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Survey Paper on Plant Leaf Identification System

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ABSTRACT

Imagine someone hiking in the Swiss mountains, where he finds a weird leaf or flower. This person has always been bad in biology but would like to know more about that plant. What's its name? Its main features? Is it rare? Is it protected? Etc. By simply taking a picture of the leaf with a Digital Camera, he or she could feed it to the database in his computer and then get all the information regarding the leaf image through an automatic leaf recognition application. Even today, identification and classification of unknown plant species are performed manually by expert personnel who are very few in number. The important aspect is to develop a system which classifies the plants. The general approach consists of three phases that are pre-processing, feature extraction, and classification phases. Since most types of plants have unique leaves. Leaves are different from each other by characteristics such as the shape, color, texture and the margin.

Keywords: Random Forest, Zernike Moment, Gabor Filters, GLCM.

I. INTRODUCTION

Since late decades, computerized picture preparing, picture investigation & machine vision have been forcefully created, and they have turned into a vital piece of manmade brainpower and the interface amongst human & machine grounded hypothesis and connected innovation. These innovations have been connected generally in industry & drug, however seldom in domain identified with horticulture or normal environments.

"A standout amongst the most imperative assignments for researchers, field aides, and others are order of plants, since plants have a critical part in the characteristic hover of life. They are key to practically every other type of life, as they shape the biggest part of the living life forms that can change over the daylight into nourishment. What's more, as all oxygen noticeable all around that people and different creatures inhale is delivered by plants, thus without plants it is hard to consider presence of human life on earth. Characterizing plants helps at guaranteeing the security and survival of all normal life. The procedure of plant characterization can be performed utilizing distinctive routes, for example, cell and atomic science and in addition utilizing the plants' takes off".

"Most sorts of plants have special leaves that are not quite the same as each other in light of various attributes, for example, shape, shading, surface, and the edge. The generous data conveyed by each can be utilized to recognize and characterize the inception or the kind of plant, so leaf acknowledgment/order is essential assignment at the procedure of plant characterization".

"Lately, there has been considerable work in the PC vision field, which handled the issue of plants arrangement utilizing leafs acknowledgment. One can without much of a stretch exchange the leaf picture to a PC and a PC can remove highlights consequently in picture handling systems. A few frameworks utilize depictions utilized by botanists. Be that as it may, it is difficult to concentrate and exchange those components to a PC naturally".

The main goal of this research is to create a Leaf recognition program based on specific characteristics extracted from photography. Hence this presents an approach where the plant can be classified based on their leaf features such as color, shape & texture and classification. The main purpose of this program is to use MATLAB resources.

II. MOTIVATION

The human visual system has no problem interpreting the subtle variations in translucency and shading in this Figure 1. Photograph and correctly segmenting the object from its background.

Figure 1. Lotus flower seen as to the naked eye.

Let's imagine a person taking a field trip, and seeing a bush or a plant on the ground, he or she would like to know whether it's a weed or any other plant but have no idea about what kind of plant it could be. With a good digital camera and a recognition program, one could get some useful information. "Plants assume a vital part in our surroundings. Without plants there will be no presence of the world's nature. Be that as it may, as of late, many sorts of plants are at the danger of termination. To ensure plants and to list different sorts of greenery diversities, a plant database is a critical stride towards protection of earth's biosphere. There are a colossal number of plant species around the world. To handle such volumes of data, improvement of a snappy and effective characterization technique has turned into a region of dynamic research. Notwithstanding the preservation angle, acknowledgment of plants is additionally important to use their restorative properties and utilizing them as wellsprings of option vitality sources like bio-fuel. There are a few approaches to perceive a plant, similar to bloom, root, and leaf, organic product and so on".

III. LITERATURE REVIEW

This section describes the previous work which had been done for Leaf Identification.

Pallavi P et al., (and other) [1] developed "a new structure for perceiving and distinguishing plants is been proposed. Shape, vein, shading and surface components have been utilized to recognize the leaf and neural system approach is utilized to arrange them. In this, GLCM gives better surface approximations and thus makes arrangement simpler". OluleyeBabatunde et al. [2] demonstrate the different systems close by their portrayals. It depicts how future analysts in this field may advance the learning area.

