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Re-texturing by intrinsic video ☆

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ABSTRACT

In this paper, we present a novel re-texturing approach using intrinsic video. Our approach first indicates the regions of interest by contour-aware layer segmentation. The intrinsic video including reflectance and illumination components within the segmented region is recovered by our weighted energy optimization. We then compute the texture coordinates in key frames and the normals for the re-textured region using the optimization approach we develop. Meanwhile, the texture coordinates in non-key frames are optimized by our energy function. When the target sample texture is specified, the re-textured video is finally created by multiplying the re-textured reflectance component with the original illumination component within the replaced region. As shown in our experimental results, our method can produce high quality video re-texturing results with a variety of sample textures, and also the lighting and shading effects of the original videos are well preserved after re-texturing.

1. Introduction

Image/video re-texturing is a process to replace the existing texture in the concerned region of a photograph or video by new textures, while preserving the original shading and lighting effects. Even for a rich body of work on image/video re-texturing [1,3,5,8,10,17,16,24], the re-texturing using intrinsic video for recovering the illumination and shading effects receives relatively little attention.

Intrinsic images are usually referred to the separation of illumination and reflectance components from an input photograph. The recovery of intrinsic images aims at decomposing an image into illumination component and reflectance component. It is still technically challenging on how to recover the intrinsic images when only a single photograph is available. There has been approaches proposed for such decomposition either from a single image or from image sequences. Tappen et al. [4] proposed an algorithm for recovering intrinsic images from a single photograph. Their approach is based on a trained classifier, which classifies the image derivatives as being caused by either shading or reflectance change. The shading

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and reflectance images are calculated by the classified derivatives. Shen et al. [12] improved Retinex-based algorithm by assuming similar textures correspond to similar reflectance. Recently, Bousseau et al. [15] presented a novel approach for calculating the intrinsic images only from a single image. Their approach requires user interactions for indicating the regions of constant reflectance or illumination, and achieves intrinsic image decomposition by a novel propagation energy using linear least-squares. Shen et al. [18,26] proposed a novel recovery algorithm of intrinsic images using optimization, which is based on the local property assumption of the objects and the Lambertian model. However, these approaches are only limited to the single image re-texturing, and do not support intrinsic video recovery and video re-texturing.

Our work is also closely related to image and video re-texturing techniques, which have been attracting large attentions for a long time, and image-based texture replacement methods have been developed. Liu et al. [3] proposed to use user-assisted adjustment on the regular grid of the real texture, and obtained a bijective mapping between the regular grid of the texture and the deformed grid of the surface image. Their method requires elaborate user interactions and is more suitable for near regular textures. Fang and Hart [1,5] proposed an efficient object texture replacement technique called Textureshop. Their method is based on the assumption that the lighting satisfies Lambertian reflectance model. However, in order to obtain an accurate normal map, non-trivial user interaction is often required. Khan et al. [6] presented an image-based material editing method for making objects transparent and translucent. Their technique also supports re-texturing of high dynamic range (HDR) images with arbitrary surface materials. The major limitation is that their approach assumes the input image is given as a high dynamic range image, so not suitable for re-texturing an ordinary image. More recently, Guo et al. [10] proposed an image and video re-texturing approach which preserved the original shading effects without knowing the underlying surface and lighting conditions. Their method however needs to create a parameterized mesh for the replaced region by the user interaction, and introduces visual artifacts when the mesh parametrization is incorrect.

In this paper, we present a novel recovery algorithm of intrinsic video for decomposing the input video into reflectance and illumination components, which is inspired by the recent work on intrinsic images [4,15]. We propose an efficient recovery approach of intrinsic video based on a new weighted energy optimization, for removing the compressed JPEG artifacts. Then a novel video re-texturing method is developed using intrinsic video, which can be used to re-texture the uniform texture regions. In order to reduce the un-consistent texture distortions in the video re-texturing process, we also present the way for optimizing texture coordinates for video re-texturing, which requires no 3D models and can generate realistic results with the input sample texture.

The main contributions of our paper are summarized as follows:

- A novel re-texturing approach is proposed using intrinsic video for uniform texture region, which is based on our new methods in computing the texture coordinates through energy optimization;
- An efficient recovery algorithm of intrinsic video is presented by using a weighted energy optimization.

The remaining parts of this paper are organized as follows. Section 2 describes our approach in intrinsic video re-texturing, including layer segmentation, weighted energy optimization, normal recovery, and intrinsic video re-texturing. Section 3 presents the experimental results using our approach and discussion with others, and Section 4 gives the summary.

2. Intrinsic video re-texturing

In our framework, we first extract the region to be replaced from the input video using contour-aware layer segmentation. We indicate the contour of the re-textured regions in key frames, and use the contour-aware layer tracking technique to identify the segmented regions in other non-key frames (Section 2.1). We recover the intrinsic video from the above segmented texture regions. Then, we use scribble brushes to indicate the pixels that share a similar illumination or a similar reflectance in key frames, and the positions of scribble brushes for other non-key frames are tracked through energy optimization. Thus, the final intrinsic video can be calculated using our new weighted energy optimization method (Section 2.2).

With the recovered intrinsic video, we compute the normal maps using optimization for the replaced regions (Section 2.3), and obtain the texture coordinates in key frames. Using the texture coordinates in the nearest adjacent key frames, we optimize the texture coordinates in other non-key frames by optical flow. When the target sample texture is specified, the re-texturing video is created through multiplying the re-textured reflectance component by the original illumination component (Section 2.4). As shown in our experimental results, our video re-texturing approach can produce high quality results with a variety of sample textures, while the lighting and shading effects of the original video are preserved well. Table 1 presents pseudocode for the proposed video re-texturing scheme. More details of intrinsic video recovery and video re-texturing scheme are presented in the following sections.

2.1. Contour-aware layer segmentation

To extract the regions to be replaced, our system supports contour-aware layer segmentation using energy optimization. Similar to the interactive tracking and segmentation approach [9,13,20], our system is based on the user defined polygon $C = \{c_k : c_k \in \Re^2\}_{k=1}^{N}$ which indicates the contour of the regions to be replaced in key frames. In order to extract the layer of the re-textured regions, we optimize the following energy function: