Computer Graphics Forum Technical Papers in EGSR 2018

Reproducing Spectral Reflectances From Tristimulus Colours

H. Otsu, M. Yamamoto and T. Hachisuka
The University of Tokyo, Japan

First published: 30 March 2018
DOI: 10.1111/cgf.13332

Abstract: Physically based rendering systems often support spectral rendering to simulate light transport in the real world. Material representations in such simulations need to be defined as spectral distributions. Since commonly available material data are in tristimulus colours, we ideally would like to obtain spectral distributions from tristimulus colours as an input to spectral rendering systems. Reproduction of spectral distributions given tristimulus colours, however, has been considered an ill-posed problem since single tristimulus colour corresponds to a set of different spectra due to metamerism. We show how to resolve this problem using a data-driven approach based on measured spectra and propose a practical algorithm that can faithfully reproduce a corresponding spectrum only from the given tristimulus colour. The key observation in colour science is that a natural measured spectrum is usually well approximated by a weighted sum of a few basis functions. We show how to reformulate conversion of tristimulus colours to spectra via principal component analysis. To improve accuracy of conversion, we propose a greedy clustering algorithm which minimizes reconstruction error. Using pre-computation, the runtime computation is just a single matrix multiplication with an input tristimulus colour. Numerical experiments show that our method well reproduces the reference measured spectra using only the tristimulus colours as input.

Re-Weighting Firefly Samples for Improved Finite-Sample Monte Carlo Estimates

Tobias Zirr, Johannes Hanika and Carsten Dachsbacher
Karlsruhe Institute of Technology, Germany

First published: 30 March 2018
DOI: 10.1111/cgf.13335

Abstract: Samples with high contribution but low probability density, often called fireflies, occur in all practical Monte Carlo estimators and are part of computing unbiased estimates. For finite-sample estimates, however, they can lead to excessive variance. Rejecting all samples classified as outliers, as suggested in previous work, leads to estimates that are too low and can cause undesirable artefacts. In this paper, we show how samples can be re-weighted depending on their contribution and sampling frequency such that the finite-sample estimate gets closer to the correct expected value and the variance can be controlled. For this, we first derive a theory for how samples should ideally be re-weighted and that this would require the probability density function of the optimal sampling strategy. As this probability density function is generally unknown, we show how the discrepancy between the optimal and the actual sampling strategy can be estimated and used for re-weighting in practice. We describe an efficient algorithm that allows for the necessary analysis of per-pixel sample distributions in the context of Monte Carlo rendering without storing any individual samples, with only minimal changes to the rendering algorithm. It causes negligible runtime overhead, works in constant memory and is well suited for parallel and progressive rendering. The re-weighting runs as a fast post-process, can be controlled interactively and our approach is non-destructive in that the unbiased result can be reconstructed at any time.

Optimal Sample Weights for Hemispherical Integral Quadratures

Ricardo Marques[1], Christian Bouville[2] and Kadi Bouatouch[2]
1. Universitat Pompeu Fabra, Spain
2. Institut de Recherche en Informatique et Systèmes Aléatoires, France

First published: 10 April 2018
DOI: 10.1111/cgf.13392

Abstract: This paper proposes optimal quadrature rules over the hemisphere for the shading integral. We leverage recent work regarding the theory of quadrature rules over the sphere in order to derive a new theoretical framework for the general case of hemispherical quadrature error analysis. We then apply our framework to the case of the shading integral. We show that our quadrature error theory can be used to derive optimal sample weights (OSW) which account for both the features of the sampling pattern and the bidirectional reflectance distribution function (BRDF). Our method significantly outperforms familiar Quasi Monte Carlo (QMC) and stochastic Monte Carlo techniques. Our results show that the OSW are very effective in compensating for possible irregularities in the sample distribution. This allows, for example, to significantly exceed the regular $O(N^{-1/2})$ convergence rate of stochastic Monte Carlo while keeping the exact same sample sets. Another important benefit of our method is that OSW can be applied whatever the sampling points distribution: the sample distribution need not follow a probability density function, which makes our technique much more flexible than QMC or stochastic Monte Carlo solutions. In particular, our theoretical framework allows to easily combine point sets derived from different sampling strategies (e.g. targeted to diffuse and glossy BRDF). In this context, our rendering results show that our approach overcomes MIS (Multiple Importance Sampling) techniques.

Turning a Digital Camera into an Absolute 2D Tele-Colorimeter

G. C. Guarnera[1], S. Bianco[2] and R. Schettini[2]
1. Norwegian University of Science and Technology, Gjøvik, Norway
2. University of Milano-Bicocca, Milano, Italy

First published: 10 April 2018
DOI: 10.1111/cgf.13393

Abstract: We present a simple and effective technique for absolute colorimetric camera characterization, invariant to changes in exposure/aperture and scene irradiance, suitable in a wide range of applications including image-based reflectance measurements, spectral pre-filtering and spectral upsampling for rendering, to improve colour accuracy in high dynamic range imaging. Our method requires a limited number of acquisitions, an off-the-shelf target and a commonly available projector, used as a controllable light source, other than the reflected radiance to be known. The characterized camera can be effectively used as a 2D tele-colorimeter, providing the user with an accurate estimate of the distribution of luminance and chromaticity in a scene, without requiring explicit knowledge of the incident lighting power spectra. We validate the approach by comparing our estimated absolute tristimulus values (XYZ data in cd/m^2) with the measurements of a professional 2D tele-colorimeter, for a set of scenes with complex geometry, spatially varying reflectance and light sources with very different spectral power distribution.