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Technical Communications

A Practical Style Transfer Pipeline for 3D Animation: Insights from Production R&D

Hideki Todo
Takushoku University

Yuki Koyama
Graphinica, Inc.

Kunihiro Sakai
Graphinica, Inc.

Akihiro Komiya
Graphinica, Inc.

Jun Kato
Arch Inc.

Before starting, ⋯ we are **anime** creators!

Hideki Todo   Yuki Koyama   Kunihiro Sakai   Akihiro Komiya   Jun Kato

Takushoku University
Invited to this anime R&D team
for his extensive expertise and his
experience in the anime industry
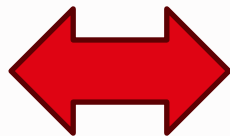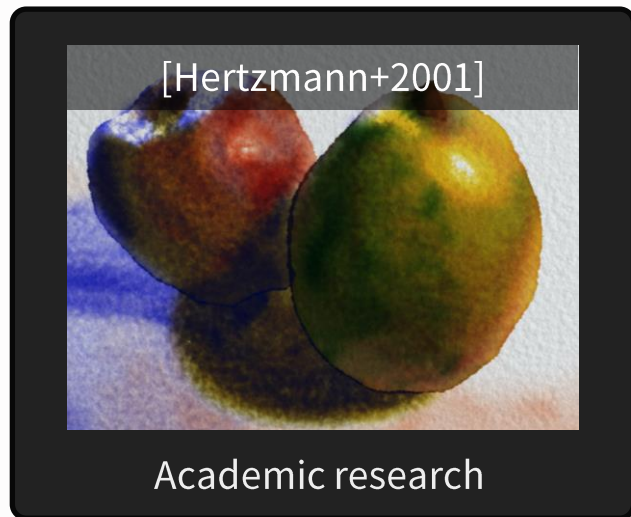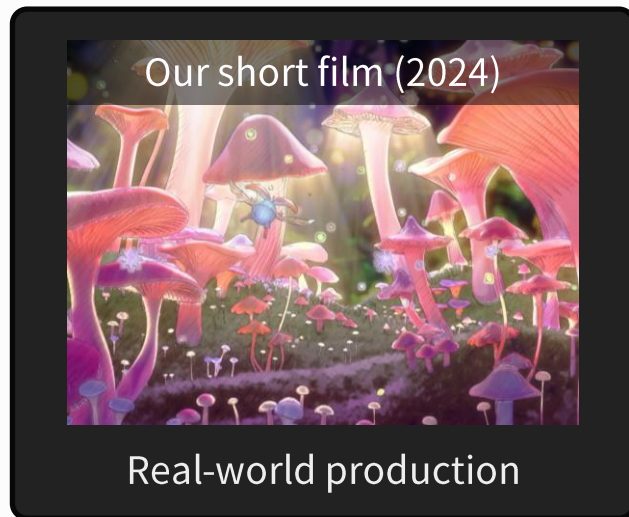
GRAPHINICA
Anime company

ARCH
Anime company

In this talk, we share the insights from our production R&D

Summary

Style transfer has not been widely used in real-world production despite its potential

Academic research

Gap!!

Our short film (2024)

Real-world production

In this talk, we discuss how to bridge the gap!

- We designed a practical pipeline for real-world production of 3D animations
- We created an experimental short film, validating the practicality of our pipeline

An Experimental Short Film: "Forest Tale"

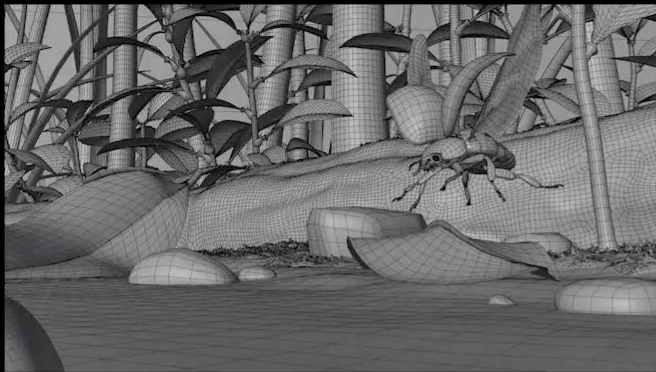Selected scenes only; the full version available on YouTube
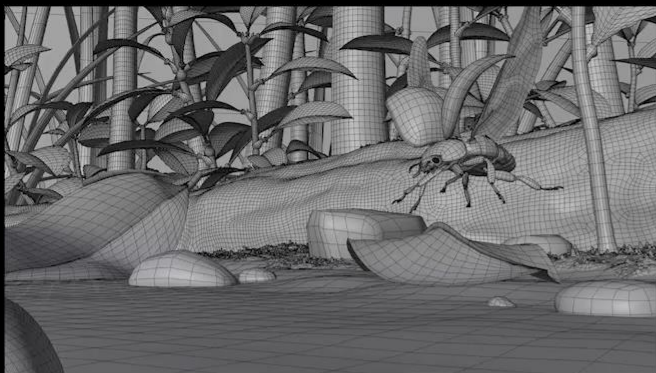
An experimental short film: "Forest Tale"

