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A CASE STUDY ON CIRCLE DETECTION & EDGE DETECTION IN GRAY SCALE IMAGES USING DIGITAL IMAGE PROCESSING TECHNIQUE

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ABSTRACT—In this study, we present a case study on circle detection &detection of the different types of edges in varied objects in the black-white & in the gray scale pictures or images using the concept digital image processing techniques.

Keywords—Image, GS, Digital, Circle, Edge, Detection, Processing, Objective.

I. INTRODUCTION REMARKS

One of the important concepts in digital image processing is the edge detection process & this is defined as an approach for detection of the object boundary with in the digital image which is stored in the memory of the computer. This edge detection concept works on the discontinuity in the brightness of the object, whether it is in the foreground stage or in the background stage or in the occlusion stage. This edge detection is used for segmentation of images & extraction of the datas or the information in computer science domains like in image processing, computer vision & in machine vision systems. The ED caters to a group of digital pictures or images, wherein the brightness of the image of the object will get abruptly changes as there will be discontinuity near the object boundaries. The fluctuations in the brightness of the objects in the image (coloured or gray scaled) are actually clubbed in to a collection of segments of curved lines called as the edges of the objects. This detection of the edges is the key challenge to find the discontinuity in especially 1D, 2D & in 3D images. Here, any change or the detection is the problem to find the signal discontinuity v/s time domain parameter, the time, t. ED is a critical concept, that too in the emerging image fields of feature extraction of objects in the images, in recognition process which are frequently used in DIP, MV & in CV. The primary motive to detect the sharp changes in the brightness of the image will be to record the primary changes in the events in the image world's attributes. It may be shown that picture brightness discontinuities are likely to correlate to discontinuities in image brightness under very general assumptions for an image creation model:

- discontinuities in depth,
- discontinuities in surface orientation,
- changes in material properties and

- variations in scene illumination.

Viewpoint dependent or viewpoint independent edges can be retrieved from a two-dimensional picture of a three-dimensional scene. The fundamental qualities of three-dimensional objects, such as surface marks and shape, are often reflected by a perspective independent edge. The geometry of the scene, such as objects occluding one another, is often reflected by a perspective dependent edge, which varies as the viewpoint changes.

The border between a block of red and a block of yellow, for example, is a typical edge. A line, on the other hand, can be a tiny number of pixels of a variable colour on an otherwise constant background (as can be retrieved by a ridge detector). As a result, there may be one edge on either side of a line in most cases.

The edges obtained from natural photos are rarely perfect step edges. In most cases, they are affected by one or more of the following effects:

- a finite depth-of-field and a finite point spread function generate focal blur.
- Penumbral blur induced by shadows cast by non-zero-radius light sources.
- shading on a smooth surface

A Gaussian smoothed step edge (an error function) has been adopted by a number of academics as the simplest modification of the ideal step edge model for describing the effects of edge blur in practical applications.Thus, a one-dimensional picture may be modeled by the mathematical model as

$$f(x) = \frac{I_r - I_l}{2}\left(erf\left(\frac{x}{\sqrt{2}\,\sigma}\right) + 1\right) + I_l$$

The blur scale of the edge is defined by the scale parameter sigma. This scale parameter should ideally be adjusted based on the image quality to avoid ruining the image's actual edges.

II. CICRLE DETECTION

The following is a three-stage procedure for determining the location of a circle. In this section, we'll go over a three-step process for determining the circumference and radius of circles. Some of the notions from the canny edge detection operators are used in the algorithm that incorporates the procedure. We consider the input image to be a grayscale image with no noise. There are no random variations in the intensity of the noise-free image examined for input. The block diagram of the suggested algorithm, which is a three-stage process for detecting the location of circles, is discussed in the next section..

III. BLOCK DIAGRAM

The block diagram in the figure depicts the proposed methodology's concept. Convolution and non-maximum suppression are the first two stages of the process. This block takes a noise-free grayscale image as input. To acquire the horizontal and vertical directions for each pixel, the horizontal and vertical convolution kernels are employed in this block. For each pixel, these values are rounded to one of the eight orientations. The image's edge strength is calculated using the vertical and horizontal convolution kernels. The resultant pixel direction and edge strength are utilised as input to the non-maximum suppression to obtain the thin edges outlined before.

