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A Comparative Study of Plant Identification Systems and Algorithms Using Images of Leaf

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ABSTRACT

To Develop an identification system for plants that are used in Siddha Medicines .The name and Medicinal values of Indian plants that are used as medicines will be available to people all over the world. The accuracy level of plant identification can be improved. The heritage value of Siddha medicines can be preserved through digital medium. Machine Learning techniques that we are trying to develop will give the suggestion about the combination of plant that can be used as medicine to a specific disease. This automatic classification system also helps botanists, consumers, forestry services, taxonomists, pharmaceutical companies and siddha practitioners to identify and classify the medicinal plants without any human assistance A correct and appropriate way to classify plant is to recognize them on the basis of the features extracted from the plant leaf images. The two most important features which are used for plant recognition based on leaf images are color and shape [2], [6-9]. An automatic plant identification system is of great.

I. INTRODUCTION

An automated plant identification nor classification system can use various different characteristics of the flora which can start from a very basic level, such as shape and color of the leaf , flower and its fruit type, its branching style, root type, seasonality, outlook, etc. to a very complex level such as tissue and cell structure and genetic structure. In present scenario the cell phones are capable of capturing high quality images with their integrated digital camera which makes the usability of such a system even wider and more. For the classification of plant a set of appropriate numerical attributes of features is extracted. In recent years the research on the utilization of moments for object characterization in both in variant and non variant objectives has gained attention [8, 9]. The concept of moments has been used in various fields ranging from engineering mechanics and statistics to image processing and pattern recognition.

1. TECHNIQUES USED IN PLANT RECOGNITION

A substantial amount of work has been done on leaf shape based plant classification, recognition and identification, but still there is a possibility of more investigations to develop more robust plant identification systems. The performance of the designed systems may vary from sample to sample. Sometimes it is also possible that two or more plants have leaves with similar shape but may vary in colors. In such a case color, features cannot be neglected. A typical image based plant identification system is shown in Fig. 1.

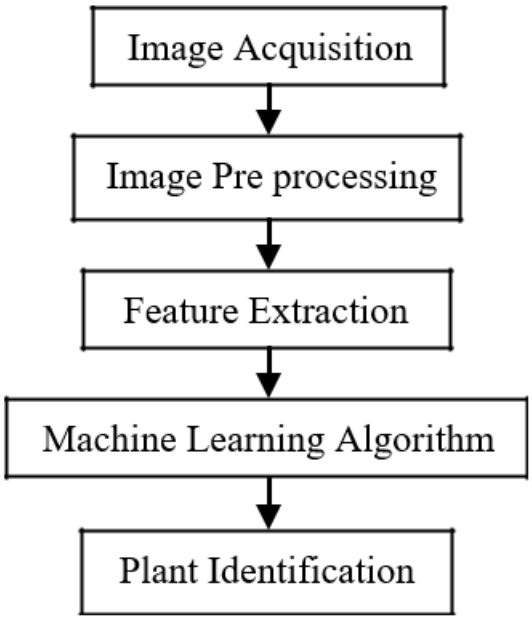

Fig 1: Plant Identification System

Wang et al. [2] proposed a method based on centroid contour distance (CCD) curve, eccentricity and angle code histogram (ACH). They analysed 1400 leaf images gathered from 140 plants. Their experimental results show that the proposed algorithms can achieve a better retrieval performance rate than both the earlier discussed methods which were curvature scale space (CSS) method and modified Fourier descriptor (MFD) method.

Fu et al. [3] proposed an ontology based leaf classification system that uses the centroid contour distance curve for the representation of leaf shapes and images. They also used machine learning algorithms for the development of an automatic leaf retrieval system.

Wang et al. [4] proposed an efficient computer aided plant species identification (CAPSI) approach which is based on recognition of plant leaf images using a shape matching methodology. They extracted seven geometric moments and sixteen Zernike moments to represent a leaf shape. The above is carried out in following stages. Firstly, an approximation algorithm, namely Douglas-Peucker is used and a new shape representation is considered to form the sequence of invariant attributes. This approximation is categorized as polygon approximation, then a modified dynamic programming (MDP) for shape matching and recognition is used for

leaf recognition. In second stage, the experimental facts and results are gathered. The experiment used 50 leaf images which were randomly selected from our image database as the query images and each query can retrieve at most 20 such similar images from the database.

