish fillets and other marine products was determined using machine vision. Chmiel et al[8].Presented the use of a vision system for estimating fat content in poultry meat chicken and turkey bodies have been chosen arbitrarily, and analyses made between the substance of white spots procured with vision framework and solid substance decided by using the reference Soxhlet method. L.S.Alandkar et al[9]. In this paper, the basic and simple object detection system was purposed. Different toolboxes and functions are used at various points during the research and implemented and using simple MATLAB code to detect the image as a result. This research also helps with future work and helps new researchers as well. Wei et al[10].Proposed an automated system for removing fruit vision the method is focused on optimizing the OHTA color space threshold algorithm. The yields were seen as binary images, and the organic product articles were naturally strategy.

3. Material and method

Object detection is a computer vision technique for recognizing and locating objects in images, videos, and real-time. Object detection can be used to count objects in a scene, determine and track their precise positions, and mark them specifically using this identification [11]. This project involves object detection from a conveyor belt. Different objects placed on the conveyor belt moves along, a camera placed above the belt takes real-time video and feeds it to the MATLAB software. It using different techniques from image processing and machine vision to detect the object and matches it to the predefined image of the object.

3.1. System setup and structure

This section describes the hardware design for the study. All experiments result was using a LAPTOP with an i5 processor, 8 GB memory, and Windows 10 64-bits. Besides, MATLAB R2019b software was used for performance evaluation of the network's architecture.Moreover, an image processing Toolbox has been utilized, which allows a framework to design and implement.To select appropriate illumination and capturing devices, one type of illumination source was used, namely, Power LED 12 V DC and combination with one model of camera 'Basler Runner ruL1024-57gm' monochrome. It is a line scan CCD series that combines high-quality line scan technology with Gigabit Ethernet (GigE) interface technology and the sensor size is 1024 pixels. A Nikon F-mount lens with an effective focal length of 28 mm is used. The runner family's validated image quality and clear GigE interface make it suitable for a wide range of applications.To transport the plastic objects, a conveyor belt system was prepared.The approximate speed is 10 sec. In this paper,we use a sport conveyor belt to classification plastic objects. Figure 1represented a model of the CDD camera and Figure 2 represented the system structure of the study.

Figure 1. Basler Runner ruL1024-57gm monochrome line san camera

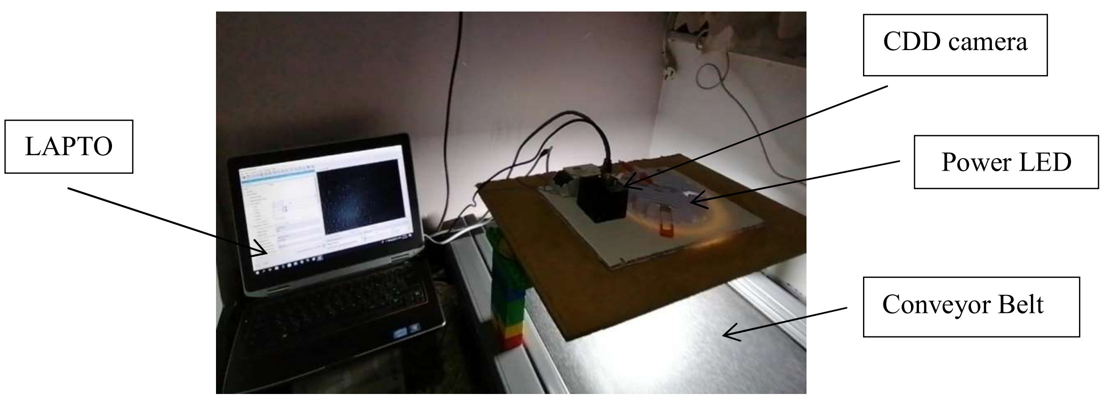

Figure 2. The System Structure

3.2. Detection algorithm

The sorting of objects using machine vision was performed using an algorithm of pattern matching named (Normalized Cross-Correlation) of machine vision. A pattern image template was built and stored in a computer's memory. When the object is sorting the application run, the camera receives the image of the object into MATLAB. The vision application investigates the image and transfers it to the classifier if the received image matches the model image or not matches [12].While cross-correlation can be accomplished effectively in the transformation domain, the normalized type of cross-correlation used in feature matching applications lacks a simple frequency domain expression. As a consequence, the spatial domain normalized cross-correlation is determined.
The implementation closely follows the formula from:

$$\gamma(u,v) = \frac{\sum_{x,y}\left[f(x,y)-\bar{f}_{u,v}\right]\left[t(x-u,y-v)-\bar{t}\right]}{\left\{\sum_{x,y}\left[f(x,y)-\bar{f}_{u,v}\right]^2 \sum_{x,y}\left[t(x-u,y-v)-\bar{t}\right]^2\right\}^{0.5}} \quad (1)$$

