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Survey on color lines model for eliminating specular reflection

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ABSTRACT

Detection of highlights is a prominent issue in computer vision, graphics. Many algorithms in image processing assume diffuse only reflections and deem specular reflections to be outliers. However, in the real world, the presence of specular reflections is inevitable since there are many dielectric inhomogeneous objects which have both diffuse and specular reflections. Hence, detection, and sometimes removal, of specular reflection (highlights) in an image may be critical. Proposed work takes help of global color-lines information to effectively recover specular and diffuse reflection. Our critical observation is that each image pixel lies along a color line in normalized RGB space and the different color lines meaning distinct diffuse chromaticities intersect at one point, known to be the illumination chromaticity. Pixels along the same color line, spread over the entire image and their distances to the illumination chromaticity give the number of specular reflection components. With such non-local overall information from these color lines, our method can effectively separate specular and diffuse reflection components in a pixel-wise way. We also present an efficient algorithm for complete removal of the highlights and it is suitable for real-time applications.

Keywords— *Diffuse reflection, Specular reflection, Illumination chromaticity, Global color lines*

1. INTRODUCTION

One of the main problems in computer graphics, vision and image processing is the detection and removal of highlights. The earlier methods of reflection removal often disunite specular reflection from an image by making use of the patch-based approach. Because of the absence of global information, these methods can't entirely distinguish the specular component of an image and tend to degrade prominent textures in the image. Specular reflection negatively affects the quality of visuals and cheapen the performance of many algorithms like image segmentation, visual tracking, detection of objects, color constancy etc.

Thus, it is important to separate specular and diffuse reflection for computer applications. In case of a complex textured image, segmenting an image into color patches is quite difficult, and the recovered image might not be optimally visual. One of the reasons behind such a failure can be the difficulty to cluster image pixels. Wrongly clustered pixels of the image leads to poor image textures. Even though the clusters are nicely formed, spreading diffuse chromaticity within a small patch is not effective to separate specular reflection. Also, patch-based methods can't search exact diffuse chromaticities for obtaining specular reflection because they lack global information. The result leads to blocky separation of specular objects.

Proposed work observes that each pixel of an image lies along a color line in the normalized RGB space. Pixels along the same color line spread over the entire image and their distances to the illumination chromaticity determine the amount of specular reflection. With this non-local information, a method to entirely separate and remove specular reflection for color images is provided. By calculating the intersection of different color lines that represent different diffuse chromaticities, an approach to correctively calculate the illumination chromaticity of a highlighted image is given. In order to robustly cluster image pixels, Cartesian coordinate system (RGB space) is converted into a spherical coordinate system, deriving two invariables, longitude and latitude. Using these, an efficient algorithm is presented to cluster image pixels to obtain color lines. The obtained specular reduced image is further refined in a matting process.

2. LITERATURE SURVEY

W. Ren, J. Tian [1] extended dichromatic reflection model and proposed a global color lines model that effectively recovers specular and diffuse reflection. However, their method doesn't work best on the highlighted image with complex textures and saturated pixels.

D. Berman, S. Avidan et al. [2] presented an algorithm based on a non local prior. Using haze lines, their algorithm recovers both the distance map and the haze-free image. The algorithm requires no training and performs well on a wide variety of images. But it fails in scenes where air-light is significantly brighter than the scene.

Q. Yang, J. Tang [3] treated specular pixels as noise. Specular highlights were removed in an image denoising fashion: an edge-preserving low-pass filter (e.g., the bilateral filter) was used to smooth the maximum fraction of the color components of the original image to remove the noise contributed by the specular pixels. The performance of their method highly depends on the approximate maximum diffuse chromaticity.

R. Fattal [4] described a method for single image dehazing that explains the color lines in the context of hazy scenes and use it for recovering the scene transmission based on the lines' offset from the origin. Their method produces erroneous results when atmospheric light is very close to the sky color in images.

H. L. Shen, Z.H. Zheng [5] calculate intensity ratios for defuse pixels to compute specular fractions of image pixels. For textured surfaces, image pixels are classified into clusters by constructing pseudo chromaticity space. The method works in a pixel-wise manner without specular pixel identification and any local interaction. The algorithm doesn't work best on dark and achromatic surfaces.

I. Omar, M. Werman [6] introduced 'color lines', an image specific color representation that is robust to color distortion and provided a compact and useful representation of the colors in a scene. The method gives a solution to the problem of deciding whether two pixels in an image have the same real-world color. But only the color information can be used while applying this approach in real time and not the texture/edge/spatial information.

S. Shafer [7] proposed an algorithm based upon a physical model of reflection which states that two distinct types of reflection (interface and body reflection) occur and that each type can be decomposed into a relative spectral distribution and a geometric scale factor. The properties of spectral projection into color space are used to derive a new model of pixel-value color distribution. Care should be taken that the noise in the measuring pixel values must be small enough that plane fitting and parallelogram fitting can proceed.

