ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Identification Of Herbal Medicinal Plant Leaves Using Image Processing Algorithm: Review.

T Vijayashree[1]*, and A Gopal[2],

[1]Research Scholar, Sathyabama Institute of Science & Technology, Chennai-119
[2]Sr.Principal Scientist and Scientist Incharge, CSIR-CEERi, Madras Complex, Taramani.

ABSTRACT

In biological sciences, images play a vital role in information data set. In earlier periods people always prefer in herbal medicine (Siddha or Ayurvedic), where in later it was entirely changed by Allopathic medicine. Nowadays in general medicinal applications of herbal leaves are not much aware. This research paper focuses on the study of classification and identification of herbal medicinal leaves based on automated leaf recognition system. The proposed system use image processing technique for image segmentation and feature extraction. The dataset includes 500 leaves of 50 different species. The leaves were compared with the stored database images and the one with least dissimilarity was considered to be the closest match. The classification was done using various parameters such as texture, shape and color. The features extracted were totally 21 including all the three parameters which gave various accuracies under various tests. The tests was carried out under different methods which includes, texture analysis, color moment classification and training the algorithm in neural network and real time implementation is done using Raspberry Pi processor. The main aim of the research work is to classify the Indian herbal leaves based on its medicinal properties in order to differentiate it from lookalike leaves based on image processing technique. The method is inexpensive which can be used by scientist in the field of agriculture for better classification. The accuracy achieved was 99.2 % for the classification of herbal medicinal leaves. The proposed system employs a novel neural network algorithm for determining the efficiency for classifying different varieties of Basil (Tulsi) leaves. Using Raspberry Pi processor, the medicinal leaf variety and its uses was displayed. The leaves were captured using a high resolution camera for better clarity and was saved to create the dataset.

Keywords: medicinal plants, image, algorithm, Basil

Corresponding author

ISSN: 0975-8585

INTRODUCTION

Herbal plants play a major role in our day to day life. These herbal leaves have a very good medicinal qualities for curing disease like Sinus, skin infection, cold, cough and many more. Due to the intercession of allopathic medicines, nowadays the use of herbal medicines has been decreased. Every herbal leaves has a unique characteristics of curing disease, which has to be

brought back for usage. Medicinal leaves are one of the most important things in our human life. In most parts of the world, particularly in rural areas, local traditional medicine, including herbalism, the only source of health care for people, where as in other parts alternative medicines has become supplementary. Identifying the herbal leaf among the lookalike leaf is the main task as of now. In order to identify the herbal medicinal qualities of leaf an automated system has been incorporated a user-friendly approach intended for the benefits of farmers for agricultural purpose and also used for normal human who are not aware of herbal medicines. Automated system includes image processing technique for creating the database of herbal leaves by extracting the features based on texture and shape parameters and also includes color parameters to classify within classes like various varieties of Tulsi (Ocimum tenuiflorum). In this classification of leaves, the unique character like vein plays a significant role which has also been taken as an important parameter into consideration. A brief description about the proposed methodology, techniques used is explained in later sections.

Section II explains the prior and related work, which narrates the previous work carried by various authors, the methodology they used, accuracy achieved and the limitations carried out in their work. Section III, gives the proposed methodology of the work carried out, techniques used. Section IV with conclusion and discussion.

PRIOR AND RELATED WORK

Ross Lagerwall and Serestina Virir[1] proposed a plant classification using leaf recognition system, in which they have carried out in two phase of work with Prinicipal-Component Analysis(PCA) and shape descriptor feature which has given the accuracy of 89.2% and the limiting factor of this method is the memory.