● Uses various hand-drawn styles (including watercolor, oil painting, and pencil with pastel)

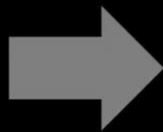● Features production-level complex scenes with many objects

3D animated scene

2D style exemplar
(hand-drawn)

3D animated scene

2D style exemplar
(hand-drawn)

Style transfer

Style transfer result
(will be used in the composite stage)
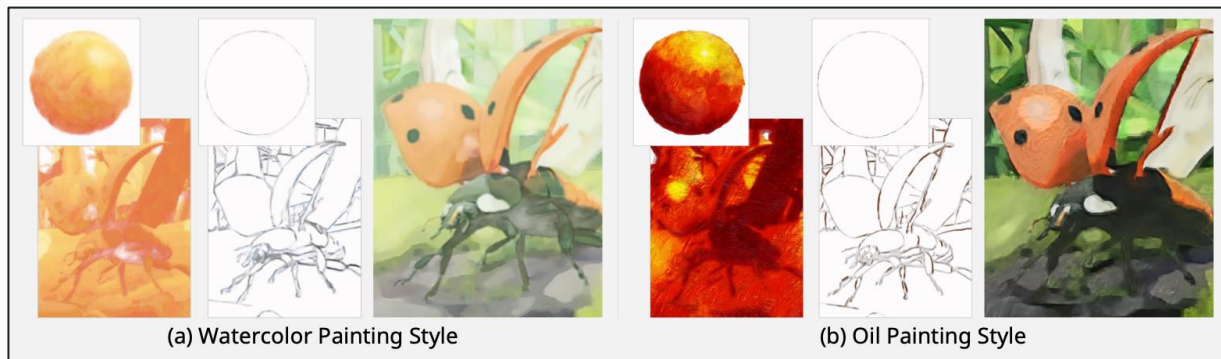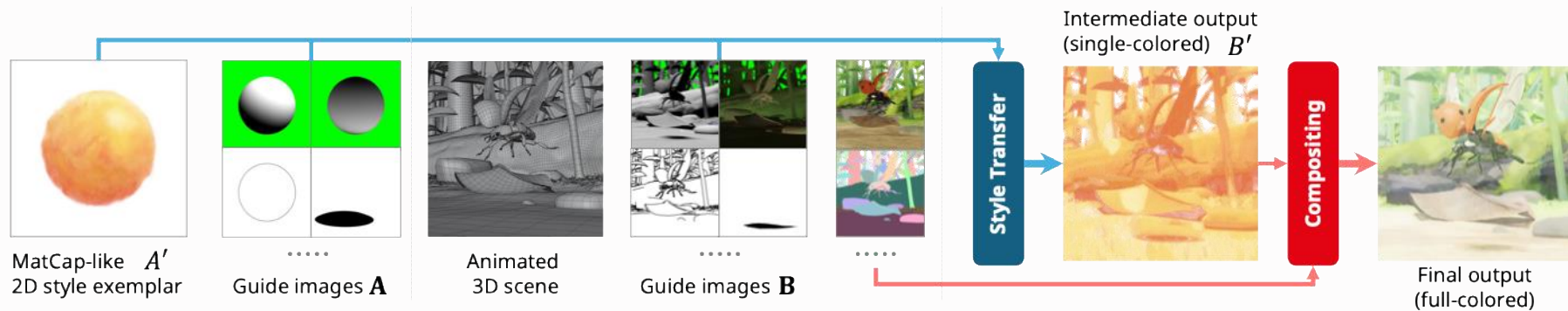
Final result after compositing

Style Transfer Pipeline

Our Method: A Practical **Style Transfer** Pipeline

Challenge: Apply style transfer [Hertzmann+2001] in actual production

MatCap-like A'
2D style exemplar

Guide images **A**

Animated
3D scene

Guide images **B**

Intermediate output
(single-colored) B'

Style Transfer

Compositing

Final output
(full-colored)

