DCT based Plant Leaf Disease Recognition Algorithm using Subtractive Clustering

Hiteshwari Sabrol* and Satish Kumar**

ABSTRACT
The main focus of the study is to implement and evaluates the DCT based plant leaf disease recognition using subtractive clustering for automatic recognition and classification. The proposed methodology of the study includes image processing and recognition by classification. The method consists of four phases: First, capturing plant leaf disease images and perform color space transformation, in the second phase, images are segmented using Otsu’s method. Next, in the third phase, we computed DCT based features of leaf infected segmented area and non-infected segmented area. Finally, the extracted features submitted to subtractive clustering based fuzzy classification. For testing and training purpose tomato late blight disease taken. The results of the proposed approach indicate that the leaf disease can recognize and classify by using image processing techniques significantly. The developed fuzzy based classifier can recognize and classify the examined disease with a precision of around 80.3%.

Keywords: Plant Disease Recognition, Cosine Transform, Feature Extraction, Subtractive Clustering

I. INTRODUCTION
The recognition of plant disease by identifying the features of the disease in digital images is one of the most challenging tasks in the area of plant pathology using image processing and pattern recognition techniques. It is difficult to identify the stress from the human eye, but it can identify with shape, color, and the texture. The manual procedure for the recognition of plant disease is the time consuming and an expensive approach. The computer-based automatic approach based on plant disease symptoms could be able to recognize accurately and provide timely information about the disease. To automate the process, the most important step involved in this is the feature extraction. The feature analysis supports to find the most informative features that have the ability to improve the classification results and reduce the complexity. In the literature, work on plant disease recognition using digital image processing found [1-6]. The discrete cosine transformation (DCT) has been widely in pattern recognition [7]. There exist many classification methods used for pattern recognition such are neural networks [8, 9], support vector machine [10], fuzzy inference system [11], etc.

In the present study, we evaluate the recognition accuracy of feature extraction based on discrete cosine transformation to acquire discriminative features of tomato plant late blight disease. The objective of the proposed method is to investigate the DCT feature extraction approach that is maximizing the classification accuracy [12] and speed up the learning process while recognition of disease is infected tomato leaf images. The rest of the paper organized as Section II describes the DCT based plant disease recognition algorithm using subtractive clustering including image dataset and image pre-processing, brief introduction of discrete cosine transformation working and subtractive clustering based fuzzy classifier. Section III discussion on experiment and results and Finally, Section IV, concludes the brief summary of the work and future perspectives of the work.

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II. PROPOSED ALGORITHM

2.1. DCT based Plant Disease Recognition algorithm using subtractive clustering –

2.1.1. Image Set and Image pre-processing

In the current study, a dataset of total 153 digital images of tomato plant leaf infected with late blight disease was obtained by using the common digital camera. For training, purpose disease infected images are 76 and healthy leaf images are 46. For testing, disease infected are 19, and healthy are 12 used. First, The Otsu’s segmentation applied on the images dataset. These segmented images are resized by 256 X 256. Next, RGB segmented images are transformed to HSV color space. As shown in Figure 1. Then compute the correlated features of Hue and Saturation.

![Figure 1: Tomato late blight infected leaf image and Color segmented image](image1)

2.1.2. Discrete Cosine Transformation for feature extraction

The method proposed in the study is using discrete cosine transformation for feature extracting distinct features from the tomato plant disease infected leaf and healthy tomato plant leaf images. These features then combined with computed correlated features of hue and saturation. These combined features are then submitted to fuzzy inference system based on subtractive clustering for recognition by classification. Figure 2. Shows the block diagram of the DCT based plant disease recognition using subtractive clustering.

![Figure 2: The DCT based plant disease recognition using subtractive clustering](image2)
The discrete cosine transformation based features calculated by applying discrete cosine transformation. The DCT is one of the most popular transforms initially used for image compression [13]. The DCT is helpful in removing the redundant data from an image. The energy compaction efficiency of the DCT is higher than that of the FFT in general. This feature of DCT used for pattern recognition [7, 15, 16]. For classification, integral DCT gives result in successful pattern recognition. For example, for face recognition applications, DCT was widely used. The DCT used to convert image data into elementary frequency components [17]. The computed high-value coefficients cluster in the upper left corner and low-value coefficients cluster in the bottom right of the array(x,y) where [x y] is the size of an image.

