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Nitrogen Management for Maize using Image Processing

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Abstract*: Maize is the third most cultivated cereal crop in India. Nitrogen is the major nutrient required to attain maximum yield for maize. But however excess application of nitrogen may have detrimental effects on the environment and there is a possibility to leach into the underground water. Managing nitrogen to match the crop requirement is very important. Six panel Leaf Colour Chart (LCC) is a tool that provides an assessment of maize's demand for nitrogen. The use of LCC is highly dependent on the person's relative colour perception. To address this limitation of the LCC, an efficient image processing application is developed in this paper. Experiments are conducted on images of different samples of leaves and the results are presented.Testing for accuracy was based on the correlation of results based on the LCC and the image processing application. After a series of sampling, it was found out that the LCC results and the application's results shows minimal discrepancy based on the Z-test one proportion*.

Keywords: Leaf Color Chart, Image Processing, Color Histogram, Z-test one proportion

1. Introduction

Maize needs nitrogen as primary nutrient to attain maximum yield. Managing nitrogen to match crop requirement is crucial part of maize cultivation. For efficient nitrogen management International Rice Research Institute [1] and Philippines Rice Research Institute [2] jointly developed a six panel LCC.

1.1 Six panel LCC

The LCC is composed of six panels each having different variations of color green. It is arranged in a ruler-shaped designed where the panels are arrayed horizontally from yellowish green to dark green. It is made of plastic and is five inches long.

The Leaf Color Chart (LCC) is an easy-to-use and inexpensive Diagnostic tool for monitoring the relative greenness of a plants leaf as an indicator of the plant nitrogen status. The nitrogen status of plant is manifested on the greenness of its leaves. The crop's demand for nitrogen varies on its growing period thus assessment and monitoring of the required nitrogen content must be done periodically. LCC is basically a guide to supply the necessary nitrogen fertilizer for the optimal nitrogen content which is very necessary in achieving maximum yield.

1.2 Applicability of six panel LCC for Maize

It is found that leaf Color chart (6 Panel LCC) based nitrogen management in different maize (Zea mays L) genotypes conducted by Punjab agricultural university (PAU) in India matching fertilizer nitrogen supply with crop demand using threshold LCC shade 5 saved 25-50% fertilizer nitrogen .This study provides evidence for the usefulness of LCC guided need based fertilizer nitrogen management technology in assuming high yields and improvement in fertilizer N recovery efficiency [4].

Figure 1.1: Manual usage of LCC in Maize [4].

But LCC usage mainly depends upon the person's visual perception in matching the color of leaf with LCC level. In this paper this problem is solved by applying image processing techniques on captured maize leaf image*s*.

1.3 Image processing

Image processing is a process of converting an image into digital form and performing some operations on it, in order to get an enhanced image or to extract some useful information from it.

1.4 Image pre-processing

Image pre-processing is improving image data that suppresses unwanted distortions or enhances some image features important for further processing.

1.5 Feature Extraction

Feature extraction is the process of defining a set of features, or image characteristics, which will most efficiently or meaningfully represent the information that is important for analysis and classification.

1.6 Image Classification

Classification of images based on its extracted features.

1.7 Histogram

Histograms are used to depict image statistics in an easily interpreted visual format. With a histogram, it is easy to determine certain types of problems in an image.. Histogram is a graphical representation showing a visual impression of the distribution of data. An Image Histogram is a type of histogram that acts as a graphical representation of the lightness/color distribution in a digital image. It plots the number of pixels for each value.

2. Related Work

There are several works done on rice plant using four level LCC.one such work uses image processing technique for feature extraction and giving these features to artificial neural networks to classify images [6]. A recent project was also developed taking advantage of the mobility of Android devices that uses image processing techniques such as color histogram analysis and pixel bitwise operations [7].

3. Proposed Work

In this paper we concentrated on implementing an image processing application for nitrogen management in maize based on the study done by PAU [4].This work includes image acquisition, image pre-processing, constructing color histograms, image classification.

3.1 Preparing six level LCC (Maize) data base

First of all, the six level PAU LCC (Maize) is bought from nitrogen parameters and it is scanned through the scanner. After that each LCC level is separated from LCC, resized to 500x500 dimension, histograms in R, G and B color planes are extracted and stored in the database.

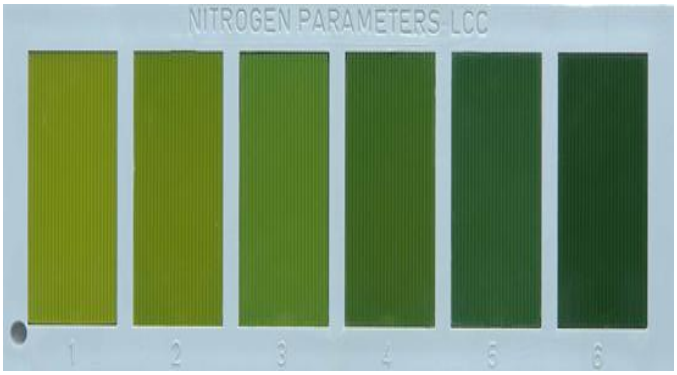

Figure 1.2: six level LCC for Maize [4]

After separating levels from the LCC, the individual levels look like

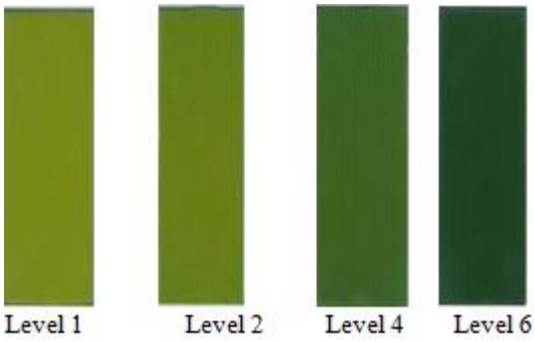

Figure 1.3: Different Levels after separating from LCC

3.2 Image Acquisition

Take picture of randomly selected first fully expanded leaf from the top in the shade of our body to avoid direct sunlight using digital camera. Take minimum of 10 pictures.

