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Development of Shape Based Leaf Categorization

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Abstract:*Leaves can be categorized based on various physical attributes but the most popular attribute is shape. For example, we can use 'shape' as a criterion to differentiate between a mango leaf and a banana leaf. Ideally this criterion can be of immense help to the user of an image database that stores, for instance, the images of different kinds of leaves. The user would often wish to retrieve images of leaf similar to the one he/she has or categorize the leaf according to its kind. This retrieval is mostly based upon the shape of the image. We investigate shape analysis methods for retrieving images and we develop an approach for doing so. In our approach we first find out the corners of the leaf by "Harris corner detection" and then determine the convex hull by joining these "corner points". The leaves are then distinguished by finding the difference between their internal angles at each control point. The same criterion is then used to retrieve images of leaves from a plant database that are identical to the one in the input image.*

Index Terms:*Shape based leaf categorization, corner detection,convex hull detection,internal angle differences.*

I. Introduction

Plants play an important role in our environment. Without plants there will be no existence of the earth's ecology. But in recent days, many types of plants are at the risk of extinction. To protect plants and to catalogue various types of flora diversities, a plant database is an important step towards conservation of earth's biosphere. There are a huge number of plant species worldwide. To handle such volumes of information, development of a quick and efficient classification method has become an area of active research. In addition to the conservation aspect, recognition of plants is also necessary to utilize their medicinal properties and using them as sources of alternative energy sources like bio-fuel. There are several ways to recognize a plant, like flower, root, leaf, fruit etc. In recent times computer vision methodologies and pattern recognition techniques have been applied towards automated procedures of plant recognition.

This paper proposes a method developed by us for shape based leaf categorization Framework.The organization of the paper is as follows: Section II provides an overview of related work in this domain,Section III describes the methodology used by us in developing the framework,Section IV provides the details of the results obtained and Section V concludes our discussion.

II. Previous Work

Many methodologies have been proposed to analyze plant leaves in an automated fashion. A large percentage of such works utilize shape recognition techniques to model and represent the contour shapes of leaves, however additionally, color and texture of leaves have also been taken into consideration to improve recognition accuracies. One of the earliest works [1] employs geometrical parameters like area, perimeter, maximum length, maximum width, elongation to differentiate between four types of rice grains, with accuracies around 95%. Use of statistical discriminant analysis along with color based clustering and neural networks have been used in [2] for classification of a flowered plant and a cactus plant. In [3] the authors use the Curvature Scale Space (CSS) technique and k-NN classifiers to classify chrysanthemum leaves. Both color and geometrical features have been reported in [4] to detect weeds in crop fields employing k-NN classifiers. In [5] the authors propose a hierarchical technique of representing leaf shapes by first their polygonal approximations and then introducing more and more local details in subsequent steps. Fuzzy logic decision making has been utilized in [6] to detect weeds in an agricultural field. In [7] the authors propose a two-step approach of using a shape characterization function called centroid-contour distance curve and the object eccentricity for leaf image retrieval. The centroid-contour distance (CCD) curve and eccentricity along with an angle code histogram (ACH) have been used in [8] for plant recognition. The effectiveness of using fractal dimensions in describing leaf shapes has been explored in [9].

In contrast to contour-based methods, region-based shape recognition techniques have been used in [10] for leaf image classification. Elliptic Fourier harmonic functions have been used to recognize leaf shapes in

[11] along with principal component analysis for selecting the best Fourier coefficients. In [12] the authors propose a leaf image retrieval scheme based on leaf venation for leaf categorization. Leaf venations are represented using points selected by the curvature scale scope corner detection method on the venation image and categorized by calculating the density of feature points using non parametric estimation density. In [13] 12 leaf features are extracted and orthogonalized into 5 principal variables which consist of the input vector of a neural network (NN). The NN is trained by 1800 leaves to classify 32 kinds of plants with accuracy greater than 90%. A new approach that combines a thresholding method and H-maxima transformation based method is proposed to extract the leaf veins. Compared with other methods, experimental results show that this combined approach is capable of extracting more accurate venation modality of the leaf for the subsequent vein pattern classification. In [14] authors propose Guiding Active Contours for Tree Leaf Segmentation and Identification. Combining global shape descriptors given by the polygonal model with local curvature-based features, the leaves are classified over nearly 50 tree species. Finally in [15] a combination of all image features viz. colour, texture and shape, have been used for leaf image retrieval, with a reported accuracy of 97.9%.

III. Methodology

We propose a methodology for retrieval of leaf images based upon the shape of the leaf image given as input by the user.For example,if the input is a mango leaf's image,then the output will be images of mango leaves.

In this approach, we follow several steps one after another each of which is explained after the steps and shown in Fig 1.

