Global Illumination-Aware Color Remapping with Fidelity for Texture Values

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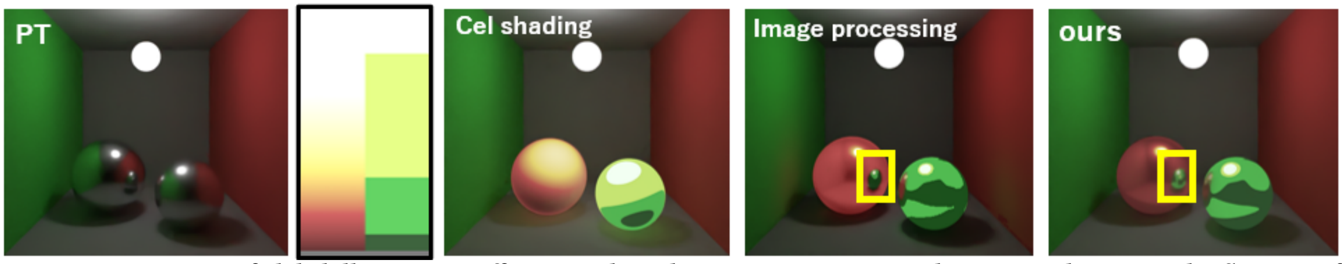

Figure 1: Comparison of global illumination effects. We show that image processing and ours reproduce mutual reflections of the two spheres (indicated by yellow boxes). The textures are inputs for cel shading and our method.

ABSTRACT

Our aim is to convert an object's appearance to an arbitrary color considering the light scattering in the entire scene, which is often called the global illumination. Existing stylization methods convert the color of an object with a 1-dimensional texture for 3-dimensional computer graphics to reproduce a typical style used in illustrations and cel animations. However, they cannot express global illumination effects such as color bleedings and soft shadows. We propose a method to compute the global illumination and convert the shading to an arbitrary color. It consists of subpath tracing from the eye to the object, and radiance estimation on the object. The radiance is stored and used later to convert its color. The method reproduces reflections in other objects with the converted color. As a result, we can convert the color of illumination effects such as soft shadows and refractions.

CCS CONCEPTS

• **Computing methodologies** → **Non-photorealistic rendering**.

KEYWORDS

Photon mapping, Stylization

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1 INTRODUCTION

In hand-painted illustrations, there are stylistic expressions that change the hue along with the brightness of an object, and others that quantize its color. In illustrations, these expressions often appear with realistic illumination effects such as caustics and soft shadows, which depend on the entire scene.

Many rendering methods have been proposed to create images in which stylized color and photorealistic shading are mixed. The cel shading [Lake et al. 2000] looks up the input texture referring to the light or viewpoint from the object to generate hard shading with a few colors as found in hand-painted cel animations. However, not all light reflected by the other objects affect the texture mapping. The same effect can be achieved by postprocessing the rendered result [Fišer et al. 2016; Magdics et al. 2013]. However, it does not directly compute the propagation of the stylized color in the scene. Therefore, these methods cannot be applied in a scene in which the light interaction are visually important, for example, the caustics caused by light passing through glass.

We propose a method that remaps the rendering equation [Kajiya 1986] in a similar processing phases to progressive photon mapping [Hachisuka et al. 2008]. It expresses the shading that varies in photorealistic shading using 1-dimensional (1D) texture, whereas it reproduces the global illumination (Fig. 1). The main contributions are as follows.

- Our color remapping method uses a 1D texture and consider the reflection and refraction among objects.
- Comparisons show that our method reproduces global illumination better than existing methods.
- The resulting image only contains the specified input texture colors (compared to our work [Doi and Morimoto 2020] with a similar concept).
- Our method contains an effective PPM-based calculation that enables the object's radiance to be converted afterward.