R. T. Tan, K. Nishino, K. Ikeuchi [8] proposed a separation method based on the distribution of specular and diffuse pixels in maximum chromaticity-intensity space. Their method is accurate in separating the reflection component when only the diffuse chromaticity of the normalized image is given.

R. Bajcsy, W. L. Sang, A. Leonardis [9] transformed color pixels in RGB space into the S space and analyzed color variations on objects in terms of brightness, hue and saturation which are defined in the S space. However, their algorithm is only effective for uniformly colored dielectric surfaces under singly colored scene illumination.

S. P. Mallick, T. E. Zickler, D. J. Kriegman and P. N. Belhumeur [10] also proposed a color space SUV, which is a rotation of RGB space, to recover the specular and diffuse components of an image. While this method works well for homogeneous surfaces in the noiseless case, many surfaces are textured and violate the homogeneous assumption.

P. Tan, S. Lin, L. Quan and H. Shum [11] presented a single image highlight removal method incorporating illumination based constraints into an image in painting. The performance of their method is limited for rougher and textured surfaces that require segmentation of the surface into different diffuse colors.

S. W. Lee and R. Bajcsy [12] proposed an algorithm for the detection of secularities based on physical models of reflection mechanisms. The limitation of their algorithm is that disocclusions are detected together with secularities and they are indistinguishable. For specular reflection separation, some methods are proposed with multiple images. With multiple color images taken from different viewing directions.

S. Lin, Y. Li, S. B. Kang, X. Tong and H. Y. Shum [13] presented an approach for identifying and separating specular components from an image sequence. Based on color analysis and multi-baseline stereo. However, the approach may fail to process image sequences that are acquired by a moving camera along a nonlinear path.

S. P. Mallick, T. Zickler, P. N. Belhumeur and D. J. Krigman [14] proposed a unified framework for separating specular and diffuse components in images and videos. Since the erosion is guided by local color and shading information, their method fails to handle large specular regions. By evolving a partial differential equation (PDE) to erode specular reflection.

3. PROPOSED SYSTEM METHODOLOGY

3.1 Problem statement

The task is to design and implement a system that can detect, differentiate and separate specular and diffuse reflection of an image in a pixel-wise way.

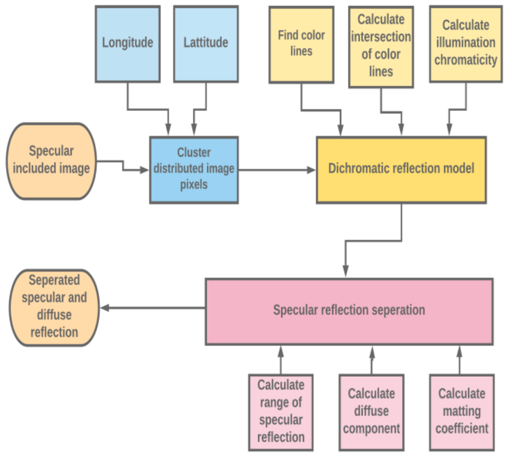

Fig. 1: Proposed system architecture

The four contributions of this work are presented as follows:

- Every image pixel in a color image lies along a color line in the normalized RGB space. Each color line represents a different diffuse chromaticity. We calculate the intersection of these color lines and name it as 'illumination chromaticity'. This is helpful for separating specular refection.
- For an image pixel in the normalized RGB space, its directional vector to the illumination chromaticity is transferred into a spherical coordinate system to derive longitude (ɵ) and latitude (ϕ). Using (ɵ) and (ϕ), we present an algorithm to cluster image pixels for obtaining color lines.
- Pixels along the same color line spread over the entire image and their distances to the illumination chromaticity reect the area and amount of specular reection. With global (non-local) information from these color lines, we propose a method to completely separate specular reection for textured images.
- The proposed method separates specular and diffuse refection of an image in a pixel-wise way, and it is suitable for real-time applications.

4. CONCLUSION

The key conclusion of this paper is that each image pixel lies along a color line in normalized RGB and different color lines representing different diffuse chromaticities intersect at illumination chromaticity. Image pixels are clustered effectively to obtain color lines. Color lines capture global chromaticity knowledge. We then calculate each pixel's distance to illumination chromaticity to separate specular reflection in a pixel-wise manner. One limitation of the proposed method is that our model may fail to handle an image with saturated pixels or high-level noise since the diffuse chromaticity information of the pixels is missing. Also, care should be taken while choosing the number of pixel clusters as it affects the separation performance. If the number of pixel clusters is small, the specular reflection in an image may be over-separated; otherwise, the specular reflection can't be completely removed. This issue has been left for future work.

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