Where

- ❖ f is the image.
- ❖ $\bar{t}$ is the mean of the template
- ❖ $\bar{f}u,v$ is the mean of f (x, y) in the region under the template.

3.3. Principle and feasibility (objects speed and line scan speed relation)

From intensity shifts in captured images and lighting directions, the normalized cross-correlation method will estimate the normal map for a target object. We suggested using a CCD image sensor to capture several images under various lighting conditions nearly simultaneously [13]. However, there is an issue with motion blur when capturing dynamic scenes. For the normalized cross-correlation, we need to set an exposure time that is long enough to capture the detailed intensity changes in the captured images. The following equation defines the relationship between object speed and line speed time taken to acquire the single image:

$$v_{max} = \frac{d}{f}\frac{s}{e'} \quad (2)$$

Wherev_{max}, f *and* $e$are the maximum speed of the object, the focal length of the camera lens, and the total exposure time. The distance between the image sensor and the scene is represented by$d$, and the pixel size of the image sensor is represented by$s$. We may disregard the motion of a target dynamic scene if the target object is projected in the same image sensor pixel over time, according to this equation. We used a CCD image sensor with pixel dimensions of 10 µm x 10 µm in our implementation. The relationship between the relevant object speed and the exposure time is shown in Figure 3. With a camera lens focal length of 25 mm, we measured the applicable object speed to get the results. By moving the target object further away from the image sensor or reducing the exposure time, we can capture multiple images from a faster dynamic scene.

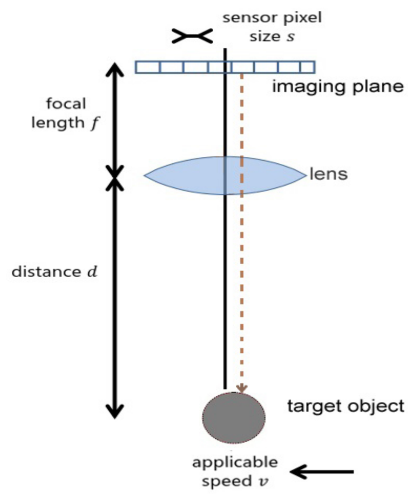

Figure 3. Relationship between object speed and the exposure time (Equation (2))

3.4. Image processing technic

This section describes in detail the functionality of the processes involved in the programming of MATLAB. The function block says image processing involves many processes. It is a multistage process. The first step is converting a grayscale image to a binary image. Converting an image into binary increases working capability and reduces the work time of the process. In MATLAB im2bw() function takes an image as input and outputs a black and white image. The conversion is done based on the threshold value. In this study, we have used some image processing operations such as the rotation technique to enhance the training data[14]. Rotating has been implemented by applying degrees of 45, 90, 135, 180, 225, 270, 315 degrees, for determining these angles we utilized the (Imrotate) function in the MATLAB environment as shown in Figure 4.

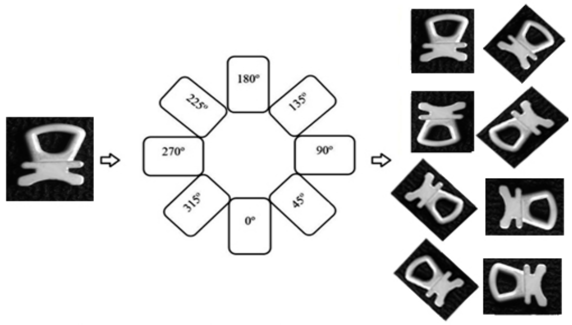

Figure 4. Rotation Process in different degrees

The most basicof image segmentation is thresholding, which is also the most common method of converting a grayscale image to a binary image[10]. We choose a threshold value in thresholding, and then all gray level values below the selected threshold value are counted as 0.5. (Black i.e. background) and all the gray level which is equal to or greater than the threshold value are classified as 1(white i.e. foreground). The thresholding is defined in the following equation[15].

