Photorealistic Computer Graphics Synthesis of Rose based on the Macro- and Micro Scopic Scale Structures

Ikuo Terado

School of Information Science,
Japan Advanced Institute of Science and Technology

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This papar describes a reflection and transparency model of rose petals for photorealistic computer graphics. Our model for each rose petals is based on the micro-scopic scale structures, such as dome-shaped and translucent cells. The model has some parameters whose values are estimated from measuring of reflected light's intensities on rose petals. The values of those parameters are adjusted for the faithful simulation of the optical phenomena on rose petals. Moreover, a reciprocal diffuse reflection and transparency model among petals is based on the macro-scopic scale structures. Finally, photorealistic images of roses are shown.

The shading models, such as diffuse and specular reflection models, represent appearance on surfaces. These are generally used for calculation of reflection distribution on any surface. The diffuse reflection which calculated using the Lambertian model with incident light angle represents matte surfaces. It is independent of the viewing direction. The specular reflection modeled ideal reflection, so represent shiny surface such as plastic. The intensity of specular reflection is calculated using the Phong model, the Blinn model and so on. The Lambertian and the Phong models is not suitable for representing the intensity of reflected light on rose petals. Because incident light on rose petals tend to reflect toward the light sources.

The reflection distribution of rose petals cause by optical phenomena on the petals' cells. Therefore, we model micro-scopic scale structures of rose petals in order to faithfully simulate optical phenomena on them. The rose petal is composed of four layers; upper epidermal cells, palisaide cells, spongy cells and lower epidermal cells. Two especially characteristic layers, such as upper epidermal cells which are dome-shaped and spongy cells which reflect much light, cause the unique appearance of rose petals. Hence we model these cells layers as follows:

- the shape model of upper epidermal cells,

  1. Modeling cell's base surfaces

     We consider a triangular grid whose interval is ω, and locate the centers of cell at the grid intersections. ω is set to be $23[\mu\mathrm{m}]$ because the upper epidermal cells' widths are approximately 23. The cell's boundarys are obtained by using Voronoi-division so that each cell's base surface shape into hexagon.

  2. Modeling dome-shaped cells on the base surfaces

     The dome-shaped cells is constructed. On each base surface, a dome-shaped cell is constructed as follows. For any point in the base surface, the height is calculated as cosine function. where h is $37[\mu\mathrm{m}]$ which is the average of the domes' height, r is distance from a center point of the cell.

- the shading model of upper epidermal cells,

  The intensity of reflection light on upper epidermal cells calculated using the Lambertian model and the Phong model. The cells are shown highlight on shiny surface.

- the shading model of spongy cells.

  The intensity of reflection light on upper epidermal cells also calculated using the Lambertian model and the Phong model. The cells are not shown highlight on dully surface.

We render the upper epidermal and the spongy cells using the Lambertian model for diffuse reflection and the Phong model for specular reflection. The total intensity of outgoing light on both the cells is calculated the sum of the intensity of these cells. These reflections coefficients are estimated from measuring of reflected light's intensities on rose petals using the least square method.

Our model is suitable for representation of the reflectance distribution of rose petals. We calculate the reflectance distribution using our model in order to confirm its validity. Our simulated results approximate the measured values.

We apply the stochastic sampling for showing the appearance of macro-scopic scale structures based on the micro-scopic scale structures. This method offers the following advantages;

- it reduces aliasing from images,

- a dully or shiny surface of a rose petal is modeled with the small or large number of the sampling points.

Moreover, the rose consists complicated shaped petals. Consequently, reciprocal diffuse reflection and transparency model among petals is based on the macro-scopic scale structures. The reciprocal diffuse reflection calculated using the radiosity method. The reciprocal transparency calculated using improved the radiosity method.

Finally, We show the photographs of a rose and computer graphics using old shading model and our micro-scopic scale structures models. The image using our shading models

looks like photographs better than the image using old shading model. We show images of rose with dully and shiny petals by using small and large number of the stochastic sampling. Moreover, We show the computer graphics using only raytracing method and using raytracing method and radiosity method based on macro-scopic scale structures.