Parvin[2] et.al has proposed a system using a chromatographic and DNA finger printing technique for which the herbal leaves were dried, powdered and mixed with various solutions for nearly 20 days to extract the medicinal qualities. Even though the author has attained the accuracy of 95%, it is protracted process. Abdul Kadir[3] et.al in order to improve his work based carried out using Polar Fourier Transform (PFT) which gave the accuracy of only 74.6875%, he included many parameters like shape, texture and color features and also combined Principal Component Analysis (PCA) and trained the dataset for which he obtained the accuracy of 93.4375%. Abdolvahab Ehsanirad and Sharath Kumar Y. H.[4], used Gray level Co-occurrence Matrix(GLCM), and PCA technique for leaf classification of plant recognition system. Individually by using GLCM technique is obtained the accuracy of 78% and when included the PCA technique he could attain the accuracy of 98%, he concluded that GLCM technique is very sensitive and cannot be used separately for leaf classification and also when GLCM combined with any other parameter the accuracy gets improved. Shazia Sultana et.al [5] worked on NEEM leaf foe extracting its uses in which the approach was completely based on powdered drug analysis.

The leaves were powdered and mixed with concentric solutions for more than 20 days to extract the medicinal properties. The author has also used a test tube method in which the powdered leaves were boiled in solutions and firmed the properties of the herbal drug. C.Ananthi et.al[6] developed a pattern recognition performance for identifying the medicinal leaves using image processing technique. Initially the preprocessing procedure was carried out using image processing and the testing part included Neural network approach in which the training of algorithm was done using back-propagation method and was analyzed using Statistical Package for the Social Science (SPSS) software. The recognition rates was 73.87% for Hibiscus when it was compared with Hibiscus, Betel, Castor and Manathakali leaves which gave the least recognition of 64.2%.

N.Valliammal [7] et.al proposed a Computer aided plant classification through leaf recognition (CAP-LR) using contrast stretching technique to fill the edges and adaptive thresholding method to increase the intensity level of the leaf images. The validation process was done by various parameters such as Peak Signal to Noise ratio (PSNR), Mean Square Error (MSE), Universal Quality Index (UQI), Energy and Evaluation Time