$$g(x,y) = \begin{cases} 1 & \text{if } f(x,y) \geq T \\ 0 & \text{otherwise} \end{cases} \qquad (3)$$

In this case, g(x, y) represents the threshold image pixel at (x, y), and f(x, y) represents the greyscale image pixel at (x, y).A threshold is set based on the percentage of matching of the two images. Image thresholding is a basic but efficient method of dividing an image into foreground and background areas[16]. This image processing technique is a method of image segmentation in which objects are isolated by transforming grayscale images to binary images. Image thresholding works well in images with a lot of contrast.BW = im2bw(I, level) converts a grayscale image I to a binary image BW by assigning the value 1 (white) to all pixels in the input image with luminance greater than level, and 0 to all other pixels (black).The next process involves removing noise from the image. Median filter 2-D is typically used for removing salt and pepper noise in images.The next process involvesremoving noise from the image. Median filter 2-D is typically used for removing salt and pepper noise in images.

Figure 5. Applying the median filter removes the noise

In the next step, small objects are removed from the image that may disrupt the matching process. BW2 = bwareaopen(BW,P) removes all associated components (objects) from the binary image BW that have less than P pixels, resulting in BW2. An area opening is a term for this procedure. This is the final process in this step of the program. The output after these three processes is shown in Figure 6.

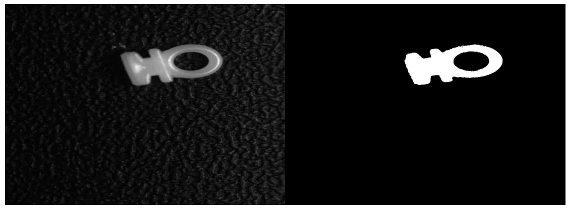

Figure 6. Greyscale image (L) processed image (R)

This final image is matched with the template image stored already using correlation. The normalized cross-correlation of the matrices template and A is computed by C = normxcorr2 (template, A). The correlation coefficients are contained in the resulting matrix C. For the normalization to be valid, the input image, defined as a numeric image, must be larger than the matrix template.

3.5. Image analysis and output

The first step is taking a snapshot from the live feed of the camera above the conveyor belt. When the program starts a prompt asks for uploading the predefined image (template image) of the object. The main program starts after that and live video is displayed on the screen. Processing of the snap is a multistep process that involves removing the noise, converting it into a binary image; blob analysis, etc.…Every frame from the live video is converted into a binary image for fast processing. A two-dimensional median filter is used for noise reduction. For further processing area of white parts of the image are calculated any area less than a specified value are rejected. The area of all objects is calculated beforehand and snaps that have an area near to the area of the object are used for further processing. In any operation, the output is extremely important. Something is done in exchange for something else. The final output is also generated by machine vision applications. Machine vision applications' outputs are usually classified as Pass/Fail. However, for Pass/Fail outputs, additional attributes may be specified, such as the number of passed/failed items, setting an alarm if the items are failed, and so on. It is dependent on the application's target. Figure 7 represented the proposed study.

