Fine-Scale Editing of Continous Volumes using Adaptive Surfaces

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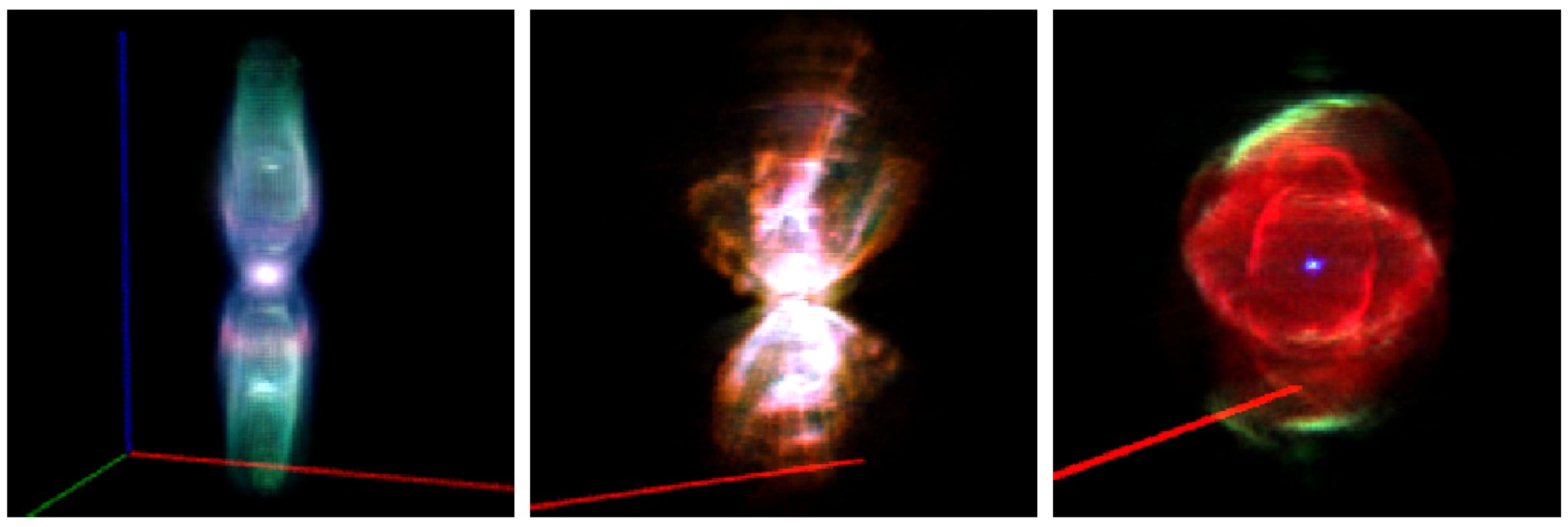
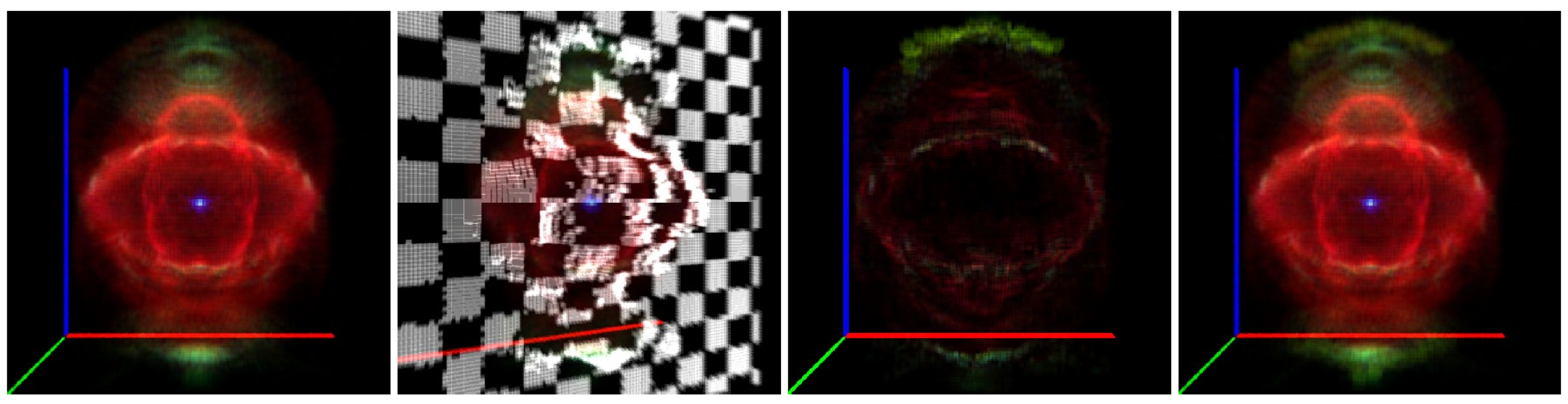
Motivation