(ET). The author concluded that the value of UQI must be high which produces good quality image, comparatively MSE and ET value must be low value to act as a good algorithm. This method was adopted for only 10 leaves and also this method was not suitable for small size leaves. Pallavi P and V.S Veena Devi [8] proposed a leaf recognition system based on feature extraction and Zernike Moments for determining the structurally complex images. Even though the training of the algorithm was lengthy, they could attain the result and the efficiency was not determined. Suman S. G, B. K. Deshpande [9], classified the plant leaf based on Artificial neural network (ANN), the work was carried out under two phases. One with training the network and the other with testing. Initially a basic image processing techniques was used for better enhancement and followed with the training. By trial and error method of adjusting the weights testing was carried out. The author has concluded that comparatively with the previous method the accuracy was better. Jyotismita Chaki et.al [10] proposed an automatic recognition system for plants based on leaf images, in which two modeling technique Moment Invariant (MI) and Centroid-Radii (CR) was used. MI alone gave an accuracy which is remarkably less when compared with CR and the parameter considered here is solely shape feature. Aamod Chemburkar et.al [11] developed an automated tool for plant leaf classification using morphological features using ANN after image processing based on edge detection and vein analysis. Using feed forward back propagation neural network was used for training set. The author has not concentrated about the accuracy and efficiency of the system. H. Fu and Z. Ch[12] developed an approach by Combined thresholding and neural network for vein pattern extraction from leaf images. The basic classification was based on vein parameter and the classifier used here was ANN for training. The work determines the vein pixel darker than background which improves performance of ANN classifier but because of lots of mathematical calculation training took more time and the segmentation was based on intensity histogram. P. S. Hiremath and Jagadeesh Pujari[12] worked on content based image retrieval based on Color, Texture and Shape features using Image and its complement gave the idea about the parameters with most significant highest priority matching system. Kue-Bum Lee and Kwang-Seok Hong [13], implemented a leaf recognition system using leaf vein and shape. The method used here was Intelligent Scissors (IS) and contour extraction. Vein extraction includes Fast Fourier transform (FFT) and projection histogram with contour and centroid distance on leaf detection. The software used here was Microsoft Visual C++ in which the database created was not constant. The average recognition accuracy of this was 97.19%. Thibaut Beghin et.al [14] and Milan Sulc et.al [15] proposed leaf identification using texture based classification. The above authors used the technique of histogram for texture based classification. The classification rate was 81% and 90% respectively. Stephen Gang Wu et.al [16] and Sapna Sham[17] has proposed leaf recognition system using back propagation neural network approach for training the data set. Anant [18], briefly described various plant recognition techniques and Anant et al. [19] gave an approach to classify plant leaf images based on higher order moment invariants and texture analysis using nearest neighbor classifier The authors [20],[21]and [22] followed the same approach for the leaf detection using ANN for its fast performance. The other authors [23][24] engaged their work with k-nearest neighbor (k-NN) classifier to classify plants using the same technique. Du et al. [25] carried out the work based on shape recognition on radial basis Probabilistic Neural Network (PNN) and trained by orthogonal least square algorithm (OLSA) and optimized by recursive OLSA. Vijay Satti et.al [26], combined his work using ANN and PNN and the network was trained with Flavia dataset. The results were compared with ANN and Euclidean (KNN) and gave an accuracy of 93.3%. H. Fu and Z. Chi [27] developed a two-stage approach for leaf vein extraction using ANN and combined the result with conventional edge detection method for extracting a more precise venation modality of the leaf for subsequent leaf recognition. J. Pan and Y. He [28], combined image processing and neural network for the classification of leaf and carried out the work in two parts. One set for training the set and the other one for testing. The accuracy the author could achieve was 80%. S.G. Wu et.al[29] H. Lin, and H. Peng [30], developed a leaf recognition algorithm for classifying the plant using PNN which gave the highest accuracy of 90% and 93.8% respectively. Y.F. Li et.al[31] proposed a leaf vein extraction model based on snake techniques with cellular neural networks (CNN). Using this technique produced a high flexible and control for contour dynamics. This method has produced a satisfactory results of leaf segmentation. P. Tzionas et.al [32] implemented an artificial vision system to extract the geometrical and morphological feature of plant leave. Back propagation training algorithm was used for training the network. The accuracy attained was 99% using 10 neurons in a hidden layer and was validated. Using back propagation network training the algorithm has been a major drawback of this system. X. Gu et.al [33] proposed a new approach for leaf recognition using the result of segmentation of leaf's skeleton based on the combination of wavelet transform (WT) and Gaussian interpolation. The classifiers used was a nearest neighbor classifier (1-NN), a K-nearest neighbor classifier (k-NN) and a radial basis probabilistic neural network (RBPNN), based on run-length features (RF) extracted from the skeleton to recognize the leaves. The recognition rate of the leaves based on this method was improved. L. Han[34], proposed the recognition of tobacco leaves using Support

Vector Machine (SVM) in Qujing area. It was grouped into two, working set and non-working set. The samples which are worngly classified in SVM are under the working set and the remaining falls under the non-working set. The result indicates that close to 95% of samples in the SVM grouping are reliable with those in the authorized grouping. Y.C. Zhang et.al [35] developed the feature selection on cotton disease leaves using fuzzy curves (FS) and fuzzy surface (FS), the result obtained is that effectiveness of features chosen by FC and FS method is improved than that method selected by human randomly. J.S. Casals et.al[36], recognised the plant leaves using perimeter characterization as a unique discrimination parameter. PCA technique was used for recognition and classification task was implemented by SVM. W. Dake, and M. Chengwei [37], proposed the leaf recognition system using SVM and Near Infrared (NIR) spectral analysis. The NIR spectral analysis was taken at different wavelengths for damaged degree (DD) of leaves infected by leafminer. They concluded that the result obtained by the spectral method can be used to measure DD of leaves infected by leafminers with SVM. X. Wang et.al[38], has developed the classification of plant leaves for complicated background using seven Hu geometric moments and sixteen Zernike moments extracted as shape features from segmented binary images after removing the leafstalk. The author has also used moving centre hypersphere (MCH) classifier for better classification. The average classification rate obtained by this method is 92.6% for twenty classes of leaves. Tapio Pahikkala et.al[39] has taken a new approach for the classification of overlapping leaves using a spectroscopic technique followed by image segmentation. Eventhough the technique is not used in the proposed methodology, this work has given an input to be considered for future work. J. Du et.al[40], proposed an efficient computer-aided plant species identification (CAPSI) approach, for plant leaf images using a shape matching technique. Using Douglas - Peucker approximation algorithm the original leaf shapes changed into a new shape. Then a modified dynamic programming (MDP) algorithm for shape matching is proposed for the plant leaf recognition. The experimental result showed that leaf shape matching is very suitable for the recognition in all aspects such as for partial, distorted and overlapped plant leaves due to its robustness. S. Zhang and Y. K. Lei [41] , modified a locally linear discriminant embedding (MLLDE) for plant recognition system.