3.3 Image pre-processing

The acquired digital image may have unwanted portions.in order to get the true color of image, image cropping have to be done.
And images are resized to 500x500 to avoid size differences.

3.4 Feature Extraction

Color histograms are constructed in Red, Green, and Blue Color planes for all resized images.

3.5 Image Classification

Based on the taxicab distance [4] between color histograms of input images and color histograms of six panel LCC color images, assign a number to the input image with a LCC level number from which it has minimum taxicab distance.

The taxicab distance between captured image I^C and LCC level image $I^L{}_{is}$ calculated as

$$Dist(I^C, I^L) = |H^C{}_R - H^L{}_R| + |H^C{}_G - H^L{}_G| + |H^C{}_B - H^L{}_B|.$$

Where $Dist(I^C, I^L)$ is the taxicab distance between captured image I^C and LCC level Image I^L.

$H^C{}_R$ =histogram of captured image in Red color plane.
$H^L{}_R$ =histogram of LCC level image in Red color plane.
$H^C{}_G$ =histogram of captured image in Green color plane.
$H^L{}_G$=histogram of LCC level image in Green color plane.
$H^C{}_B$ =histogram of captured image in Blue color plane.
$H^L{}_B$=histogram of LCC level image in Blue color plane.

3.6 Nitrogen Recommendations

Apply 25 kg urea per acre at the time of sowing of maize Take images of ten randomly selected maize plant's first fully exposed leaf from top, starting from 21 days after sowing maize till initiation of silking at 10 day interval [4]. Out of ten captured images if six or more images are of LCC level less than five then apply 25kg of urea per acre. If five or

more leaves are equal to or greater than LCC level five then no need to apply nitrogen [4].

3.7 Proposed Algorithm

Input: Ten maize leaf images.
Output: Nitrogen recommendation
Method:
1. for each input maize leaf image
2. generate color histograms in R,G and B color planes
3. for each generated R,G and B color histograms of LCC leaf level image //taken from data base.
4. find the taxicab distance between color histogram of input image and respective color histogram of each six LCC leave Levels.
5. end for;
assign an LCC level number to an input image with which its histogram Difference is minimum.
6. end for;
7. if the number of input images with LCC level number less than five are more than six then
8. print apply 25kg of urea per acre;
9. elseif number of input with LCC level number greater than five then
10. .print no need of applying urea.
11. else
12. print capture other images and try again.
13. endif;

4. Results and Discussion

A Z-test one proportion is a statistical test for which the distribution of the test statistic under the null hypothesis can be approximated by a normal distribution. Due to the central limit theorem, this test statistic is approximately normally distributed for large samples.

Table 1: Set 1

Sample number	*Manual LCC*	*Using image processing*	*Result(1 if equal,0 if not)*
1	4	4	1
2	4	4	1
3	5	5	1
5	6	6	1
6	6	6	1
7	6	6	1
8	3	2	0
9	3	3	1
10	3	3	1

Table 2: Set 2

Sample number	*Manual LCC*	*Using image processing*	*Result(1 if equal,0 if not)*
1	4	4	1
2	4	4	1
3	3	3	1
4	2	1	0
5	1	1	1
6	5	5	1
7	3	3	1
8	1	1	1
9	3	3	1
10	6	6	1

Table 3: Set 3

Sample number	*Manual LCC*	*Using image processing*	*Result(1 if equal,0 if not)*
1	2	2	1
2	2	2	1
3	3	3	1
4	4	5	0
5	1	1	1
6	5	5	1
7	3	3	1
8	1	1	1
9	4	3	0
10	1	1	1

Total number of samples: 30
Correctly classified : 26
Success rate considering Z-test One Proportion: 26/30.
Statistical method: Z-test One Proportion
Null hypothesis (H_0): the output of automated device is Not significantly different from the Manual output.
Decision: reject H_0 if computed < 1.2 (critical value by Looking at z-table).
Where Z-value $=(p1-p)/\sqrt{p(1-p)(1/n)}$
Where p1=x/n.
p=hypothesized value.
x=number of success.
n=number of samples.
P1=26/30.
Z-value= $(0.86-0.77)/\sqrt{0.77(1-0.77)(1/30)}$.

The final testing was consisted of 30 leaf samples which were divided in three sets with 10 leaf samples each. The leaf samples were manually checked by a maize specialist in the Department of Agriculture, who's an expert regarding in Leaf Colour Chart.

It can be seen that after the final testing, out of 30 leaf samples 26 of the readings of image processing application matched the readings of LCC by maize specialist. The values gathered in the final testing was then set to the formula of Z-test one proportion and the output was 1.2. Since the test statistic of 1.17 exceeds the critical value of 1.2, the null hypothesis (H_0) is accepted, thus it can be concluded that the readings of image processing application matched the readings of Leaf Colour Chart.

5. Conclusion and Future work

During the actual testing, it was found that the discrepancy of reading was very minimal comparing the leaf colour chart to the developed image processing application. The application is able to overcome the bias of color perception and color blindness since anyone who is not oriented to use LCC and with the disability of color perception cannot do readings without the bias of color perception.

Applicability to other crops since the leaf color chart adopted as standard in this Application is only applied to maize. Multi-user functionality since the application does not have the ability to distinguish one user from another which might pertain to a different maize population

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