- Astronomical nebulae are continuous volumes without object boundaries – how to edit?
- Fine-scale painting inside a volume should be as easy as painting on a 2D image



Step 1: Planar surfaces

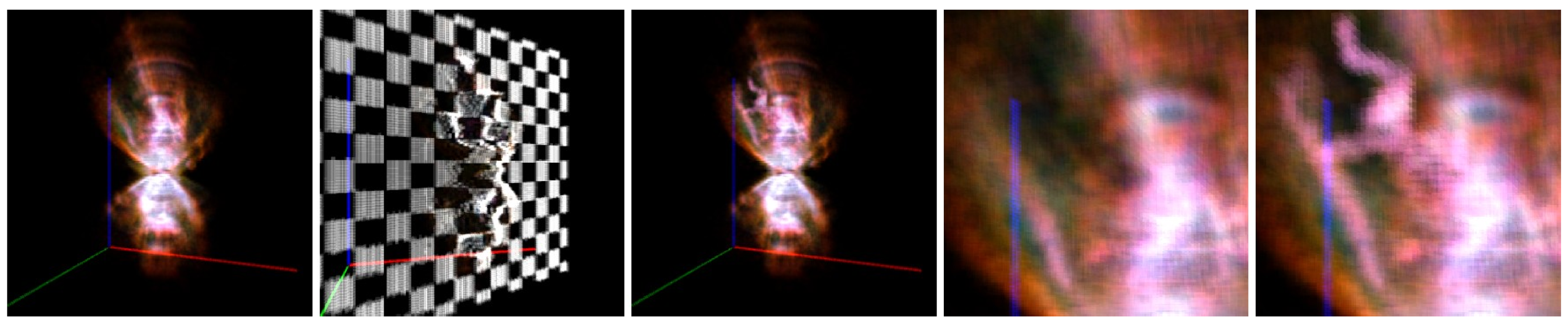
- Volume $V : \mathbb{R}^3 \rightarrow \mathbb{R}^3$ of tuples $\mathbf{v} = (r, g, b)$ at positions $\mathbf{x} = (x, y, z)$, with size $s \times s \times s$
- Axis-aligned slices: Each z-step represented by one layer $I : \mathbb{R}^2 \rightarrow \mathbb{R}^3$ centered at $\mathbf{x}_I = (\frac{s}{2}, \frac{s}{2}, z_i)$ shifted along z_i ; painting per layer as in [1]
- Rotating slices: Angles ϕ_x, ϕ_y to adapt locally to nebula structures, shift along plane normal $\vec{n}_z$



