Symmetrical Axis Determination and Center Curve

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ABSTRACT

This paper represent an efficient computational method to identify symmetry axis and centre curve in a 2-dimensional text, image and structure. An adaptive technique is proposed for symmetrical axis determination using mirror image. The proposed approach can adopt threshold value from first computation. Exclusive OR of logical original and mirror image is used for adopt threshold value. Here local symmetry such as 1-fold, 2-fold, 3-fold, 4-fold, 5-fold and 6-fold are identified that exist in certain limited region on the 2-dimensional structure. Another important symmetry as mirror symmetry and centre of symmetry is also characterizing the structure of objects. Locations of local symmetry axes can be used in structure averaging as well as in detecting small structural variations among different copies of the same protein.

General Terms

Image processing, Pattern recognition

Keywords

Symmetrical axis, Rotational symmetry, Centre curve, Mirror image, Exclusive OR, polar coordinate.

1. INTRODUCTION

Symmetry or deviation from symmetry is the central theme of many different art forms, ranging from music, painting, sculpture to various decorative and folk arts.

Symmetry or near-symmetry is ubiquitous in the world around us. Automatic detection of symmetry in natural and man-made objects has been a lasting research interest in computer vision and pattern recognition [1].Many objects around is symmetrical. Domestic objects such as bowls, cans, cups and boxes have symmetrical axis about a straight line. How to grab an object strongly can find from symmetrical axis. To grasp a box force is applied from opposite sides of symmetrical axis, just like perpendicular on symmetrical axis. Symmetry analysis is also important is text detection and positioning, face analysis [2], crystal structure, medical image analysis [3], reconstruction [4, 5, 6], digital paper cutting [7], vehicle and aircraft detection [8].

In this paper, a novel approach is introduced to draw a symmetrical axis and central axis of an object from a 2D digital image. In this process symmetry is considered in overall orientation. It can also detect multiple axis of symmetry, mirror symmetry.

2. RELATED WORKS

For many reason and application symmetry detection play vital role in computer vision [9]. Symmetry is used in composition and architectural design because of its visual attention. Some researchers consider entire image as signal from which symmetric properties are inferred. Spatial region of integration for visual symmetry detection [10] proposed by Steven C. Dakin. The orientation of the dominant bilateral symmetry axis could be computed from the histogram of gradient orientations [11] is presented by C.Sun. Matching symmetric pairs of feature point's method generate dense sets of feature points and matching these between images [12, 13, 14, 15]. Feather point method defines the orientation and scale of each feature. Seungkyu Lee [16] proposed a unifying, local feature-based approach for curved glide reflection symmetry detection from real, unsegmented images .Algebraic approach and employed Fourier analysis to detect symmetry [17] is shown by Yosi Keller and Yoel Shkolnisky. Multiscale Symmetric Part Detection and Grouping [18] is the process of object's silhouette into a set of symmetric parts. In this process image clustering is applied for symmetrical part structure.

3. SYMMETRY OPERATIONS AND ELEMENTS

A Symmetry operation is an operation that can be performed either physically or imaginatively that results in no change in the appearance of an object. Symmetry can be internal or external of an object. Hence only 2D image or objects are going to concentrate on external symmetry were analyzed, because this is what can be observed. The axis along which the rotation is performed is an element of symmetry referred to as a rotation axis. There are various types of rotational symmetry axes are possible. Such as, if an object requires rotation of a full 360^o in order to restore it to its original appearance has no rotational symmetry. Since it repeats itself 1 time every 360^o it is said to have a 1-fold axis of rotational symmetry. Similarly if an object appears identical after a rotation of 180^o, that is twice in a 360^o rotation, then it is said to have a 2-fold rotation axis (360/180 = 2). So depending upon the repetition times of an object, it is called n-fold rotation axis (360/rotation angle at which object appears identical=n). A mirror symmetry operation is an imaginary operation that can be performed to reproduce an object. The operation is done by imagining that you cut the object in half, and then place a mirror next to one of the halves of the object along the cut. If the reflection in the mirror reproduces the other half of the object, then the object is said to have mirror symmetry. The plane of the mirror is an element of symmetry referred to as a mirror plane. As an example, the human body is an object that approximates mirror symmetry.

4. EXPERIMENTAL OBJECTS

This section describes the types of object is used for symmetrical axis determination. Mainly two dimensional gray text pictures, color aircraft, geometrical figure and other pictures are used for the experiments.

5. SYMMETRICAL AXIS DETECTION

In this section, the processing steps of the proposed approach are presented. This paper's aim is to determine possible number of symmetrical axis of an object from an image and its category.