The proposed method was compared with various techniques like PCA, LLE and modified maximizing margin criterion (MMMC) and determined that MLLDE has shown a better result for plant classification. Ojala, T et.al [42] has given a comparative study of texture measures with classification based on feature distribution. This article gives the basis of leaf classification system and concluded that the pair of complementary measures improves the accuracy. Marko Heikkil et.al [43] proposed a description of region of interest with local binary patterns in which he used center-symmetric local binary pattern (CS-LBP). It produced a remarkably excellent result compared to scale-invariant feature transform (SIFT).T. Randen [44] has given a comparative study about various the texture measures in his paper, which are used for the classification based on feature distribution. The authors of [45-49] has worked on with LBP to build a reliable descriptor.The texture operator has given a high successful rate on various computer vision problems, such as face recognition, background subtraction and recognition of 3D textured surfaces, where describing interest regions has not been worked so far. Prof. Sanjay B.

Dhaygude and Mr.Nitin P.Kumbhar [50], developed an automation system for detecting the disease in plant leaves using image processing based on four steps, color transformation, image segmentation, texture statistics and finally evaluation. Texture analysis was done by color co-occurrence matrix and then the sample was compared with the test images. S. Arivazhagan et.al [51] has worked on the detection of unhealthy region of plant leaves and classifying them using texture features. By assigning a specific threshold value the segmentation was carried out and the result produced an efficiency of 94% for determining the infected leaves. Helly et al.[52] developed a new technique in which Hue Saturation Intensity (HSI) transformation is applied to the input image and then segmented using Fuzzy C-mean algorithm. Feature extraction parameters included color, size and shape of the spot and finally classification was done using neural networks. The classification produced an accuracy of 86.77% using Minimum Distance Criterion (MDE) and 94.74% on using SVM classifiers. Prof. R. N.kadu et.al[53] proposed a leaf detection using ARM 7 and image processing techniques. The author has used SVM method for classifying the leaves. The statistical texture analysis was done by G.Srinivasan et.al [54] which has been taken for better understanding to list out the parameters that comes under texture. With a brief explanation given by Andrzej Materka and Michal Strzelecki [55] it is been studied that texture has been classified into four categories such as Structural, Statistical, model based and transform which has given the wide knowledge about the texture parameter. The texture parameters include mean, variance, correlation, contrast, inverse difference moment (IDM), entropy, sum average, sum entropy,

sum variance, difference variance, difference entropy, information measures of correlation. WY Ma, BS Manjunath [56], has given a clear idea about image segmentation technique.

PROPOSED METHODOLOGY

In this proposed methodology shown in figure1, image capturing is done using a high resolution camera of more than 16 pixels and more was used for better clarity. For the captured leaves, image segmentation technique using region based, gradient based along with histogram was preceded. Image segmentation includes edge-detection based on discontinuity segmentation which involves smoothing, detection and localization using Canny edge detector for enhanced continuity. Region based image segmentation technique works on the principle of homogeneity, considering that the neighboring pixels inside the region posses same characteristics and remaining pixels in other region. Every pixel is compared with its neighboring pixel for similarity check such as grey level, color, texture and shape.

