Science and Technology Journal, Vol. 7 Issue: 1 ISSN: 2321-3388

Interactive Color Image Segmentation using HSV Color Space

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Abstract—The primary goal of this research work is to extract only the essential foreground fragments of a color image through segmentation. This technique serves as the foundation for implementing object detection algorithms. The color image can be segmented better in HSV color space model than other color models. An interactive GUI tool is developed in Python and implemented to extract only the foreground from an image by adjusting the values for H (Hue), S (Saturation) and V (Value). The input is an RGB image and the output will be a segmented color image.

Keywords: Color Spaces, CMYK, HSV, Segmentation

INTRODUCTION

Image Processing

Human eyes can perceive and understand the objects in an image. In order to design a machine that can understand like a human, it requires appropriate algorithm and massive training. An image is a visual representation of any real world object that can be manipulated computationally. Image Processing is an extensive area of research that gains attention in many applications including Vehicle detection where the author (Kaur 2017) has implemented Image Enhancement, Morphological operations, Segmentation, Otsu Threshold and Edge Detection to detect vehicles from satellite images, Fabric defect Detection (Tamil Selvi and Nasira 2017) is performed where Artificial Neural Networks (ANN) and Support Vector Machines (SVM) have been used to classify fabrics with defects. Image processing involves processing of data where input and output are images.

Digital Image processing processes the image using pixel values and is deployed in Machines. Low-level Image processing techniques are noise reduction, contrast enhancement and image sharpening. Mid-level Image processing techniques are segmentation, image classification, object description and recognition. The High-level Image processing techniques are image analysis and cognitive functions to emulate the human vision. Computer vision is another branch of research where Digital Image processing plays a vital role to learn, make inferences and perform actions based on visual inputs.

Color Models and Spaces

A color model is an abstract mathematical model in which colors are represented as tuples of numbers either three or four values or color components. When the color model is associated with an accurate description of how the components are to be inferred and the conditions are viewed, the set of resulting colors is called "color space." Color space can also describe the ways in which human color vision can be modeled. In few instances, color space and color models are significantly equal. There are different color spaces like RGB, NTSC, YCbCr, HSV, CMY, CMYK and HSI. Given an RGB image, converting it into any other color space is performed using any transformative functions. RGB Color space is the basic form of image representation, but some applications may find it more convenient to use other color spaces as well.

RGB

The default color model of an image is RGB (Red, Green, and Blue). In this model, an image is an I x J x 3 array of color pixels,

http://doi.org/10.22232/stj.2019.07.01.05

where each pixel is a triplet of three colors red, green and blue at a spatial location (I, J). These three color components can be viewed as a stack of three individual layers. Every pixel in an image will have a red layer, blue layer and green layer that will result in a RGB image. All these color components can be viewed as a 3-D model. In additive color mixing, when all three color channels have a value of zero, it means that light is not emitted hence, resulting color is black. When all three color channels are set to their maximum values i.e., 255, then the resulting color is white. Television Monitors are very good examples which uses the concept of additive color mixing.

HSV

HSV (Hue, Saturation, Value) color space is considerably closer to RGB color space in which humans describe color sensations and perceive colors. Hue is the dominant color observed by humans. Saturation is the amount of white light assorted with hue. Value is the brightness/ Intensity. In short form, Hue refers to tint, Saturation refers to shade and Value refers to tone. A HSV color space can be viewed as a geometric cylinder, where the angular dimension represents Hue(H), starting at the primary red at 0°, and moving to primary green at 120° and primary blue at 240°, and then finally wrapping back to red at 360°.The distance from the central axis of HSV cylinder corresponds to Saturation(S). A saturation value moving towards the outer edge means that the colorfulness value is at the maximum for the color defined by the hue. The central vertical axis of HSV color space is the Value (V), ranging from black at the bottom with lightness or value 0, to white at the top with a lightness or value 1.

CMYK

The CMYK color space involves subtractive primary colors like Cyan(C), Magenta (M), Yellow(Y) and Black (K). A large range of colors seen by humans can be obtained by combining cyan, magenta and yellow transparent inks on a white substrate. A fourth ink, black is added to enhance the reproduction of some dark colors. The cyan color absorbs red light but it transmits green and blue color. The magenta color absorbs green light but transmits red and blue color, and the yellow color absorbs blue light but transmits red and green color. The white color reflects the transmitted light back to the viewer. CMYK color space is mainly used for printers and for photographs.

NTSC

The NTSC color space is used in television. In this color space, gray-scale information is separated from color data, hence the single signal can be used for both color and monochrome television sets. In this color space, an image is represented as three components such as luminance, hue and saturation. Luminance is the gray-scale information whereas the other two components are the color information of a TV signal.

Segmentation

Image Segmentation is the process of dividing an image into its constituent regions or objects. The level of subdividing an image depends on the problem being solved. Segmentation process can stop when the objects of interest is isolated for further processing. There is wide range of applications which require image segmentation. Based on the area of image application, appropriate Segmentation techniques can be used. There is an evolutionary process of region immigration and deportation along with watershed algorithm (Roohollah and Kazem 2017). Image segmentation is very helpful in the field of medical applications to detect breast cancer (Samson 2015), liver diseases (Pandey 2018)etc. There also has been a hybridization of Otsu method and median filter to segment the desired image (Firas and Fawzi 2013). The color images are segmented using a combination of grab cut and color spaces for foreground extraction (Dina 2014). Watershed algorithm and region merging (Ji and Harris 1998) using artificial neural networks is also used for color image segmentation. In this research work, we have developed an interactive tool that has 3 Control bars for Hue, Saturation and Value. When an input image is given, the GUI interface is opened, and the Control bars will be displayed for H, S and V with minimum and maximum limits. The User can interactively drag the control bars towards left and right and witness the changes that happen in the image. When the desired result is obtained, the process of adjusting the HSV values can be stopped and the procedure can be repeated for multiple images under study.

