

HAAR TRANSFORM BASED ESTIMATION OF CHLOROPHYLL AND STRUCTURE OF THE LEAF

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Abstract

In this paper, the health of a plant is estimated using various non-destructive Image Processing Techniques. Chlorophyll content was detected based on colour Image Processing. The Haar transform is applied to get size of leaf and the parameters.

Keywords:

Haar Transform, Chlorophyll, Decomposition, Gaussian Filter

1. INTRODUCTION

Chlorophyll is a green pigment present in a leaf which is essential for photosynthesis. It is the marker of plant's health and also important in agriculture industry. Previously, Mahdi M. Ali, Ahmed and Al-Ani [3] have shown the correlation between healthiness of plant and chlorophyll content using destructive techniques. Yuzhu et al. [6] has shown that $G/(R+G+B)$ gives the best correlation with chlorophyll content while earlier Kawashima and Nakatani [5] had given $(R-B)/(R+B)$ using colour Image processing. But Mahdi M. Ali [3] has given $\text{logsig}[(G-(R/3)-(B/3))/255]$, the formula to determine chlorophyll changes from plant to plant and also with the environmental conditions. This study was carried out to find out applicability of colour image processing in different kind of plants in Indian scenario.

Further size of leaf is also a good indicator for use of pesticides. Generally, the structure of leaf [9] is determined using image segmentation. But N. Valliammal [8] has proposed a new way to determine the structure of the leaf by using wavelet transform and K-means clustering. The paper is concentrated on getting size of leaf using structure detection [8]. If any pest distorts the boundaries of the leaf, then in such case the result would be different from the healthy leaf. Thus it will be helpful in guiding the need of type and the amount of the pesticide which will be very helpful in agriculture industry.

2. METHOD

The experiment was conducted on leaves of different plants. Various pictures of leaves of each plant were captured and then processed to bring out the final results. The images were captured using CANNON digital camera. The resolution of the pictures was then brought down to 256×256 so as to apply Haar transform. The step wise procedure is given below.

2.1 INITIAL STEP

The images were captured and Gaussian filter was applied to the images to smoothen it. This is done so as to get good results at the end; otherwise the results will not be satisfactory. This was the first pre-processing step. The images are shown in Fig. 1.

The images shown are arranged in descending order of the chlorophyll content. Leaf 1 has maximum chlorophyll content whereas Leaf 5 has minimum chlorophyll content.

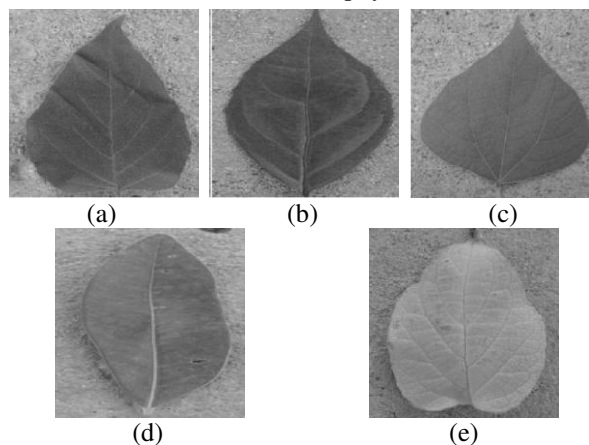


Fig.1. Original images of leaves

2.2 TO DERIVE CHLOROPHYLL CONTENT IN A LEAF

The green colour of a leaf is due to the chlorophyll content of a leaf. This fact is used to estimate chlorophyll in a non-destructive way.

Red, Green and Blue planes of the image were separated and their average values were determined individually. Then various combinations of these components were analysed and tabulated, to match it with the chlorophyll content of the leaf.