Stephen Gang Wu et al. [3] utilize "Probabilistic Neural Network (PNN) with picture and information handling systems to execute broadly useful robotized leaf acknowledgment for plant grouping. 12 leaf elements are separated and orthogonalized into 5 chief factors which comprise the info vector of the PNN. The PNN is prepared by 1800 leaves to group 32 sorts of plants with precision more noteworthy than 90%".

AnandHanda et al. [4] finish up with the continuous work in the present zone and the other existing issues in the region. "The programmed advanced plant grouping should be possible by removing different elements from its leaves and still there exist potential outcomes to enhance plant species distinguishing proof through the planning of another computerized programmed plant recognizable proof and acknowledgment framework".

M. M. Amlekar et al. [5] different administrators are examined for the leaf extraction from pictures by utilizing the picture handling strategies.

A Gopal et al. [6] prepare product with as well (10 number of every plant species) leaves and tried with 50 (tried with various plant species) clears out. The efficiency of system is to be 92%.

EsraaElhariri et al. [7] introduce“a grouping approach in view of RF and LDA calculations for characterizing the distinctive sorts of plants. Leaves are not quite the same as each other by qualities, for example, the shape, shading, surface and the edge.LDA accomplished characterization exactness of (92.65 %) against the RF that accomplished precision of (88.82 %) with mix of shape, first request surface, Gray Level Co-event Matrix (GLCM), HSV shading minutes, and vein highlights”.

AnantBhardwaj et al. [8] displayed “different successful calculations utilized for plant order utilizing leaf pictures and audit the principle computational, morphological and picture preparing techniques that have been utilized as a part of late years”.

BoranSekeroglua et al. [9] presented “intelligent recognition system to recognize and identify 27 different types of leaves using back propagation neural network and results show that the developed system is superior to recent researches with the recognition rate of 97.2%”.

Rongxiang Hu, Wei Jia et al. [10] connected “the proposed strategy to the undertaking of plan leaf acknowledgment with trials on two datasets: the Swedish Leaf dataset and the ICL Leaf dataset”.

TrishenMunisami et al. [11] Developed“a mobile application to allow a user to take pictures of leaves and upload them on server. The server runs pre-processing and feature extraction techniques on the image before a pattern matcher compares information from this image with the ones in database in order to get potential matches”.

AjinkyaGawade et al. [12]are attempting to acquire atomization this procedure to such an extent that with no past learning of the leaf species to layman simply utilizing its picture.

Sachin D et al. [13] present“a computer based automatic plant identification system. Out of all available organs of plant, leaf is selected to obtain the features of plant. Five geometrical parameters are calculated using digital image processing techniques. On the basis of these geometrical parameters six basic morphological features are extracted. Vein feature as a derived feature is extracted based on leaf structure”.

Miss. NeedaSamreen I et al. [14] discusses “the leaf recognition which enables the user to recognize the type of leaf using a approach that depends on neural network. Scanned images are being introduced into the computer initially, image enhancement and reduction of noise modifies their quality, further followed by feature extraction”.

Xiaowei Shao et al. [15] another sort of detecting gadget, the Kinect profundity sensor which measures the genuine separation to objects straightforwardly and can catch high-determination profundity pictures, is abused for the programmed acknowledgment and extraction of takes off.

Arunpriya C et al. [16] comprises of three stages, for example, preprocessing, include extraction and characterization to prepare the stacked picture. The tea leaf pictures can be distinguished precisely in the preprocessing stage by fluffy denoising utilizing Dual Tree Discrete Wavelet Transform (DT-DWT). In the component extraction stage, Digital Morphological Features (DMFs) are inferred to enhance the grouping precision.

KshitijFulsoundar et al. [17] portray the improvement of an Android application that gives clients the capacity to recognize plant species in light of photos of the plant's leaves brought with a cell phone. The Core of this system is a calculation that secures morphological components of the leaves, registers very much archived measurements.

JyotismitaChakia et al. [18] show“a new strategy of portraying and perceiving plant leaves utilizing a blend of surface and shape highlights. Surface of the leaf is demonstrated utilizing Gabor channel and Gray Level Co-event Matrix (GLCM)”.

ShyamVijayraoPundkar et al. [19] demonstrate that picture handling is driving area in recognizable proof of restorative plant.

Deore Nikita R et al. [20] use “mobile phones for real time monitoring of plant disease for proper diagnosis and treatment. A central server is placed at the pathological laboratory for sharing of the data collected by the mobile phones”.

