# *Whether color, shape and texture of leaves are the key features for image processing based plant recognition? An analysis!*

Jibi G Thanikkal[1], Ashwani Kumar Dubey[2], Thomas. M.T[3]
[1]Dept. of Computer Science and Engineering, [2]Dept. of Electronics and Communication Engineering, [3]Dept. of Botany
[1,2]Amity University Uttar Pradesh, Noida, India
[3]St.Thomas' College, Thrissur, Kerala, India
[1]jibimary@gmail.com, [2]dubey1ak@gmail.com, [3]thomastbgri@gmail.com

***Abstract*—Studies on plant identification through image processing consider shape, color and texture features of leafs. But botanist's uses leaf morphology, leaf arrangement, types of venation, leave shapes, leave bases, leaf margins and leaf apices for recognizing a plant. This paper introduces the leaf venation, leaf margin, leaf apies, and leaf bases models for improving plant leaf identification. These new features along with shape, color and feature increases the accuracy of the plant identification.**

***Keywords— Plant recognition, Image processing, Shape matching, Morphological features, Leaf image.***

## I. INTRODUCTION

Image Processing based plant recognition system depends on the key features extracted from the input images. Shape, color, texture are the commonly using image processing based plant leaf identification features.Leaf color may vary according to seasons and climate conditions [1]. For the color based leaf identification technique, color frequency histograms are extracted from the input image and compared to database using similarity measuring algorithm [2].Leaf shape identification process require image segmentation algorithms [2]. The basic shape analysis approaches are region based and boundary (contour) based [3].The patterns formed in the leaf image surface according to the color and grayscale variations constitute the leaf texture [2]. Texture based leaf identification can be done with the help of image gray matrices in spatial domain [2].

In this paper, we concentrate on common plant leaf identification features and also introduce some other morphological features that can increase the accuracy of the leaf plant Identification. Moreover, a detailed comparative study on shape, color, and texture features and new features also included.The rest of the paper is organized into following sections: Section 1 introductory part describes the commonly used features in digital image processing for leaf plant identification. Section 2 describes a brief literature review on existing image processing based plant leaf identification features. Section 3 the proposed leaf identification features those can improve the quality and accuracy of the image processing based plant leaf identification algorithms. Section 4 gives the comparison and discussion on the different existing pnd proposed features. Finally a summary of contributions and future work are discussed in Section 5.

## II. RELATED WORK\LITERATURE REVIEW

Image identification process mainly depends on the performance of feature identification algorithms. Most of the studies in the leaf identification is using low level extracted features like shape, color and texture. Some researchers are used combination of these features for better results.

Ghasab et al.[4], focused on color based image identification algorithms. Venters and Cooper[5], Smeulders et al.[6] studied the content based image retrieval systems using color as main feature. Tico et al.[7] proposed image retrieval using color histogram. Stricker and Orengo [8] studied the extraction of color features and similarity calculation of color images.Arun et al.[9] and Kadir et al. [10] concentrated on texture feature extraction for plant identification. Texture based leaf identification using Curvelet transforms was described by Prasad et al. [11]. Rashad et al.[12] studied the Combined Classifier based textural features. Leaf contours using texture analysis is described by Hajjdiab and Maskari [13]. Sá Junior et al.[14] analyzed leaf color and texture information based anatomical identification of plant species. In Backes et al. [15] deterministic tourist walk using texture feature was explained. Different algorithms have also explained based on the image processing texture features [16-21].

Shape feature for the plant leaf identification is mostly studied [22-50]. These studies explained shape features (ovate, elliptical...etc) detection algorithms, combination of shape features with color and texture features. Shape based detection is easy but the accuracy of the result is questionable. Recent studies have developed applications in android and IOS for leaf plant detection[22, 27]. Some leaf recognition algorithm [30, 30-34] different kind of neural network classifiers based features are explained. Shape similarity based object recognition and matching techniques are represented in [46-47].