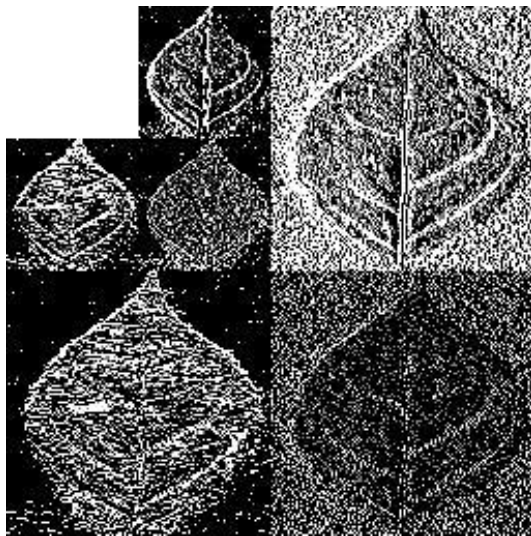
To get reliable results, YCbCr components were also taken into consideration. Y here is for luminance component and CbCr for Chrominance. So in order to estimate the chlorophyll content, the CbCr components were extracted and studied.

Various linear combinations of the above components were tried out and then tabulated to find which combination gives best result with the chlorophyll. The chlorophyll content of a green leaf is more than the yellow leaf. This is clearly depicted in Table.1 in later section.

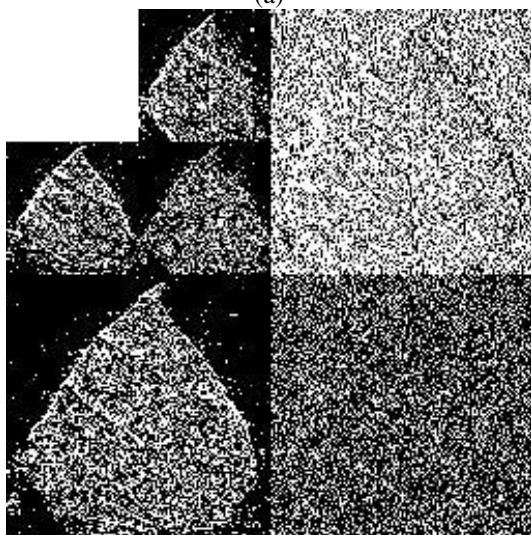
2.3 APPLICATION OF HAAR TRANSFORM

After the pre-processing, the three level decomposition Haar transform was applied to the image [8]. This gives four components of the image. Top left is the Low-Low component generated from a two dimensional LPF. Top right component is the High - Low component. This is generated by applying two different filters in horizontal and vertical directions. HPF is applied in horizontal direction and LPF is applied in vertical direction. The lower left component is also generated by applying two different filters. In this case LPF is applied in

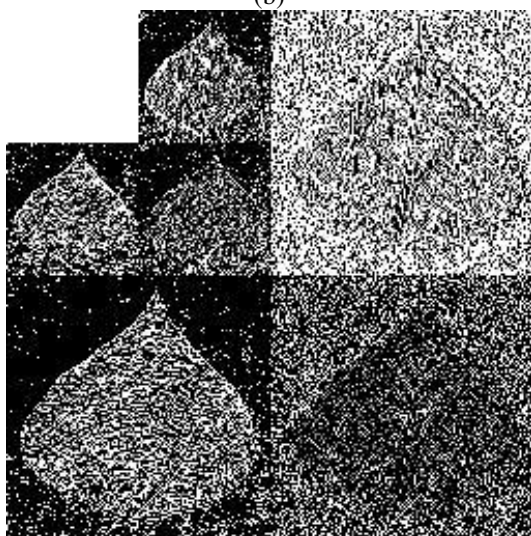
horizontal direction and HPF is applied in vertical direction. This is called Low-high component. The last component, that is, lower right is obtained by applying a two dimensional high pass filter. This is the high-high component. These components are shown in Fig.2 below.