IV. METHODOLOGY

Pattern recognition is a very important field within computer vision, and the aim of pattern recognition/classification is to classify or recognize the patterns based on extracted features from them. The pattern recognition involves three steps (1) Pre-processing (2) Feature Extraction (3) Classification. In Pre-processing one usually process the image data so it should be in suitable form e.g. one gets an isolated objects after this step. In second step measure the properties of object of interest and in third step, determine the class of object based on features. The basic steps of Pattern recognition for plant identification are shown in Figure 2.

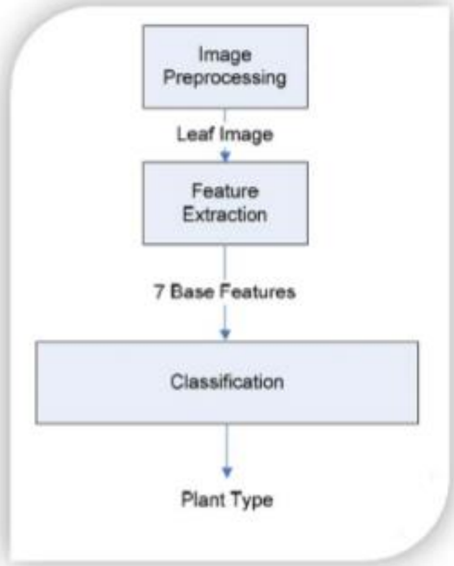

Figure 2. Basic Steps of the System

A. Image Preprocessing

Prior to the operations, a portion of the leaf pictures are turned physically to help the program to mastermind leaf summit course to the correct side. A short time later, programmed Preprocessing systems are connected to the greater part of the leaf pictures. These Preprocessing steps are shown on a picture as found in Figure 4, while overlooking the shading data. Thus, just Gray segment for every pixel is processed from the shading picture by

Gray=0.299*Red+0.578*Green+0.114*Blue

Where Red, Green and Blue relate to the shade of the pixel individually.

The rectangle of intrigue (ROI) of the leaf picture ought to incorporate every one of the pixels their Gray qualities are littler than a particular edge, and afterward the twofold picture of the leaf is recovered. In this approach the limit is consequently gotten by histogram of the leaf Gray picture. At that point the shape of leaf can be extricated.

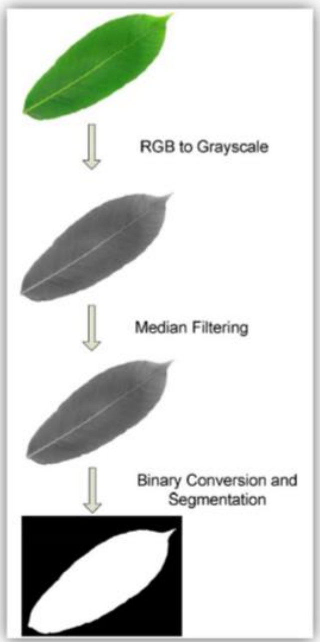

Figure 4. Image Preprocessing Steps.

B. Feature Extraction

The features can be used are described as given below:

1. Shape Features

Important geometric features are as follows.

Eccentricity: "is defined as the ratio of the distance between the foci of the ellipse and its major axis length. It is used to differentiate rounded and long leafs".

Solidity: "is the ratio between object's area and area of the object's convex hull. It may be considered as a certain measure of convexity".

$$\text{Solidity}=\frac{A(I)}{A(H(I))}$$

Where A(I) is the object area and A(H(I)) is the area of object's convex hull.

Aspect Ratio (AR): "is the ratio between the maximum length D_{MAX} and the minimum length D_{MIN} of the minimum bounding rectangle".

$$AR = \frac{D_{MAX}}{D_{MIN}}$$

Width Ratio (WR): "is the ratio of width at half of major axis to maximum width".

Perimeter: "is scalar that specifies the distance around boundary of the region.".

Area: "is scalar that specifies the actual number of pixels in the region".

Roundness or Circularity: "is the ratio of 4*PI*Area of the leaf to the square of perimeter".

EquivDiameter: "is scalar that specifies the diameter of a circle with same area as the region computed as sqrt (4*Area/pi)".

Centroid: "is 1 by Q vector that specifies the center of mass of region. First element of centroid is horizontal coordinate of center of mass and second element is the vertical coordinate".