The low level features, shape, color and texture explained above are the mainly utilizing features for plant

leaf identification but some researchers tried to combine some other features like leaf vein, apices, leaf edge and leaf lobe for plant classification. Larese et al. [51] proposed classification of legumes using extracted leaf vein details. Abdolvahab and Sharath [52] explained leaf recognition and leaf based plant classification with the help of vein feature. Park et al. [53] utilized ventation features for leaf image retrieval. Vein features based reorganization

images from complicated background are described Wang et al. in [54]. In [55-58] detailed extractions of the above features are made. Plant leaf classification based on the help of leaf edge and texture is detailed in [55]. Zheng [56]et al. used the combination of leaf apices, leaf edge and leaf lobe features for plant identification. In [57] an unsupervised classification technique using neural networks and cluster analysis algorithms are developed help of leaf apices and leaf edge.

Table 1 shows the summary of the mostly studied features for plant identification.

TABLE 1. FEATURES USED FOR PLANT IDENTIFICATION

| Authors | Feature | | |
|---|---|---|---|
| | Colour | Shape | Texture |
| Ghasab et al. [4] | Y | | |
| Venters and Cooper D.M.[5] | Y | | |
| Smeulders et al.[6] | Y | | |
| Tico et al.[7] | Y | | |
| Stricker and Orengo [8] | Y | | |
| Arun et al.[9] | | | Y |
| Kadir et al.[10] | Y | | Y |
| Prasad et al.[11] | | | Y |
| Rashad et al.[12] | | | Y |
| Hajjdiab and Maskari[13] | | | Y |
| Junior et al.[14] | Y | | Y |
| Backes et al.[15] | | | Y |
| Ramos and Fernandez [16] | | | Y |
| Backes et al.[17] | | | Y |
| Bruno et al.[18] | | | Y |
| Wang et al.[19] | | | Y |
| Zheru Chi et al.[20] | | | Y |
| Yusof et al.[21] | | | Y |
| Zhao et al.[22] | | Y | |
| Wang et al.[23] | | Y | |
| Clark et al.[24] | | Y | |
| Cope et al.[25] | | Y | |
| Corney et al.[26] | | Y | |
| Kumar et al.[27] | | Y | |
| Hu et al[28] | | Y | |
| Abdul Kadir et al.[29] | Y | Y | Y |
| Chaki and Parekh[30] | | Y | |
| Beghin et al.[31] | | Y | Y |
| Lexer et al.[32] | | Y | |
| Lei Zhang et al.[33] | | Y | |
| Wu et al.[34] | | Y | |
| El-ghazal et al[35] | | Y | |
| Du et al.[36] | | Y | |
| Du et al.[37] | | Y | |
| Neto et al.[38] | | Y | |
| Agarwal et al[39] | | Y | |
| Mokhtarian et al.[40] | | Y | |
| Park and Kim [41] | | Y | |
| Mokhtarian and Abbasi [42] | | Y | |
| Wang et al.[43] | | Y | |
| Zhang and Lu[44] | | Y | |
| Meade and Parnell [45] | | Y | |
| Belogie et al[46] | | Y | |
| Abbasi et al[47] | | Y | |
| Ingrouille and Laird [48] | | Y | |
| Bober et al.[49] | | Y | |
| Ling and Jacobs[50] | | Y | |

Table 2 shows identification rate for feature and combination features.

TABLE 2. COMPARISON OF IDENTIFICATION RATE FOR SINGLE FEATURE AND COMBINATION FEATURES [59]

| Features | Identification Rate |
|---|---|
| Shape | 86.8% |
| Color | 86% |
| Texture | 92% |
| Color + Shape | 86% |
| Color + Texture | 93.4% |
| Texture + Shape | 91.2% |
| Color + Texture + Shape | 94% |

## III. PROPOSED FEATURE SET.

From the detailed survey on existing Plant leaf identification system in Image Processing area, it is showing that the most of the researchers considered the color, shape and texture as their key features. But in reality botanists are considering the features like leaf morphology, arrangement of leaves, types of venation, leave shapes, leave bases, leaf margins and leaf apices for the identification of plant leaf. Plant color, Shape and texture feature may vary according to the seasonal and other

physical impacts. In the proposed feature set the combination of low level features like shape, color and texture as well as leaf vein, apices, leaf margins, leaf bases for plant leaf identification is explained. More than single use of these features combined use of these features achieved highest identification rate. If the sample image is altered in their shape considering the venation will give more accuracy. Similarly margins, apies and bases also play bigger role in the plant leaf identification system.

