Multiple Nutrient Deficiency Detection in Paddy Leaf Images using Color and Pattern Analysis

M V Latte, Sushila Shidnal

***Abstract*—Paddy being the staple food of India is majorly affected by deficiency of primary nutrient elements like nitrogen, phosphorus and potassium. Leaves can be deficient with multiple nutrient elements at a same time. This can alter natural color of paddy leaves. Such leaves are considered as defective. The proposed work is to automate multiple nutrient element deficiency identification of paddy leaves. Pattern analysis RGB color features are extracted to identify defective paddy leaves. Firstly the database of healthy, nitrogen, phosphorus and potassium defected paddy leaves are created. For any test image effective comparison at different levels are employed such as multiple color comparison, multiple pattern comparison and combination of color and patterns comparison, so that defectiveness is accurately identified for combination of deficiency such as nitrogen-phosphorus(NP), nitrogen-potassium(NK) and phosphorous- potassium (KP).**

***Index Terms*—Paddy leaves, NP, PK, NK Deficiency and pattern recognition.**

I. INTRODUCTION

Agriculture is one of the ancient and sacred occupations of mankind and still continues to play a vital role in the lives of humankind. Among the several food crops, paddy is most preferred staple food of India. Paddy is the principal and dominant crop of the country. Among the paddy growing countries India has the largest area under cultivation and accounts for 20% of all world rice production. Common technological applications like human computer interaction, virtual environment, robotics and multimedia, include computer vision, image processing and speech processing are possible in the field of agriculture. Computer vision [1-2] helps in analyzing the visual input from an image and produces a description to interact with the world. Better crop yield needs to be ensured in future for growing population around the world. This is made possible through early detection of deficiency of nutrients in crop. Primary nutrients required for optimal yield of paddy plants are nitrogen, phosphorus and potassium.

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Many researchers have worked on plant disease recognition using feature based approach like color [3-8], vein pattern [9], edge detection [3][10], Gaussian distribution [1], texture and color features [6]. The classification algorithms used are rule based approach [5], neural network [7] and pattern recognition techniques [4]. Proposed method aims at recognizing combined nutrient elements in paddy leaf using color properties and pattern recognition. The remaining part of the paper is organized into four sections. Section II deals with the proposed method which further explains image acquisition, preprocessing, color feature extraction, pattern analysis, the proposed algorithm for classification. Section III explains results and discussion and finally section IV deals with conclusion

II. PROPOSED METHOD

Crop defective ranking is used to measure defective pixel density of leaf images. Based upon obtained ranking timely detection and identification of specific deficiencies is made. The basis for proposed methodology is deficiency in nitrogen-phosphorus can make leaf look yellowish in color and leaf turns into brownish over large area, deficiency in potassium – nitrogen can make leaf appear with brown dots and yellowish and deficiency in phosphorus- potassium can make leaf look brownish over a large area with brown spots. Sample image of healthy, NP defective, PK defective and NK defective images are as shown in Fig. 1.

Fig. 1. Images of healthy, NP, PK and NK defective leaf.

The proposed methodology begins with obtaining healthy leaf properties such as red, green and blue color indexes. Healthy leaves are dominant in green color compared to red and blue colors. Along with healthy leaves defected leaf properties are also examined and stored. Finally algorithm extracts test image color properties and patterns for comparison with stored pre data. Proposed algorithm determines deficiency in combination of elements. The

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architecture for the proposed algorithm is s shown in the figure 2a and figure 2b.