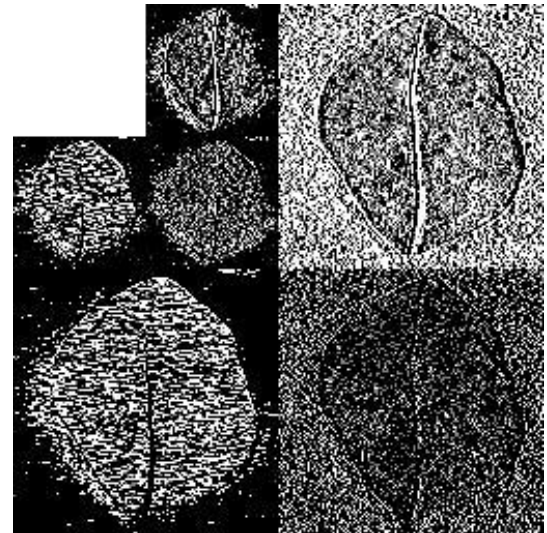
(a)



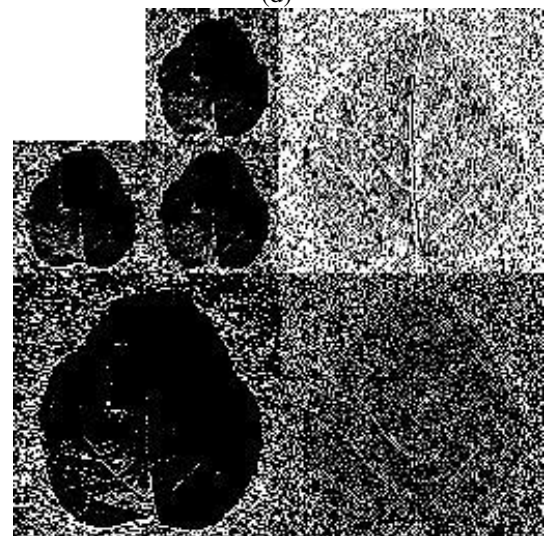
(b)



(c)



(d)



(e)

Fig.2. Haar Transformed Images

2.4 IMAGE EXTRACTION

Next the Low-High component is separated out and then various filters are applied to it to get the image of the leaf and suppress the noises which are present. Firstly, Laplacian of Gaussian filter and then an averaging filter is applied to the extracted image. This removes noise and gives the smoothed image of the leaf. After this, boundary of the leaf is extracted. The number of pixels on the boundary element gives the rough estimation of size of the leaf. The size is then compared with the size of the original healthy leaf template.

2.5 TEXTURE ANALYSIS

Using the Haar wavelet transform, the decomposition components were found out. The detailed decomposition components that are cd values are taken as the factor to determine any ambiguity in the leaf. If there is any pest attack or any kind of dryness in leaf, it will give a different value.

3. RESULT AND OBSERVATION

3.1 ANALYSIS OF CHLOROPHYLL

The images of the leaves above in Fig.1 have been arranged in descending order of their chlorophyll content, first leaf having the highest amount of chlorophyll in moles per gram. Table.1 shows result of various linear combinations and thus give the clear view of which component matches perfectly with the chlorophyll content.

The parameter $\frac{B}{R+G+B}$ shows perfect matching with the chlorophyll content of the leaf. As it can clearly be observed from the table and the graph in Fig.3, it keeps on decreasing as the chlorophyll content decreases from leaf 1 to leaf 5.

Another component 2G-B is inversely proportional to the chlorophyll content. It keeps on increasing from leaf 1 to leaf 5.

Table.1. Linear Combinations of RGB Components

| Parameters | Leaf 1 | Leaf 2 | Leaf 3 | Leaf 4 | Leaf 5 |
|------------------|--------|--------|--------|--------|--------|
| R | 94.36 | 103.62 | 118.82 | 116.84 | 152.97 |
| G | 119.8 | 130.66 | 133.15 | 139.93 | 136.71 |
| B | 94.90 | 96.61 | 93.35 | 90.80 | 81.38 |
| Y | 109.35 | 118.69 | 124.33 | 127.43 | 135.27 |
| Cb | 119.75 | 115.44 | 110.42 | 107.24 | 97.50 |
| Cr | 117.29 | 117.23 | 124.04 | 120.42 | 140.56 |
| 2G-R | 145.23 | 157.7 | 147.47 | 163.03 | 120.4 |
| 2G-B | 144.69 | 164.70 | 172.95 | 189.07 | 192.05 |
| B/(R+G+B) | 0.30 | 0.2 | 0.27 | 0.26 | 0.21 |
| G/(R+G+B) | 0.38 | 0.39 | 0.38 | 0.40 | 0.36 |