Gu et al. [5] also used an approximation algorithm in order to extract leaf shape features. Gu et al. used the result of leaf segmentation which is based on wavelet transform (WT) and Gaussian interpolation. It is a new and efficient approach for leaf classification. The approach uses various classifiers, a nearest neighbor classifier i.e. 1-NN, a radial basis probabilistic neural network (RBPNN), a k –nearest neighbor classifier (k-NN) are used. The above mentioned features are based on run length features (RLF) which are extracted from the skeleton to recognize the leaves.

Wang et al. [6] for the classification of leaf images used Centroid Contour Distance (CCD). They extracted various geometric features like rectangularity, circularity, eccentricity and seven other moment invariants for the classification of leaf images. The following seven functions are computed and they form central moments with respect to object scale, translation and rotation: images with complicated background Marker controlled watershed segmentation method is selected. In addition to the above specified parameters a moving center hypersphere (MCH) classifier based on shape features is proposed for classifying a large number of leaves. The use of conventional classifiers like K-NN or Neural Network tends the classification process to be time and space consuming. The class of patterns as a series of **"hyper-spheres" is used in new approaches while in earlier** approaches these patterns from one class are all treated as a set of points. The experimental results classified more than 20 classes of plant leaves successfully with an average recognition rate up to 92.2%

Du et al. [7] applied leaf shape recognition based on radial basis probabilistic neural network (RBPNN). Orthogonal least square algorithm (OLSA) is further applied to train the system and further it is optimized by recursive OLSA. It performs plant recognition and classification through modified Fourier descriptors. The advantage is that it can identify the type of plant from a partially damaged leaf. A set of unique features is used and experimental result shows that the proposed methodology achieves a higher recognition rate and efficiency than both the approaches, namely radial basis function neural network (RBFNN), BP neural network (BPNN).

Hu et al. [8] proposed a methodology based on the combination of wavelet transform (WT) and Gaussian interpolation. They used the result of segmentation of leaf skeleton. Hu [8] proposed

the utilization of moment invariants for image analysis and representat**ion of the object in 1961. Hu's Uniqueness Theorem** states that if f(x,y) is piecewise continuous and has non zero values in the finite part of the f(x, y) plane, then geometric moments of all orders exist. It can then be shown that the moment set {mpq} is uniquely determined by f(x, y) and conversely f(x,y) is uniquely determined by {mpq}.

Wang et al. [9] extracted various geometric features like rectangularity, circularity, eccentricity and 7 moment invariants for plan classification. T. H. Resis [9] stated that moment used by Hu is incorrect. The four moments under general linear transformation shows an error.

Du et al [10] proposed shape detection based on radial basis probabilistic neural network, which is trained by OLSA and which is further optimized by recursive OLSA. The modified Fourier descriptors of leaf shape are used for plant recognition. Maitre [10] modified the seven moment invariant proposed by Hu which are independent of change. The categories of change were transformation, scale, rotation and contrast also. A curvature scale space image is used by Mokhtarian and Abbasi Apart from the above mentioned features 15 more features are threshold selection , segmentation method is used to address those extracted from the pre processed leaf. In that paper an iterative classification. Similarly a new set of moment invariants with try. leaf images which are having simple background for the representation of leaf shapes and is applied for eaf images which are having simple background.

In case of leaf Wu et al. [11] extracted digital morphological features which were further orthogonalized into five principal variables. The classification of 32 varieties of plant is done by using PNN through a sample of 1800 leaves. The leaf image is firstly converted into a binary image from the RGB image using the given formula. Wu et al [11] used twelve different digital morphological features which were further orthogonalized into five principal variables. They used a set of 1800 leaves for Apart from the above mentioned features 15 more features are

Gray= 0.2989 * Red +0.5870 * Green +0.1140 * Blue

After the application of spatial masks we obtain a set of geometric features such as Diameter, Physiological length, Physiological width, leaf area and leaf perimeter and after that 12 morphological features as aspect ratio, form factor, rectangularity, narrow factor, perimeter ratio of Physiological length, Physiological width and 5 vein features were extracted for leaf classification and recognition. PCA is further used for transforming the data into a new coordinate system.

Du and Zhang [12] proposed a new methodology for plant classification and leaf recognition. The method is named as move median centers (MMC) hypersphere classifier. They explained the algorithm of MMC, classification stage and the Data preprocessing for the application of the MMC. The advantage of MMC classifier is that it not only saves the storage space but also reduces the classification time. In comparison to 1-NN and k-NN classifiers the method is more robust as it is not dependent on the contour features.