Step 2: Adaptive surfaces

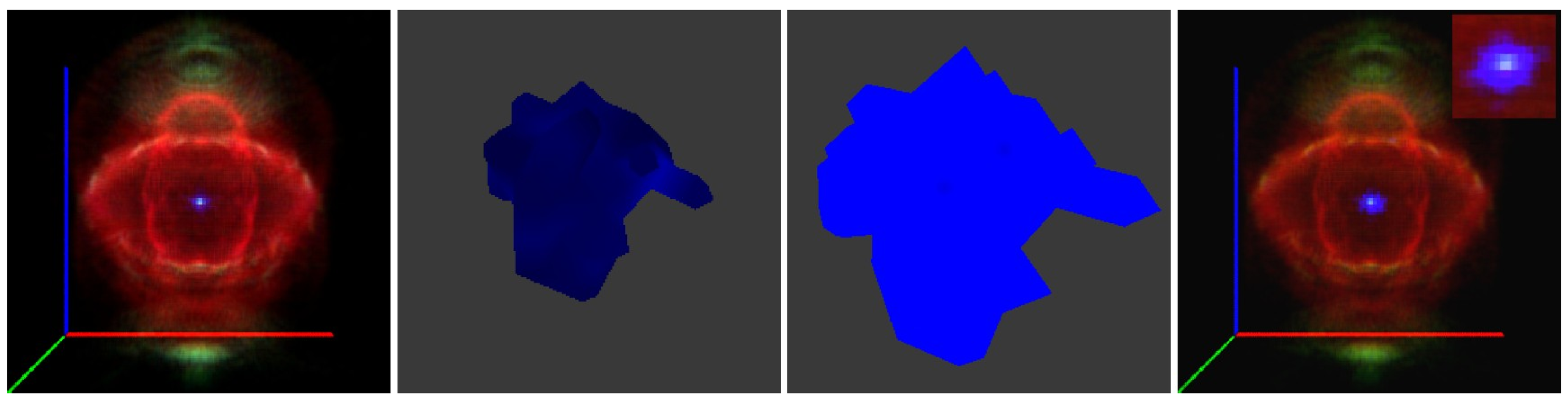
- Find curved surface I_c which snaps to user-picked color $\mathbf{c}$, expressed as energy:

$$\min_{z(x,y)} \iint \Big(\overbrace{\|\mathbf{c} - V(I(x,y) + z(x,y)\vec{n}_z)\|_1}^{\text{data term}} + \underbrace{\lambda_s \|\nabla z(x,y)\|_2}_{\text{smoothness}} + \underbrace{\lambda_r |z(x,y)|}_{\text{inertia}} \Big)\, dx\, dy$$



Step 3: Solve for Adaptive surface

- Evaluate data term (color constancy) and inertia term (closeness to original surface I) pointwise along the $\vec{n}_z$ direction in $V(I + z\vec{n}_z)$
- Smooth with Gaussian kernel of user-specified size k_s for more or less curvature
- Usually only one iteration necessary to achieve good results at real-time performance.
- Paint on surface via standard raytracing.



Future work

- Explicitly build layered representation, deform all surfaces at once
- Directly deform volume without any assumed knowledge of surfaces.

Contribution

- First to explore interactive fine-scale editing of continous volumes without having intrinsically segmentable surfaces.

References

[1] C. Anstey, "3Dish" axis-aligned volumetric slice editor, 2011, http://code.google.com/p/3dishvolumetric-editor/

[2] K. Bürger, J. Bürger, J. Westermann: Direct volume editing. IEEE Transactions on Visualization and Computer Graphics 14, 6 (2008), pp. 1388–1395.

[3] W. Steffen, N. Koning, S. Wenger, C. Morisset, M. Magnor: Shape: A 3D modeling tool for astrophysics. IEEE Transactions on Visualization and Computer Graphics (TVCG) 17, 4 (Apr. 2011), pages 454–465.

[4] S. Wenger, M. Ament, W. Steffen, N. Koning, D. Weiskopf, M. Magnor: Interactive visualization and simulation of astronomical nebulae. Computing in Science & Engineering 14, 3 (2012), pp. 78–87.

http://graphics.tu-bs.de/publications/ruhl2013vmv