- Leaf venation:
  The leaf has a central vein which extends from the base, where the petiole attaches to the blade, to the apex of the leaf. In Figure 1 Different kinds of leaf vein examples are showing.

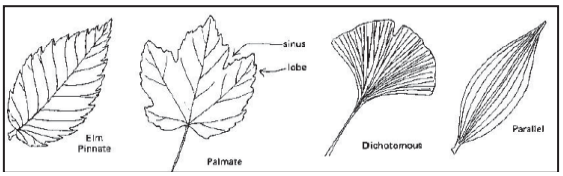


Figure 1.Different kinds of leaf veins [60]

- Leaf margins:
  Considering leaf margin along with leaf shape will improve the quality of plant leaf identification. In figure 2 Different kinds of leaf margins are shown

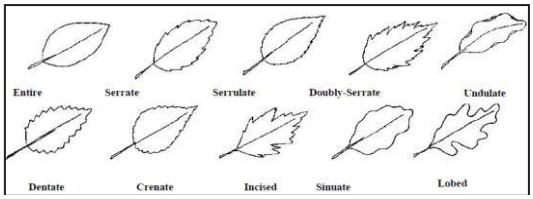


Figure 2.Different kinds of leaf margins [60]

- Leaf apies:
  Leaf apies / tips are shown in Figure 3.

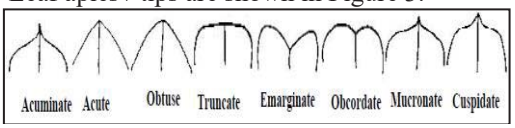


Figure 3.Different kinds of leaf apies [60]

- Leaf bases:
  Sample of leaf bases models are shown in Figure 4.

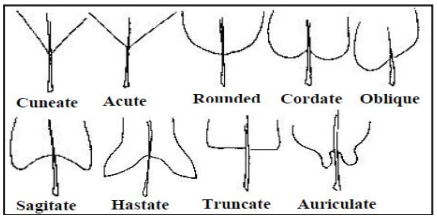


Figure 4.Different kinds of leaf bases [60]

## IV. DISCUSSION

From the above study limiting the leaf plant identification with the common feature like shape, color and texture is not fare. By considering the other physical features like leaf morphology, arrangement of leaves, types of venation, leave shapes, leave bases, leaf margins and leaf apices will improve the quality of the plant leaf identification. From table 2, the combination of two features given 86% to 91% accuracy. By considering three features like shape color and texture feature given average identification rate of 94%.So Increasing the number of features for identification will increase the accuracy of the recognition system. For medicinal plant identification system like application it is necessary to be result should be accurate.

## V. CONCLUSION AND FUTURE WORK

For Plant recognition increasing the number of features for identification will increase the accuracy of the recognition system. Increasing the accuracy by increasing number of features but effect the speed of recognition. By considering features leaf morphology, arrangement of leaves, types of venation, leave shapes, leave bases, leaf margins and leaf apices with color, shape and texture improve quality of the system also accuracy of the critical application like medicinal plant identification system.

Performance evaluation measurement for finding identification rate for these new features not performed in this paper. By evaluating measurements for shape, color, texture leaf morphology, arrangement of leaves, types of venation, leave shapes, leave bases, leaf margins and leaf apices using recall precision curve, F-measure etc definitely be used before reaching conclusion.

## REFERENCES


[1] S.Sharma and C. Gupta, "A review of plant recognition methods and algorithms", Intl. Jurnl *IRAE*, vol.2, Jun. 2015.

[2] H. Kepapci et.al, "Plant image retrieval using color, shape,and texture features" , Oxford Jurnls, 2011, vol.54 no.9

[3] El-ghazal, A.,Basi, and S. Belkasim, "Shape based image retrieval using pair wise candidate co-ranking ", *ICIAR*, pp. 650-661.

[4] MAJ. Ghasab, S. Khamis, F. Mohammad and HJ. Fariman, "Feature decision-making ant colony optimization system for an automated recognition of plant species". Expert Systems with Applications 2015; vol.42 no.5, pp.2361-2370

[5] C. C Venters and D. M. Cooper, (2000) ,"A review of content based image retrieval systems. Technical report" , Manchester Visualization Centre, Manchester Computing, University of Manchester, Manchester, UK.