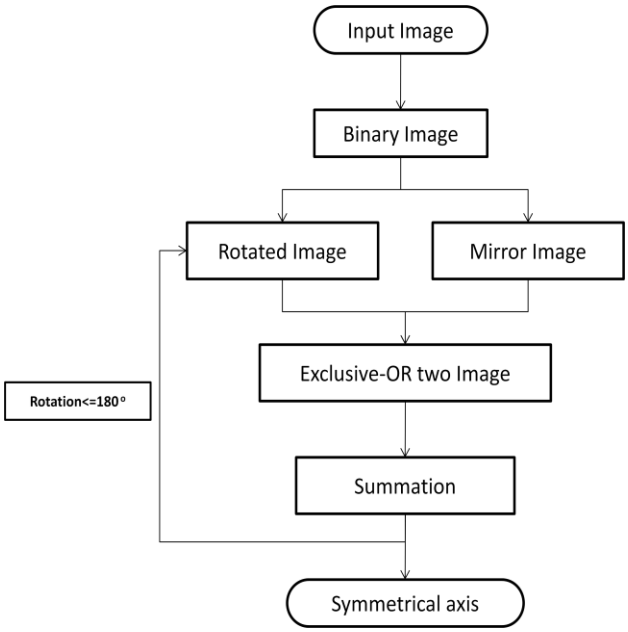
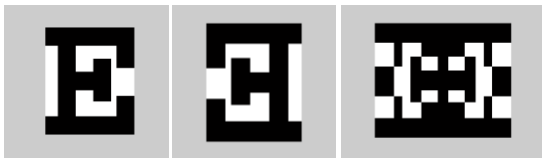


Figure 1: Flow chart of the proposed approach.

At first the image is converted from RGB to gray scale image. A grayscale image is a two dimensional data matrix which values represent intensity if an image. Then gray image is converted to binary image based on threshold value. When an image is represented by using 0 and 1 it's called binary image. Black region is shown by 0 and white by 1. After that remove the small objects which containing less than 50 pixels. Here objects contain less than 50 pixels is removed because those objects have pixel less than 50 is not generally a part of main object. To find the symmetrical axis rotate the image (R_i) from 0^o to 180^o. For every rotation make the mirror image (M_i) of the rotated image (R_i). Perform logical exclusive-OR operation upon two images (R_i and M_i). Make the summation of logical matrix, which means summation of all remaining 1's after logical exclusive-OR operation. If the two logical images are identical or best match have then the summation will be minimum. The angle for which the minimum summation value have is the symmetrical angle. It is possible to find more symmetrical axis for one object and sometimes more symmetrical axis near to the actual symmetrical axis.



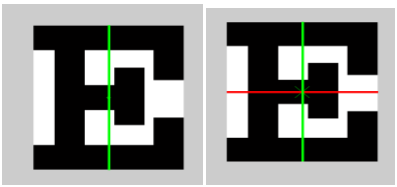
(a) (b) (c)

Figure 2: (a) image of text E with 0^o rotation, (b) mirror view of fig (a), (c) exclusive-OR of two logical text image fig (a) and fig (b).

(a) (b) (c)

Figure 3: (a) image of text E with 90^o rotation, (b) mirror view of fig (a), (c)

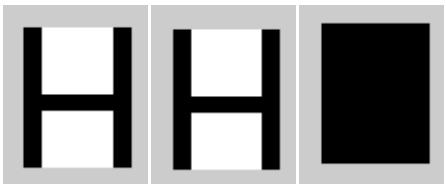
exclusive-OR of two logical text image fig (a) and fig (b).



(a) (b)

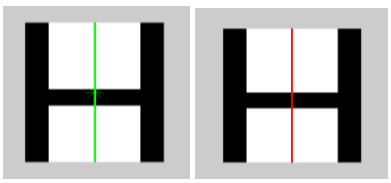
Figure 3: (a) image of text E with reference green line (b) image of text E with symmetrical axis at 90^o from reference green line.

Here in this example shown in figures 2 &3 that symmetrical operation at 0^o and 90^o rotation. At 90^o rotation both the rotated and mirror image are similar and so the exclusive-OR of two logical images are minimum. Hence the symmetrical axis is found at 90^o from the reference axis. Some similar example for symmetrical axis with text H & W is given below figure 4, 5, 6 & 7.



(a) (b) (c)

Figure 4: (a) image of text H with 0^o rotation, (b) mirror view of fig (a), (c) exclusive-OR of two logical text image fig (a) and fig (b).