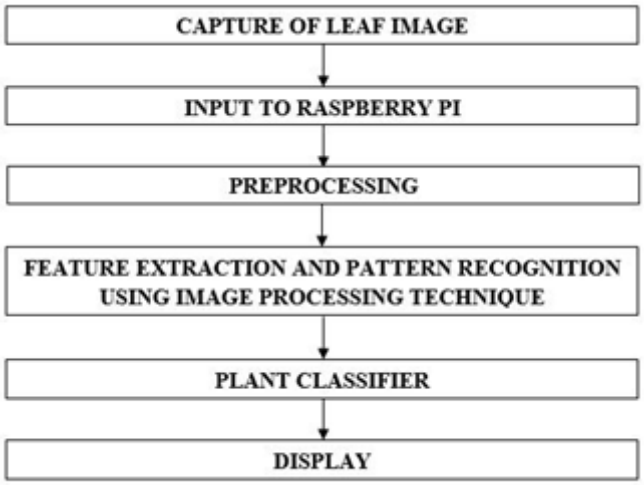

Fig 1: Proposed block diagram

Feature extraction step is followed after image segmentation, database creation and then compared with the test image. The one with least dissimilarity is said to be the herbal leaf. Raspberry pi is stored with a program to classify the input image based on the parameters of leaves. The quality and authenticity of the leaves are to be ensured for the preparation of herbal medicines. The image of medicinal plant leaves are thoroughly screened, analyzed and compared with the database stored in Raspberry pi to give the correct measures of the texture of leaf with which we can find category to which it belongs to along with the medicinal usage. This is the advanced method of interfacing image processing with Raspberry Pi processor and utilizing the capabilities in advanced computing technique.

CONCLUSION

With the overall literature survey it is been concluded that the plant classification includes the parameters likes, texture and shape. The better classification was done using texture parameter alone with the accuracy 93.3%. In order to improve the accuracy and better classification, texture, shape and color feature extraction can be combined together and with the closest similarity match the leaf can be identified and can be incorporated using Raspberry Pi processor

REFERENCES

[1] Ross Lagerwall and Serestina Virir, “Plant Classification Using Leaf Recognition”, www.prasa.org/proceedings/2011/prasa2011-17.pdf.

[2] Pravin H. Nikam, Joseph Kareparamban, ArunaJadhav and Vilasrao Kadam, “Future trends in standardization of herbal drugs”, Journal of Applied Pharmaceutical Sciences 02(06); 2012; 38-44.

[3] Abdul Kadir, Lukito Edi Nugroho, AdhiSusanta, Paulus InsapSantosa, "Leaf Classification using shape, color and texture features", International Journal of Computer Trends and Technology July to Aug issue 2011, ISSN: 2231-2803.

[4] AbdolvahabEhsanirad and Sharath Kumar. sY.H, "Leaf recognition for plant classification using GLCM and PCA methods", Oriental Journal of Computer Science & Technology, vol. 3 (1), 31-36, 2010.

[5] Shazia Sultana, Mir Ajab Khan, Mushtaq Ahmad, AsghariBano, "Authentication of Herbal Medicine NEEM (Azadirachta Indica A. Juss.) By using Taxonomic and Pharmacognostic Techniques" Pak.J.Bot., 43:141-150.

[6] C.Ananthi, Azha. Periyasamy, S.Muruganand, " Pattern Recognition of medicinal leaves using image processing techniques, Journal of nanoscience and nanotechnology, vol 2, Issue 2, Spring edition DOI:February 2014, pp. 214-218, ISSN: 2279-0381.

[7] N.Valliammai and Dr.S.N. Geethalakshmi, "A Hybrid method for enhancement of plant leaf recognition", World of Computer Science and Information Technology Journal, ISSN: 2221-0741, Vol. 1, No. 9, 370-375, 2011.\

[8] Pallavi. P, V.S.Veena Devi, "Leaf Recognition based on feature extraction and Zernike moments",International Journal of Innovative Research in Computer and Communication Engineering, Vol 2, Special Issue 2, May 2014.

[9] Suman S. G, B. K. Deshpande, "Plant leaf Classification using Artificial Neural Network Classifier", International Journal of Innovative Research in Computer and Communication Engineering, Vol. 5, Issue 5, May 2017, pp10189-10196.

[10] Jyotismita Chaki and Ranjan Pare, "Plant Leaf Recognition using Gabor Filter" International Journal of Computer Applications (0975 – 8887) Volume 56– No.10, October 2012, pp-56-59.

[11] Aamod Chemburkar, Anand Sartape, Ajinkya Gawade, Prasad Somawanshi, "Automated Tool for Plant Leaf Classification Using Morphological Features ",International Journal Of Engineering And Computer Science ISSN:2319-7242 Volume 3 Issue 11 November, 2014 Page No. 9098-9102

[12] H. Fu, Z. Chi, D. Feng, and J. Song(2004), "Machine learning techniques for ontology-based leaf classification," in IEEE 2004 8th International Conference on Control, Automation, Robotics and Vision, Kunming, China

[13] Kue-Bum Lee and Kwang-Seok Hong, " An Implementation of Leaf Recognition System using Leaf Vein and Shape", International Journal of Bio-Science and Bio-Technology Vol. 5, No. 2, April, 2013 pp 57-66.

[14] Thibaut Beghin, James S Cope, Paolo Remagnino, and Sarah Barman, "Shape And Texture Based Plant Leaf Classification", pp-1-9.

[15] Milan Sulc and Ji˘r´ı Matas, "Texture-Based Leaf Identification", Published by Center for Machine Perception, Department of Cybernetics Faculty of Electrical Engineering, Czech Technical University Technick´a 2, 166 27 Prague 6, Czech Republic, ISSN 1213-2365, Computer Vision ECCV 2014 workshops pp185-200.

[16] S. G. F. Wu, S. Bao, E. Y. Y. Xu, X. Y. Wang, F. Chang and Q. L. Xiang, "A Leaf Recognition Algorithm for Plant Classification using Probabilistic Neural Network", The 7th IEEE International Symposium on Signal Processing and Information Technology, **(2007)** Cairo, Egypt.

[17] Sapna Sharma, Dr. Chitvan Gupta, "Recognition of Plant Species based on leaf images using Multilayer Feed Forward Neural Network", International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 Issue 6, Volume 2 (June 2015), pp 104-110.

[18] Anant Bhardwaj, Manpreet Kaur, "A Review On Plant Recognition And Classification Techniques Using Leaf Images", International Journal of Engineering Trends and Technology- Volume 4 Issue 2- 2013 ISSN 2231-5381, pp 86-91.

[19] Anant Bhardwaj, Manpreet Kaur, "Recognition of plants by Leaf Image using Moment Invariant and Texture Analysis", International Journal of Innovation and Applied Studies ISSN 2028-9324 Vol. 3 No. 1 May 2013, pp. 237-248 2013 Innovative Space of Scientific Research Journals.

[20] "A Leaf Recognition Algorithm for Plant Classification Using Probabilistic Neural Network, Stephen Gang Wu, Forrest Sheng Bao, Eric You Xu, Yu-Xuan Wang, Yi-Fan Chang and Qiao-Liang Xiang arXiv:0707.4289v1 [cs.AI] 29 Jul 2007.

[21] H. Fu, Z. Chi, D. Feng, and J. Song, "Machine learning techniques for ontology-based leaf classification," IEEE 2004 8th International Conference on Control, Automation, Robotics and Vision, Kunming, China, 2004.

[22] J. Du, D. Huang, X. Wang, and X. Gu, "Shape recognition based on radial basis probabilistic neural network and application to plant species identification," in Proceedings of 2005 International Symposium of Neural Networks, ser. LNCS 3497. Springer, 2005.