Convex Area: "is scalar that specifies the number of pixels in convex Image".

Convex Hull: "is p by 2 matrixes that specify smallest convex polygon that contain the region".

Figure 5. Leaf Shape Features

2. Color Features

Mean, standard deviation, skewness, and kurtosis for a color image of size N x M pixels are defined.

$$\bar{X}_i = \frac{\sum_{j=1}^{MN} X_{i,j}}{M \cdot N}$$

$$\vartheta_i = \sqrt{\frac{1}{M \cdot N}\sum_{j=1}^{MN}(X_{i,j} - \bar{X}_i)^2}$$

$$S_i = \sqrt[3]{\frac{1}{M \cdot N}\sum_{j=1}^{MN}(X_{i,j} - \bar{X}_i)^3}$$

$$K_i = \sqrt[4]{\frac{1}{M \cdot N}\sum_{j=1}^{MN}(X_{i,j} - \bar{X}_i)^4}$$

Where $X_{i,j}$ is the value of image pixel j of color channel i. $\bar{X}_i$ is the mean for each channel i. ϑ_i is the standard deviation , S_i is skewness and K_i is kurtosis for each channel.

3. Vein Features

Vein features are features derived from vein of the leaf. There are four kinds of vein features, defined as follows: V1=A1/A, V2=A2/A, V3=A3/A, V4=A4/A WhereA1, A2, A3 and A4 are pixel number that constructs the vein and A is area of the leaf. The vein of the leaf is constructed by using morphological operation called opening. This operation is performed on the Gray scale image with flat, disk-shaped structuring element of radius 1, 2, 3, 4 and subtracted remaining image by the margin. As a result, a structure like vein is obtained. Conversion from RGB image to Gray scale image is done by using formula below:

Gray = 0.2989*R+0.5870*G+0.1140*B

The algorithm involves following steps:

1. Convert RGB image of the leaf to Gray scale image:
   - Gray scale leaf
2. Obtain the threshold value of the Gray scale image and convert the Gray scale image to binary image with the above threshold value:
   - Binary leaf
3. Create four structure elements with disk shape and the radius 1,2,3 and 4 respectively:
   - SE1- disk shape structure element, radius=1
   - SE2 - disk shape structure element, radius=2
   - SE3 - disk shape structure element, radius=3
   - SE4 - disk shape structure element, radius=4
4. Perform opening operation to both the structure elements:
   - O1 - opening (SE1)
   - O2 - opening (SE2)
   - O3 - opening (SE3)
   - O4 - opening (SE4)
5. Subtract the Grayscale images of the leaf by the result of the opening operation:
   - R1 - subtract (Grayscale leaf, O1)
   - R2 - subtract (Grayscale leaf, O2)
   - R3 - subtract (Grayscale leaf, O3)
   - R4 - subtract (Grayscale leaf, O4)
6. Get the binary images of R1, R2,R3 and R4 by using Otsu method:
   - BW1 – Segmented by Otsu (O1)
   - BW2 – Segmented by Otsu (O2)
   - BW3 – Segmented by Otsu (O3)
   - BW4 – Segmented by Otsu (O4)
7. Calculate the total of pixels of BW1, BW2, BW3, and BW4:
   - A1 - pixel number of BW1
   - A2 - pixel number of BW2
   - A3 - pixel number of BW3
   - A4 - pixel number of BW4
8. Calculate area of the leaf:
   - A - Area of (Binary leaf)
9. Calculate the ratio of:
   - V1: A1 / A
   - V2: A2 / A
   - V3: A3/ A
   - V4: A4 / A
10. Join four elements as a vector V= [V1 V2 V3 V4].

4. Texture Features

Surface components allude to the data portrays the game plan of pixels in any example. Surface components have been utilized for acknowledgment reason in many works in writing.