Hossain and Amin [13] proposed a computationally effective technique for plant species recognition using a leaf image. The proposed methodology is only applied to the plants with wide flat leaves are generally two dimensional in nature. There are five major phases. Firstly, leaf images are captured and then the base point of the leaf and a small number of reference points on the leaf blades are decided by the user. A binary image is

generated according to the above reference points on the leaf blades. After this stage the leaf is aligned horizontally by keeping its base point to the left of the image. Then area, major axis, minor axis, eccentricity, perimeter, equivalent diameter, convex area and extent are obtained as done before. A distinguished collection of features is obtained from the leaves by segmenting it across the major axis and parallel to the minor axis. In the next stage the feature points are normalized by considering the ratio of the slice lengths and leaf lengths (major axis). Then these features are provided as inputs to the PNN.

Prasad et al. [14]roposed a new technique for feature extraction from a plant leaf image. An automated living plant species identification is proposed which would be helpful for botanical students to carry out their research for plant species identification. A novel multi-resolution and multidirectional Curvelet transform is executed on sub segmented leaf images to obtain leaf information. The accuracy rate can be enhanced if the orientation of the object in the image is not taken into account. These coefficients are given as the input to a trained SVM classifier for categorization of the result.

Abdul kadir [15] proposed foliage plant identification systems. The proposed methodology can handle two or more plants that have the same or may be similar shape, but the color patterns on the leaves must be different. In case of same color patterns Zernike moments were used in combination with features like color moments, geometric features and gray-level co-occurrence matrix (GCLM). In order to implement the system two different approaches were designed. In the first approach a distance measure is used and in the second approach PNN is used. The experimental results have proven that Zernike Moments have a better prospect as features in leaf identification and recognition systems when they are combined with other features.

An automated leaf recognition system has been proposed by J. Chaki and R. Parekh [16] based on leaf images. It specifically uses two modeling technique, namely Moments Invariant (M-I) and Centroid Radii (C-R) model. In case of MI, the first four normalized central moments have been considered and studied in various combinations. In addition, there are 7 moment features that can be used to describe shapes and these are invariant to rotation, translation and scaling. In case of CR model, the identification of the boundary of the leaf shape is done by an edge detector. Each pixel is identified by either its color or by the x and y coordinates on a two dimensional plane. The classifier that was used for discrimination is a neural network.

An automated system based on the leaf vein shape for plant identification was proposed by Lee and Hong [17]. The proposed methodology uses major vein and frequency domain data. FFT methods are used with distances between contour and centroid on detecting leaf. In total 21 features were extracted for the leaf recognition, which are the distance feature between centroid and all points of leaf contour. Frequency domain data by FFT that was performed using the distances and 10 features of all 21 leaf features were extracted using morphological features using 4 basic geometric features and 5 vein features and the last 1 feature was extracted using the convex hull.

Leaf recognition of plant species based on ANN was proposed by Sajeevan G [18]. The leaf shape features such as aspect ratio, apex ratio, base angle, centroid deviation ratio, moment ratio and circularity were extracted with the help of image processing techniques. These features are used as input parameters to the neural network for classifying the plants. The experiments were performed on a set of 534 leaves of 20 kinds. Out of these, 400 leaves were trained. The 134 testing samples were recognized with an accuracy rate of 92 %.

Rahim et al. [19] proposed normalization of the tip and base of leaf as both of them influence data extraction process. Center Contour Gradient CCG is used as the extraction method which calculates the gradient between pairs of boundary points corresponding to interval angle. The experimental results have shown that CCG has outperformed CCD (Centroid Contour Distance) as it captures the curvature of the tip and base of leaf.

CCD is used to find out the distance between centroid point and **the pixel's on the leaf's contour point, whereas CCG is used in calculating the gradient between two pixels on the leaf's contour**

corresponding to the interval angle. The accuracy in classifying the tip of the leaf using CCG is 99.47%

The Classification of Medicinal Plant Leaves Based on Multispectral and Texture Feature Using Machine Learning Approach[20] Five machine learning classifiers named as a multi-layer perceptron, logit-boost, bagging, random forest, and simple logistic are deployed on an optimized medicinal plant leaves dataset, and it is observed that the multi-layer perceptron classifier shows a relatively promising accuracy of 99.01% as compared to the competition.