1. User uploads an image of leaf of his/her choice.
2. Next, we find out the corners or key points [16] by using "Harris corner Detection" [17].
3. We find out the convex hull of the leaf.
4. Then we determine each internal angles of the image.

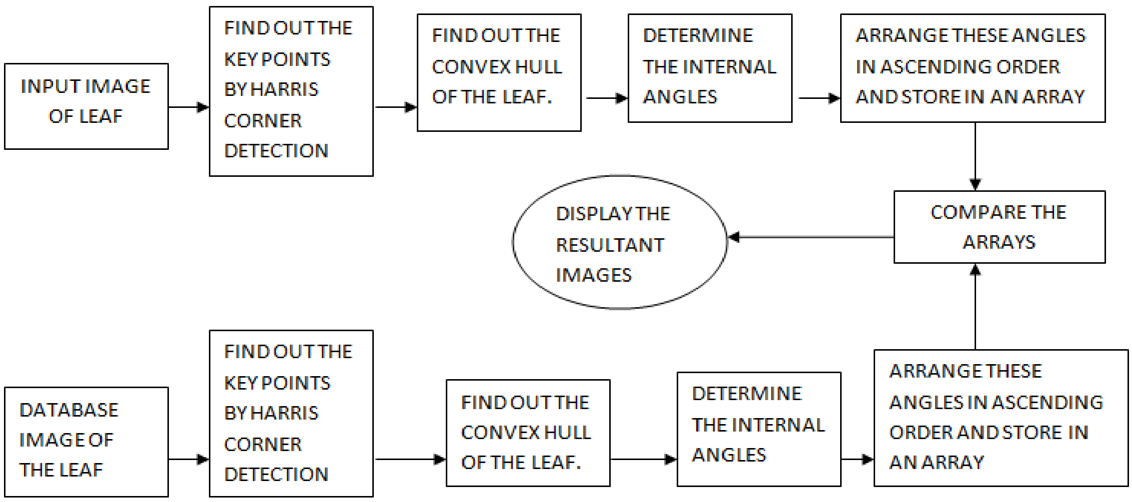


Fig 1: Flow diagram showing the algorithm developed for shape based leaf categorization framework

5. Arrange these angles in ascending order and store in an array (say a1).
6. Follow the above steps for all other images in database and determine their angle arrays (say a2,a3,a4 and so on).
7. Compare the arrays of the images in database with the array of uploaded image, i.e. compare each of a2, a3, a4 with a1.
8. The least unmatched image is displayed.

We elaborate each step in details.

Step 1: Image Upload
User can upload any image of a leaf in jpeg or png format of his or her choice.

Step 2: Binarisation
Binarisation[18] is a process where each pixel in an image is converted into one bit and we assign the value as '1' or '0' depending upon the mean value of all the pixel. If greater then mean value then its '1' otherwise its '0'.Fig 2 shows image of a leaf and its corresponding binarised image.

Fig 2: Binarisation of leaf's image.

Step 3: Key Point Detection

Here, we determine the key points of an image by "HARRIS CORNER DETECTION". **Corner detection** is an approach usedwithin Computer vision systems to extract certain kinds of features and infer the contents of an image. Corner detection is frequently used in object recognition. A corner can be defined as the intersection of two edges. A corner can also be defined as points for which there are two dominant and different edge directions in a local neighbourhood of the point.These points obtained are the key points.

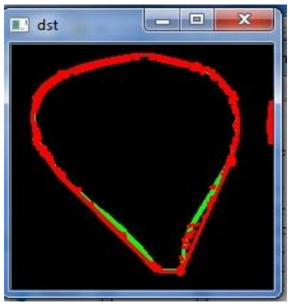


Fig 3: Key points detected.

Step 4: Convex Hull Formation

We determine the convex hull of the image. The **convex hull** [19]or **convex envelope** of a set X of points is the smallest convex set that contains X. For instance, when X is a bounded subset of the plane, the convex hull may be visualized as the shape formed by a rubber band stretched around X.

Formally, the convex hull may be defined as the intersection of all convex sets containing X or as the set of all convex combination of points in X. After key points detection,we form the convex hull by joining the key points as shown in Fig 4 below.

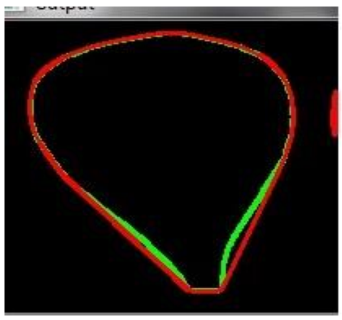


Fig 4: Convex hull formation after key points detection.

