Plant Leaf Classification Using Supervised Classification Algorithm

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Abstract

Human can benefit from so many species available on planet. To benefit from the species one should effectively identify and make sure that the identified plant species can appropriately bring the required changes in the society and help people to get themselves cured from ailments. Further, to make the plant leaf identification easier, development of a convenient and effective image classification method to automatically classify different leaf species is required. Thus an approach is put forward to provide a system which can appropriately classify the leaves and could help the researchers to achieve their goals to use the correct species wherever it is required to. Classification is done based on its hues, shape and texture. In order to extract the color feature HSV (Hue, Saturation, Value) color model is used, for the extraction of texture feature GLCM (Gray Level Co-occurrence Matrix) and for shape features extraction shapes global features are used. Further, to classify the images ANN (Artificial Neural Network) algorithm and SVM (Support Vector Machine) is used. Classification is done using feature extraction from color feature, texture features and shapes feature, standalone and also with combined features. In the developed system dataset of 285 images is taken, 210 images are trained with ANN and 75 images used for testing set. We have observed that instead of using single features combined features gives better result. The system gives approximate 93.33% accuracy with ANN. The above result is verified and found out that it is almost 50% accurate, making ANN perform better than the SVM. Matlab is used to perform the above image processing task.

Keywords: Image Processing, Leaf Classification, Texture Feature, Artificial Neural Network.

I. INTRODUCTION

Plants are a boon to the biosphere and an integral part of the system. Plants play a very important role for the survival of animals and humans alike. Right from Vedic times the importance of leaves in curing diseases is well known. But in this technical world using means to find the proper leaves for finding cure for diseases is a major breakthrough. Obtaining the leaves and capturing their images are convenient and inexpensive. Using digital leaf image the plant can be very well identified, for that design of a convenient and effective image classification method to automatically classify different species is required. Manually identifying leaves is a tedious task but here in this system by using classification algorithm automatically one can identify the plant using the digital image of the leaves [8].

Classification includes a broad range of decision making theoretical approaches for the identification of images. All classification algorithms are based on the assumption that the image in the question depicts one or more features (e.g., shape, texture) and that each of these features belong to one of the several distinct and exclusive classes. The proposed system recognizes the images of the plant leaves and classifies them into different families [1].

There has been considerable work performed in recent years in the field for leaf biometric recognition. Such as, Wu and co-workers have used twelve morphological features (including vein features) along with a neural network to achieve 90.3% classification accuracy [2]. Beigbin and workers have developed Contour signature method for shape classification and the Sobel operator for texture classification. The method provided accuracy of 81.1%, however, the difficulty with these techniques is that they require some manual intervention such as correctly orienting the image or identifying the end points of the leaf’s main vein. [3][9].

To identify various plant leaves based on their surface parameter is challenging and complex task. Plant leaf surface parameters are color, texture, shape and shape etc. The individual or combined feature extracted from each of its parameter can be used for further classification. In this work we have used color analysis, texture analysis and shape analysis for feature extraction[10].

The rest of the paper is organized as follows. Section II discusses the methodology used for feature extraction. Section III gives an overview of the different classification techniques and more information about ANN and SVM classifier methods. Section IV gives the details about results and discussions and Section V concludes the paper.

II. METHODOLOGY AND FEATURE EXTRACTION

The captured digital leaf images were pre-processed using image pre-processing techniques to obtain a smooth and noise free images so that the desired features can be extracted from the leaf image. The expressions used for feature extraction process are given below.

a. Feature Extraction Using color Analysis

Color moments represent color features that can be used to characterize a color image.
The HSI or HSV Model

Color can be specified by the three quantities hue, saturation and intensity or value. Hue is measured from red and saturation is given by distance from the axis. Hue of a color refers to pure color, which it resembles. Saturation defines how white the color is, white has saturation of 0 whereas pure red has saturation of 1. The value of a color/lightness, describes how dark the color is, for black the value is 0.

Conversion between the RGB model and the HSV model is quite complicated. The Hue and intensity is given by

\[ H = \begin{cases} \theta & \text{if } B \leq G \\ 360 - \theta & \text{if } B > G \end{cases} \]

\[ I = \frac{R+G+B}{3} \]

where, the quantities R, G and B are the amounts of the red, green and blue components, normalized to the range [0,1]. The intensity is therefore just the average of the red, green and blue components [4].

