Volumetric Style Transfer using Neural Cellular Automata

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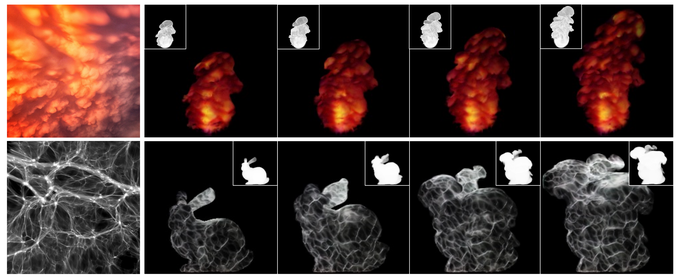
Problem

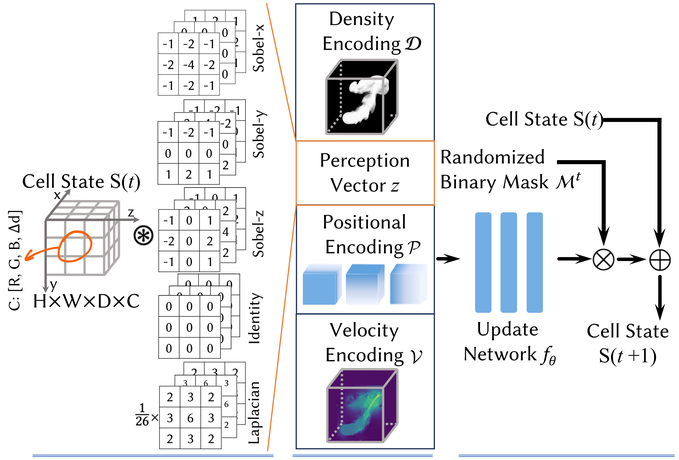
The difficulty of exemplar-based stylization of 3D volumetric smoke data:
- Ensuring the stylization consistency across multi-views and time frames
- Preserving visually plausible motion as the original smoke data.
- Requiring reasonable time and computational resources.



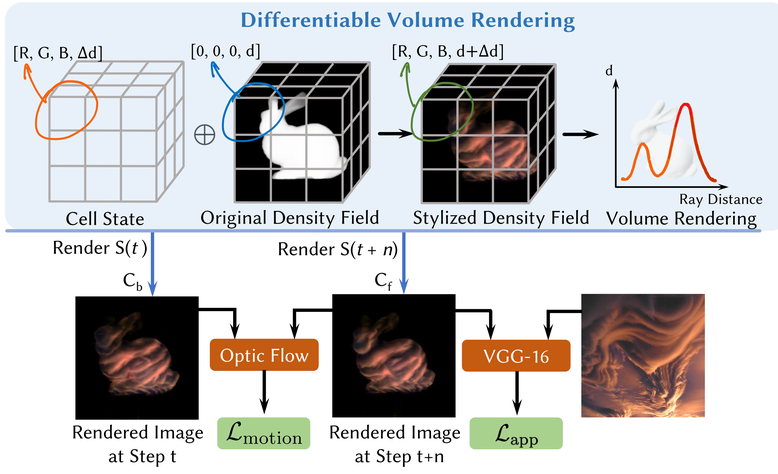
Style Image Stylized Smoke Sequence

We introduce Volumetric Neural Cellular Automata (VNCA), a novel method synthesizing volumetric temporal textures for smoke stylizations in real-time.