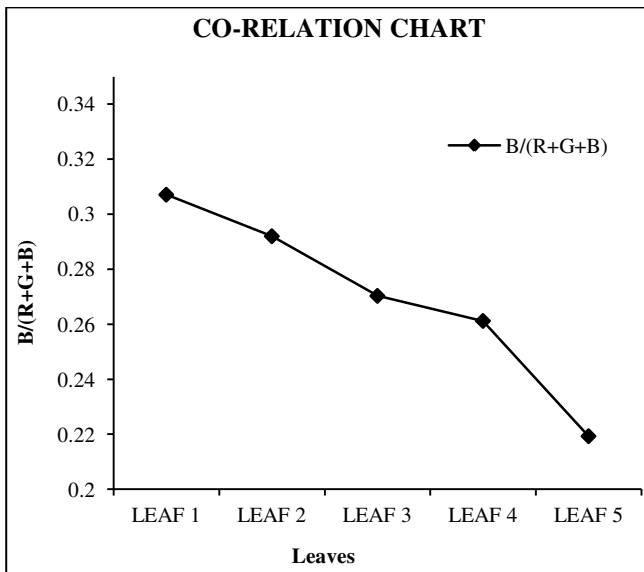


Fig.3. Co-relation graph of chlorophyll content and parameter chosen

3.2 ANALYSIS OF GROWTH RATE OF THE PLANT

Growth rate plays an important role in determining the health of the plant. The growth rate of the plant is directly proportional to the size of the plant. If size of the leaf is up to an appropriate level and the leaf also has enough amount of chlorophyll then the leaf can be declared as a healthy leaf. More the number of healthy leaves, healthier the plant is.

The size of the leaf is easily estimated by counting number of pixels on the boundary of the leaf. Boundary of the Low-High component is obtained. Size of all the above five leaves were determined and tabulated in Table.2.

Table.2. Size of the Leaves

| LEAVES | SIZE |
|--------|------|
| LEAF 1 | 448 |
| LEAF 2 | 479 |
| LEAF 3 | 605 |
| LEAF 4 | 482 |
| LEAF 5 | 650 |

3.3 DETERMING PLANT NECESSITIES

According to the texture analysis by the Haar wavelet Transform, the various ca and cd values were tabulated and are shown in Table.3.

Table.3. Haar Transform Coefficients

| LEAVES | ca | cd |
|--------|----------|---------|
| LEAF 1 | 218.3855 | -0.8418 |
| LEAF 2 | 232.5166 | -0.7536 |
| LEAF 3 | 230.2903 | -0.6684 |
| LEAF 4 | 219.529 | 0.58 |
| LEAF 5 | 187.3943 | -0.9612 |

The tabulation above clearly tells that there is some problem with the leaf 4 as it has got a positive ca value. It can also be seen from original image of leaf 4 in Fig.1 that it has imperfections on its surface which is due to improper amount of pesticides. Thus, pesticide requirement of the plant is known. The proper amount of pesticide needed can stop the soil infertility problem.

4. CONCLUSION

From the Table.1, Table.2 and Table.3 above, relationship between chlorophyll content of the leaf and healthiness of plant, with the help of various techniques, is determined. This can be used to determine the chlorophyll content instead of going for destructive methods that involves various chemical methods. This method proves to be an easy and simple one. Moreover, size of the leaf is also taken into consideration. These two factors can further be used in estimating the mineral which the soil is lacking. Originally, this method was tested on 40 different kinds of plants in a nursery. Here only five leaves, each from

different plant is taken for demonstration. On an average, five leaves per plant can be tested for both chlorophyll and size to declare if the plant is healthy or not. The size also tells about the growth rate of the plant. If the growth rate is below threshold limit then excess manure and fertilisers are needed. The texture analysis tells about the healthiness of the leaf. If some pest attack is there, then the value of the cd will go above certain value. This tells about the amount of the pesticide needed by the plant.

Using these techniques, the various requirements of the plant like soil, manure, fertilisers, pesticides etc. can be determined from time to time, without damaging the plant unlike the various chemical methods.

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