2 METHOD

We refer to the object in the scene to be color converted as the remapping object. We map a color to another color to edit the

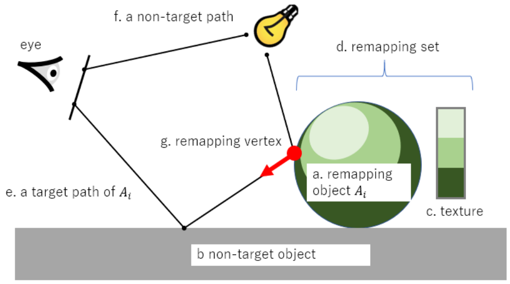

Figure 2: Overview of our method. We apply the color conversion to the vertices of the target paths.

appearance of the remapping object with a 1D texture. We define the target path as a light transport path that has vertices on a remapping object (Fig. 2a). An object that is not the remapping object is defined as non-target object (Fig. 2b), and a path in which all vertices are on non-target objects is defined as a non-target path (Fig. 2f). We assign a texture t (Fig. 2c) to each remapping object, and we define the assignment (A,t) the remapping set (Fig. 2d). The vertex of a target path where we convert the radiance is defined as the remapping vertex (Fig. 2g).

Our method calculates the components of all non-target paths (Fig. 3a) and components of the target paths of each remapping object (Fig. 3b, c) that is chosen without overlap from the union of all the target paths of all remapping objects. In Fig. 3, the two spheres reflect light from each other to yield a path that belongs to the target path of both the spheres, but such a path is classified as either a contribution component of b or c in Figure 3. To obtain the components for each remapping object, we compute the radiance of the remapping vertices and accumulate the arbitrarily converted color with the assigned texture from the radiance in the following steps. Here we deal with only fully diffuse or fully specular objects for our implementation however a simple extension of our method would render not-fully diffuse or -specular objects.

1. Ray tracing phase: We trace paths from the eye in the scene and store one remapping vertex on the remapping object for each path (Fig. 3g). The attenuation rates of each R, G, and B channel through the subpath is stored along with each remapping vertex. To generate the results in this paper, we classified those paths in the ray tracing phase so that diffuse reflective objects return the texture values assigned to themselves and objects with specular reflective components appear to be the color of the reflected object.
2. Photon tracing phases: We create a photon map in which each photon travels along arbitrary path starting from the light source. We then use PPM to obtain the radiance of the remapping vertices (Fig. 3g). The estimation is stored with each remapping vertex.
3. Accumulation: For each remapping vertex, we convert the radiance using the assigned texture, and the multiplication of the texture values by the attenuation rates are added to the corresponding pixel.

This ray tracing phase differs from common photon mapping. Whereas photon mapping stores intersection points on the first diffuse object during ray tracing, the proposed method continues ray tracing until it reaches to the remapping object. We use PT to obtain the contribution of all non-target paths (Fig. 3a) separated of those of target paths. Finally, we total all components (Fig. 3a, b, c) to obtain the output image (Fig. 3d).

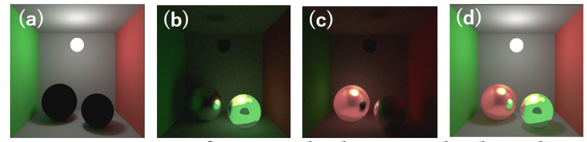

Figure 3: Overview of our method. We apply the color conversion to the vertices of the target paths.

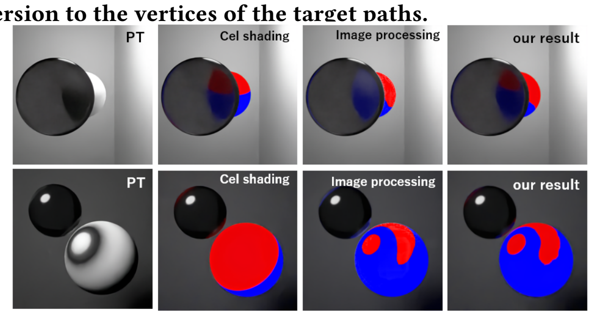

Figure 4: Comparison of refraction (top) and caustics (bottom)

3 RESULT

We compared the effect of global illumination of our method with existing methods. The existing methods can be divided into two groups: those that use the scene geometry and those that use the rendered pixel values. For the first group, we chose cel shading [Lake et al. 2000] as a comparison method. For the second group, we implemented an image processing method that can take into account the interreflections among the surroundings. We compared the results using the existing methods and ours with two scenes that include caustics and refraction, respectively (Fig. 4). In both comparisons, our results retained the shape and color characteristics of shading.

We proposed a method which enable stylized shading of 3D scene considering the global illumination. Our method determines the texture values reproducing the effects of global illumination with other objects when compared with existing methods. Furthermore, it enables converting the radiance of the objects afterward.

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