4.1. Gray Level Co- occurrence Matrix (GLCM):

"GLCM is defined over an image to be the distribution of co-occurring values at a given offset".

$$Angular\ Second\ Moment = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1} P_{ij}^{\ 2}$$

$$Contrast = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}(i-j)^2 P_{ij}$$

$$Correlation = \frac{1}{\vartheta_x \vartheta_y} \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} [ijP_{ij} - \mu_x \mu_y]$$

$$Entropy = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} P_{ij} \log P_{ij}$$

$$variance = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} (i - \pi)^2 P_{ij}$$

$$Homogeneity = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \frac{1}{(i-j)^2} P_{ij}$$

$$Sum\ of\ Entropy = -\sum_{i=2}^{2G-2} P_{x+y}(i) \log P_{x+y}(i)$$

$$Cluster\ Shade = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} (i + j - \pi_x - \pi_y)^3 P_{ij}$$

$$Prominence = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} (i + j - \pi_x - \pi_y)^4 P_{ij}$$

Where $\mu_x, \mu_y, \vartheta_x$ and ϑ_y mean and standard deviation of corresponding distribution and G are is number of Gray levels.

4.2. Gabor Filter [18]

"A complex Gabor filter is defined as the product of a Gaussian kernel and a complex sinusoid. A 2D Gaussian curve g with a spread of σ in both x and y directions", is represented as below:

$$g(x, y, \sigma) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{x^2 + y^2}{2\sigma^2}\right)$$

$(x,y,u,\theta,\varphi) = \exp\{j2\pi(x.u\cos\theta + y.u\sin\theta)+\varphi\}$

The complex Gabor function h is therefore

$h(x,y,\sigma,u,\theta,\varphi) = g(x,y,\sigma).s(x,y,u,\theta,\varphi)$

"A Grayscale image $(x,)$ is convolved with Gabor filter h with experimentally determined parameters to produce a set of complex signals J".

$J(x,y) = I(x,y) \otimes h(x,y,\sigma,u,\theta,\varphi)$

"The real (rgg) and imaginary (igg) parts of the signal are separated out".

$(x,y) = \mathrm{Re}\{J(x,y)\}$

$(x,y) = \mathrm{Im}\{J(x,y)\}$

5. Zernike Moment

"Plants are for the most part perceived utilizing the state of the leaf. Hence they can't be fittingly depicted with the assistance of customary shape descriptors like circularity, linearity etc. Thus Zernike minutes can be received. These minutes have higher space highlight vector and are regularly of request N. On the off chance that extra request of minutes is viewed as, and then we accomplish better the acknowledgment likelihood. Zernike minutes are gotten from a changed unit circle space that takes into consideration the extraction of shape descriptors which are invariant to pivot, interpretation, and scale and skew and extend, along these lines saving more shape data for the element extraction handle. Figure 4 demonstrates the computational square chart".

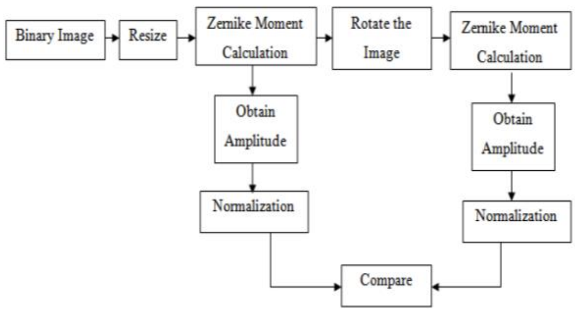

Figure 5. Zernike Moment Computation

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n the event that a picture is dared to be a question, its descriptors are perceived as its element vectors. "The Zernike polynomials characterized over the inside of a unit circle x2+ y2= 1 are an arrangement of perplexing and orthogonal polynomials. Zernike snapshot of request n and redundancy m is characterized concerning a persistent picture work f(x, y) are characterized as",

$$V_{nm}(\rho, \theta) = \frac{n+1}{\pi} \int_0^{2\pi} \int_0^1 f(\rho, \theta) R_{nm}(\rho) e^{(-jm\theta)} \rho\, d\rho\, d\theta$$

In xy image plane

$$V_{nm}(x, y) = \frac{n+1}{\pi} \iint f(x, y) V^*_{nm}(\rho, \theta)\, dx\, dy;\ x^2 + y^2 \leq 1$$

The real valued radial polynomial R_{nm} is defined as

$$R_{nm}(\rho,\theta) = \sum_{s=0}^{\frac{n-|m|}{2}} (-1^{s}) \frac{(n-s)!}{s!\left(\frac{n-|m|}{2}-s\right)!\left(\frac{n-|m|}{2}-s\right)!}$$

C. Classification

Once the features have been extracted and fused, then these features are to be used to classify and identify an object using classifier to classify plants.