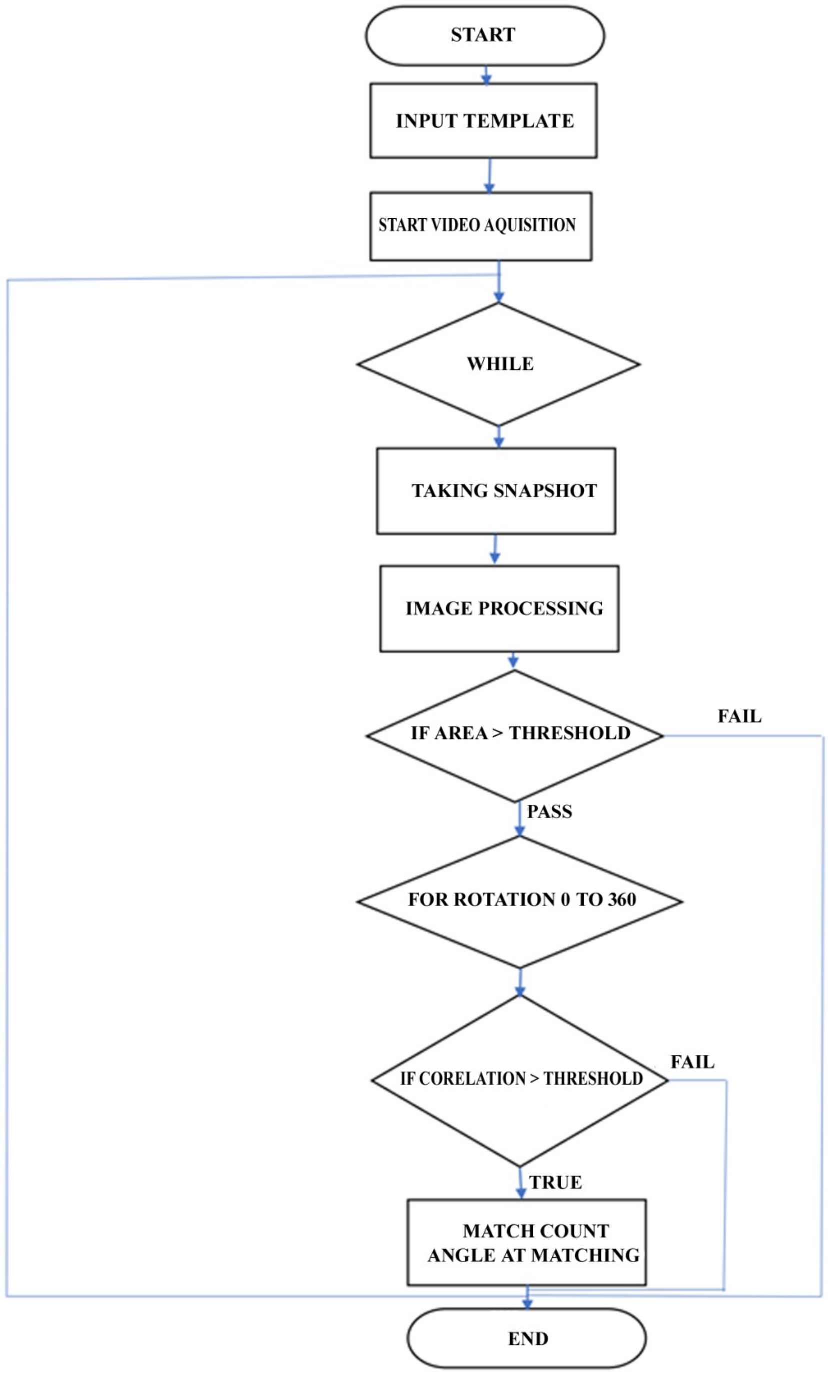

Figure 7. Proposed work of object sorting

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3.6. Implementation

The implementation of the object sorting method is described in this section. First, we need to determine the duration of the exposure. The length of the exposure and the amount of noise in the recorded images are a trade-off. Long exposure times trigger motion blur when the speed of a dynamic scene is high. By reducing the exposure time this effect can be reduced; Short exposure times result in lower SNR (Signal-to-Noise Ratio)[17], which affects the precision of the estimated surface standard. As a result, we determined the target dynamic scene and devised a sufficient exposure time. Then we designed the camera lighting system and created the light sources.

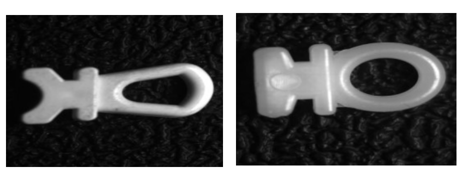
4. Results and discussion

4.1. Experimental Environment

In this section, the experimental environment is set as an industrial inspection system; the mono-color background is used and simple objects recognized. The Mono-colour background leads to the clear separation between the background and foreground. The clear separation also helps the clear edge detection in pre-processing. To reduce the time consuming we limited the intersection of line feature to be formed on the edge and its neighbor only. Finally, the normalized cross-correlation algorithm is performed by using the relation between the geometric features. The objective of this research was to sort different shapes and cracks of objects from different rotation. The results are shown in Tables 1, 2, 3.

