Concentric Shapes Detector using Derivatives of Gaussian

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1 Introduction

This paper proposes a method for detecting concentric shapes using an alternative directional edge detector. The directional edge detector is applied to each pixel of the input image in order to detect edges with a selected orientation. The selection of the orientation depends exclusively on the shape of the object. Directional edge detection is achieved using convolution masks. The values of the convolution masks depend on the orientation of the edge to be detected and they will be generated from derivatives of a Gaussian function. It will be shown that the method can perform a basic segmentation of superimposed patterns.

2 Concentric Shapes Detection

Detecting the presence of an object in a given black and white input image, using conventional image processing methods, is a common and easy task. Useful object data like its area, center of gravity, etc. can be calculated even without knowing the shape or the form of the object. It is in that point (shape detection) that the problem switches from a common task to one that is being study nowadays.

Our research focusses in developing a system capable of detecting the shape of an object of interest from a given image. To achieve our goal, the response of pixels that belong to a pre-determined shape must be increased. This effect can be easily obtained using a common edge detection process. Edge Detection is a well known image processing technique used to divide an image into regions which are made up of pixels with a common property. It is employed in segmentation, image recognition and stereo vision problems[1].

2.1 Directional Edge Detection

Using a conventional edge detection method presents a problem because the response of pixels that do not belong to the pre-determined shape will also be increased. To solve this problem a directional edge detection method is applied. Directional edge detection will increase the response of any pixel if the angle orientation of the edge present in that pixel fulfill a pre-determined condition, i.e, belongs to a pre-determined shape.

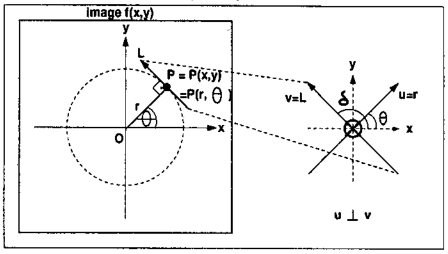

Figure 1: Determination of the edge orientation.

For example, consider the circular shape shown in Fig.1 with a reference point O. The shape can be expressed as a set of pixels P that fulfill a condition with respect to the reference point O. Therefore, the circular shape will be detected if, at a given pixel P, only the edges with orientation δ are selected. Conventional edge detection methods use convolution masks to detect edges. In this sense the problem now it is to determine the correct convolution mask to be applied at pixel P.

3 Derivatives of Gaussian

Derivatives of Gaussian are a set of operators used in image processing. As the name indicates, they are obtained from successive derivations of a Gauss function. A Gauss function in three dimensions is defined as:

$$G(u,v) = \frac{e^{-\frac{u^2+v^2}{2\sigma^2}}}{\sigma\sqrt{2\pi}}\ , \qquad (1)$$

where σ is called the standard deviation. For our research, a partial derivative of a Gaussian function is used to produce values for the convolution masks. Partial derivatives of Eq.(1) are are obtained as:

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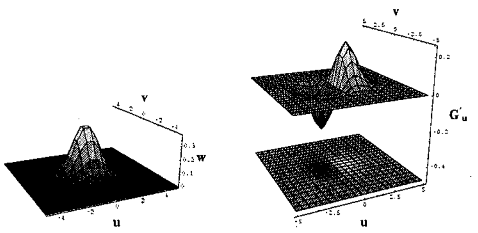


(a) (b)

Figure 2: Derivatives of Gaussian, (a) Gauss function $G(u, v)$, (b)First partial derivative G'_u.

$$\frac{\delta G}{\delta u} = G'_u = \frac{e^{-\frac{u^2+v^2}{2\sigma^2}}}{\sigma^3\sqrt{2\pi}} u \ , \qquad \frac{\delta G}{\delta v} = G'_v = \frac{e^{-\frac{u^2+v^2}{2\sigma^2}}}{\sigma^3\sqrt{2\pi}} v \ . \quad (2)$$

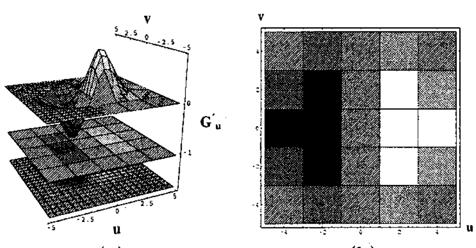
Figure 2(b) shows the representation of G'_u. This function was used to obtain the values for the convolution masks. It was shown in [2] that G'_u is able to detect edges with an orientation perpendicular to the u axis while G'_v is able to erase the same edges.

3.1 Generation of Convolution Masks

The values of the convolution masks to be applied to a pixel P are sampled from the partial derivative function G'_u. This idea is shown in Fig.3. For example, to obtain the values of the convolution masks capable to detect an edge with angle orientation equal to δ (see Fig.1), the function G'_u is rotated an angle equal to θ where $\theta = \frac{\delta}{2}$. The rotated function is sampled always in the same points.

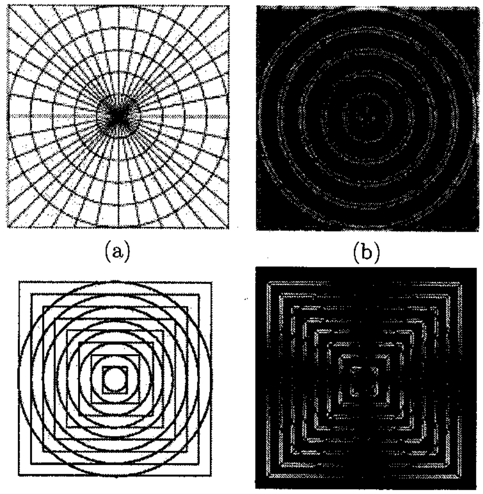
4 Simulation and Results

Black and white images of 255 × 255 pixels were used. Concentric shapes were generated by com-



(a) (b)

Figure 3: Generation of values for the convolution masks, (a) Sampling process of function G'_u, (b) Convolution mask with size of 5 × 5 pixels.



(a) (b) (c) (d)

Figure 4: (a) Original image **Type A**, (b) Circular shapes detected from **A**, (c) Original image **Type B**, (d) Square shapes detected from **B**.

puter. The size of the convolution masks was fixed to 5 × 5 pixels. Fig.4 displays the results obtained. In Fig.4(b) and Fig.4(d) can be observed that our method is capable of detecting a pre-determined shape. Also a basic segmentation was achieved. Some other properties can be observed in [2, 3].

5 Conclusions

An alternative edge detector using derivatives of gaussian was introduced. Using the detector, a basic segmentation and detection of shapes was achieved. The authors expect to improve the operator in future works.

References

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