RF (Random Forest) Classifier:

RF is one of the best characterization and relapse methods, which can order expansive dataset with astounding precision. Arbitrary Forests calculation creates a group of choice trees. Outfit techniques primary standard is to gather frail learners together to manufacture a solid learner. RF calculation can be performed by applying the accompanying strides:

1) Draw Ntree bootstrap tests from the first information.
2) For each of the bootstrap tests, grow an un-pruned characterization or relapse tree.
3) At each inward hub, instead of picking the best split among all indicators, arbitrarily select mtry of the M indicators and decide the best split utilizing just those indicators.
4) Save tree as seems to be, close by those constructed consequently far(Do not perform cost many-sided quality pruning).
5) Predict new information by amassing the forecasts of the Ntree trees.

$$s = \frac{1}{K}\sum_{k=1}^{K} K^{th}$$

Where S is a random forests prediction, K^{th} is a tree response, and k is the index runs over the individual trees in the forest.

Neural Network Classifier

"The input layer accepts an input vector. The pattern layer processed the input vector by using weight vector came from training dataset. This layer compute the distances from the input layer to the training input. As a result, a vector that indicates how close the input is to a training input. Then, in the Summation layer, a vector contains probabilities is found by summing up the contributions for each class. This vector of probabilities is sent to the output layer. The last layer in PNN structure produces a classification decision, in which a class with maximum probabilities will be assigned by 1 and other classes will be assigned by 0.Figure 6 shows the general architecture of neural network".

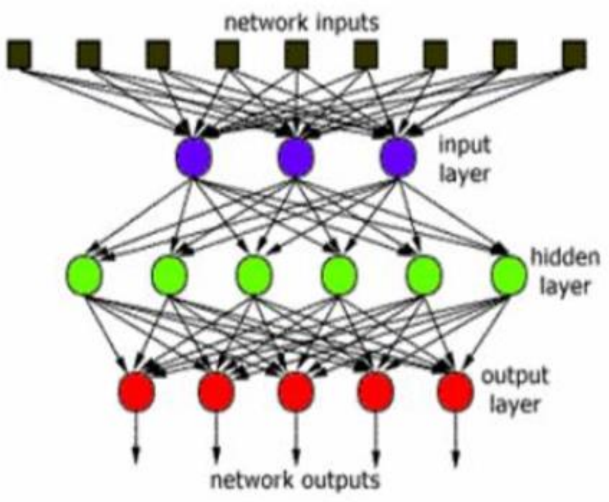

Figure 6. General Neural Network Architecture

"For training the neural network, all features of training samples are inputted to the network. The next step, weights of the neural network that are obtained from training phase will be used to test the network. The results are compared to original classes to get performance of the system. This is done by matching an unknown leaf by the user".

Linear Discriminant Analysis (LDA)

"Linear Discriminant Analysis (LDA) is a commonly used technique for data classification and dimensionality reduction. Linear Discriminant Analysis easily handles the case where the within class frequencies are unequal and their performances has been examined on randomly generated test data. It's basic idea is to find a linear transformation that best discriminate among classes, then classification can be performed in transformed space based on some metrics such as Euclidean distance. [7]".

Given data Yi, Xi, $i = _1^n$, where Yi ∈1, 2, ... ,K is the class label, K is the number of classes and Xi is a vector of features or predictors, we seek to find the best direction in the predictor space in which the classes are separated as much as possible.

Mathematically, LDA implementation is carried out via scatter matrix analysis. For all samples of all classes, two measures have been defined as follows:

Within-class scatter matrix, which is defined by equation:

$$S_W = \sum_{j=1}^{K} \sum_{i=1}^{N_j} (X_i^j - \mu_j)(X_i^j - \mu_j)^T$$

Where Xij is the ith sample of class j, μ_j is the mean of class j, K is the number of classes, and Nj is the number of samples in class j .

Between-class scatter matrix, which is defined by equation:

$$S_b = \sum_{j=1}^{K} (\mu_j - \mu)(\mu_j - \mu)^T$$

Where μ represents the mean of all classes. This method maximizes the ratio of between-class measure to the within-class measure in any particular data set thereby guaranteeing maximal separability. The maximization of $\frac{\delta |S_b|}{\delta |S_w|}$.