(a) Watercolor Painting Style

(b) Oil Painting Style

R&D:
- Style Transfer Setting
- Handling of Multiple Colors
- Separation of Outlines and Shadows
- Temporal Noise Reduction

Style Transfer: Simulate reference style through **texture synthesis**

Input		Output

A
(Base)

A'
(Stylized)

B
(Base)

B'
(Stylized)

Image Source: [Hertzmann2001]

Introduction: Image Analogies [Hertzmann2001]

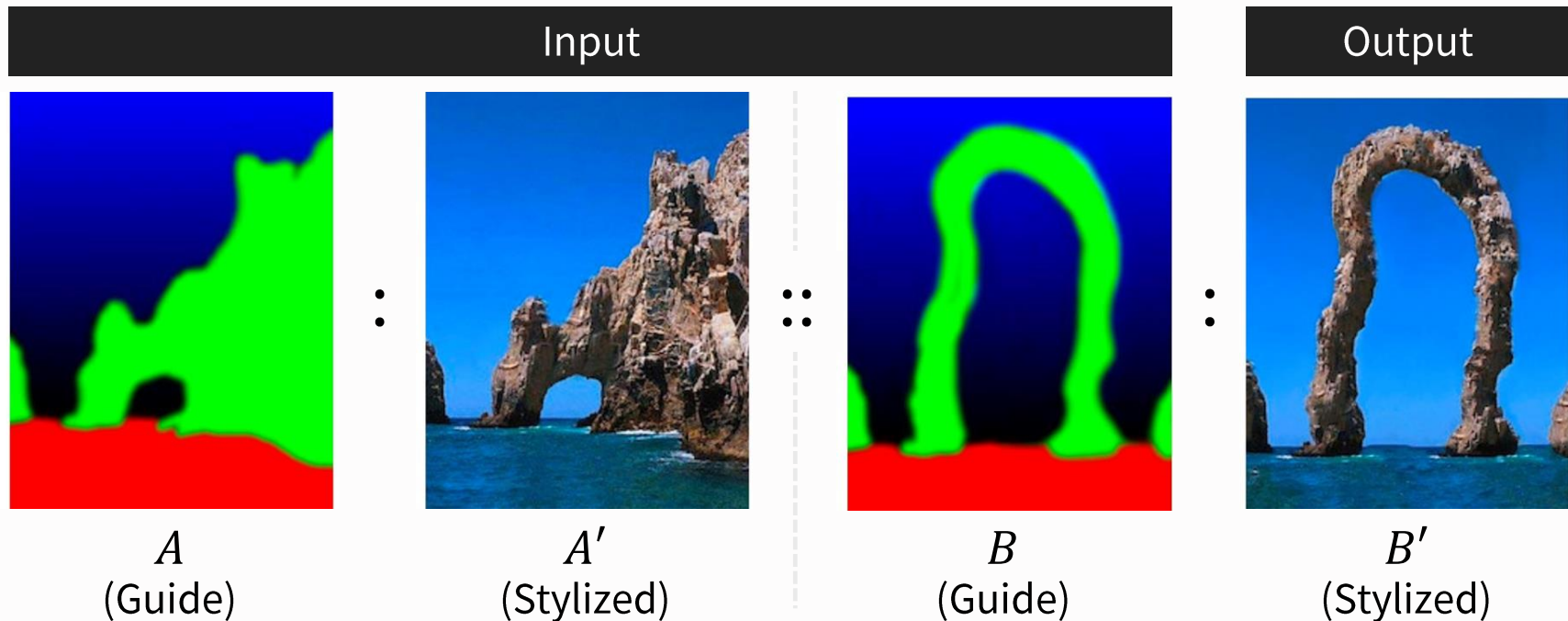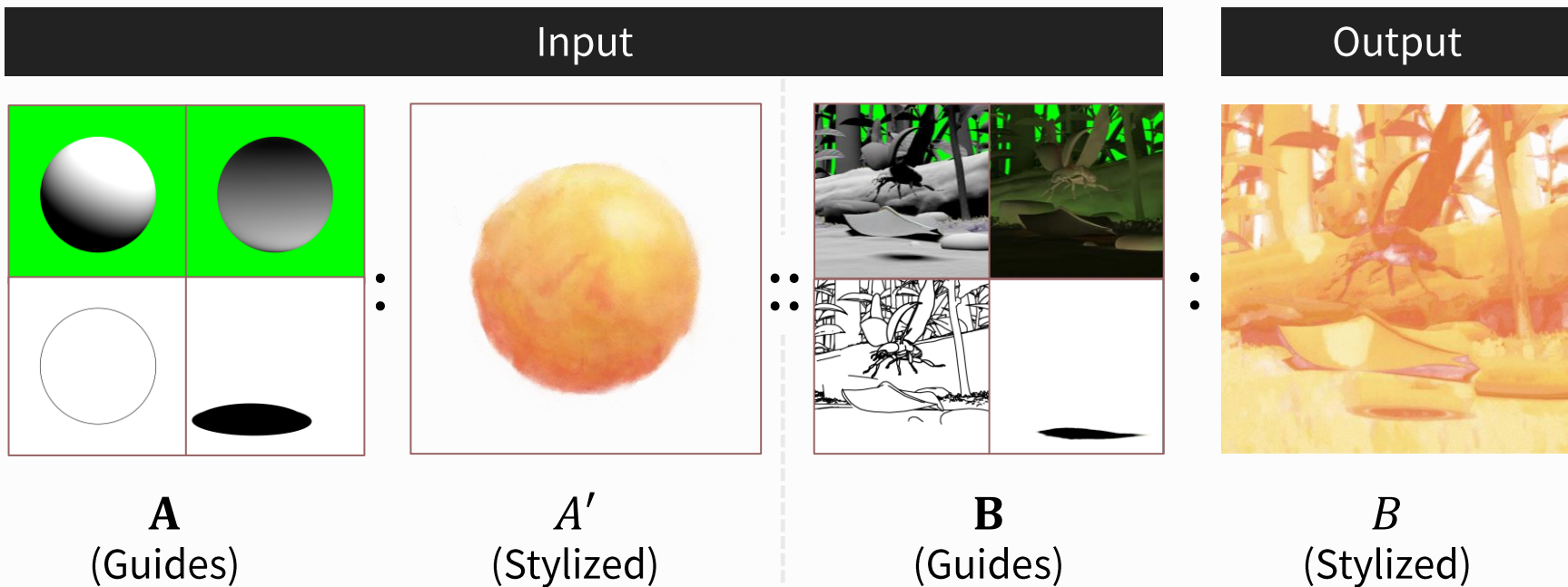**Texture-by-numbers**: **Guide channel** for **texture synthesis**

