Real-Time Rendering of Billboard Plants in a Dynamic Lighting Environment

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1 Introduction

Realistic rendering of nature is still a very challenging task. Even a small part of a forest includes thousands of trees, shrubs and other plants. To achieve real-time rates it is necessary to use very simplified models. Since the foliage consists of many arbitrary orientated elements, standard level of detail methods producing inaccurate results. Décoret *et al.* [Décoret et al. 2003] introduced billboard clouds to reduce the complexity of polygonal models. A modified version of this approach can be used for plants as well. A tree is converted into a collection of billboards, that are representing individual parts of the original object. This method however leads to problems when rendering the new models, because the position and normal of the elements were changed during the creation process. In our sketch we present a new approach to render billboard plants in a dynamic low-frequency lighting environment. A additional illumination texture enables us to include many lighting effects like self-shadowing or subsurface scattering in real-time.

Figure 1: Comparison of the original and the billboard model.

2 Exposition

Plant tissue has a lot of interesting optical properties, that can be rendered in a photo-realistic way using a ray tracing approach [Franzke and Deussen 2003]. Although the calculation is fast it still takes some minutes to visualize a tree. Spherical harmonic lighting [Sloan et al. 2002] on the other hand is able to handle almost every lighting effect in real-time including translucency. In a preprocessing step spherical harmonic coefficients of the plants are calculated and stored at each vertex of the models. Now these objects could be rendered directly using the latest shader technology. To reduce the number of necessary triangles a billboard cloud is calculated from the original plant. For each billboard we render a color and a illumination image from the combined elements. The first texture includes the unlit base color of the original model. During runtime a alpha channel is used to mask the invisible parts of the billboard. The illumination texture represents the bilinear interpolated spherical harmonic coefficients of the original plant. The simplified models can be rendered in real-time using a very simple pixel shader, that uses the current value of the illumination texture to relight the base color of the fragment. Some care has to be taken while creating the mip-map images. Otherwise the bilinear interpolation during access of the texture leads to incorrect coefficients, which can be seen as unrealistic colored pixels. We solved this problem by expanding the illumination image with respect to the alpha mask. The spherical harmonics solution is able to include arbitrary shaped reflection functions (BSSRDF). To minimize the size of the textures we are only using diffuse BSSRDFs during preprocessing. Since natural scenes are usually surrounded by a low-frequency lighting environment we found that two spherical harmonic bands are enough to render the plants. In this case only one image with four channels is needed for the illumination texture. Since the coefficients were calculated using the original plant we are able to relight the simplified model in a very realistic way. Global lighting effects like shadows from one tree on another are not yet included in the solution. In natural environments the sun is the most important light source. We exploited this fact, by additionally rendering a standard shadow map for the sun. During rendering of the billboard plants the shadowing of the current fragment is used to attenuate the spherical harmonic illumination. Using this approach we were able to visualize large landscapes, that are covered by thousands of plants in real-time. It is possible to dynamically change the lighting environment, which enables us to render the scene at different day-times and weather conditions.

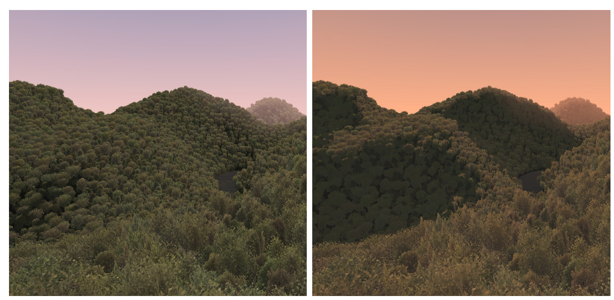

Figure 2: A natural landscape at different day-times. (4 - 21 FpS)

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