Classification of Used Electronic Components based on Circular Hough Transform

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***Abstract*—** Classification of Electronic components can be done based on various parameters such as shape, size, color, texture, number of terminals. Electronic components such as LDR, transistor, disc capacitor are circular in shape. For identification and classification of these components into different categories according to their functionalities different methods such as Profile based method, template matching methods, circular Hough transform can be used .

In this paper use of circular Hough Transform to identify the circular shaped electronic components has been discussed. Hough transform has been used for detecting the circles on the images of components. Circular electronic components such as LDR, transistors and disc capacitors have been identified by using circular Hough transform. These components have been classified into different classes according to their functionality. The algorithm has been tested on twenty images of each component using MATLAB.

***Keywords*—** *Hough transform; classification; electronic components; E waste; MATLAB*

I. INTRODUCTION

Electronic component manufacturing and semiconductor Industries employ automated visual inspection systems[1] These systems are used for quality improvement in production line. Components with defect such as surface defect, missing lead terminals, wrongly placed terminals etc. are rejected to increase the efficiency of production system[2] Different techniques are used for visual inspection of different components. The surveys of various optical inspection systems in the semiconductor industry has been presented in[3]

Automated visual inspection during manufacturing process is conducted using an image-processing technique for quality control [4] .The vision-based algorithms that had been used in the visual inspection systems include projection methods, filtering-based approaches, learning-based approaches, and hybrid methods. The practical systems of automated visual inspection in the semiconductor industry covers the manufacturing and production of wafer, thin-film transistor liquid crystal displays, and light-emitting diodes.[5]

To achieve a high robustness and computational efficiency of automated visual inspection, interdisciplinary knowledge between precision manufacturing and advanced image-processing techniques is required in the novel system design. Template matching technique has been the popular technique used in semiconductor and electronic industries.[6] Use of such systems for E waste Management at component level has not been reported so far. There is a need of low cost machine vision systems to solve this problem.[7]. Because of use and through tendency many components mounted on the printed circuit boards are thrown away event though they are in working condition. To reduce the E waste some measures should be taken to recover the working components from these PCBs.[8] Automatic de soldering techniques must be employed to separate the components from the PCBs and with the help of machine vision system [9].Classification and sorting of these recovered components could be carried out using different computer vision algorithms such as template matching for matching the shape of a component, profile based technique to detect the broken terminal[10], optical character recognition for recognition of printed information on the body of components based on technical information [11]

This paper discusses the application of circular Hough transform for detection of circles on the image of some through hole electronic components which exhibit circular shape. Classification of circular shape components into their respective classes viz. LDR, Signal Transistor, Power transistor and Disc Capacitor has been carried out using circular Hough transform.

II. RELATED WORK

A. Hough Transform

Hough transform was originally introduced to detect lines in binary images by Paul Hough[12 It was later used to detect circle and ellipse in the binary images and was extended further to detect any arbitrary shape[13] Hough transform has been applied by many researchers in many applications such as Traffic and Transform to detect lane lines[14],lane departure warning system[15],driver assistance[16] and lane marking system[17],vehicle license plate detection[18],road sign recognition[19]. In Biomedical applications Hough transform has been used for generic hand detection[20],hand gesture and tracking etc.[21]

B. Circular Hough Transform

The Hough transform is used to isolate features of a particular shape within an image. It requires that the desired features be specified in some parametric form. The classical Hough transform is most commonly used for the detection of

regular curves such as lines, circles, ellipses, etc. A generalized Hough transform can be employed in applications where a simple analytic description of a feature(s) is not possible. The main advantage of the Hough transform is that it is tolerant of gaps in feature boundary descriptions and is relatively unaffected by image noise. Due to noise immunity Hough transform has been widely used in many applications, for example, 3D applications, object and shape detection, lane and road sign recognition, industrial and medical applications, pipe and cable inspection, underwater tracking etc.[24]

Circular Hough transform has been employed to locate eyes and head for people detection[22], for object detection and tracking. Detection of circular features in objects during industrial production has been of prime importance.[23] .Hough transform is the most preferred technique used to detect the single or multiple circles in the image.

C. Basic Circular Hough Transform

Circle Hough transform can be used to determine parameters of a circle if number of points on the perimeter are known.

A circle with center (a, b) and radius r in a binary image is, specified by the parameters (a ,b, r) and represented by the equation

$$(x-a)^2 + (y- b)^2 = r^2 \quad (1)$$

Where (x, y) is the set of edge pixels that make the circumference of the circle. The same circle can be described with the parametric equations

$$x=a+r\cos\Theta \quad (2)$$

$$y=b+ r\sin\Theta$$

When the angle θ sweeps through the 360 degree range, the points(x, y) trace the perimeter of a circle. For each edge pixel, the basic Hough transform method constructs a circular cone in the (a, b, r) parameter space or Hough space. Hough space is obtained from the voting process of the (a, b, r) parameters whose associated circles pass through the considered pixel by using a fourfold loop over x, y, a and b[25] is shown in figure 1

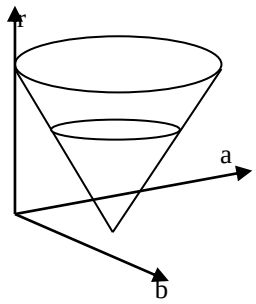

Figure1 Circular Cone

If the circles in an image are of known radius R, then the search can be reduced to 2D.The locus of (a,b)points in the parameter space fall on a circle of radius R centered at (x,y). The true center point will be common to all parameter circles, and can be found with a Hough accumulation array as shown in figure 2. Each point in geometric space (left) generates a circle in parameter space (right). The circles in parameter space intersect at the (a,b) that is the center in geometric space