Input	Output

A
(Guide)

A'
(Stylized)

B
(Guide)

B'
(Stylized)
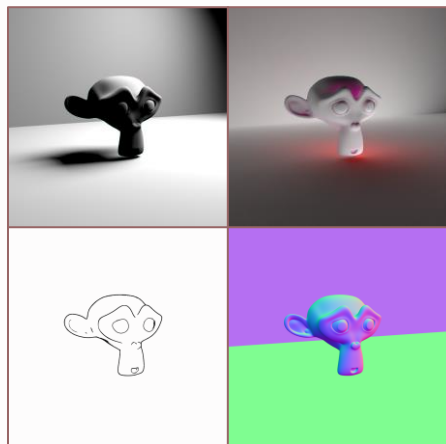
Image Source: https://mrl.cs.nyu.edu/projects/image-analogies/arch.html

Introduction: Our Extension for Guide Channels

Our Style Transfer Setting: Multiple guide channels from render elements

Input		Output

A
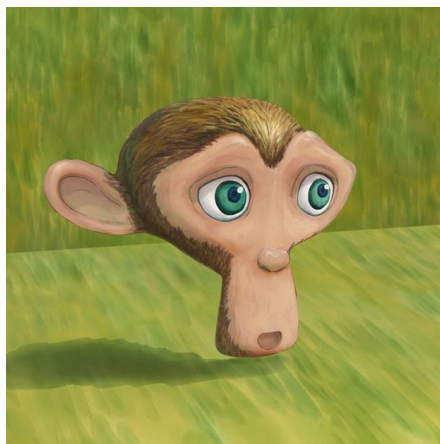(Guides)

A'
(Stylized)

B
(Guides)

B
(Stylized)

Style Transfer Setting: Same Object

- Style transfer with the **same object** causes **unstable transfer regions**
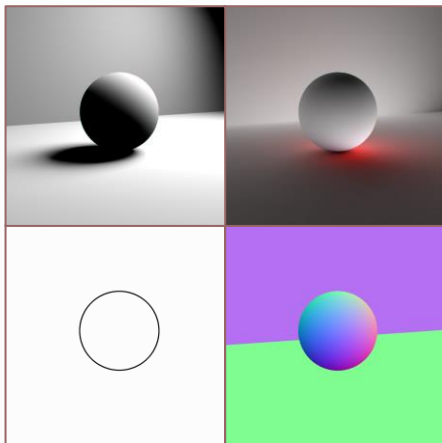

