Segmentation of Tomato Plant Leaf

S. Aparna and R. Aarthi

Abstract In today's world there is a huge need for constant monitoring of crops, plants in agricultural fields to avoid diseases in plants. Since we cannot rely on the ability and accuracy of the human eye, it is only natural to depend on electronic equipment to detect diseases in crops and plants. Use of electronics for monitoring crops will help prevent plants from infection since this is the need of the hour, hence, making this an essential research paper. Most crops such as tomato, chilli, paddy etc. are attacked by bacteria, fungus or viruses leading to change in color, texture or function of a plant as it responds to pathogens. Common fungal infections include leaf rust, stem rust or white mold formation on the plant. Bacterial infections such as leaf spot with yellow halo, fruit spot, canker and crown gall all affect crops severely. In plants that are effected by viruses, one can find ring spots, pale green color in leaves and the plant stops growing and becomes distorted. We take these visual changes into account and process these images to identify whether a plant is healthy or not. There are three main steps for segmentation and identification of this disease.

1. Acquiring the RGB image and converting it into a suitable color domain such as HSV, YCbCr etc.
2. Mask the green pixels using a suitable threshold.
3. Choose a particular component in the chosen color domain after analyzing which component gives the most feasible result.

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1 Introduction

Healthy food and lifestyle has become a major issue in the recent years. Agriculturists work to provide crops that give maximum productivity with lower cost. Continuous assessment of crops and timely addressing of diseases is needed to ensure profit and quality. The general approach for monitoring of crops is by detecting the changes with our eyes. Since in most cases farmers are either not aware of all the diseases present in plants or lack the required skills to detect them, agriculture experts are generally employed to aid the farmers. Such help is generally provided to the farmer based on the request to the agriculture department or the surveys happen with the large time gap. However, this involves more cost and man power with a compromise in quality of crops. The lack of availability of such experts and unawareness of non-native diseases of crops makes the farmer's job tedious [1]. The other way to identify diseases is molecular designs like polymerase chain reaction. It is used to identify diseases in crops but these require detailed processing and laborious processing procedure [2]. Another way is to use electronic devices to take an image of the plant and it can be captured with the help of image processing tools, diseases can be detected with accuracy and much more efficiency.

Tomato is one of the most popular vegetables in TamilNadu state of India that gets affected by diseases easily [3]. Since tomato plants are in high demand, farmers try to find new ways to increase the productivity. Dry farming, amending soil with salt and crop rotation are some methods used by farmers to meet these demands [4]. However, in most cases, people are left with no choice but to compromise in the quality of this vegetable. Eating such vegetables will cause problems such as food poisoning, liver infection etc. Healthy generation and production of tomato plants will ensure satisfied and healthy consumers. In general, tomato plants that grow in wet, humid climate are susceptible to diseases. Dark brown or black spots appear on the surface of leaves first. It is then followed by yellowing or browning usually to those leaves at the lower branches. Removal of these infected leaves as soon as they appear may help reduce its spread [5]. Figure 1a shows a picture of a healthy leaf.

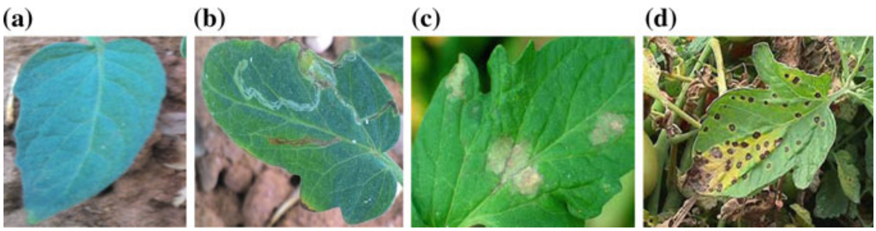

Fig. 1 **a** Healthy tomato leaf. **b** Leaf infected by 'leaf miner'. **c** Symptoms of bacterial cancer. **d** Leaf infected by 'early blight'

In (b), (c) and (d) the infected leaf is attacked by a disease called leaf miner, bacterial cancer and fungus alternaria solani. Leaf miner is a very common disease and it can be easily avoided if detected in its initial stages by careful monitoring. If detected in the later stages, the entire crop will have to be removed.