The saturation is given by:

\[ S = 1 - \frac{\min(R,G,B)}{I} = 1 - \frac{3 \min(R,G,B)}{R+G+B} \]

where, the \( \min(R,G,B) \) term is really just indicating the amount of white present. If any of R, G or B is zero, there is no white and we have a pure color.

b. Feature Extraction Using Texture Analysis

Leaf image texture gives information regarding the spatial arrangement of color or intensity in a leaf image. A diversity of techniques is available for extraction of texture values and in this study we have employed the GLCM matrix concept.

GLCM method: Here it defines the texture of an image by calculating how frequently pairs of pixel with defined values and in a specific spatial relationship that appear in an image, from that it creates a GLCM, and then extracts statistical measures from that matrix. The statistics mentioned below provides idea about the texture of an image.

a) Contrast: is defined as a measure of the intensity contrast between a pixel and its neighbor over the whole image. Range = \([0 \text{ (size (GLCM, 1)-1)}^2]\), Contrast is 0 for a constant image.

Contrast Equation:

\[ \sum_{i,j=0}^{N-1} P_{i,j} (i-j)^2 \]

b) Correlation: is defined as a measure of how correlated a pixel is to its neighbor over the whole image. Range = \([-1 1]\)

Correlation is 1 or -1 for a perfectly positively or negatively correlated image. Correlation is Nan for a constant image.

Correlation Equation:

\[ \sum_{i,j=0}^{N-1} \frac{P_{i,j}}{I} \]

(c) Energy: is defined as the sum of squared elements in the GLCM. Range = \([0 1]\), Energy is 1 for a constant image.

Energy Equation:

\[ \sum_{i,j=0}^{N-1} P_{i,j}^2 \]

(4) Homogeneity: is defined as a value that measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. Range = \([0 1]\), Homogeneity is 1 for a diagonal GLCM.

\[ \sum_{i,j=0}^{N-1} \frac{(i-\mu)(j-\mu)}{\sqrt{\sigma_i \sigma_j}} \]

Mean:

\[ \mu_i = \frac{\sum_{i,j=0}^{N-1} i P_{i,j}}{\sum_{i,j=0}^{N-1} P_{i,j}} \]

\[ \mu_j = \frac{\sum_{i,j=0}^{N-1} j P_{i,j}}{\sum_{i,j=0}^{N-1} P_{i,j}} \]

Variance:

\[ \sigma_i^2 = \frac{\sum_{i,j=0}^{N-1} (i-\mu_i)^2 P_{i,j}}{\sum_{i,j=0}^{N-1} P_{i,j}} \]

\[ \sigma_j^2 = \frac{\sum_{i,j=0}^{N-1} (j-\mu_j)^2 P_{i,j}}{\sum_{i,j=0}^{N-1} P_{i,j}} \]

\[ \sigma_i = \sqrt{\sigma_i^2} \]

\[ \sigma_j = \sqrt{\sigma_j^2} \]

Figure 1. Flow diagram of HSV, GLCM and Shape features using SVM

c. Feature Extraction Using Shape Analysis

The growth of leaves has specific pattern and shape then they are stop. So shape of leaf is useful to identify the
class of plant leaf. Different parameters considered for leaf shape classification.

a) **Area**: the number of pixels in the interior.

b) **Aspect Ratio**: Aspect ratio is defined as the ratio between the maximum length $D_{\text{max}}$ and the minimum length $D_{\text{min}}$ of the minimum-bounding rectangle.

c) **Convex Hull**: convex hull is defined as a p-by-2 matrix that specifies the smallest convex polygon that can contain the region. Each row of the matrix contains the x- and y-coordinates of one vertex of the polygon.

d) **Equiv Diameter**: equiv diameter is defined as a scalar that specifies the diameter of a circle with the same area as the region. Computed as $\sqrt{4 \cdot \text{Area}/\pi}$.

e) **Max Intensity**: Max Intensity is defined as a scalar that specifies the value of the pixel with the greatest intensity in the region.

f) **Mean Intensity**: Mean Intensity is defined as a scalar that specifies the mean of all the intensity values in the region.

**g) Min Intensity**: Min Intensity Returns a scalar that specifies the value of the pixel with the lowest intensity in the region.

III. **IMAGE CLASSIFICATION**

Image classification is one of the most important parts of digital image analysis. It is expected to have a clear image, showing a magnitude of colors illustrating various features of the underlying territory, but it is quite useless until you know what is the average of the colors i.e. the mean of the colors. Two main classification methods are Supervised Classification and Unsupervised Classification.

