Image-Based Tomographic Reconstruction of Flames

Ivo Ihrke and Marcus Magnor
Max-Planck-Institut für Informatik, Saarbrücken, Germany

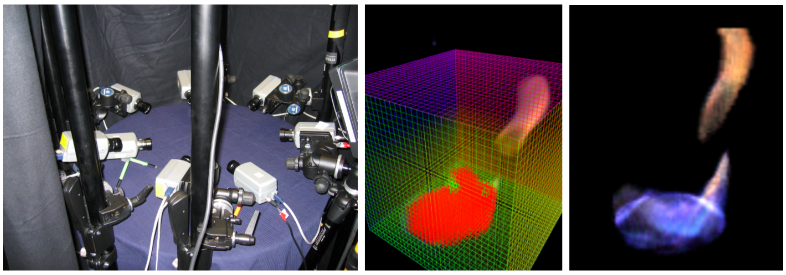

Figure 1: Camera setup for recording fire, image-based reconstruction, rendering

1 Description

Non-invasively determining the three-dimensional structure of real flames is a challenging task. We present a method for reconstructing a dynamic volumetric voxel model from multiple images of fire. The resulting three-dimensional flame model is useful for analyzing gas-dynamics in fires, as well as for realistic rendering of flames. The chaotic behavior of fire is generally not well captured in current modeling methods. We use an image based approach to model the three-dimensional distribution of emissivities in real flames. To that end we apply a three-dimensional sparse view tomographic method.

Transparent phenomena have not received a lot of attention in image based reconstruction up to now. There have been some approaches trying to extend surface reconstruction by taking transparency into account [Bonet and Viola 1999]. Computerized tomographic methods have been applied to rigid body reconstructions [Gering and Wells III 1999]. The only work the authors are aware of that treats transparent, volumetric phenomena is the work of Hasinoff et. al. [2003].

Our work, in contrast to previous work, is a real three-dimensional approach, being essentially a three-dimensional computerized tomography approach with perspective projection taken into account. We differ with the existing computerized tomography literature in that we restrict the solution by using additional information about the visual hull of the phenomena to discard variables (voxel emissivities) that need not to be computed. This is not possible in the inversion of the Radon-transform which is usually used to solve the problem efficiently. Therefore we chose to use an algebraic representation of the inversion formula, discretizing the space into a set of basis functions with local support. The coefficients of these basis functions are estimated by solving a large sparse linear system of equations. We use the iterative conjugate gradient method which has regularizing properties and is therefore suited for solving ill-posed problems.

2 Experiments

We record a multi-video-sequence with 8 cameras at a resolution of 640x480 pixels with 15 frames per second. An approximately circular camera setup is used to acquire the images. The recording is performed in a darkened room, the fire being the only source of light. It is therefore possible to circumvent the step of background subtraction, which is nontrivial for transparent phenomena.

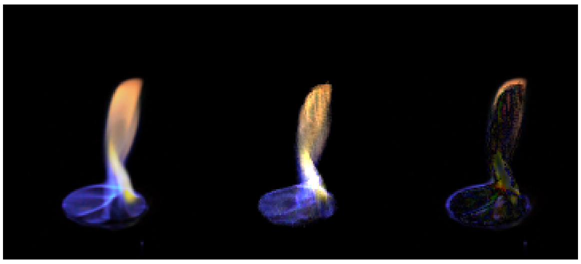

Figure 2: Original, unused view - reconstruction - difference.

Since we aim at creating photo-realistic images from arbitrary view points using the reconstructed volumetric model, we rendered the model after reconstructing it. The reconstruction was performed using all views except for one, which in turn was used to validate a rendered image of the model by computing the difference between the two images. One of the frames of this validation is shown in Fig. 2. The outline in the difference image results from inaccurate calibration of the cameras.

References

BONET, J. S. D., AND VIOLA, P. A. 1999. Roxels: Responsibility Weighted 3D Volume Reconstruction. In *ICCV 1999*, 418 – 425.

GERING, D. T., AND WELLS III, W. M. 1999. Object Modeling using Tomography and Photography. In *Proceedings of IEEE Workshop on Multi-View Modeling and Analysis of Visual Scenes*, 11–18.

HASINOFF, S. W., AND KUTULAKOS, K. N. 2003. Photo-Consistent 3D Fire by Flame-Sheet Decomposition. In *In Proceedings of 9th IEEE International Conference on Computer Vision ICCV 2003*, 1184 – 1191.

HASINOFF, S. W., 2002. Three-Dimensional Reconstruction of Fire from Images. MSc Thesis, University of Toronto, Department of Computer Science.