Wei Tian, Wenhe Liao, proposed [21], Identifying Chinese Herbal Medicine by Image with Three Deep CNNs Automated identification of CHM using images is a challenging task owing to the fine-grained variability in the appearance of CHM. This paper presented an application study of transfer learning using deep convolutional neural networks (CNNs) for image classification to identify CHM. Fine-tuning the pre-training model of AlexNet, VGGNet, and ResNet based on transfer learning. The verification results of the three models with 10,806 images show, that the recognition accuracy of the ResNet model is the highest at 98.17%.

[22] Identification of ayurvedic medicinal plants by image processing of leaf samples [24]The main features required to identify a medicinal plant is its leaf shape, colour and texture. Colour and texture from both sides of the leaf contain deterministic parameters to identify the species. This paper explores feature vectors from both the front and back side of a green leaf along with morphological features to arrive at a unique optimum combination of features that maximizes the identification Rate

A novel method for identification of Ayurvedic medicinal plants from images of front and back side of leaf has been proposed. The work is based on a database of leaf images of medicinal plants created by the authors. Unique combinations of morphological, colour and texture feature have been identified that maximizes identification rate of green leaves. Identification rates up to 99% have been obtained for this combination. A

unique feature set combination to identify plants from dry leaves has been proposed with minimum number of features, getting identification rates up to 94.5%.The selected feature sets for both dry and green leaves have been tested on 14 different classifiers using Weka tool to ascertain authenticity. Highest identification rate is achieved using MLP Neural Network classifier for both dry and green leaves. Inclusion of both front and back features increase identification rate when green leaves are used to identify plant

Sabu, A and his team proposed [23] Med leaf Detection using Image Processing Algorithm Identification of the plant can be done from leaves, fruits, roots, etc. But for a computer vision to identify a 3D object is very difficult. Except for the leaf, all other parts are 3D objects and increase the complexity. However, plant leaves are 2D objects which carry sufficient information to recognize the plant. This paper has proposed and implemented a system for automatic identification of medicinal plants from their leaves. The proposed system makes use of computer vision and machine learning approaches to identify a pre-trained medicinal plant from its leaf. Main highlight of this work is the non-use of typical shape and color features of leaves which are computationally expensive to extract as they are spatial features. The proposed system uses a blend of SURF and HOG features which provided nearly 100% of accuracy when experimented with k-nn classifier. Scope for future work includes expanding the leaf dataset, changing the classifier from k-nn to SVM or ANN and to experiment with a blend of more features added with HOG and SURF.

A simple method for leaf recognition based on bisection of leaves was proposed by Caner Uluturk and Aybars Ugur [26]. After pre-processing 7 low cost morphological features are extracted. In the next stage leaf orientation is done about its major axis and the two parts are acquired by slicing leaf on its centroid vertically. Area, extent and eccentricity features are extracted for each part and their proportions to each other are taken as new features. These all 10 features are used as an input to probabilistic neural network (PNN). PNN is trained with 1120 leaf images from 32 different plant species which are taken from FLAVIA dataset. Nearly 160 leaf images of the plant species are used for testing. The experiments and comparisons show that method based on half leaf features has reached one of the best results with 92.5% recognition accuracy. An Overview of the various plant classification techniques:

However, several problems have been identified through our research. A first problem category refers to image dataset generation and availability. A second problem category has to do with approaches used by software developers. Concerning the first type of problems, datasets of images of wood cuts are few, uneven across taxa, and small. This is even more so for microscopic anatomical images. In addition, xylotheques do not yet consider automated image-based identification of forest species a goal. As a result, they do not normally have large digital collections of images, nor metadata standards for data sharing or image capturing. However, a new opportunity to address the small dataset problem is to use recently developed techniques such as meta-learning. With respect to the second problem category, in spite of the deep learning and CNNs boom.