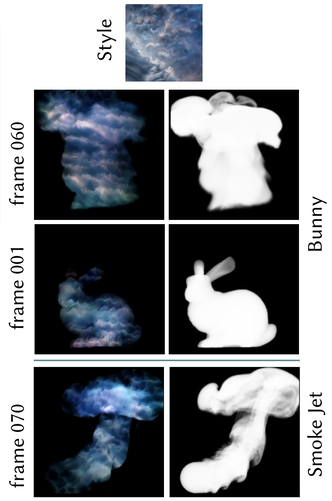
VNCA Update Rule



Training Scheme



Generalization Ability

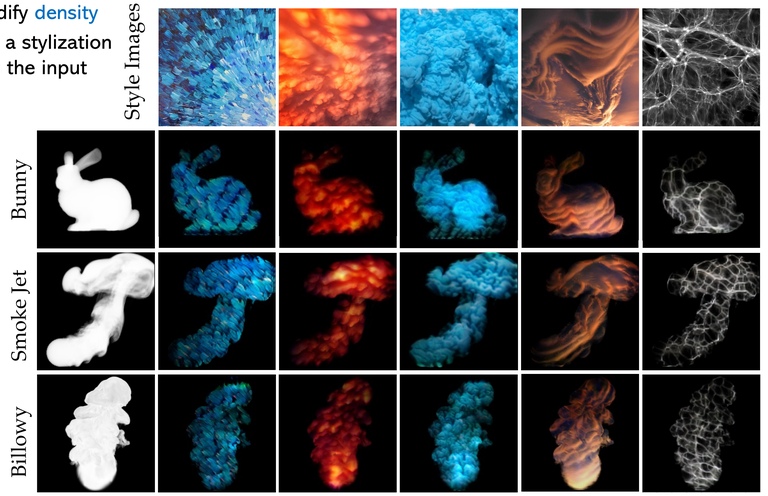


Contributions

- VNCA present a novel volumetric temporal texturing method for real-time stylization of 3D smoke simulations that is consistent w.r.t the style image with visually plausible smoke motion.
- VNCA speed up baseline training by over an order of magnitude.
- VNCA synthesize texture volumes for mesh stylization.

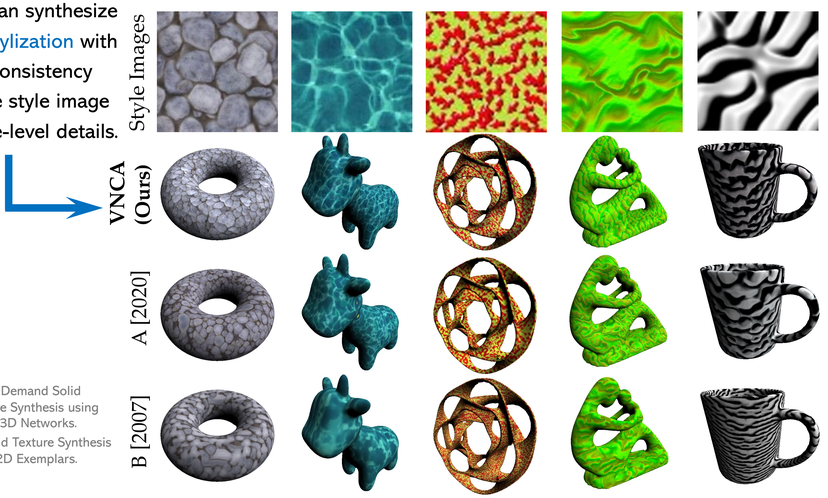
Stylization on Smoke Simulations

VNCA can both synthesize colour and modify density distribution for a stylization consistent with the input style image.



Stylization on Meshes

VNCA can synthesize mesh stylization with better consistency with the style image and fine-level details.



A. On Demand Solid Texture Synthesis using Deep 3D Networks.
B. Solid Texture Synthesis from 2D Exemplars.

Comparison of Relevant Methods

A. No training time scale up.
B. Inter-frame consistent.
C. Generalize to unseen smoke.
D. Color and density 3D stylization.
E. Inference time < 10s/frame.
F. Training GPU < 12GB.
G. Generalize to mesh texturing.

Methods	A	B	C	D	E	F	G	Type
Kim et al. [2019]	✗	✓	✗	✗	✗	✓	✗	Optim.
Kim et al. [2020]	✗	✓	✗	✗	✗	✓	✗	Optim.
Aurand et al. [2022]	✗	✓	✗	✗	✓	✓	✗	Optim.
Guo et al. 2021	✓	✓	✓	✗	✓	✗	✗	Feed Forward
Aurand et al. [2022]	✓	✗	✗	✗	✓	✗	✗	Feed Forward
VNCA (Ours)	✓	✓	✓	✓	✓	✗	✓	Feed Forward

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