Specular removal of monochrome image using polarization and deep learning

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***Abstract*—We have proposed a method to remove specular reflection from a single polarization image. Most existing methods use color information for specular removal, however, those methods can neither be applied to monochrome images nor achromatic objects. To overcome this problem, we use polarization for specular removal. Most methods not only use polarization camera but also use polarized light, while we use polarization camera and unpolarized light. In addition to polarization, we also use a deep neural network to stably remove specular reflection in a grayscale image.**

***Index Terms*—Polarization, specular removal, CNN, single image, deep neural network, reflection component separation**

I. Introduction

Some works [1]–[3] applied the deep learning to the specular removal problem, however, they do not use polarization.

Umeyama and Godin [4] remove the specular reflection in monochromatic image. Polarizing filter set is set in front of the camera and it is not set in front of the light source. They maximized the mutual information between the diffuse image and the specular image. The measured data may contain some noises, but noise interferes with the value of mutual information.

Our specular removal (reflection component separation) method uses both polarization and deep learning [5], and do not use mutual information. Our method can be applied to a monochrome image or achromatic (black, gray, and white) objects. We use polarization camera, however, we allow the light to be unpolarized.

II. Specular removal

The input grayscale image is taken by a polarization camera without a polarizer set in front of the light source. We obtain the maximum brightness $I_{\max}$, the average brightness I_{avg}, and the minimum brightness $I_{\min}$. We merge these three grayscale images into one color image ($I_{\max}$, I_{avg}, $I_{\min}$), which is a pseudocolor image where the specular reflection is represented as red. The output grayscale image is taken by polarization camera with polarizer set in front of the light source. We copy the minimum brightness $I_{\min}$ into one color image ($I_{\min}, I_{\min}, I_{\min}$), which is a grayscale image without specular reflection. Namely, the input image used as training data is the specular included image ($I_{\text{s},\max} + I_{\text{d}}, I_{\text{s,avg}} + I_{\text{d}}, I_{\text{s},\min} + I_{\text{d}}$). The output image used as training data is the diffuse only image ($I_{\text{d}}, I_{\text{d}}, I_{\text{d}}$).

Fig. 1 shows the result of our method, where ($I_{\max}$, I_{avg}, $I_{\min}$) is pseudo coded as (R, G, B). We emphasize that the input images $I_{\max}$, I_{avg}, and $I_{\min}$ are all monochromatic, and the colored image in Fig. 1 (a) is solely a pseudo-color representation. The color-coded specular reflection shown in Fig. 1 (a) is perfectly removed as shown in Fig. 1 (b).

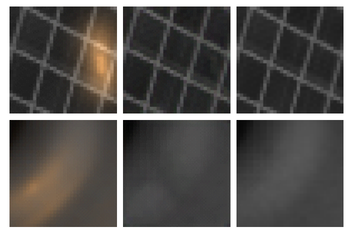

Fig. 1. Result of proposed method: (a) Input image, (b) output image, and (c) ground truth.

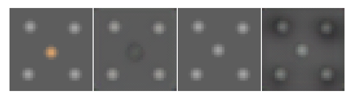

Fig. 2. Qualitative evaluation: (a) Input image of proposed method, (b) output image of proposed method, (c) input image of baseline method, and (d) output image of baseline method.

We also trained the network without polarization for comparison. Our method, which uses polarization, can distinguish the specular reflection from object texture (Fig. 2 (a)), and thus can robustly remove specular reflection (Fig. 2 (b)). The baseline method which does not use polarization cannot distinguish the specular reflection from object texture (Fig. 2 (c)). We have empirically proved that polarization is useful also in CNN-based specular removal.

References

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