A

A'

B'

Style Transfer Setting: MatCap-like Sphere Format

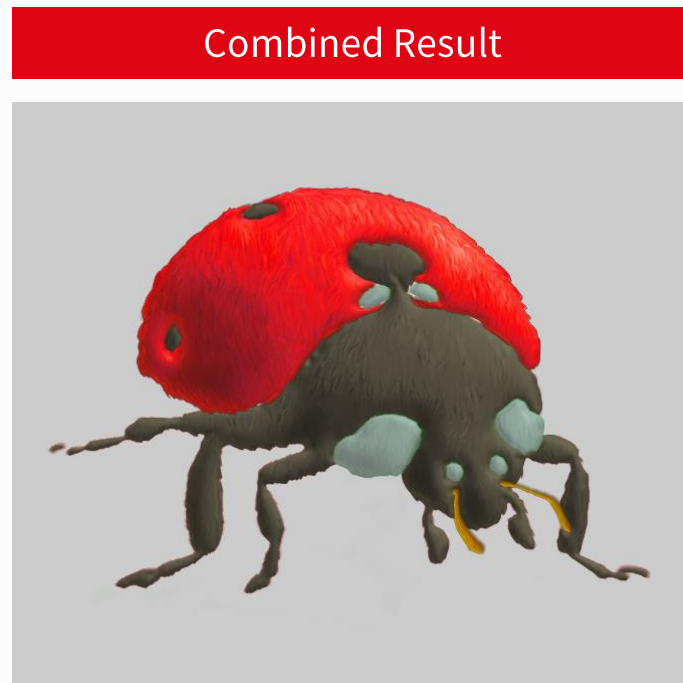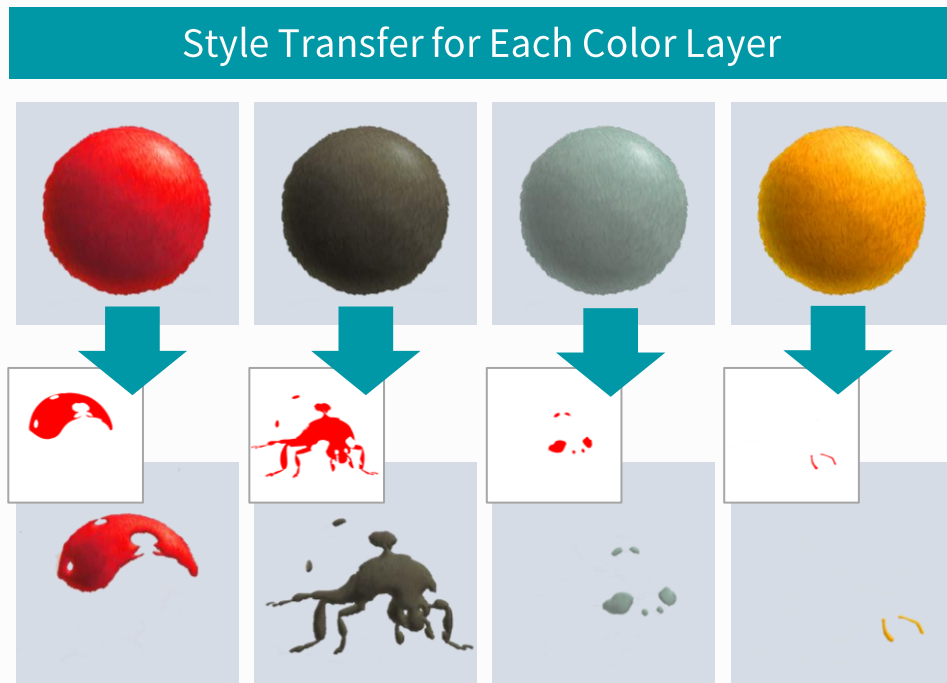● The **MatCap-like sphere format** ensures greater **stable transfer results**

A
      A'
      B'

