論文の内容の要旨

SURFACE COLOR ESTIMATION OF LARGE SCALE DIFFUSE OBJECTS UNDER OUTDOOR ENVIRONMENT

（屋外環境下における大規模拡散反射物体の表面色推定）

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Digital three-dimensional models created by the computer vision and graphics technique are becoming widely used in a variety of scenes. Specifically, modeling cultural heritage objects have attracted a lot of attention, since such objects are worth preserving and the data can be utilized for restoration when an object faces the crisis of collapse. Automation for creating 3D models have therefore attracted many interest, since currently, most models are created by manual operation; it causes the significant increase of the cost.

To model an accurate appearance of an object, the object's shape and surface reflectance properties are required. Acquiring shape information has been facilitated by the development of sensors and the progress of data processing algorithms, while acquiring surface reflectance properties remains a challenge, specifically with outdoor objects.

This paper targets a large-scale object such as an architectural structure under outdoor environment. The size of target objects is up to around 100 m by 100 m by 50m. Regarding such a huge object, measuring the surface properties becomes a challenge. The appearance of an object can be modeled by mapping image textures to the known shape of the object. To achieve the consistent colors between image textures, the effect of illumination has to be removed, before mapping them, by the surface color estimation and surface reflectance estimation techniques.

Two methods that calculate a surface color by a pixel-based operation are presented. Most previous methods assume uniform illumination in a scene, while this is not always true in images with shadows or with curved objects. The methods enable pixel-based operation by utilizing the illumination change.　Two models of illumination colors that we introduce make a surface color to be uniquely determined from two pixel values. First, the paper proposes a method that uses blackbody radiation. It analyzes the stability and practicality of the method. Then, a more practical method that can perform robust estimation is proposed, which uses a statistical model derived from outdoor illumination data. The robust estimation is realized by introducing the plausible range of outdoor illumination colors.

In practical situation, surface reflectance would be required for relighting purpose. A method is presented to estimate surface reflectance from spherical images with known shape information. Spherical images have nearly 360 degree field of view; it captures the target objects and surrounding illumination at one shot. Owing to that, neither specific apparatus nor calibration of exposure times, apertures and camera gain factors is needed. Furthermore, geometric calibration between an image and shape information tends to be robust owing to the characteristic of a spherical camera. Measurement and data-processing cost will be decreased by the method compared to previous methods that need elaborate procedures. This is critical specifically for large-scale objects.

The main contribution of this thesis is that the author has proposed three methods that estimate surface properties of an object. It can be summarized by the three following points: First, the research provides insights of the stability and practicality on pixel-based surface color estimation. Second, a pixel-based method for surface color estimation has been developed that is robust and accurate even for real outdoor objects. None of the conventional methods can perform a pixel-based operation with higher accuracy than the proposed method, so far as the author's knowledge. Third, an efficient method has been developed that estimates surface reflectance of large-scale objects under outdoor environment. The proposed techniques would form the foundation of developing a system that models the appearance of a large-scale object under outdoor environment.