Rendering Plant Leaves Faithfully

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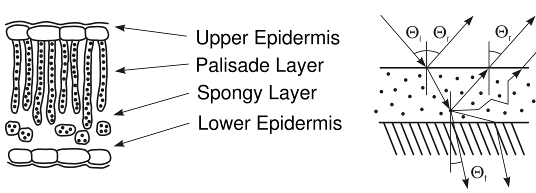
We present a practical approach for an improved representation of translucency in plants. This approach is based on a set of specially obtained textures that are combined with a biologically motivated optical model for leaves.

Figure 1: A plant model illuminated from different sides. Using the proposed method the translucency is rendered correctly

A leaf is usually modelled by four layers with different optical properties [Vogelmann 1993]. The upper and lower epidermis cover the leaf, in the interior a layer of elongated palisade parenchyma is arranged densely in parallel to the incident radiation (cf. Figure 2).



(a) (b)

Figure 2: (a) Leaf interior b) scattering of light in an optical layer

The light passes through these cells into the spongy layer of the leaf. The elliptical cells, which are interspersed with intercellular air spaces, cause internal scattering of the incident radiation and thereby distribute the light within the leaf. This process is important for an optimal absorption of the light by the leaf's mesophyll. In several papers the spectral reflection of leaves was measured [Hosgood et al. 1995; Wolley 1971]. Also, some attempts have been made to simulate this behaviour [Govaerts et al. 1996]. However, the rendering of some leaves still needs about 95 minutes on an SGI R10000 (cf. [Baranoski and Rokne 2001]). On the other hand, efficient methods for rendering subsurface scattering were proposed by Jensen et al. [Jensen et al. 2001].

In our ray tracing approach the leaf is represented by a set of textures obtained from real leaves. The leaf is modelled by three layers with two internal and two external borders. The reflection of upper and lower side is modelled by a reflection scan of the corresponding plant leaves. The leafs extinction is obtained by a through light scan and serves also as a source for a thickness map.

During ray tracing, the ray is refracted at each border, optical experiments show that mostly forward scattering takes place in plant leaves, hence backscattering can be neglected. Similarly to Jensen et al. [Jensen et al. 2001] the ray is traced through the scattering media of the interior of the leaf and the single scatter term is computed. Light intensity is reduced exponentially according to the extinction map. The multi scatter term is approximated by a small ambient factor - optical experiments justify this for thin leaves. The internal structure of the leaf (the spongy layer) is represented by the textures and the corresponding reflection as well as transmission functions. For efficiency reasons we omitted modelling the interior geometrically. Using our technique we are able to render medium sized plants in high resolution within a few minutes. The accompanying video demonstrates that the results are suitable for animations. In the future we will extend our model to larger plants and try to implement a good approximation in hardware using vertex and pixel shaders.

Figure 3: A small bush rendered with translucency.

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