Handling of Multiple Colors: A Naïve Approach

● Perform **style transfer for each color layer** and then **combine**

Style Transfer for Each Color Layer

Combined Result

Handling of Multiple Colors: A Naïve Approach

- Perform **style transfer for each color layer** and then **combine**
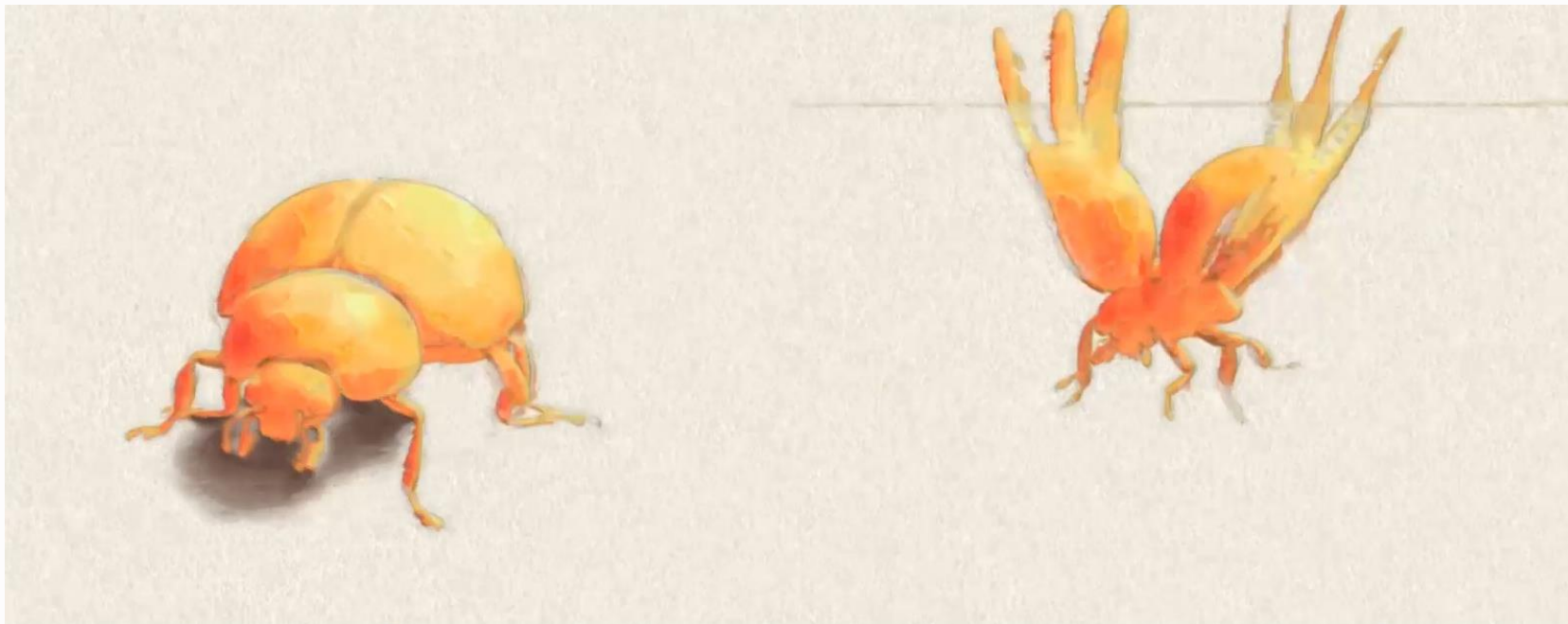- Suffer from **undesirable artifacts**