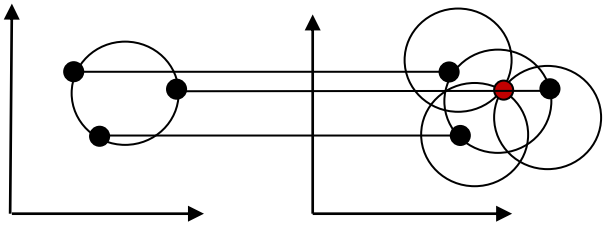

Figure 2 Multiple circles

III. EXPERIMENTAL SET UP

In this paper use of circular Hough Transform to identify the circular shaped electronic components has been discussed. Hough transform has been used for detecting the circles on the images of components. Circular electronic components such as LDR, transistors and disc capacitors have been identified by using circular Hough transform. These components have been classified into different classes according to their functionality. The algorithm has been tested on twenty images of each component using MATLAB. Experimental set up is shown in figure 1. Experimental set up for classification of circular electronic components consists of web camera, conveyor belt, PC/Laptop , Mechanical sorting system and Microcontroller to control the speed of a conveyor belt and position of bins in a sorting system.

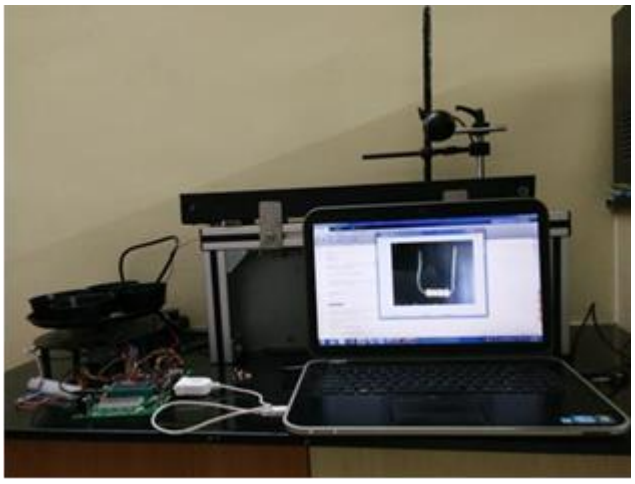

Figure 3 Experimental Set Up

IV. METHODOLOGY

For classification of electronic components, images of used electronic components have been captured. Robok20 web camera has been used. Twenty images of each of the

components have been acquired and have been stored in database. The images are in RGB color format with 640 x 480 pixel resolution. To acquire images three types of circular components viz., circular g LDR, ceramic disc capacitor signal transistor and power transistor were selected. Images of the components have been captured by keeping the distance between the object and the camera fix i.e. 9 cm.

After capturing the image of a component, the RGB image was converted to gray scale Image. Gray scale image was then converted to binary image by using thresholding method. Binary image was segmented using edge detection technique. Hough circle was then detected on the image using imfindcircle function from image processing toolbox of MATLAB. Radius obtained as a result after implementing this function was used to compare with the radius of the circle in other components for classification. Imitation of Hough transform is that the value of a radius should be known before application of Hough transform. To overcome this difficulty, radius has been calculated prior to applying Hough transform. Radius has been calculated using regionprops. Steps involved in object detection

a) Acquire the image of a component placed on the conveyor belt.

b) Convert the image to gray scale Image

c) Binarize the image using threshold method eletion: Delete the author and affiliation lines for the second affiliation.

d) Isolate the electronic component from the background

e) Evaluate radius of the circle to be detected using

f) Evaluate radius of the circle to be detected using

g) Classify the component based on the value of radii.

After applying the circle Hough transform to images of signal transistor, power transistor, Light dependent resistor and disc capacitor the results obtained are shown if figure 2,3,4,5 respectively.

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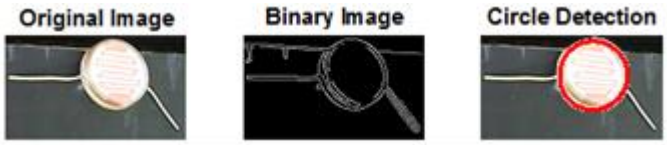
a) b) c)

Figure4 a) Image of a signal transistor
b) Segmented Image(Canny detector)
c) Detected circles

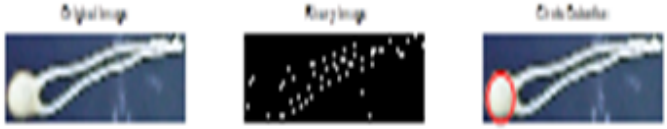
a) b) c)

Figure5 a) Image of a Power Transistor
b) Segmented Image(Canny detector)
c) Detected Circle



a) b) c)

Figure 4 a) Image of a LDR
b) Segmented Image(Canny detector)
c) Detected Circle



a) b) c)

Figure 5 a) Image of a Disc Capacitor
b) Segmented Image
c) Detected circle

IV Result and Conclusion

Hough circles have been detected in the images of power transistor, LDR and disc capacitor. It has been observed that the radii of the circles detected in the images of component depend on the size of the component. Hence the classification has been done based on the radius of a circle

In Detected in the image. Circular Hough transform has been successfully used for classification of used electronic components that are having circular shape. Result of the classification has been further used for sorting the components based on their functionality and the material used for construction of these components.

Limitation of Hough transform is that it runs slowly because of large number of mathematical operations. This increases the computational cost of the transform and large stroage

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TABLE I.

Radius evaluated by Hough Transform	
Name of the Component	Radius in Pixel
Signal Transistor	50

PO55 Transistor	62.8
LDR	53.6
Disc Capacitor	14.6

Sample of a Table footnote. *(Table footnote)*

a.

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