[23] X. Gu, J. Du, and X. Wang, "Leaf recognition based on the combination of wavelet transform and gaussian interpolation," in Proceedings of International Conference on Intelligent Computing 2005, ser. LNCS 3644. Springer, 2005.
[24] X. Wang, J. Du, and G. Zhang, "Recognition of leaf images based on shape features using a hypersphere classifier," in Proceedings of International Conference on Intelligent Computing 2005, ser. LNCS 3644. Springer, 2005.
[25] J. Du, D. Huang, X. Wang, and X. Gu, "Shape recognition based on radial basis probabilistic neural network and application to plant species identification," in Proceedings of 2005 International Symposium of Neural Networks, ser. LNCS 3497. Springer, 2005
[26] Vijay Satti, Anshul Satya And Shanu Sharma,' An Automatic Leaf Recognition System For Plant Identification Using Machine Vision Technology", in International Journal of Engineering Science and Technology (IJEST), ISSN : 0975-5462, Vol. 5 No.04 April 2013 pp. 874-879.
[27] H. Fu, and Z. Chi, "A Two-Stage Approach for Leaf Vein Extraction", in Proceeding on International Conference on Neural Network & Signal Processing, Nanjing, China, 14-17 October 2003, pp. 208-211.
[28] J. Pan, and Y. He, "Recognition of plant by leaves digital image and neural network", in Proceeding of International Conference on Computer Science and Software Engineering, Wuhan, Hubei, China, 12-14 December 2008, pp. 906-910.
[29] S.G. Wu, F.S. Bao, E.Y. Xu, Y.X. Wang, Y.F. Chang, and Q.L. Xiang, "A Leaf Recognition Algorithm for Plant Classification Using Probabilistic Neural Network", in Proceeding of International Symposium on Signal Processing and Information Technology, Cairo, Egypt, 15-18 December 2007, pp. 11-16.
[30] H. Lin, and H. Peng, "Machine Recognition for Broad-Leaved Trees Based on Synthetic Features of Leaves Using Probabilistic Neural Network", in Proceeding of International Conference on Computer Sience. and Software Engineering, Wuhan, Hubei, China, 12-14 December 2008, pp. 871-877.
[31] Y.F. Li, Q.S. Zhu, Y.K. Cao, and C.L. Wang, A leaf Vein Extraction Method Based on Snakes Technique, in Proceeding of International Conference on Neural Networks and Brain, Beijing, China, 13-15 October 2005, pp. 885-888.
[32] P. Tzionas, S.E. Papadakis, and D. Manolakis, "Plant leaves classification based on morphological features and a fuzzy surface selection technique", in Proceeding of International Conference on Technology and Automation, Thessaloniki, Greece, 15-16 October 2005, pp. 365-370.
[33] X. Gu, J.X. Du, and X.F. Wang, "Leaf Recognition Based on the Combination of Wavelet Transform and Gaussian Interpolation", in Proceeding of International Conference on Intelligent Computer, Hefei, China, 23-26 August 2005, pp. 253-262.
[34] L. Han, "Recognition of the Part of Growth of Flue-Cured Tabacco Leaves Based on Support Vector Machine", in Proceeding of the World Congress on Intelligent Control and Automation, Chongqing, China. 25-27 June 2008, pp. 3624-3627.
[35] Y.C. Zhang, H.P. Mao, B. Hu, and M.X. Li, "Features Selection of Cotton Disease Leaves Image Based on Fuzzy Feature Selection Techniques", in Proceeding of the International Conference on Wavelet Analysis and Pattern Recognition, Beijing, China. 2-4 November 2007, pp. 124-129.
[36] J.S. Casals, C.M. Travieso, J.B. Alonso, and M.A. Ferrer, "Improving a Leaves Automatic Recognition Process Using PCA", in Proceeding of Inter Workshop on Practical Applications of Computational Biology & Bio Informatics, Salamanca, Spain, 22-24 October 2008, pp. 243-251.
[37] W. Dake, and M. Chengwei, "The Support Vector Machine-Based Near-Infrared Spectrum Recognition of Leaves Infected by the Leafminers", in Proceeding of International Conference on Innovation Comp. Information & Control, Beijing, China, 30 August – 1 September 2006, pp. 448-451.
[38] X. Wang, D. Huang, J. Dua, H. Xu and L. Heutte, "Classification of plant leaf images with complicated background", Appl. Math. Comput., vol. 205, 2008 pp 916-926.
[39] Tapio Pahikkala, Kim Kari , Heta Mattila, Anna Lepistö, Jukka Teuhola, Olli S. Nevalainen , Esa Tyystjärvi, "Classification of plant species from images of overlapping leaves", Computers and Electronics in Agriculture 118 2015, 186–192.
[40] J. Du, D. Huang, X. Wang and X. Gu, "Computer-aided plant species identification (CAPSI) based on leaf shape matching technique", Trans. Inst. Meas. Control, vol. 23, 2006 pp 275-284.
[41] S. Zhang and Y. K. Lei, "Modified locally linear discriminant embedding for plant leaf recognition", Neuro computing, vol. 74, Issue 14-15, July 2011 pp 2284-2290.
[42] Ojala, T., Pietik¨ainen, M., Harwood, D, "A comparative study of texture measures with classification based on featured distributions". Pattern Recognition 29 (1), 1996, pp 51–59.
[43] Marko Heikkil, MattiPietik, , CordeliaSchmid, "Description of interest regions with local binary patterns", Pattern Recognition 42 2009, pp 425 – 436.