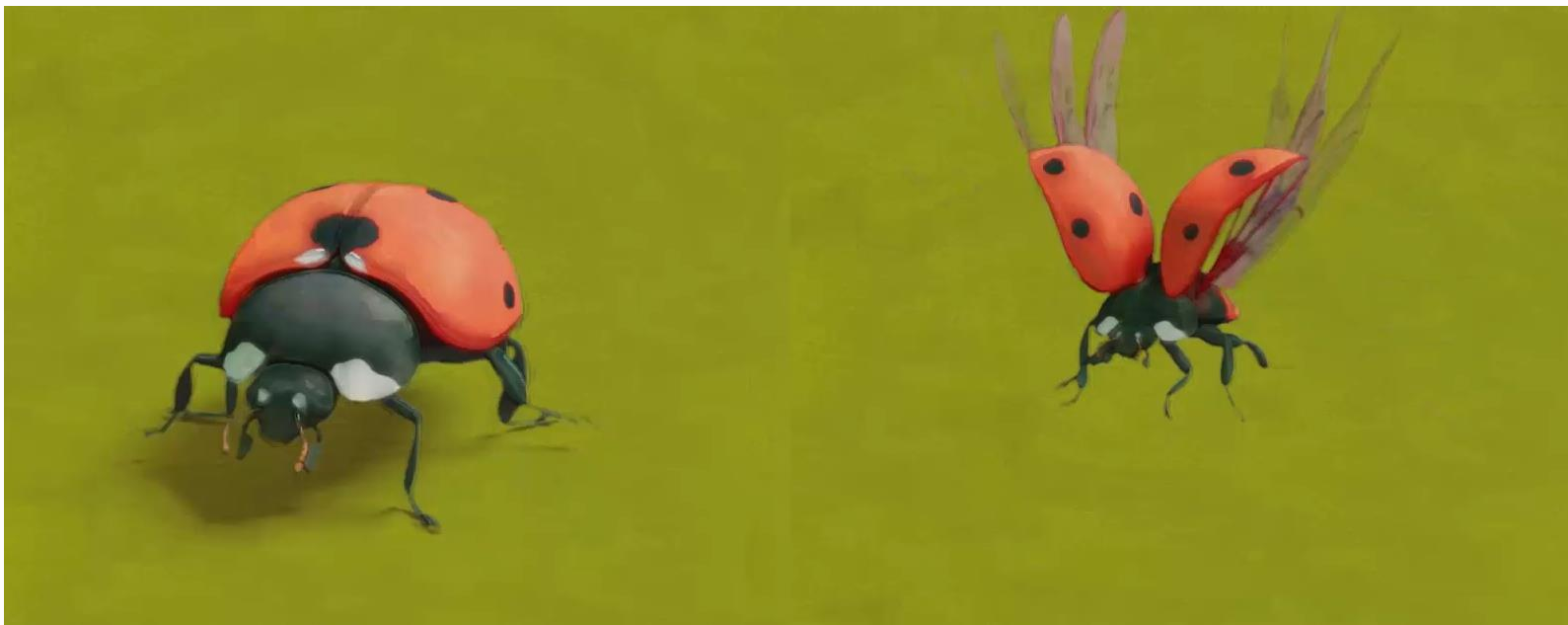Artifact (bumps)

Artifact (region gaps)

Handling of Multiple Colors: Our Approach

- Perform **style transfer for single color layer**
- **Resolve issues** of the naïve approach

Handling of Multiple Colors: Our Approach

- Perform **style transfer for single color layer** then **add colors through compositing**
- The pipeline became more **flexible for artists to control**

Separation of **Outlines** and Shadows

All elements together
(less artist control)

