An Efficient Approach for Sky Detection

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Abstract— Blue color has been proven to be a useful and robust cue for sky detection, localization and for tracking RGB color in different applications of image processing. In this paper a pixel based solution utilizing the sky color information has been proposed for sky detection. The sky color information is extracted through the comparison of RGB values of a pixel. Based on the experimental results on highly complex still images, our approach for sky detection has been proved to be accurate, fast and simple.

Key words: Sky detection, RGB, pixel based sky detection, Color spaces.

1. INTRODUCTION

The sky detection is not a new problem for the researchers in the image processing domain. Due to its vast range of applications in weather forecasting, solar exposure prediction, image acquisition and understanding and in image retrieval and orientation, sky detection has been a keen area for researchers.

Sky detection becomes very difficult under certain circumstances, especially in overcast conditions and different types of clouds makes a real challenge for sky detection algorithms.

Mostly the pixel based approaches are used for sky detection in images/ videos to improve the image/ video quality as it becomes very easy to predict noise in the sky regions in an image because of its smooth appearance.

The color is considered the most robust and accurate feature for the sky detection. In this paper, we proposed a three step pixel based approach to sky detection that incorporates the RGB values for pixels classification. Simple if else conditions are used for the identification of sky region pixels in an image.

2. RELATED WORK

Due to various applications like video/image quality enhancement, solar exposure prediction and weather forecasting, sky detection has been thoroughly studied and tackled through various approaches. Zafarifar et al. [1] represent a novel approach for sky detection using two different features. This algorithm utilizes the adaptive positioning and color modeling for segmentation and extracting the sky region information in an image/video. The proposed algorithm produced better performance compared to state-of-the-art approaches in sky detection in natural scenes.

Schmitt et al. [2] used color, position and shape as features for the sky detection in their approach. The performance of the proposed algorithm was tested on a number of outdoor images and the based on the analysis of different of the experimental results under different weather and lighting conditions the author claim for highly accurate performance in classifying the sky regions in images taken in clear, overcast and partially clouded weather.

Laungrungthip et al. [3] represent a solar exposure system based on the image processing techniques. Image processing algorithms are used for segmentation of the outdoor images taken under different lighting conditions to segment out the sky regions in a scene. A robust approach composed of canny edge detection algorithm [4] and Morphological closing algorithm [5], was adopted for identifying and separating the sky regions in color images.

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Gallagher et al. [6] used two-dimensional polynomial model for sky detection. Their approach is composed of two parts, in 1st part the high confidence blue sky regions are detected while in 2nd phase the other candidate regions for sky are tested through two dimensional polynomial model. The performance of this algorithm is evaluated on 83 different images and produced accurate results.

3. COLOR SPACES DISTRIBUTION FOR SKY COLOR

Computer 3D graphic card and video communication standards have given origin to many color spaces with different properties. As our proposed approach use the color information for sky detection so a short overview of different color spaces and other issues related to color spaces is presented in this section.

3.1. RGB COLOR COMBINATION

RGB color space is based on Cathode rays tube display applications and is composed of three basic colors including: Red, Green and Blue. RGB is widely used in different applications of image/video processing, however the high correlation and significant perceptual non-uniformity are among the major drawbacks of this color space. Apart from this, the chrominance and illumination problems mitigate its significance in color analysis and color based recognition algorithms [7]. As for as, the sky color is concerned, it's a perceptual phenomenon not a physical property of an object. The general perception about the sky color is that it represents blue color; however it depends on the weather forecasting and this mixing of chrominance and luminance is a real challenge in color based sky detection approaches.

3.2. RGB COLOR RATIO

The sky regions in an image invariably contain a large number of pixels having values of blue color. Using this consideration, most of the values of R/G ratio are used as skin presence indicators as discussed by Warket al. [8]. The significance of R/G ratio in skin pixel identification encouraged us to utilize this concept of RGB color ratio in sky detection.

3.3. NORMALIZED RGB

Normalized RGB is easily obtained by the following three equations

$$r' = R^*/R^*+G^*+B^* \quad (1)$$
$$g' = G^*/R^*+G^*+B^* \quad (2)$$
$$b' = B^*/R^*+G^*+B^* \quad (3)$$

The sum of the above three equations is equal to 1 i.e. ($r'+g'+b'=1$), which is a standard equation for getting the normalized value of RBG. The 3rd component is important factor in our proposed algorithm because its main focus is on blue color in an image. The other two remaining components are called "pure color".
In the presence of "r" and "g", the brightness of RGB color is reduced by the normalization to get the required result to point out the sky blue areas in an image.

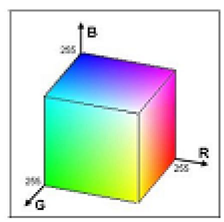

Figure.1: RGB Color Model [9]

3.4. HSI, HSV, HSL

To explain different color ranges with natural values, are based on the idea of artist's tint, saturation and tone. Hue represents the dominant color (such as red, green, purple and yellow) in the specific define area, saturation calculates for the colorfulness of an area in proportion to its

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brightness in the different images [10]. The term lightness is related to the color luminance which is naturally presented in nature. The intuitiveness of the color spaces components and explicit discrimination between luminance and chrominance properties make these color spaces very effective in skin color segmentation [11.12, 13]. Here the same concept is used to detect the sky color in an image by targeting the specific pixels in an image.
The polar coordinate system of Hue-Saturation spaces, resulting in nature cycle of the color-space makes it difficult for parametric sky color models that need tight clustering of sky colors for best performance.