The thin edges identified in the first step are contour traced in the second stage, using the pixel direction of each pixel to discover the arcs that satisfy the circle's requirements. In this stage, any spurious points or edge pixels that do not meet the criteria for being a component of a circle are discarded. As a result, the arcs that have a higher chance of being part of the circle are kept.. Objects having more than 2 surfaces, edges, vertices are called as polyhedral objects. Exs. : Cube, prism, tetrahedron.

The parameters of any polyhedral objects are the curves, edges, sides, boundary, corner points, vertices, area, volume, surface, orientation as shown in Fig. 1. We have to determine the dimensions (edges, vertices) of polyhedral objects in the image using robot vision.

IV. EDGE DETECTION TECHNIQUES

To start with, the polyhedral object is properly illuminated, captured by a camera and its image is taken. The analog image or a raw image i (x, y) obtained from the output of the camera is digitized. Hence, we get a digital image or gray scale image, I (k, j) as shown in Fig. 2. Now, we have to determine the dimensions of the polyhedral object from its 2D gray scale image given in Fig. 2. When surfaces of the object are smooth, homogeneous, opaque, not transparent, lighting is uniform and the shadows are eliminated ; then, the reflected light intensity is constant over the surface of the object. But, at the edges, there is sudden change in light intensity, where the light intensity is changing from one gray scale value to another gray scale value, i.e., there is a jump discontinuity in the light intensity at the edges or between the boundaries of two surfaces. This concept of sudden change in light intensity can be made use of to locate the edges of an polyhedral object in the image by making use of one type of operators called as gradient operators. Gradient operators are the operators which are used to locate edge pixels/edges of polyhedral objects in a digital or a gray scale image and is a vector quantity having both magnitude and direction and is represented by □□i (x, y).

V. MAGNITUDE CRITERION

Find the gradient of the intensity vector ∇i (x, y) along the x and y directions. Gradient along x direction is

$$\nabla I_1(k, j) = \frac{[I(k+1, j) - I(k, j)] + [I(k+1, j+1) - I(k, j+1)]}{2\Delta x}.$$

Gradient along y direction is

$$\nabla I_2(k, j) = \frac{[I(k, j+1) - I(k, j)] + [I(k+1, j+1) - I(k+1, j)]}{2\Delta y}.$$

Overall magnitude of the gradient vector required to locate an edge pixel is given by

$$\|\nabla I(k, j)\| = \left\|\nabla I(k, j)\right\| = \sqrt{\nabla I_1^2(k, j) + \nabla I_2^2(k, j)}$$

$$\|\nabla I(k, j)\|^2 = \nabla I_1^2(k, j) + \nabla I_2^2(k, j).$$

Note : Aspect ratio, $\left(\frac{\Delta x}{\Delta y}\right) = 1$. If $\psi_{xy} \neq 1$, then circles in the analog image i (x, y) will be represented as ellipses in the digital image I (k, j) and vice - versa.

An edge pixel is present at p (k, j) if $||\nabla I(k, j)|| \geq \varepsilon$ (i.e., if magnitude of the intensity gradient is ≥ some threshold value ε). If an edge pixel is present, construct a binary image L (k, j) and in that binary image, put L (k, j) = 1, else put a zero if edge pixel is not present as shown in Fig. 2. Thus, from the gray scale image, we obtain a binary image which consists of only 1's and 0's, where 1's represents edge pixels and 0's represents no edge pixels. Count the total number of pixels along a particular edge, we get the length of the edge in pixels as shown in the Fig. 2. This is how we determine the edges of an object in an image.

