論文の内容の要旨

Abstract

論文題目　　　Spectral Modeling of Reflective-Fluorescent Scenes
（反射と蛍光を含むシーンの分光特性モデリング）

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（本文 Body）

Fluorescence frequently occurs in many objects, such as natural gems and corals, fluorescent dyes used for clothing, and plant containing chlorophyll to name a few. In fact, it was reported that fluorescent surfaces are present in 20% of randomly constructed scenes. This is a significant proportion of scenes that have not been considered in the past. Another important point is that reflective and fluorescent components behave very differently under different illuminants. Thus to accurately predict the color of objects, separate modeling of all spectral properties of both reflective and fluorescent components is essential. The goal of this research is to model the full spectral reflective and fluorescent components of an entire scene, and make use of the fluorescence with various computer vision techniques.

The first part of this thesis describes efficient separation and recovery of reflectance and fluorescence emission spectra through the use of two high frequency illuminations modulated in the spectral domain. With the obtained fluorescence emission spectra from the high frequency illuminants, it is then described how to estimate the fluorescence absorption spectrum of a material given its emission spectrum. In addition, I provide an in depth analysis of the method and also show that filters can be used in conjunction with standard light sources to generate the required high frequency illuminants. The proposed method is also tested under ambient light to demonstrate its applicability to synthetic relighting of real scenes.

In the second part, a more practical approach is presented to hyperspectral imaging of reflective-fluorescent scenes using only a conventional RGB camera and varied colored illuminants. The key idea of the proposed approach is to exploit a unique property of fluorescence: the chromaticity of fluorescent emissions is invariant under different illuminants. This allows to robustly estimate spectral reflectance and fluorescent emission chromaticity. Then, given the spectral reflectance and fluorescent chromaticity, the fluorescence absorption and emission spectra can also be estimated. Experimental results demonstrate that all scene spectra can be accurately estimated from RGB images. It is also shown that the proposed method can be used to accurately relight scenes under novel lighting.

In the third part, a novel method is proposed for removing interreflections from only a single image using fluorescence. From a bispectral observation of reflective and fluorescent components recorded in distinct color channels, the proposed method separates direct lighting from interreflections. Experimental results demonstrate the effectiveness of the proposed method on complex and dynamic scenes. In addition, it is shown how the proposed method

improves an existing photometric stereo method in shape recovery.

The main contributions of this dissertation are three folds: the spectral property under high frequency illumination is explored to model the spectral of reflective-fluorescent scenes; a more practical approach is presented to hyperspectral imaging of reflective-fluorescent scenes using only a conventional RGB camera and varied colored illuminants; the bispectral measurement of the fluorescent material is investigate to remove interreflection by using only a single image. The efforts and achievements in this thesis effectively model the spectra of reflective-fluorescent scenes under different capture conditions and equipments and promote the practical capabilities of interreflection removal by only a single image.