論文の内容の要旨

論文題目　Estimation of Atmospheric Turbidity from a Sky Image and Its Applications
（天空画像からの大気混濁係数推定とその応用）

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Sky turbidity is defined as the ratio of optical thickness of the haze atmosphere as opposed to molecules; it is widely used in the computer graphics and vision community for modeling the outdoor illumination.

This thesis investigates the sky turbidity and provides three applications for it. Specifically, the sky turbidity is estimated by matching the brightness distribution between a sky model and an actual image. After the sky turbidity is acquired, it is used for modeling the outdoor illumination environment. By using the estimated sky turbidity, we recover the spectral sensitivity of digital cameras from images, estimate the reflectance of outdoor diffuse object from a single perspective image and insert the virtual object into a real scene.

Camera spectral sensitivity plays an important role for many physics-based computer vision methods, such as demosaicing, color correction and illumination estimation. However, less attention has been paid to estimating the spectral sensitivity. This is unfortunate, because this parameter significantly affect the image colors. We have proposed a novel method for estimating the spectral sensitivity from images. The basic idea is to use the sky images from which the spectra of sky can be inferred. Given the input image, the sky turbidity is estimated by fitting the brightness distribution to a sky model. Assuming the sun direction with respect to the camera view direction can be estimated, the sky spectra is calculated from the estimated sky turbidity. Having obtained the pairs of image RGB values and corresponding spectra, the spectral sensitivity is calculated by using basis-functions. The basis functions are extracted from the database which consists of collected spectral sensitivities of different digital cameras. The utilization of the basis functions makes the estimation accurate and robust.

Three-dimension models have been widely used in many fields. The reflectance is necessary for making a realistic 3D model. However, how to estimate the reflectance still remains a challenge, especially for outdoor objects, because it is difficult to precisely model the outdoor illumination. Much effort has been made to capture the outdoor illumination, but these methods need expensive equipments and massive calibrations. We propose a novel method for estimating the reflectance of outdoor diffuse object from a single perspective image. The sky turbidity is first estimated from the

input image, and then the whole illumination condition is recovered from the estimated sky turbidity. The reflectance is calculated from the surface radiance and irradiance value. The proposed method also solves the problem of inter-reflection, which exists between concave surfaces. We assume the object surface consists of hundreds of small facets, and the inter-reflection is calculated as the incoming light energy from all other facets.

The main contributions of this thesis are that a novel sky turbidity estimation method and its three applications. It can be summarized by the four following points: First, the sky turbidity is estimated by matching the brightness distributions between a sky model and an actual image. Second, the estimated sky turbidity is used for recovering the camera spectral sensitivity. Third, the estimated sky turbidity is used to modeling the outdoor illumination for estimating the reflectance of outdoor diffuse object. Fourth, the estimated sky turbidity is used to calculate the aerial perspective, which makes the appearance of the object change according to distance.

「論文の内容の要旨」の概要

１．課程の別　　課程博士
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３．学位の種類　　博士（情報理工学）
４．学位記番号　　博工　第　　号
５．学位授与日　　平成　年　月　日
６．論文題目　　Estimation of Atmospheric Turbidity　from a Sky Image and Its Applications
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