One of the major cues is the color change of the leaf from normal surface. Other way is to recognize patterns of the leaf. The major features that support to categorize the pattern of diseases is color and texture. The main challenge is to extract the tomato leaf regions in the screen so it can be classified [6]. So our main focus in this work is to design an algorithm that detects tomato leaves in various scenes so that the segmented part can be can be further processed to detect diseases. Segmentation is used to separate the leaf regions from the background so that the infected leaf can be classified. Watershed image segmentation is based on the theory of mathematical morphology. We can say that the watershed is a set of crest lines radiating from saddle points [7]. Another method for segmenting an image is by using k-means algorithm. In this method, a few seed points are taken and the distance between the seed points and the nearby pixel is calculated. All pixels within a given distance from the seed point will be grouped into that particular cluster. The process will be repeated till no two seed points have the same pixels [8]. Our procedure takes advantage of color cue to segregate the background and leaf region. The color cues are used for detection of various like skin regions [9], vehicles in roads [10].

1.1 The Proposed Approach

Here is the step-by-step procedure of the proposed approach:

1. Acquisition of RGB image.
2. Converting image to HSV color domain.
3. Masking the green pixels by choosing a suitable threshold.
4. Performing pre-processing techniques.
5. Segmentation of image.

1.1.1 Acquisition of RGB Image

The image is taken from a relative distance from the crop to avoid loss of data and clarity. Since the height of an average tomato plant will be around three feet, the camera height can be fitted from three and a half feet to capture the image with a top view [11]. To obtain an image with a horizontal view, an image can be captured from around one foot away from the plant. Illumination variation due to sun light is also a major problem. The shadow of adjacent leaves on a particular leaf may make it darker.

1.1.2 Converting to HSV Color Domain

HSV stands for Hue, Saturation and Value where hue is a color attribute that describes pure color as perceived by an observer. Saturation refers to the relative purity or the amount of white added to hue and value refers to amplitude of light. We use HSV over RGB because it can separate color from intensity. On doing so, we can remove shadow effect or create changes in lighting conditions [12]. It is also easier to implement with a direct conversion of RGB to this domain. We do not choose YCbCr because some of its values may be out of range of RGB. Also when we analyzed a sample image using RGB domain and masked the green, red and blue component separately by setting specific threshold values, we noticed that it is difficult to get a fixed value. There were colors which were present in all the three color components, thereby making the segmentation process difficult. Figure 2 shows the sample image analyzed and the results obtained.

Due to these inconsistencies and the fact that color and intensities can be separated in HSV, we have chosen it over our RGB color space. Surveys on color segmentation shows that HSV is the most suitable color domain in image processing [9].

1.1.3 Masking of the Green Pixels

Masking means setting the pixel value in an image to zero or some other value. Here average of the image containing healthy green is computed in hue, saturation and value [13]. For this, the image is initially cropped after converting it to HSV. The average of hue, saturation and value are computed separately and a range of

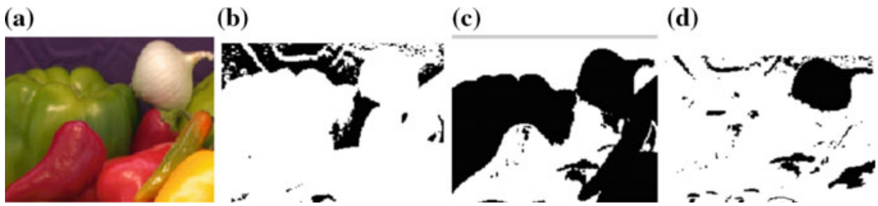

Fig. 2 **a** Original RGB image. **b** Masked red image. **c** Masked green image. **d** Masked blue image

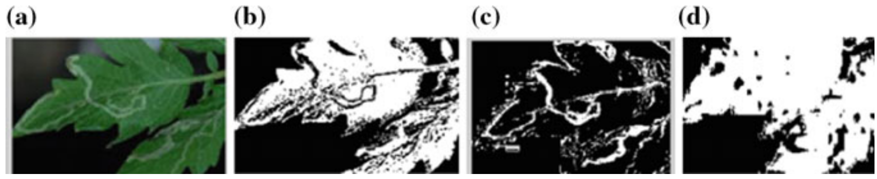

Fig. 3 **a** Acquired RGB image. **b** Hue component. **c** Saturation component. **d** Value component

