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In-situ multi-scattering tomography

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Abstract

To recover the three dimensional (3D) volumetric distribution of matter in an object, images of the object are captured from multiple directions and locations. Using these images tomographic computations extract the distribution. In highly scattering media and constrained, natural irradiance, tomography must explicitly account for off-axis scattering. Furthermore, the tomographic model and recovery must function when imaging is done in-situ, as occurs in medical imaging and ground-based atmospheric sensing. We formulate tomography that handles arbitrary orders of scattering, using a monte-carlo model. Moreover, the model is highly parallelizable in our formulation. This enables large scale rendering and recovery of volumetric scenes having a large number of variables. We solve stability and conditioning problems that stem from radiative transfer (RT) modeling in-situ.

1 Introduction

Recovering scenes via participating media [1–6] often focus on observing background objects [7–9]. However, it also important to recover the medium itself, as done in remote sensing of the atmosphere. Recent works seek volumetric recovery of a three dimensional (3D) heterogeneous scattering media, focusing on the atmosphere. Being very large, recovery of the atmosphere generally requires passive imaging, using the steady, uniform and collimated Sun as the radiation source. The data is images acquired from multiple directions [10], which sample the scene's light-field.

Based on multi-view image data, computational tomography (CT) yields 3D volumetric recovery in many domains [11–14], including biomedical imaging. However, in most CT models, as in X-ray, direct-transmission [15] forms the signal, while small-angle scattering has been considered to be a perturbation. In contrast, in a medium as the atmosphere, the source (unidirectional sun) and detector (wide angle camera) are generally not aligned: *scattering*