[44] T. Randen, J.H. Husoy, Filtering for texture classification: a comparative study, IEEE Trans. Pattern Anal. Mach. Intell. 21 1999, pp 291–310.
[45] T.Ojala,M.Pietik¨ainen, D.Harwood, A comparative study of texture measures with classification based on feature distributions, PatternRecognition29(1), 1996, pp 51–59.
[46] T.Ojala, M.Pietik¨, T.M¨aenp¨a, Multi resolution gray-scale and rotation invariant texture classification with local binary patterns, IEEE Transaction on Pattern Analysis Machine Intelligence 24, 2002, pp 971–987.
[47] T.Ahonen, A.Hadid, M.Pietik,Face description with local binary patterns: Application to face recognition, IEEE Transaction on Pattern Analysis Machine Intelligence 28 (12) 2006, pp 2037–2041.
[48] M.Heikkil, M.Pietik, A texture-based method for modeling the background and detecting moving objects, IEEE Transaction on Pattern Analysis Machine Intelligence 28 (4) 2006, pp 657–662.
[49] M.Pietik, T.Nurmela, T.M¨aenp¨a M.Turtinen, View-based recognition of real-world textures, Pattern Recognition 37 (2) (2004) pp 313–323.
[50] [1]Prof. Sanjay B. Dhaygude, [2]Mr.Nitin P.Kumbhar, "Agricultural plant Leaf Disease Detection Using Image Processing, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 1, January 2013 ISSN: 2278 – 8875,pp 599-602.
[51] S. Arivazhagan, R. Newlin Shebiah, S. Ananthi, S. Vishnu Varthini, "Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features", March, 2013 Agric Eng Int: CIGR Journal, Open access at http://www.cigrjournal.org Vol. 15, No.1, pp 211-217.
[52] Helly, M. E., A. Rafea, and Salsa-El-Gammal "An integrated image processing system for leaf disease detection and diagnosis" 2003 in Proc. IICAI, pp.1182-1195.
[53] Prof. R. N.kadu , S. Kangane , S.Vikhe , R.Pandita , V. Inamke, "Leaf Disease Detection Using Arm7 and Image Processing", Int. Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 5, Issue 2, (Part -1) February 2015, pp.68-71.
[54] G. N. Srinivasan, and Shobha G, "Statistical Texture Analysis', Proceedings Of World Academy Of Science, Engineering And Technology Volume 36 December 2008 ISSN 2070-3740, pp 1264-1269.
[55] A. Materka, M. Strzelecki, Texture Analysis Methods – A Review, Technical University of Lodz, Institute of Electronics, COST B11 report, Brussels 1998.
[56] WY Ma, BS Manjunath ,"EdgeFlow: a technique for boundary detection and image segmentation" on Image Processing, IEEE Transactions, 2000