**Supervised Classification**

With supervised classification, different classes of information of interest in the image can be identified. These are called "training sites". The image processing software system is then used to develop a statistical characterization of the reflectance for each information class. This stage is called "signature analysis". It involves developing a simple characterization such as the mean or the rage of reflectance on each band, or complex characterization such as detailed analyses of the mean, variances and covariance over all bands. After statistical characterization has been achieved for each information class, the image is then classified by examining the reflectance for each pixel and making a decision about which of the signatures it resembles most [5].

The description of training classes is an extremely important component of the supervised classification. In supervised classification, statistical processes or distribution-free processes can be used to extract class descriptors.

1. **Artificial Neural Network**

Artificial neural network is closely bear a resemblance to human brain; it has multiple layers of neurons known as simple processing elements which are connected to its neighbors with coefficients of connectivity that represent the strengths of these connections. It has three layers. The first layer has input neurons that send data via synapses to the second layer of neurons, and then via more synapses to the third layer of output neurons [6].

The interconnection pattern between the different layers of neurons. The learning process for updating the weights of the interconnections and The learning process for updating the weights of the interconnections are the three types of parameter which define artificial neuron network.

2. **Support vector machines (SVMs)**

Support vector machine is type of classifier which is group of related supervised learning technique used especially for the purpose of classification and regression. Given a set of training samples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that predicts whether a new sample falls into one category or the other category [7].

**Unsupervised classification**

Unsupervised classification inspects a large number of unknown pixels and divides them into a number of classed based on natural groups existing in the image values. Contrary to supervised classification, unsupervised classification does not need analyst-specified training data. The unsupervised classification is devised using the clustering algorithms to regularly fragment the training data into prototype classes.

IV. **EXPERIMENTAL RESULTS AND DISCUSSION**

The images were initially preprocessed and then the features were extracted from each leaf image with the help of the above-mentioned equations. Separate pre-processing steps were employed for geometric, color and texture based analysis. It involves the removal of background information from the leaf images, filling of holes, resizing and cropping of images to a standard size during GLCM based calculation. Normalization was done for GLCM matrix to avoid high range values. These extracted image features were stored in a separate database. These values were fed to the 2-layer feed forward neural network after which the network was trained using the back propagation algorithm.

The tables were outlined and results found for each phase using single and combined feature with NN and SVM.

**Table 1. Results of NN and SVM**

<table>
<thead>
<tr>
<th>Features</th>
<th>NN (%)</th>
<th>SVM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSV</td>
<td>80</td>
<td>28</td>
</tr>
<tr>
<td>GLCM</td>
<td>60</td>
<td>16</td>
</tr>
<tr>
<td>Shape</td>
<td>57.33</td>
<td>24</td>
</tr>
<tr>
<td>HSV &amp; GLCM</td>
<td>80</td>
<td>38.66</td>
</tr>
<tr>
<td>HSV &amp; Shape</td>
<td>85.33</td>
<td>38.66</td>
</tr>
<tr>
<td>GLCM &amp; Shape</td>
<td>78.66</td>
<td>25.33</td>
</tr>
<tr>
<td>Combined</td>
<td>93.33</td>
<td>48</td>
</tr>
</tbody>
</table>
V. CONCLUSION

Plants leaves are identified and classified into different classes by using Color, texture and shape features to extract the features of leaf images. ANN classifier was used as the classification algorithm. Dataset of 285 images were taken, 210 images were used for training set and 75 images were used for testing set. 5 images were taken from each class for testing.

Color features, texture features and shape features with NN gave 80%, 60% and 57.33% average accuracy results respectively. Whereas combination of color & texture, color & shape and texture & shape with NN gave 80%, 85.33 and 78.66% average accuracy result respectively. However, while combining all three features color, texture and shape with NN gave 93.33% average accuracy, hence as compared to single or double features use of combine three features gave superior results.

In other experiment with SVM features like color, texture, and shape gave 28%, 16% and 24% average accuracy result respectively. Again combination of color & texture, color & shape and texture & shape with SVM gave 38.66%, 38.66% and 25.33% average accuracy result respectively. Whereas combined color, texture and shape with SVM gave 48% average accuracy, similar to NN with SVM also compared to using single features combined three features gave better results. Thus, these data suggest that data analysis using NN gives higher accuracy as compared to SVM. In future work of this research combining color, texture and shape feature together with NN can be used for accurate plant leaf identification.

REFERENCES


