Spring Conference on Computer Graphics 2009

Genetic Algorithms for Estimation of Reflectance Parameters

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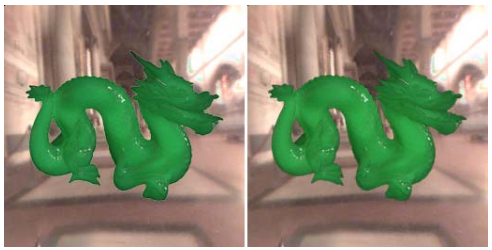
Most of the current appearance acquisition methods require the use of specialized equipment and/or involved capture sessions. We propose a single-image approach based on genetic algorithms which greatly simplifies the process, and allows to estimate reflectance properties of both opaque and translucent objects. Given the underconstrained nature of an image-based approach, we leverage two well-known illumination models, Phong and the diffuse approximation, to reduce the high-dimensional parameter space. Additionally, a study was carried out to provide guidance in the election of the configuration parameters of the genetic algorithm.

Methodology

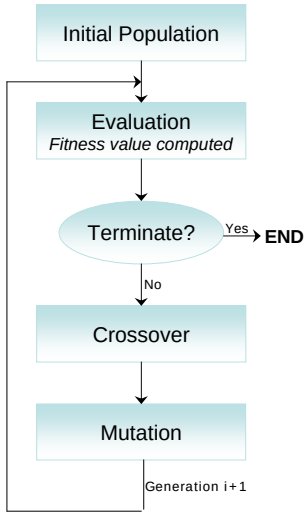
Our approach poses appearance acquisition as an optimization problem. Starting from an initial set of reflectance parameters, successive images are rendered and compared with the original input image until the objective function, defined as the error between both images, falls below a certain value (or alternatively until a maximum execution time is exceeded). We assume that the rest of the information of the 3D scene (lights, geometry, etc.) is known.

Results

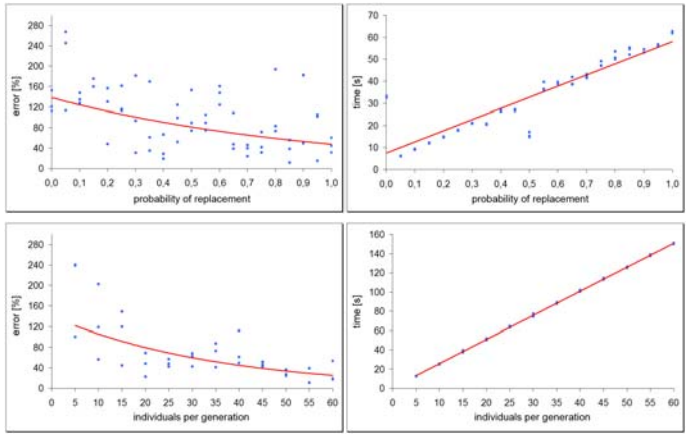


Each pair depicts the input image and the image rendered with our algorithm. Translucent materials (*left*) are modeled with the diffuse approximation illumination model [1], whereas for opaque materials (*below*) the Phong model is employed. Rendering times are around 20 minutes for the translucent ones and 1 minute for the opaque one.

Configuring the genetic algorithm



Structure of a genetic algorithm. The population is formed by strings of the sought parameters, each string being an individual.



Genetic algorithms have a series of input parameters whose correct configuration is vital in reaching a consistent solution within a reasonable execution time.
The graphs show the effect of two of the most significant parameters (probability of replacement, which accounts for the percentage of individuals eliminated in each evaluation step, and number of individuals per generation) in the accuracy and computational cost of the final result. These data correspond to the Phong model.

Relevance of the size of the search space: original image, image rendered using a global search space and image rendered using a reduced search space. The latter approximates the ground truth image more closely for the same number of iterations.

References: [1] Jensen, H. W et al. 2001. A practical model for subsurface light transport. In SIGGRAPH, ACM, Los Angeles, California, 511–518.