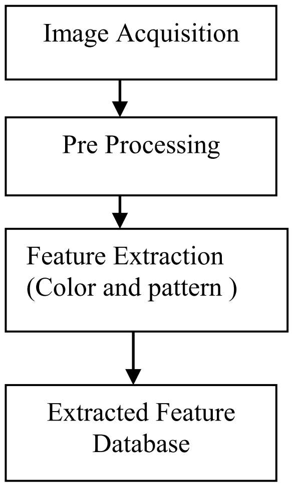

Fig 2a. Proposed work flow

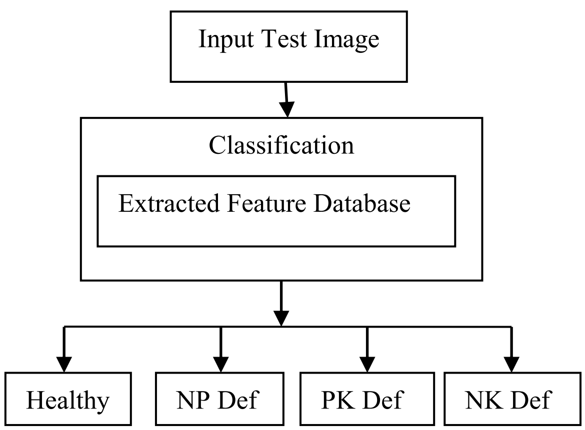

Fig. 2a. Proposed work flow

A. Leaf image acquisition

The paddy leaf images are captured using Sony digital camera with resolution of 24 megapixels. The images are taken in white background under fixed focal length and normal illumination condition. A total of 500 images are taken consisting of healthy, nitrogen - potassium defected, phosphorus-Potassium defected and phosphorus- nitrogen defected images, around 100 images in each category. Remaining 100 images are used as test images.

B. Preprocessing

To get the region of interest in defective paddy leaves manual cropping is done. The leaf image captured is 2592 X 1944 pixels size. The images after manual cropping are then resized to 256 X 256 pixel size images. Noise level in the resized images is reduced using median filter.

C. Color Feature and pattern analysis.

The algorithm computes red, green and blue color values for all paddy leaf images. The pixel value of each color varies from 0 to 255. From RGB values average red, green and blue values computed along with average color band ratios of G/R and G/B. Since the identification is with respect to healthy leaf properties mainly considered band ratios are G/R and G/B as healthy leaves are predominant with green color. Next G/R mean, G/R median, G/B mean, G/B median along with ratios of Gavg/Ravg and Gavg/Bavg are computed to identify specific nutrient deficiency accurately. These color features are repeated for all images in all four categories which are considered for the study. Along with color features patterns like circles are identified. If the circle is identified its area, diameter and then color in the circle is extracted.

D. Extracted feature database

Color features of healthy paddy leaves are calculated and stored in the database. Similarly the color properties and pattern range of defective leaves are computed and stored in the database. This database is further used to classify a test image as healthy or unhealthy.

E. Algorithm

The algorithm consists of the following 4 steps.

1) Healthy image defective image properties and tolerance

Color features of multiple healthy single paddy leaf images are extracted and the color properties range for healthy leaves is computed. Similarly color properties and range for defective images is also computed.

2) Test image properties

Color properties, pattern properties and color tolerance range are computed for input test images.

3) Defect identification

Based upon test image properties such as color properties, pixel density and patterns properties compared at different levels with respect to both healthy and pre stored combinational defective images to classify test image as healthy or defective. In case of defective deficiency in the specific combined nutrient elements is determined and classified accordingly.

F. Classification.

Algorithm classifies test image as healthy or unhealthy. In case of unhealthy, it detects combination of deficiencies such as nitrogen-potassium, phosphorus-potassium and nitrogen – phosphorus.

III. RESULTS AND DISCUSSION

Color properties such as red, green and blue are computed for 50 healthy leaves, then min, max, mean values are computed. Along with this color ratios such as G/R and G/B are also computed. Fig. 3 shows the computed properties with reference to healthy leaves.

B_Avg	<1x15 double>	21.6978	40.5361	34.6553
G_Avg	<1x15 double>	77.5719	101.02...	94.0933
GbyB	2.8568	2.8568	2.8568	2.8568
GbyB_median	2.7459	2.7459	2.7459	2.7459
GbyBmean	<1x15 double>	2.0806	4.3107	2.7978
GbyR	1.3165	1.3165	1.3165	1.3165
GbyR_median	1.3177	1.3177	1.3177	1.3177
GbyRmean	<1x15 double>	1.2653	1.4469	1.3202

Fig. 3. Healthy leaf image properties

To detect leaf defected by both phosphorus and nitrogen, test image is feed as input and its color properties extracted. Combined nutrient defective leaf shows G/R median value is less than 1 which indicates that leaf is phosphorus defective and shows yellow spots which can be identified by finding circles with yellow color using pattern recognition and pixel properties at the centre. If centre color properties (G/R) lies as per range given below, it is concluded that test image is nitrogen defective.