Table 1 HSV values of tomato leaf before normalization

Name of image	Hue average	Saturation average	Value average	Hue range	Saturation range	Value range	Size of image
Image1	110.66	120.5	161	100–130	110–140	150–180	1222 × 617 × 3 uint8
Image2	55	122.18	147.95	50–80	120–140	140–180	194 × 260 × 3 uint8
Image3	82	112	87	80–110	120–150	85–110	184 × 274 × 3 uint8
Image4	70	134	174	60–90	130–180	165–200	1836 × 3264 × 3 uint8
Image5	89.1	80	120	80–120	130–160	115–140	1836 × 3264 × 3 uint8
Image6	83	95	147	80–120	90–130	150–185	1836 × 3264 × 3 uint8
Image7	99	107	143	90–120	90–130	150–185	760 × 994 × 3 uint8
Image8	107	117	143	105–130	115–140	150–180	1836 × 3264 × 3 uint8
Image9	54	173	105	50–90	175–210	100–140	194 × 259 × 3 uint8
Image10	57	170	106.11	50–90	150–190	100–140	1836 × 3264 × 3 uint8
Image11	51	201	128	50–90	190–230	120–150	1836 × 3264 × 3 uint8
Image12	76	96	157	90–120	100–130	150–180	1836 × 3264 × 3 uint8
Image13	74	103	155	80–110	100–140	150–190	1836 × 3264 × 3 uint8

Table 2 HSV values of tomato leaf after normalization

Name of image	Hue average	Saturation average	Value average	Hue range	Saturation range	Value range
Image10	87.7	77.6	134	60–90	60–100	100–140
Image11	76	145	142	60–90	130–180	130–180
Image12	125	95	175	120–150	130–180	160–200
Image13	93	83	144	70–120	70–120	140–180
Image14	100	134	137	70–110	130–160	130–160
Image15	56	31	142	40–80	20–50	140–180
Image7	110	132	134	100–130	120–150	140–180
Image6	96	99	114	90–130	120–150	110–140
Image4	97	60	174	80–130	50–90	150–190
Image1	120	162	162	80–130	150–190	150–190
Image8	98.7	143	136	100–130	150–190	130–160
Image17	77	143	140	60–100	130–160	130–160
Image16	75	65	163	70–100	60–90	160–180

values are given to them separately. Here any pixel falling within this range is set to white or 255 in grey scale. Any pixel outside this range is set to black or 0. In this way it is very easy to detect any color change apart from the normal. Figure 3 shows an RGB image and hue, saturation and value extracted separately and the green areas masked.

Table 1 gives the names of images of different tomato leaves analyzed and their respective hue, saturation and value averages and the most accurate ranges available.

These were the results before pre-processing techniques were done on the image.

1.1.4 Applying Pre-processing Techniques

Since the range of values for hue, saturation and value are so vast it is difficult to come to a narrow range. None of the images have a common average or range of values. This can be due to the effect of shadows on the leaf or even due to the lighting conditions. If the image was captured in the morning or the afternoon, the color of the image will also change due to the position of the sun. To avoid this problem we have to apply uniform lighting to all the images. This can be done by performing histogram equalization on the images by taking one image as reference. Since images have same content, we introduce histogram equalization to bring a contrast to the image. This will be enough to render any grey scale differences in our resulting image [11]. Hence, all of our images will have the same lighting conditions and one of the images will be kept as the reference image.

Table 2 gives us the range of values for hue, saturation and value using an image by name ‘image5’ as reference. Now, we can see a clear range of values for hue, saturation and value averages and their ranges.

1.1.5 Segmentation of Image

Taking the range of hue from 80 to 120, saturation range from 60 to 150 and value range from 135 to 170, we get the following results. Figure 4 shows a picture of the results obtained on setting the images to the ranges specified above. As seen in these sample images, most of the pictures used for analysis are close up images of the tomato leaf.

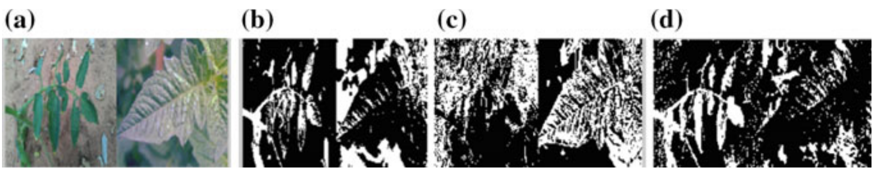

Fig. 4 **a** Original RGB image with reference image after pre-processing. **b** Saturation component of image. **c** Value component of image. **d** Hue component of image

2 Conclusions

We can clearly see that saturation component of image gives better results than the other two components. The leaf is clearly segmented too. Hence we can conclude by saying that saturation component in the HSV domain gives best results for detection of diseases in crops. With the information we have gathered we can use detect diseases in crops by acquiring the image of the crop and using saturation component in the HSV image. This will make the job of farmers easier thereby making our lives safer and healthier.

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