Plant leaf images computerized segmentation

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Abstract. In this paper the comparison of RGB, HSV and CIELab color spaces is considered in view of diseased leaf images segmentation by color thresholding method. In such tasks HSV and CIELab outperform RGB. Thresholding method based upon HSV or CIELab color spaces can be applied to measuring leaves total area, diseased and healthy surfaces area, as well as dataset composing in machine learning.

1. Introduction

Nowadays plant leaf images segmentation is important field of research that can be useful in plant protection. It can be used as a part of decision support system to provide qualitative and early diagnosis of plant severity. It allows agriculturists to put phytosanitary state in perspective during farming.

There are plenty image segmentation technics based on classical computer vision approaches [1] along with deep learning [2]. The one of the simplest ones is color thresholding method which allows the color range selection to highlight an object of a certain class. In context of plant leaves segmentation, it is necessary to accurate highlighting of both diseased and healthy leaf regions and their boundaries. Despite its simplicity the method put in a satisfying performance in comparison with K-means algorithm on wheat diseased leaves images segmentation. The limitation of the method is disability to segment an image in fully automatic mode.

The comparison of different color spaces in image segmentation tasks using classical computer vision approaches is the subject of many studies [4-6]. Usually in such task HSV and CIELab are used due to some advantage over RGB. In the text below aforementioned color spaces pros and cons will be revealed in terms of their application in the color thresholding method.

2. Color spaces comparison

Color spaces will be evaluated using the image of wheat leaf on the homogeneous black background (figure 1).

![Image with wheat leaf diseased by leaf rust](image1.jpg)

Figure 1. Image with wheat leaf diseased by leaf rust
This image will be visualized as 3D and 2D scatter plots. The points in these plots will be distributed across dimensions according to the color spaces channels.

2.1. RGB color space
This color space represents image pixels by mixing red green and blue colors in special ratio. The more intensive color is mixed the brighter the pixel. With mixing all RGB channels of maximal intensity it results white color, of minimal intensity – black. Because of its relative simplicity RGB color space is used in computers to visualize the colors. But for segmentation tasks it is not convenient.

Figure 2 shows that pixels of orange tint, corresponding to leaf diseased areas, have a different values and are spread across all channels. To select them accurately at least three range limiters are needed (one for each channel, figure 3(d)), and in case of another tints occurrence – six limiters (two for each channel). Upon that their adjustment is extremely time-taking process.

![RGB scatter plots](image)

Figure 2. RGB scatter plots. (a) 3D plot; (b) 2D plot, G and R channels; (c) 2D plot, G and B channels; (d) 2D plot, B and R channels with range limiter

2.2. HSV color space
Since all images and graphics are represented in RGB, conversion to another color spaces, like HSV [7], is performed by applying of certain relations.

HSV color space consists of three channels: H(Hue) – the dominant color, S(Saturation) – the purity of color and V(Value) – the color brightness. Herein two components are about the illumination level and another one about the color. It means that it is possible to disregard the image illumination conditions and use the color channel to segment the objects from image.

Plots on the figure 3 indicate (they are only two, as there is just one color channel) that HSV space facilitates the much more concentrated pixel location of orange and green tints. To select intended color it is sufficient to limit the values of Hue dimension. In the best-case scenario the single limiter is required, otherwise the couple. The points of black color will not be considered, since they go with Value channel.
Figure 3. HSV scatter plots. (a) 3D plot; (b) 2D plot, V and H channels with range limiter

Hue channel has the values range from 0 to 179, which corresponds to shade scale shown on figure 4. It reveals that red color tints are localized near 0 and 179.

Figure 4 Hue channel shade scale

Thus, if the leaf will be infected by disease with a red color visual features (figure 5(a)) a scatter plot may look similar to the one from figure 5(b).

Figure 5. The result of adding red tint pixels. (a) image; (b) 2D scatter plot with range limiter

From the figure 5 it follows that in case of red color on the image it may be necessary to use at least two limiters or dedicated logic converting Hue scale to the round for red tint tails conjunction.

2.3. CIELab color space

Patterns and specifics of RGB to CIELab conversion are described in [8]. CIELab is color-opponent space with coordinates L* (Lightness, at L* = 0 black color is displayed, and with L* = 180 diffused white color occurs), a* (value in range between red – positive – and green – negative – colors) and b* (range between yellow – positive – and blue – negative – colors).

Pixel scatter plots shown in figure 6 (they are also only two, as a* and b* channels are visualized on one plot) make it clear that diseased areas pixels concentrate at large a* and b* values, while healthy areas at lower. Hence, in this case, to segment diseased areas single range limiter is needed.
Figure 6. CIELab scatter plots. (a) 3D plot; (b) 2D plot, channels a* and b* with range limiter

If image contains the areas with various color tints (noises etc., figure 7(a)) the single or couple limiters may be not enough, since they will cover unnecessary pixels (figure 7(b)). It means that the most versatile and effective way to segment by CIELab is to use the Region Of Interest (ROI). ROI has the closed form (rectangle, circle etc.) of a custom size. Also figure 7(b) shows that HSV lack is mitigated and red tints are in one region.

Figure 7. The result of adding different color pixels – (a) image, (b) 2D scatter plot with ROI

3. Conclusion

As a result of aforementioned color spaces comparison, it follows that HSV and CIELab are able to yield the same results with different implementation. For there are no red tints in the image a simpler and computationally efficient way is to use HSV color space, otherwise – CIELab. Finally, both methods require quite complex implementation in case of images containing variable color tints (which vary from image to image).

Today HSV and CIELab color spaces are widely used in the image segmentation field. Also, color thresholding method is utilized. For example [9,10] authors applied it to mask the diseased leaf areas, which were later used to train convolutional neural networks. In such a way the usage of specific color spaces makes explicit thresholding method a good tool for complex intelligence systems developing.

References

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