3.5. NATURE OF TINT, SATURATION AND LIGHTNESS

The standardized TSL Color space (Tint, Saturation, and Lightness) is a convolution of the standardized RGB into more likely close to hue and saturation and can be explained by the standard equations given below.

$$S = [9/5(r'^2 + g'^2)]^{1/2} \quad (4)$$

$$T = \begin{cases} \arctan(r'/g')/2\pi + 1/4, g' > 0 \\ \arctan(r'/g')/2\pi + 3/4, g' < 0 \\ 0, g' = 0 \end{cases} \quad (5)$$

$$L = ..299R + .587G + .114B \quad (6)$$

let r'= r − 1/3, g'= g − 1/3 and r, g are taken from equation (1) and equation (2). Terril-lon et al. [14] have compared nine different color spaces for skin detection with a uni-model Gaussian joint pdf (only chrominance components of the color spaces were used). The proposed algorithm uses this concept for sky color detection with much improved results.

3.6. TECHNIQUE FOR RGB

YCrCb is most widely used technique now-a-days for an encoded nonlinear RGB color signal, which is mostly used by international television networks worldwide for image compression in different applications. General Color is Classified by luminance (computed as weighted sum from RBG values), and two color difference values Cr and Cb that are formed by subtracting luminance from RGB red and blue components as shown in given equations.

$$Y = .299R + .587G + .114B \quad (7)$$

$$C_r = R - Y \quad (8)$$

$$C_b = B - Y \quad (9)$$

The transformation and separation of luminance and chrominance components makes this color space attractive for skin color modeling which were proofed in different state of art work such as presented by Phung et al. [15], Zarit et al. [11] and Menser et al. [16]. We used that concept in our algorithm for sky color modeling to separate the blue color from the rest of the colors in an image.

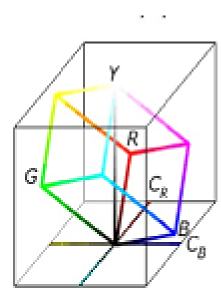

Figure.2: YCrCb Color Model relative to RGB Model

4. IDENTIFYING THE SKY BLUE AREA

After a number of experiments with the sky color images: the following generic rule was extracted:

1. If the red and green values are close to each other, and if the blue value is greater than the red and green values, the color is going to be in the blue range.
2. Identify the blue sky pixels by turning them off i.e. assign a 0.

More specifically, the final algorithm works on the following principle:

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if (abs(R - G)<5 &&  abs(G - B)<5 && B > R
&& B>G && B>50 && B<230 )
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5. DATASET

Caltech dataset [18] is used for the evaluation of proposed algorithm for sky detection. The dataset contains complex images with cloudy and partially cloudy sky images. We also include some images containing different objects too to test the algorithm to separate the sky regions from the other objects in images.

6. RESULTS AND ANALYSIS

The figures 3 and 4 show the resultant images of some of the experiments. It is clear from the Figure 3 that the proposed algorithm has successfully detected the sky regions in the background of the aero planes. 1st column in Figure 3 shows the original images with clear, clouded and partially clouded sky which are accurately detected by the proposed algorithm.

The Figure 4 shows the experimental results on other types of images with partially clouded and clear sky. The proposed algorithm detected the sky regions efficiently in this case too.

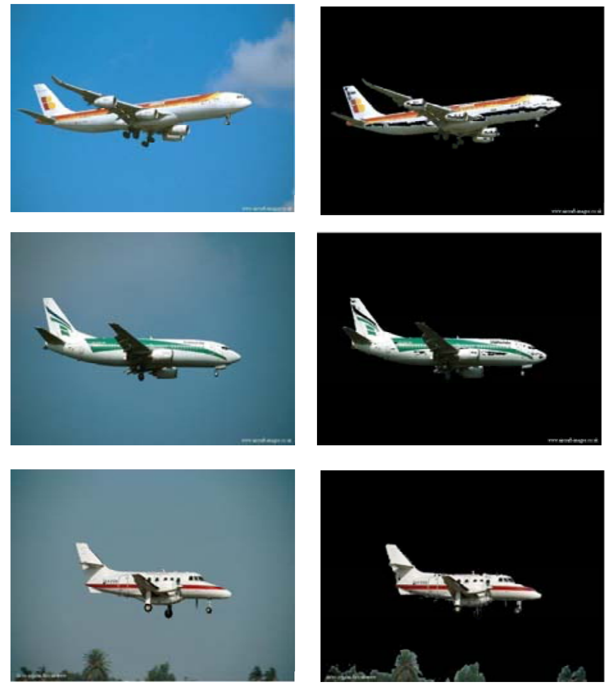

Figure.3: Experimental Results

Figure.4: Experimental results

7. CONCLUSION

Sky detection problem is very versatile in its applications ranging from entertainment (video/image quality enhancement) to weather forecasting and solar exposure prediction. A

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robust algorithm is needed to fulfill the demands of its all applications. Based on experimental results on a number of images it can be concluded that RGB values plays an important role in identifying the sky regions in an image and leads to an accurate and robust approach that fulfill all the requirements of sky detection in demanding applications.

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