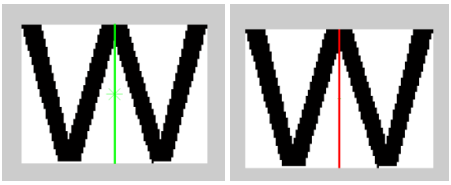
(a) (b)

Figure 5: (a) image of text H with reference green line (b) image of text H with symmetrical axis at 0^o from reference green line.

(a) (b) (c)

Figure 6: (a) image of text W with 0^o rotation, (b) mirror view of fig (a), (c)

exclusive-OR of two logical text image fig (a) and fig (b).



(a) (b)

Figure 7: (a) image of text W with reference green line (b) image of text W with symmetrical axis at 90^o from reference green line.

6. CENTER POINT DETECTION

Already symmetrical axis has been determined but the complexity is to draw it upon the image. In symmetry detection algorithm to draw the symmetrical axis is the first step to identify the centre point of the object. Centre point is the half of column and half of row. From centre point the evaluated axis is extend on both side upon the object. To extent the symmetrical axis deduce the radius vector of the image

$$r = \sqrt{a^2 + b^2}$$

Where

r = radius vector

a= highest column number of digital image

b= highest row number of digital image

The half of radius vector (r/2) is used to extend axis in both side from centre point. So here we already get the angle (θ) of the symmetrical axis and the radius vector i.e. the polar coordinate. To plot the

symmetrical axis, polar coordinate is converted into Cartesian coordinate. The Cartesian coordinate (x,y) is calculated by

$$x = r\cos\theta$$
$$y = r\sin\theta$$

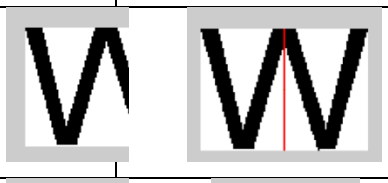
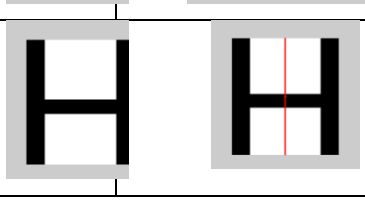
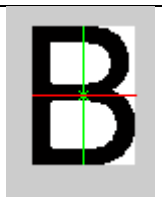
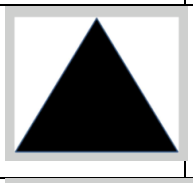
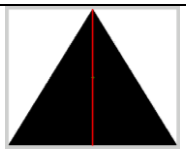
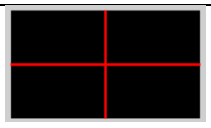
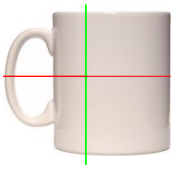
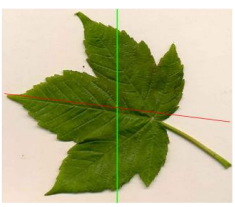
As the angle (θ) is fixed so with the increase of radius Cartesian coordinate is increased.

7. RESULTS & EVALUATION

From various research results it has been seen that symmetry is defined in different respect. Some researchers segment [18] the entire image and find out symmetry of individual parts and finally connect these. In segmentation process actual object is not identified because the object is segmented at lots of pieces. Some other researchers showed symmetrical axis as a curve line. These curves not fulfill the definition of symmetry, it's actually show the skeleton of an object. When two halves of an object is mirror images of each other it's called symmetry and the line mirror is placed is symmetrical axis. In this paper main focus on symmetry for shape. In order to evaluate the proposed approach, we carry out experiment on text and geometrical figure. Table-I shows the object & symmetrical axis. The proposed method can detect the symmetrical axis. If there is no accurate symmetrical axis in an object this method can this method can determine the most nearest symmetrical axis.

Table – I

Text & Text with symmetrical axis

Object	Object with Symmetrical Axis	Symmetrical Axis
		Symmetrical axis at 0^o
		Symmetrical axis at 0^o
		Symmetrical axis at 90^o
		Symmetrical axis at 0^o
		Symmetrical axis at 0^o & 90^o
		Symmetrical axis at 90^o
		Symmetrical axis at 86^o

7. CONCLUSION

Symmetry is one of many attention mechanisms that humans use in everyday life. Many objects in the domestic environment are symmetrical. We have presented a

constructive approach to detecting symmetrical axis and centre curve. The centre curve makes up a skeletal branch.

The outcome of this proposed algorithm can be used for image matching, curvature detection in biomedical images and object recognition.

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