The N×N image, f(x,y) of discrete cosine transform is given as:

\[
C(u)(v) = W(u)W(v)\sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \cdot \cos \left( \frac{\pi(2x+1)u}{2N} \right) \cos \left( \frac{\pi(2y+1)v}{2N} \right)
\]

The inverse transformation is given as

\[
F(x,y) = \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} W(u)W(v)C(u,v) \cdot \cos \left( \frac{\pi(2x+1)u}{2N} \right) \cos \left( \frac{\pi(2y+1)v}{2N} \right)
\]

For u, v = 0, 1, 2, …, N-1. Where, W(u)=W(v) = \frac{1}{\sqrt{N}}, for u, v=0 and W(u)=W(v) = \frac{i}{\sqrt{N}}, for u, v ≠ 0

In this work, after applying Otsu’s method for segmentation on RGB images of disease infected and healthy images next these segmented images transformed to HSV color space. After that, we computed correlated features of Hue and Saturation of these segmented images. Then DCT based features computed from these segmented images as shown in Figure 3. Finally, both these extracted features combined. To normalize the extracted feature, we perform zero mean and unit variance normalization. Feature normalization applies to feature vectors extracted from disease infected and non-infected plant images. The normalized combined extracted features finally submit for classification to subtractive clustering based fuzzy classifier.

2.1.3. Classification using Subtractive Clustering based Fuzzy Classifier

The combined extracted features using DCT and correlated Hue and saturation submitted to subtractive clustering based fuzzy classifier. From the extracted training data, subtractive clustering used to create fuzzy rules. In subtractive clustering, initial cluster centers and the number of clusters estimated and the rules generated from training data using sugeno based fuzzy rules. The method used to find the point with the highest number of neighbors as a center of a cluster [18].

These rules used for fuzzy inference model based on Takagi-Sugeno-Kang[11]. The sugeno system mostly used for a systematic approach to generating fuzzy rules from given input-output data.

\[
R_r = \text{if } F_1 \text{ is } C_{r1} \text{ and } \text{if } F_2 \text{ is } C_{r2} \text{ and... and } F_m \text{ is } C_{rm} \text{ then } y_r, f_r(F)
\]

where \( f_r(F) = a_{r0} + a_{r1} + \ldots + a_r^m \). In which \( r = (1, \ldots, m) \) and \( F_j (1 \leq j \leq m) \) are the input variables and \( y_r \) is the consequent of \( r \)th rule, \( C_{r1} \) and \( a_r^m \) are membership functions and regression parameter in \( r \)th rule and \( f_r(F) \) is
a linear function, respectively. M is the total number of features extracted. C is the total number of clusters generated by subtractive clustering and \( fr(F) \) is the total number of images category i.e. 2 (includes late blight disease infected and healthy images).

### III. EXPERIMENT AND RESULT

The experiment conducted to analyze the recognition of plant disease in digital images using discrete cosine transformation and subtractive clustering based fuzzy classifier. The training purpose we use total 122 images including 76 images of tomato late blight infected leaf images and 46 of healthy leaf images. For testing purpose, we use total 31 including 19 for late blight infected and 12 for healthy images.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Experiment Result</th>
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<tbody>
<tr>
<td></td>
<td>Tomato Late Blight Disease</td>
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<td></td>
<td>Infected Leaf Images</td>
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<tr>
<td><strong>Subtractive Clustering based Fuzzy Classifier</strong></td>
<td><strong>Training</strong></td>
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<td></td>
<td>Samples (57)</td>
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<tr>
<td>Correct Recognition</td>
<td>78.9%</td>
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<tr>
<td>Error (%) in Recognition</td>
<td>21.0%</td>
</tr>
</tbody>
</table>

Table 1 shows the recognition accuracy of disease infected and healthy. The proposed method of DCT based plant disease recognition using subtractive clustering yielded the recognition accuracy 78.9% for late blight infected images with an error of 21.0% and Healthy images recognition accuracy is 83% with an error of incorrect recognition is 16%. The overall recognition accuracy reported 80.3% that is quite satisfactory with an error of incorrect recognition is19.9%.

### IV. CONCLUSION

Feature extraction is an important step in pattern recognition systems. In the study, we have evaluated the effectiveness of DCT based computed features for recognition. These extracted features submitted to subtractive based fuzzy classifier to evaluate the recognition accuracy. The results have demonstrated that the combination of extracted correlated features Hue and Saturation with DCT lead to satisfactory recognition accuracy. This technique can integrate into the future work in the area of plant pathologies. The performance of the method not only depend on the feature extraction but also on the various steps involve in the recognition system from pre-processing stage to classification stage. In future work, the combination of some statistical and geometric features with more other classifiers can use in the same area of research. The proposed study could be useful to automate the process of plant disease recognition and classification. It may also help to the researchers and scientists those working in the field of automation of detection and recognition of plant pathologies.

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REFERENCES