4.2. Experimental Matching Result

We experimented with two different model objects and tested with 6 different target live videos two repeats per object. The average for each object is calculated to evaluate the accuracy of one object per line scan that is provided in the Tables below. The classification accuracy of the proposed algorithm is about equal to or more than 90%, at a speed of 6 m/s per image, which can meet the requirements of the system. It can be found from Tables 1, 2 that, the correct percentage of match objects is relatively high; this is due to the quality that the feature of match objects may vary greatly, and the classifier tends to classify it to be a good object.Small plastic models with varying parameters of shape and size were prepared to consider items with varying attributes (large, small, cracked, and different).A conveyor belt system was used to transport these blocks.A camera captured the image in real-time.The setting's background was kept simple black to allow for proper object detection.Standard light was used to provide illumination. Figure8 shows the simple plastic objects model used in the present work.



Object model 1   Object model 2

Figure 8. The simple plastic objects model

According to Table 1 and Figure 9 model 1 of an object has used approximately 0 degrees and obtained 93.12 %, but for the second repeat of the object is 92.87 %, while the detection rate of both repeated obtained 92.99 % in an inspection time of 6.7893 m/s per repeat. While when used 90 degrees and obtained 98.16 %, but 97.96 % was replicated for the second, while the detection rate of both repeated obtained 98.06 % per repeat in an inspection time 6.4529 m/s. When used 135 degrees and obtained 95.23%, but for the second repeat of the object, is 94.97%, while the detection rate of both repeated obtained 95.01% in 5.9743 m/s per repeat. Object model 1 has used 180 degrees and obtained 92.99 %, but for the second repeat of the object, is 93.03 %, while the detection rate of both

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repeated obtained 93.01 % in 5.6468 m/s per repeat. Also, object model 1 has used 225 degrees and obtained 99.13 %, but for the second repeat of the object is 98.94 %, while the detection rate of both repeated obtained 99.03 % in 6.2587 m/s per repeat. Also when used 270 degrees and obtained 96.83 %, but the second repeat of an object is 97.04 %, while detection rate of both repeated obtained 96.93 % in 5.8793 m/s per repeat.

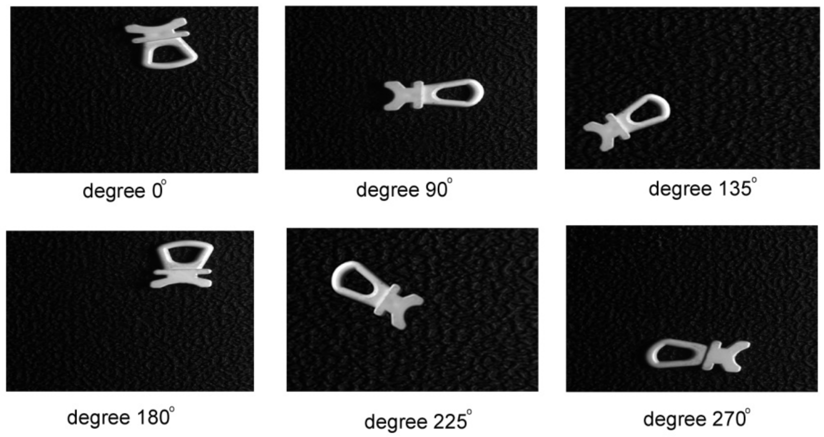

Figure 9. Results on target object model 1

Table1. The detection rate of sorting object model 1 during 2 replications by cross-correlation

Object	Rotation degrees	Repeat 1(%)	Repeat 2(%)	Detection rate	Inspection time (m/sec)
Model 1	0	93.12	92.87	92.99	6.7893
Model 1	90	98.16	97.96	98.06	6.4529
Model 1	135	95.23	94.97	95.01	5.9743
Model 1	180	92.99	93.03	93.01	5.6468
Model 1	225	99.13	98.94	99.03	6.2587
Model 1	270	96.83	97.04	96.93	5.8793