[6] A. W. M Smeulders, M. Worring, S. Santini, A. Gupta, and R. Jain, (2000) "Content-based image retrieval at the end of the early years." , IEEE Trans. *Pattern Anal. Mach. Intell*.,vol. 22, pp. 1349–1380

[7] H.J. Tico, M, K. P. (2000) "A method of color histogram creation for image retrieval". Proceedings of the Nordic Signal Processing Symposium (NORSIG'2000), Kolmarden, Sweden, Jun, pp. 157–160

[8] MA. Stricker and M. Orengo. "Similarity of color images". IS&T/SPIE's Symposium on Electronic Imaging: Science & Technology; 1995. pp. 381–392.

[9] MA. Stricker and M. Orengo, C. H. Arun, W. R. Sam Emmanuel, and D. Christopher Durairaj, "Texture feature extraction for identification of medicinal plants and comparison of different classifiers", Intl Jurnl of *Comput Applications* (0975-8887), vol. no. 62,No.12,Jan 2013, pp.1-9. IS&T/SPIE's Symposium on Electronic Imaging: Science & Technology; 1995. pp. 381–392.

[10] A .Kadir, LE .Nugroho, A. Susanto and PI. Santosa. "Experiments of zernike moments for leaf identification". Jurnl of Theoretical and Applied Information Technology 2012; vol.41 no.1, pp.83-93

[11] S. Prasad, P. Kumar and Tripathi R.C. (2011) "Plant leaf species identification using curvelet transform " , 2nd Intl Conference on Comput and Communication Technology (ICCCT), pp.646–652.

[12] M.Z. Rashad, B.S El-Desouky and M.S Khawasik, 2011. "Plants images classification based on textural features using combined classifier ". Intl Jurnl of Comput Science & InformationTechnology (IJCSIT), vol.3 no.4, pp. 93-100. doi:10.5121/ijcsit.2011.3407

[13] H. Hajjdiab and I. Al Maskari . 2011 . "Plant species recognition using leaf contours ". In Proceedings of the IEEE Intl Conference on Imaging Systems and Techniques, pp. 17–18 May 2011

[14] Sá Junior JJM, AR Backes, DR Rossatto, RM Kolb and Bruno OM (2011) , "Measuring and analyzing color and texture information in anatomical leaf cross sections: an approach using comput vision to aid plant species identification" . vol 89, pp. 467–479. doi: 10.1139/b11-038

[15] AR Backes, WN Gonçalves, AS Martinez and OM Bruno. "Texture analysis and classification using deterministic tourist walk ". *Pattern Recogn*,2010; vol. 43, pp. 685–694.

[16] E. Ramos and DS Fernandez. "Classification of leaf epidermis microphotographs using texture features". *Ecol Inform*.2009; vol.4, pp. 177–181.

[17] AR. Backes, D. Casanova and OM. Bruno (2009) "Plant leaf identification based on volumetric fractal dimension". Intl Jurnl of *Pattern Recognition and Artificial Intelligence (IJPRAI)* vol 23, pp. 1145–1160.doi: 10.1142/S0218001409007508

[18] OM. Bruno, R. de Oliveira Plotze, M. Falvo, and M. de Castro. "Fractal dimension applied to plant identification" . Information Sciences, vol 178. No.12, pp. 2722 –2733, 2008.

[19] XF. Wang, JX. Du and GJ. Zhang (2005) "Recognition of leaf images based on shape features using a hypersphere classifier". *Advances in Intelligent Computing, Springer Berlin Heidelberg*, vol. no. 3644 pp. 87–96.

[20] Zheru Chi Li Houqiang, and Wang Chad, "Plant species recognition based on bark patterns using novel gabor filter banks" , IEEE Intl *Conference on Neural Networks and Signal Processing*, (2003), pp. 1035-1038.

[21] R. Yusof, N.R. Rosli and M.Khalid, "Using gabor filters as image multiplier for tropical wood species Recognition system", Intl conference on comput Modelling and simulation (UKSim), pp. 289-294, 2010

[22] Zhao ZQ, Ma LH, Cheung YM, Wu X, Tang Y, Chen CLP. "ApLeaf: An efficient android-based plant leaf identification system". *Neurocomputing* 2015; vol. 151, pp. 1112-1119.