COLOR IMAGE SEGMENTATION USING HSV

Color image segmentation is frequently used for human skin color detection. Skin color detection (Hanaa and salma 2018) using all three color spaces like RGB, HSV and YCbCr is carried out as a segmentation step. A new color image segmentation method (Gustavo 2016) such as split & merge and region growing, and the combination of the

RGB and HSV color representation models was reviewed. In our work, the foreground object from the given image is segmented for detecting and recognizing the object. This is performed as a two-step algorithm. The first step is to select the Region of Interest (ROI) from the given image and the second step is to adjust HSV values in the ROI to extract the foreground image.

In the first step, an RGB image is converted to HSV image. Each component Hue, Saturation and Value is separated, and its value is represented in a range using a GUI developed in Python. The HSV values are chosen interactively by adjusting the GUI based track bar for each component Hue, Saturation and Value. The Hue is in the range of 0-179 whereas Saturation and Value is in the range of 0-255.By dragging the track bar and adjusting its value over it, an optimum value for all H, S and V is identified. Hereby, the background is masked and only the objects of interest are found. A single H, S and V may not be applicable for all kind of images. But by using an interactive tool, the user will have a provision to select the H, S and V values for different category of images. When the selected object of interest is segmented completely, the HSV adjustments can be stopped and the foreground image can be saved for further processing. The process flow for this technique to segment only the foreground image is given in Fig.1.

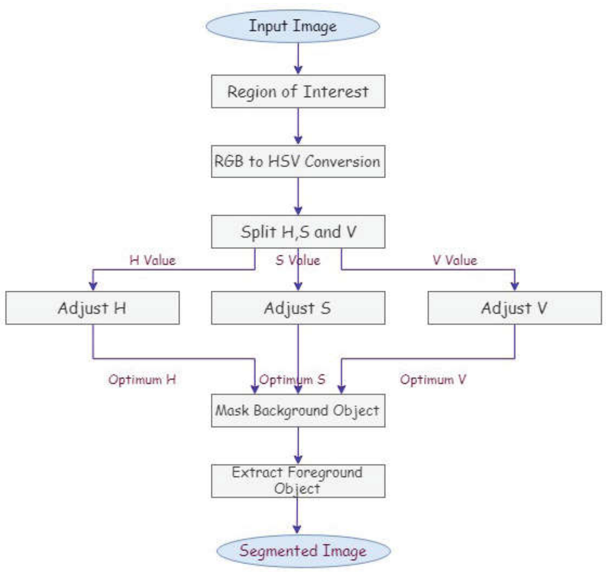

Fig. 1: Color Image Segmentation Technique using HSV

RESULTS & DISCUSSION

The object of interest is based on the application in which it requires further high-level image processing techniques like Object recognition, Scene classification etc. The Color image segmentation using HSV is achieved until the object to be processed is extracted. Each object is segmented for different HSV values. The same HSV values are not applicable for all images under study. Hence, the HSV values are adjusted in the track bar to find the optimum value for each set of images. The Experimental results of this segmentation process is given in Fig.2. The different set of Original image like human face, bird, flower, bottle and chair is Fig. 2(a), Region of Interest is Fig.2 (b), segmented image using HSV is Fig.2(c) and manually segmented image is Fig.2 (d). The images obtained as a result of this HSV segmentation technique can be used for further process of feature extraction and classification techniques.

Structural Similarity Index

To evaluate the performance of the HSV color image segmentation technique deployed in this work, a metric called Structural Similarity Index (SSIM) is calculated between the HSV segmented images and manually segmented images. SSIM is a metric widely used to measure the similarity between two images. The SSIM has a value that ranges from 0 to 1. The maximum value of 1 indicates that the two images to be compared are structurally similar while a value of 0 indicates no structural similarity between two images. The SSIM value for the 5 set of images is given in Table 1.

From the SSIM values, it can be visualized that the images segmented using HSV technique and manually segmented images are more or less similar. When the images are seen through human eyes, there is a negligible difference that can be seen between the set of images in Fig. 2(d) and Fig. 2. (c).

(a) (b) (c) (d)

Fig. 2: Original Image (a), ROI (b), Segmented Image using HSV(c) and Manually Segmented Image (d) for Human Face, Bird, Flower, Bottle and Chair

Table 1: SSIM Values between HSV Segmented and Manually Segmented Images

Image	SSIM
Human face	0.4932
Bird	0.8608
Flower	0.6132
Water bottle	0.6513
Chair	0.8769

CONCLUSION

Image Segmentation can either be low-level or high level processing and it is based on the needs of the user who is incorporating the ideas. In this paper, we have focused on color image segmentation for object detection and learning. Sometimes it can also be a major research area which requires large scale image processing techniques and automatic classification of image. To the best of my knowledge, most of the papers have implemented color space segmentation for only single set of object class. But in this paper, color image segmentation is performed to extract not only human skin color but also for other objects from background. To enhance this segmentation process, the segmented images can be followed by or integrated with any other morphological operations.

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