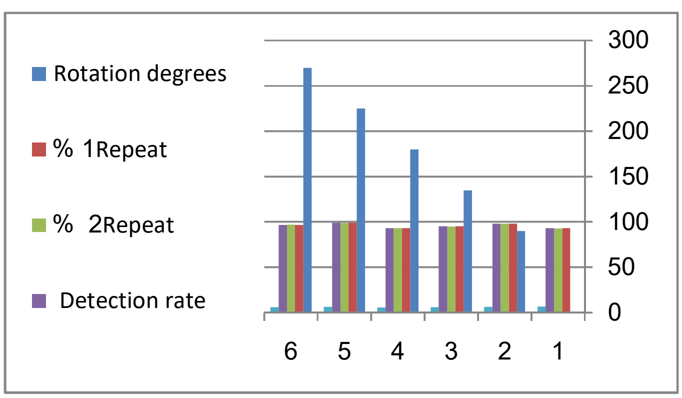

Figure 10. Line chart of detection rate of sorting object model 1

According to Table 2 and Figure 11 object model 2 has used 0 degrees and obtained 94.77 %, but for the second repeat of the object is 95.17 %, while the detection rate of both repeated obtained 94.97 % in 6.4879 m/s per repeat. While used 45 degrees and obtained 98.14 %, but 97.97 % was replicated for the second, while the detection rate of both repeated obtained 98.05 percent per repeat in 5.9984 m/s. Object model 2 has used 90 degrees and obtained 96.88%, but for the second repeat of the object is 97.19%, while the detection rate of both repeated obtained 97.03% in 6.1289 m/s per repeat. When object model 2 has used 270 degrees and obtained 99.56 %, but for the second repeat of the object is 99.14 %, while the detection rate of both repeated obtained 99.35 % in 5.1223 m/s per repeat. Also when used 180 degrees and obtained 94.14 %, but the second repeat of the object is 93.89 %, while the detection rate of both repeated obtained 94.01 % in 5.7823 m/s per repeat. When used 315 degrees and obtained 99.29 %, but the second repeat of the object is 98.95 %, while the detection rate of both repeated obtained 99.12 % in 6.7233 m/s per repeat.

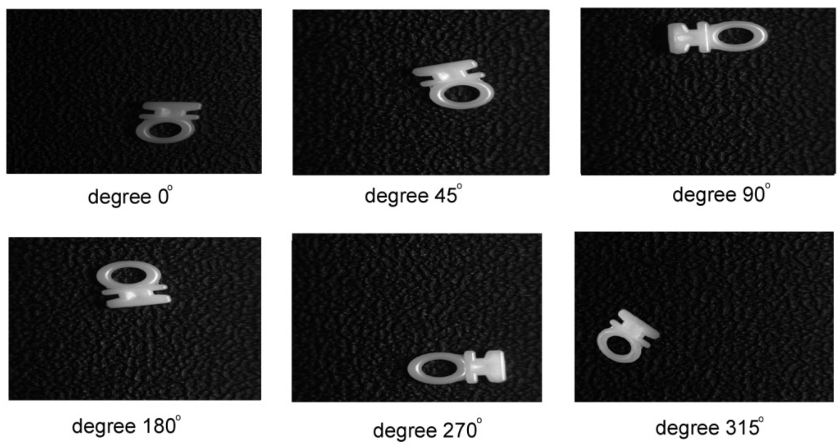

Figure 11. Results on target object model 2

Table 2. The detection rate of sorting object model 2 during 2 replications by cross-correlation

Object	Rotation degrees	Repeat 1(%)	Repeat 2(%)	Detection rate	Inspection time (m/sec)
Model 2	0	94.77	95.17	94.97	6.4879
Model 2	45	98.14	97.97	98.05	5.9984
Model 2	90	96.88	97.19	97.03	6.1289
Model 2	180	94.14	93.89	94.01	5.7823
Model 2	270	99.56	99.14	99.35	5.1223
Model 2	315	99.29	98.95	99.12	6.7233

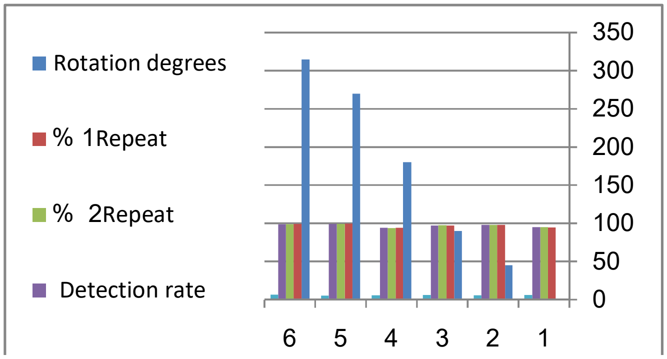

Figure 12. Line chart of detection rate of sorting object model 2

According to Table 3 and Figure 13 object model 1 has used 90 degrees and obtained 63.15 %, in 5.2945 m/s for once, but for the second time of object has used 270 degrees is 86.96 %, in 5.9843 for once, while the detection rate of both obtained 63.15 % and 86.96 % respectively.Object model 2 has used 225 degrees and obtained 46.33 %, in 5.5464 m/s for once, but for the second time object model 1has used 90 degrees is 51.04 %, in 6.4982 m/s for once, while the detection rate of both obtained 46.33 % and 51.04 % respectively.