VI. ANGLE CRITERION

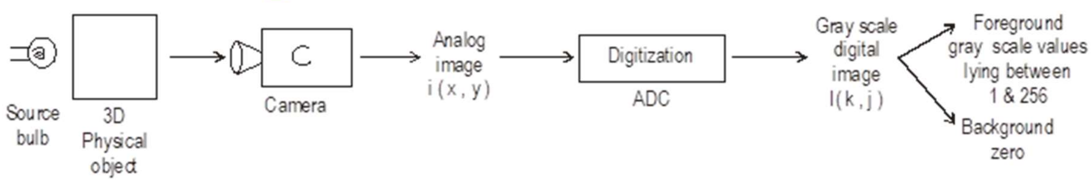
$\nabla I_1(k, j) \propto \cos\phi$ and $\nabla I_2(k, j) \propto \sin\phi$; where φ is in the direction of increasing intensity.

Angle of the gradient vector is given by $\phi(k,j) = \tan^{-1}\left(\frac{\nabla I_2(k,j)}{\nabla I_1(k,j)}\right)$

VII. USES OF THE GRADIENT VECTOR

The uses are the magnitude criterion is used to locate for the edge pixels, where as the angle criterion is used to determine which side of edge corresponds to which object in an image as there will be multiple objects in an image.

$||\nabla I(k, j)||^2$ and φ(k, j) together collectively is known as the*Robert's Cross Operator*.



Over the surfaces of the objects ∇ Gradient of light intensity is uniform or constant.

∇i (x, y) = constant (or uniformly varying over the surface) Similar to a step signal, the slope of the signal for t > 0 is 0, but, at the edges of the objects ∇ Gradient of light intensity or the slope of the light intensity = ∇ ; since as there is a sudden change in intensity (jump discontinuity). ∇i (x, y) = ∇ ; Similar to a step signal, the slope of the signal at t = 0 is ∇.

In order to find out whether a given pixel in the kth row and the jth columnis a edge pixel or not, consider that particular pixel p (k, j) and its immediate three neighbors to the south and to the east as shown in Fig. 2 ; i.e., one to the east, one to the south east and the other to the south. Note that any pixel p (k, j) has got 8 neighbors.

	j	→	
k	p (k, j)	p (k, j +1)	
↓	p (k +1, j)	p (k +1, j +1)	↕Δx
		←-----------→ Δy	

Fig. 1. Pixels used to approximate the intensity gradient

VIII. CIRCLE DETECTION FLOW-CHART OR THE DFD

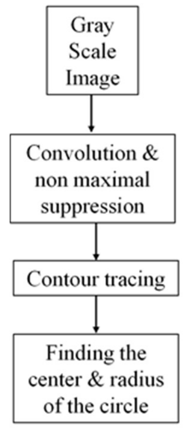


Fig. 2. The three stages of the proposed circle detection algorithm

IX. CONCLUSIVE REMARKS

In this section, we present the conclusive remarks w.r.t. the detection of circles & edges in the gray scale images using the concepts of digital image processing techniques. This is done using the gradient operators.

X. PROGRAM DEVELOPED

```
Program:Input
%% Read Image
Inputimage=imread('a.jpg');
%% Show image
figure(1)
imshow(Inputimage);
title('INPUT IMAGE WITH NOISE')
%% Convert to gray scale
if size(Inputimage,3)==3 % RGB image
 Inputimage=rgb2gray(Inputimage);
end
%% Convert to binary image
threshold = graythresh(Inputimage);
Inputimage =~im2bw(Inputimage,threshold);
%% Remove all object containing fewer than 30 pixels
Inputimage = bwareaopen(Inputimage,30);
pause(1);
%% Label connected components
[L Ne]=bwlabel(Inputimage);
propied=regionprops(L,'BoundingBox');
imshow(~Inputimage);
hold on
for n=1:size(propied,1)
 rectangle('Position',propied(n).BoundingBox,'EdgeColor','g','LineWidth',2)
end
hold off
pause (1);
%% Objects extraction
figure
for n=1:Ne
 [r,c] = find(L==n);
 n1=Inputimage(min(r):max(r),min(c):max(c));
 imshow(~n1);
 pause(0.5)
end
```

PROGRAM OUTPUT:
KING OF BATS

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