[23] F Wang, DW. Liao, Li JW and Liao GP. "Two-dimensional multifractal detrended fluctuation analysis for plant identification" . Plant Methods 2015; vol. 11 no.1, pp.12

*[24]* J. Y Clark, D. P. A. Corney, and H. L. Tang. 2012. "Automated plant identification using artificial neural networks". pp. 342–348. 2012 IEEE *Symposium on computational intelligence in bioinformatics and computational biology (CIBCB). IEEE, San Diego, California.*

[25] J. S.Cope, D. Corney, J. Y. Clark, P. Remagnino, and P. Wilkin. 2012. "Plant species identification using digital morphometrics: a review" . Expert Systems with Applications, vol. 39, pp. 7562–7573.

[26] D. P. A Corney, H. L. Tang, J. Y. Clark, Y. Hu, and J. Jin. 2012a. "Automating digital leaf measurement: The tooth, the whole tooth, and nothing but the tooth.". PLoS One. Public Library of Science.

[27] N. Kumar, P.N. Belhumeur, A. Biswas , D.W. Jacobs, W.J. Kress, I. Lopez, and V.B. Soares, 2011. "Leafsnap: A comput vision system for automatic plant species identication" .

[28] R.Hu, W.Jia, H.Ling, and D.Huang, "Multi scale distance matrix for fast plant leaf recognition" , IEEE Trans. Image Process. Vol. 21 no.11, (2012) pp. 4667–4672.

[29] A. Kadir, L. E. Nugroho, and P. I. Santosa, "Leaf classification using shape, color, and texture", Intl Jurnl *of Comput Trends & Technology (IJCTT),* Aug 2011,pp.225-230.

[30] J Chaki, R Parekh and R Bhattacharya. "Plant leaf recognition using texture and shape features with neural classifiers. Pattern Recognition", *Letters* 2015; vol 58, pp. 61-68.

[31] T. Beghin, J. S. Cope, P. Remagnino, and S. Barman. "Shape And Texture Based Plant Leaf Classification" (2010).

[32] C. Lexer, J. Joseph, MV Loo, G Prenner, B Heinze and Chase MW, "The use of digital image-based morphometrics to study the phenotypic mosaic in taxa with porous genomes". *Taxon.*2009; vol. 58, pp. 349–364.

[33] L. Zhang, J. Kong, X. Zeng and J. Ren, "Plant Species Identification Based on Neural Network" Forth Intl Conference on Natural Computation (ICNC '08) vol. no. 5, pp. 90-94, 2008.

[34] S. G. Wu, F. S. Bao, E. Y. Xu, Y. X. Wang, Y. F. Chang and Q. L. Xiang, (2007). "A Leaf Recognition Algorithm for Plant Classification Using Probablistic Neural Network" *, IEEE Intl Symposium on Signal Processing and Information Technology, Giza,* pp. 11-16.

[35] A. El-ghazal, , O. A. Basir, and S. Belkasim, (2007) "Shape based image retrieval using pair-wise candidate co-ranking. In Kamel, M. S. and Campilho, A. C. (eds.), *ICIAR, Lecture Notes in Comput Science,* pp. 650–661.

[36] JX Du, XF Wang, GJ Zhang. "Leaf shape based plant species recognition" . *Appl Math Comput.* 2007; vol. 185 no.2, pp. 883–893.

[37] J.-X. Du, D.-S. Huang, X.-F. Wang, and X. Gu, "Comput-aided plant species identification (capsi) based on leaf shape matching technique," *Transactions of the Institute of Measurement and Control*, vol. no. 28, 2006.

[38] J Neto, G Meyer, D Jones and A Samal. "Plant species identication using elliptic Fourier leaf shape analysis". *Comput Electron* Agr.2006; vol 50, pp. 121–134.

[39] G. Agarwal, P. Belhumeur, S. Feiner, D. Jacobs, W. J. Kress and Ramamoorthi R. "First steps toward an electronic field guide for plants". *Taxon*.2006; vol. 55, pp. 597.