REFERENCES

[1] "Leaf Recognition Based on Feature Extraction and Zernike Moments", Pallavi P, V.S Veena Devi, International Journal of Innovative Research in Computer and Communication Engineering, May 2014.

[2] "A survey of computer-based vision systems for automatic identification of plant species", OluleyeBabatunde, Leisa Armstrong, Dean Diepeveen, JinsongLeng, Journal of Agricultural Informatics. 2015.

[3] "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, International Symposium on Signal Processing and Information Technology, 2007

[4] "A Review and a Comparative Study of Various Plant Recognition and Classification Techniques using Leaf Images", AnandHanda And RashiAgarwal, International Journal of Computer Applications, August 2015

[5] "Leaf Shape Extraction For Plant Classification", M. M. Amlekar, A. T. Gaikwad, R. R. Manza, P. L. Yannawar, 2015 International Conference on Pervasive Computing (ICPC), 2015

[6] "Classification of selected medicinal plants leaf using image processing", Gopal, A, S. Prudhveeswar Reddy, and V. Gayatri. 2012 International Conference on Machine Vision and Image Processing (MVIP), 2012.

[7] "Plant classification system based on leaf features", Elhariri, Esraa, Nashwa El-Bendary, and Aboul Ella Hassanien, 2014 9th International Conference on Computer Engineering & Systems (ICCES), 2014

[8] "A review on plant recognition and classification techniques using leaf images", AnantBhardwaj, ManpreetKaur, International Journal of Engineering Trends and Technology- Volume 4 Issue 2- 2013

[9] "Leaves recognition system using a neural network", BoranSekeroglua, YucelLnan, 12th International Conference on Application of Fuzzy Systems and Soft Computing, ICAFS, 2016

[10] "Multiscale Distance Matrix for Fast Plant Leaf Recognition", Hu, Rongxiang, Wei Jia, Haibin Ling, and De- Shuang Huang. IEEE Transactions on Image Processing, 2012.

[11] "Plant leaf recognition using shape features and colour histogram with k-nearest neighbour classifiers", TrishenMunisami, MahessRamsurn, SomveerKishnah, SameerchandPudaruth, Second International Symposium on Computer Vision and the Internet, Elsevier, 2015

[12] “Automated Tool for Plant Leaf Identification using Morphological Features”, AjinkyaGawade, AnandSartape, AamodChemburkar, Prasad Somawanshi, ReenaPagare, JayshreeGhorpade, International Journal of Emerging Research in Management &Technology, May 2015

[13] “Plant Identification Using Leaf Images.”, Sachin D. Chothe, V.R.Ratnaparkhe, International Journal of Innovative Research in Science, Engineering and Technology, May 2015

[14] “A Review on Off-line Leaf Recognition Using Neural Network”, Miss. NeedaSamreenI.Khan, Prof. Rajesh B.Pandhare, International Journal of Computer Science and Mobile Computing, Jan 2015

[15] "Leaf recognition and segmentation by using depth image", Shao, Xiaowei, Yun Shi, Wenbing Wu, Peng Yang, Zhongxin Chen, and RyosukeShibasaki, 2014 The Third International Conference on Agro- Geoinformatics, 2014

[16] “An Effective Tea Leaf Recognition Algorithm for Plant Classification Using Radial Basis Function Machine”, ArunpriyaC., Antony SelvadossThanamani, International Journal of Modern Engineering Research (IJMER), Mar. 2014

[17] “Detection and classification of plant leaf diseases”, KshitijFulsoundar, TusharKadlag, SanmanBhadale, Pratik Bharvirkar, Prof S.P.Godse, International Journal of Engineering Research and General Science Volume 2, Issue 6, October-November, 2014

[18] “Plant Leaf Recognition using Texture and Shape features with Neural Classifiers”, JyotismitaChakia, RanjanParekha, and Samar Bhattacharyaa, Pattern Recognition Letters, 2015

[19] “Study of Various Techniques for Medicinal Plant Identification”, ShyamVijayraoPundkar, Prof. M.M. Waghmare, International Journal on Recent and Innovation Trends in Computing and Communication, November 2014

[20] “Plant Leaf Disease Identificationand Prevention by Mobile Vision System”, Deore Nikita R., KhadeChhaya A., KotwalPooja R.&PatilKalyani J, Imperial Journal of Interdisciplinary Research (IJIR) , 2016