Step 5: Convex Hull Based Characterisation

In this step, we determine the internal angles of an image, by finding out the difference of slopes of its edges.

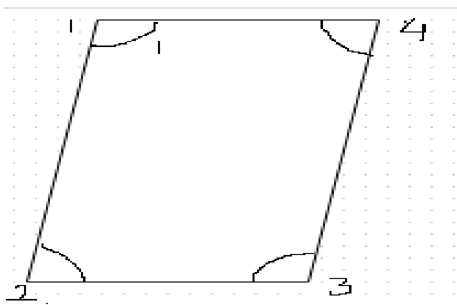


Fig 5: Internal angles of a rectangle.

For example in the above figure, the value of angle 1, is found by determining the difference in slopes of lines 1-2 (say m1) and 1-4(say m2).Thus, the difference, m1-m2 gives the value of angle,1. In this manner, we find the other 3 angles also, and arrange them in “ASCENDING ORDER” in an array say a1.We perform the above 3 steps for each image in the database and obtain their array of angles, say a2,a3,a4 and so on.We compare the arrays a2,a3,a4 each with a1, the array of the uploaded image.Then, we note the differences.We arrange the differences in ascending order and display the images in the same format i.e. the image which matches the most with the uploaded image is displayed first and so on.

IV. Experimental Results And Discussions

We consider the following binarised input images shown below in table 1.

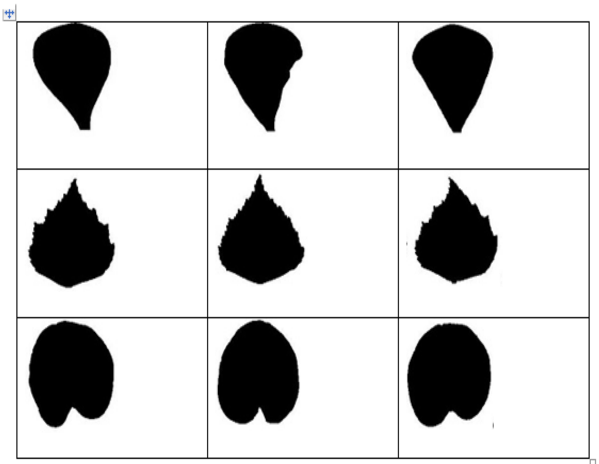


Table 1: Table of input images

We provide each image of leaf as input and obtain the output matching of leaves from the database of leaves.Here we consider Table 1 as our Database and for each outputour application shows the percentage difference with the input image.

Table 2 below shows some of the results obtained in this process.

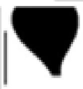
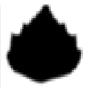
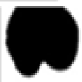
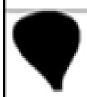
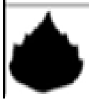
INPUT IMAGE	DATABASE IMAGES 		
	-44.13	-28.25	-54.28
	-28.25	-44.13	-29.56

Table 2: Table for 3x3 dissimilarity score

The values of the table 2 are the difference of the angle arrays of the two images compared.

Our application also works for any image which has undergone geometric transformations like rotation,scale up and scale down.For example, a user may upload a 90 degree rotated image of a pear leaf’s image or a scaled up or scaled down image of the same leaf.Our application identifies these images as the same image with a minute difference in angle arrays.

Now based on the difference of the two arrays, we determine if the images are similar or not. If difference is

- less than 20 , then the images are considered to be similar
- Greater than 20 but less than 60, then we rotate the image and find any image matching, the transformed,i.e.rotated image.
- Greater than 60, then the images are said to be Unmatched.

Table 3 – Table 6 below shows another set of results.

INPUT IMAGES	DATABASE IMAGES				
					
	0	28	1045	1200	28
	28	15	1500	1562	0
	0	35	1045	1200	10

Table 3: Difference between input and database images

INPUT IMAGE	DATABASE IMAGES				
					
	0	25	1045	1200	1032

Table 4: Difference between input image and database images.

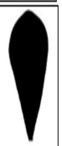
INPUT IMAGE	DATABASE IMAGES				
					
	2100	2500	0	1821	1206

Table5: Difference between input image and database images

			
	44.13	28.25	54.28
	28.25	44.13	29.56
	54.28	29.56	44.13

Table 6: Difference between input image and database images

V. Conclusion

In this paper we propose a methodology for shape based leaf categorization framework.We find out the key points of the image of the leaf uploaded by the user and then we find out the convex hull,next we find the internal angles and sort them to find out the angle array and compare it with another leaf's angle array; thus finding out the differences.Then the application displays the images with the minimum difference with the input image.

Future work will be to find out the skeleton of the leaf[20]that is its vein structure etc which will help in further classification and even determining the scientific family to which the leaf belongs.

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