[40] F. Mokhtarian, Y. Khim ung , and Z. Wang . 2005 . "Automatic fitting of digitised contours at multiple scales through the curvature scale space technique" . *Computs & Graphics* vol. 29 pp. 961 – 971 .

[41] J. S. Park, and T.Y. Kim, (2004) " Shape based image retrieval using invariant features". Advances in Multimedia Information Processing - PCM 2004, *Berlin / Heidelberg Lecture Notes in Comput Science*, pp. 146–153.

[42] F Mokhtarian and S. Abbasi. "Matching shapes with self-intersection: application to leaf classification", *IEEE T Image Processing.* 2004; vol. 13, pp. 653–661.

[43] Z. Wang, Z. Chi, and D. Feng, "Shape based leaf image retrieval," IEE Proceedings-Vision, Image and Signal Processing, vol.150, no. 1, Feb 2003

[44] D. ZHANG and G. LU . 2003a ." Evaluation of MPEG-7 shape descriptors against other shape descriptors". *Multimedia Systems* vol. 9, pp. 15 – 30. .

[45] C Meade, J Parnell., "Multivariate analysis of leaf shape patterns in Asian species of the Uvaria group(Annonaceae)". Bot J Linn Soc.2003; vol. 143, pp. 231–242.

[46] S. Belongie, J Malik, and J. Puzicha, 2002. "Shape matching and object recognition using shape context". *IEEE Trans. on PAMI,* vol. 24 no. 24, pp.509–522.

[47] S. Abbasi, F. Mokhtarian, and J. Kittler, (1999) "Curvature scale space image in shape similarity retrieval". *Multimedia Systems*, vol. 7, pp. 467–476.

[48] MJ. Ingrouille and SM Laird. " A quantitative approach to oak variability in some north London woodlands". LON Nat).1986; vol. 65,pp. 35–46.

[49] M. Bober, F. Preteux and W.I.Kim . 2002 . "Shape descriptors" , Introduction to MPEG-7: Multimedia content description interface, pp. 231–260.

[50] H. Ling and D. Jacobs. "Shape classification using the inner-distance". IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 29 no.2, pp. 286 –299, Feb. 2007.

[51] MG Larese, R Namías, RM Craviotto and MR Arango. "Automatic classification of legumes using leaf vein image features". Pattern Recogn.2014, vol. 47 no. 1, pp. 158–168.

[52] E. Abdolvahab and S. Kumar, 2010. "Leaf recognition for plant classification using GLCM and PCA methods"

[53] J Park, E Hwang and Y Nam. "Utilizing venation features for efficient leaf image retrieval". J Syst Software. 2008; vol. 81 no.1, pp. 71–82.

[54] X. Wang, D. Huang, J. Du, H. Xu, L. Heutte, "Classication of plant leaf images with complicated background", *Applied Mathematics and Computation*. vol. 205 (2008), pp.916-926.

[55] C. S. Sumathi and A. V. Senthil Kumar, "Edge and Texture Fusion for Plant Leaf Classification", Intl Jurnl

*of Comput Science and Telecommunications*, vol. no. 3, Issue 6, Jun 2012,pp. 6-9.

[56] X Zheng, X Wang, J Gao. "Application of SUSAN algorithm in feature extraction of leaf margin". *Chin. Agric. Sci. Bull*.2011; vol. 27, pp.174–178.

[57] JY Clark. "Neural networks and cluster analysis for unsupervised classification of cultivated species of Tilia (Malvaceae)" . *Bot J Linn Soc*.2009; vol.159, pp. 300–314.

[58] SM Smith and JM Brady. " SUSAN-a new approach to low level image processing" . *Int J Comput Vision*.1997; vol. 23 no. 1,pp. 45–78.

[59] N. Jamil, N. Aslina, C. Hussin, S. Nordin and K. Awang "Automatic Plant Identification: Is Shape the Key Feature?", 2015 *IEEE Intl Symposium on Robotics and Intelligent Sensors (IRIS 2015),*vol. 76 ( 2015 ) pp. 436 – 442.

[60] https://www.ndsu.edu/pubweb/chiwonlee/plsc211/labmanual/lab1.PDF