Table 1: Comparison of Various Plant Classification Techniques

Researchers	Leaf Features	Algorithm Used	Accuracy
Sabu, A., Sreekumar, K., Nair, R.R	explores feature vectors from both the front and back side of a green leaf along with morphological features to arrive at a unique optimum combination of features that maximizes the identification rate	The proposed system uses a combination of SURF and HOG features extracted from leaf images and a classification using k-NN classifier	99%
Samreen Naeem 1 , Aqib Ali 1,2 , Christophe Chesneau 3 , Muhammad H. Tahir 4 , Farrukh Jamal 4 , Rehan Ahmad Khan Sherwani 5 and Mahmood Ul Hassan 6	edge/line detection, fused features extraction, optimized extracted features and select the most valuable features and select the efficient MLclassifier	a multi-layer perceptron, logit-boost, bagging, random forest, and simple logistic	98%

Researchers	Leaf Features	Algorithm Used	Accuracy
X. Gu, J. Du, and X. Wang	The result of segmentate ion of leaf's skeleton based on the combinate on of Wavelet transform and Gaussian interpolate on.	Combination n of wavelet transform (WT) and Gaussian interpolation n, k -nearest neighbour classifier (kNN) and a radial basis probabilistic neural network (RBPNN) are used with runlength features (RLF)	Close to 95%
X. Wang, J. Du, and G. Zhang	Features like rectangular rity, circularity, eccentricity y and seven moment invariant s are used	hyper sphere classifier	92.20%

Wei Tian, Wenhe Liao, Baochang cai, Boli	Fine-tuning the pre-training model of AlexNet, VGGNet, and ResNet based on transfer learning.	convolutional neural networks (CNNs)	98.17%.
Manojkumar P., Surya C. M., Varun P. Gopi	leaf shape, colour and texture. Colour and texture from both sides of the leaf contain deterministic parameters to identify the species	MLP AND SVM	99%
Z. Wang, Z. Chi, and D. Feng	Centroid Contour Distance, eccentricity y and angle code histogram. C	Curvature scale space (CSS) and modified Fourier descriptor (MFD) method	An average recall rate of 75.6% was achieved
H. Fu, Z. Chi, D. Feng, and J. Song	Vein Texture is extracted Leaf classification n and centroid	contour distance curve method	94.26%
3 J. Du, D. Huang, X. Wang, and X. Gu	Shape of plant leaf is used as identification ion tool.	Computer aided plant species identification n (CAPSI)	

J. Du, D. Huang, X. Wang, and X	Gu It performs plant recognition on through modified Fourier descriptor s of leaf shape.	Radial basis probabilistic c neural network which is trained by orthogonal least square algorithm (OLSA) optimized by recursive OLSA.	96.20%
S. Wu, F. Bao, E. Xu, Y. Wang, Y. Chang, and Q. Xiang	12 digital morphology gical features are used. The base point of leaf and a few reference points on the leaf blades are also used	PCA technique and training, testing with Probabilistic c Neural Network	90.31%
J.-X. Du, X.-F. Wang and G.- J. Zhang	8 Digital Morphologic cal features are used as parameter to the algorithms	Move median centers (MMC) hypersphere e classifier	The recognition n rate is greater than 75%
Hossain and M.A. Amin	9 Features like eccentricity y, area, perimeter, major axis, minor axis, equivalent diameter and convex area	Features are selected after 5 major phases and used as inputs to the probabilistic c neural network	91.41%
S. Prasad, P. Kumar and R.C. Tripathi	Feature used for extracti on is shape and texture	New multiresolution and multidirectional al curvelet	95.60%

		approach with Doublespeaker approximate on and modified dynamic programming g (MDP) algorithm	
Abdul Kadir, L.E. Nugroho, A.susanto, P.Insap Santosa Zernike	moment s were combin ed with other features like geometric icy features , color moment s and gray level cooccurrence matrix.	A distance measure and Probalistic Neural Networks are used	92.20%
Jyotismita Chaki, Ranjan Parekh	Moments Invariant and Centroid d Radii are used	Neural networks are used as classifiers for discrimination	Ranging from 90-100 %

		transform is applied	
Kue-Bum Lee and Kwang Seok Hong	Leaf Vein Shape	frequency domain data by using FFT methods 97	97.19%
Sajeevan G	Aspect Ratio, apex ratio, base angle, centroid deviation n ratio, moment ratio and circularity	ANN is used to identify plant by inputting leaf image	92%

3. CONCLUSION

In this paper we have discussed several plants identification systems and leaf recognition system. It must be clear from the above comparative study that there is no single method that provides a solution for all problems but this analysis helps in identifying the best approach for leaf features extraction and classification. The accuracy measure helps in analyzing the performance of the system. Hence, other features will be researched and extracted in future for better performance.

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