G/Rdot_min = 0.53;
G/Rdot_max = 1.57;

The phosphorus – nitrogen defected leaf typically looks as shown in Fig. 4.

Fig. 4. Nitrogen – Phosphorus defected leaf.

To detect leaf defected by both potassium and phosphorus, in input test image is examined to identify the circles in test image, if any circles found, obtain circle's centre color properties (G/R and G/B). If color properties of G/ R variable at the centre it is in between 0.45 to 0.91 and G/B at the centre of circle are in between 1.23 to 2.02, it is concluded as potassium defective. Also if G/R median value is less than 1 then leaf is phosphorus defective. Data obtained from potassium defected image shows basic blue color more than green.

G/Rdot_min = 0.45; G/Bdot_min = 1.23;
G/Rdot_max = 0.91; G/Bdot_max = 2.02;

Typical Phosphorus- Potassium defected leaf looks as shown in Fig. 5.

Fig. 5. Phosphorus-Potassium defected leaf.

Circular spots in the input test image obtained by identifying circles in test image. All circles examined are tested for brown color at the centre of circle and around its centre. If brown color at the centre of circle is found its binary filtered image is calculated. Fig. 6 and Fig. 7 shows circular spot identification along with binary image.

Fig 6. Circular spot detection in potassium defected leaf.

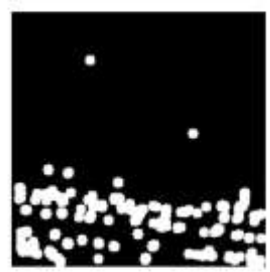

Fig. 7. Binary image of potassium defected leaf.

To identify nitrogen and potassium deficiency yellow spots are identified by finding circles with yellow color using pattern recognition and pixel properties at the centre. If centre color properties (G/R) lies as per range given below it is concluded that test image is nitrogen defective.

G/Rdot_min = 0.53; G/Rdot_max = 1.57;

Also if basic blue color more than green color properties leaf is potassium defective and follow below mentioned values.

G/Rdot_min = 0.45; G/Bdot_min = 1.23;
G/Rdot_max = 0.91; G/Bdot_max = 2.02;

Typical nitrogen-potassium deficient image looks as shown in Fig. 8.

Fig. 8. Nitrogen- Potassiumdefected leaf.

Circular spots filled with yellow color to determine nitrogen deficiency shown in Fig. 9.

Fig. 9. Circular yellow spots detection in nitrogen defected leaf

Binary filtered image with yellow spots shown in Fig. 10.

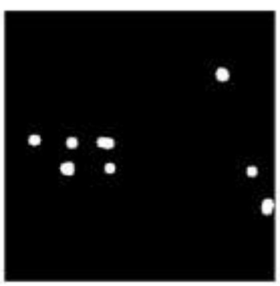

Fig. 10. Binary image of nitrogen defected leaf

Finally to determine input test image as healthy, the healthy leaf color properties are used. Rigorous testing has proved that test image should be at least 85% similar to average values of healthy leaf G/R and G/B median values. And median values follow as per below condition.

$$(Test\_G/R\_med>(0.85*G/R\_med))$$
$$\&\&(Test\_G/B\_med>0.85*G/B\_med))$$

IV. CONCLUSION

The algorithm is based on pattern recognition combined with color property examination and is tested for multiple images with multiple deficiency. The result indicates an average accuracy of 90% and can further be increased by increasing database and fine tuning of the rules. The algorithm can be extended to identify all three deficiencies (NPK) present in a single leaf and also the algorithm can also be applied on images of paddy fields. The algorithm finds an application for early detection of multiple deficiencies and helps in to take precaution so that yield can be increased.

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