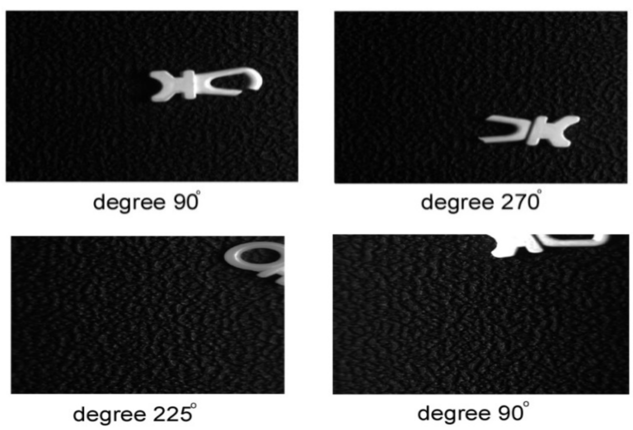

Figure 13. Results on target cracked and mismatched object model 1 and 2

Table 3. The detection rate of sorting object cracked, mismatched model 1 and 2 by cross-correlation

Object	Rotation degrees	Detection rate	Inspection time (m/sec)	Pass/Fail
Model 1	90	63.15	5.2945	Fail
Model 1	270	86.96	5.9843	Fail
Model 2	225	46.33	5.5464	Fail
Model 1	90	51.04	6.4982	Fail

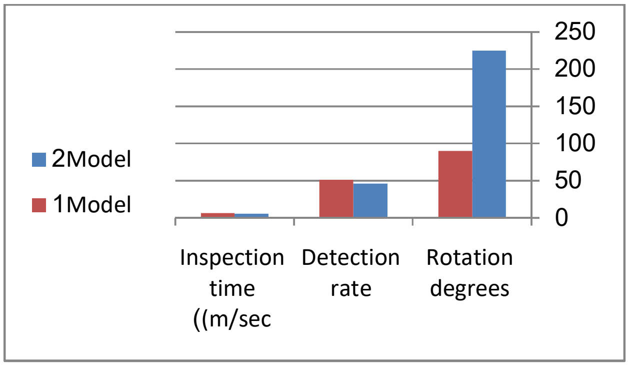

Figure 14. Line chart of detection rate of mismatch and crack object model 1 and 2

5. Discussion

System compared the results with two different objects from different shapes and degrees estimated using the proposed method with those estimated using the previously normalized cross-correlation. The method with a high-speed camera and we repeat the object on the conveyor belt two times to compare results to know the detection rate increased or decreased. We captured one image of the object as a template for the target dynamic scene. We set exposure times of more than 60 seconds per object while crossing on a conveyor belt in the comparison experiments. Also, we need to know which object is matched, not match or mismatch, and crack from which degree as shown in Figures 9, 11, and 13. When we see both object models 1 and 2 for case pass in degrees 0, 45, 90, 135, 180, 225, 270, and 315 we get approximately the same detection rate. Those results depend on the speed of executing algorithm and camera in a good position and other case cracked and mismatched object the system does not pass and is rejectedA speed coder must be used to obtain the relative speed between the detected target and the line-scan CCD camera image capture system to correct the image error created by the speed mismatch in the line-scan process.

6. Conclusions

When it comes to sorting objects, quality is essential. Object detection has attracted a large number of researchers who have made significant progress in this area. To detect object flaws effectively and with high accuracy, many vision-based automated object detection algorithms have been proposed. Before we apply any kind of detection process, we must ensure that the image quality is accurate to ensure the accuracy of the detection result. However, as we know, all camera lenses have distortions, especially radial distortion. Much research has gone into 2-D camera image correction to eliminate the distortion and correct the image. The vision system used in this paper is an interactive system with built-in MATLAB software with a vision assistant module for the recognition of objects in terms of their attributes, such as shape and size. The user can see the field of view from various degrees, as well as the number of sections in each group. Small, big, and cracked shapes can all be differentiated in the same way. The camera can separate objects in this analysis. Also, the program can identify any objects.

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