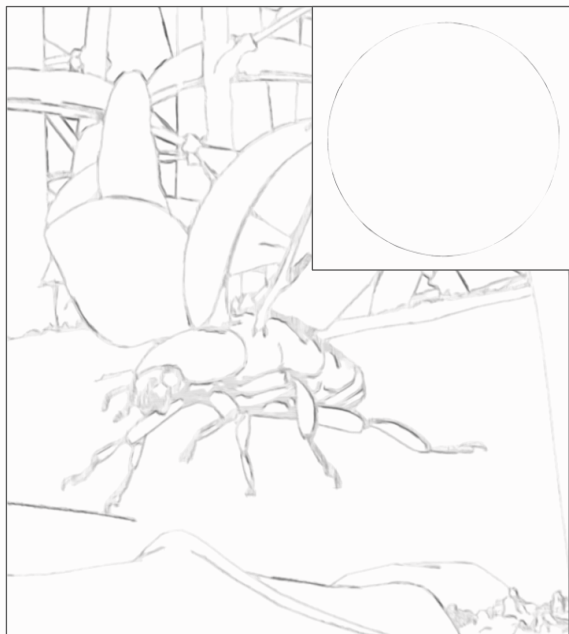Base Touch   +   Outline   +   Shadow

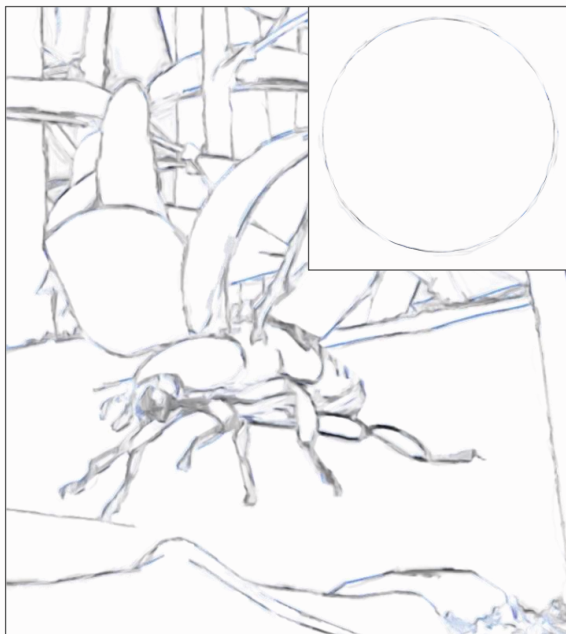**Finer artist control for each layer**
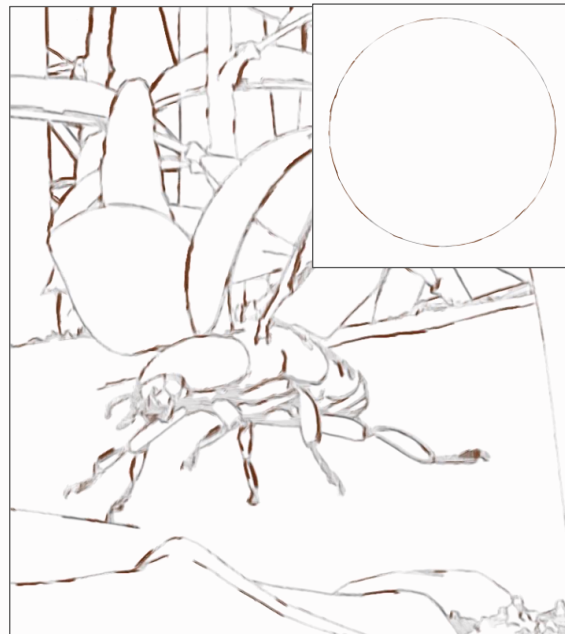
Separation of Outlines and Shadows

● **Patch-based texture synthesis** works well for **outlines**

Pastel Painting Style

Watercolor Painting Style

Oil Painting Style

Separation of **Outlines** and Shadows
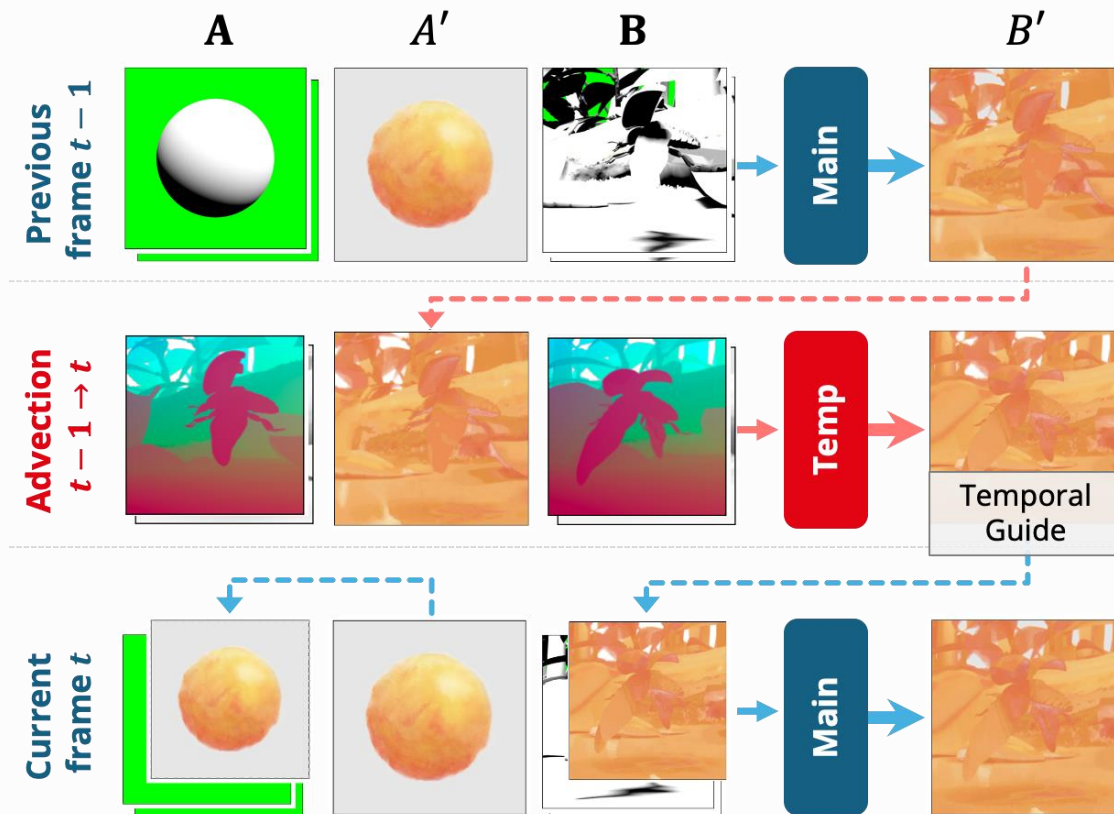
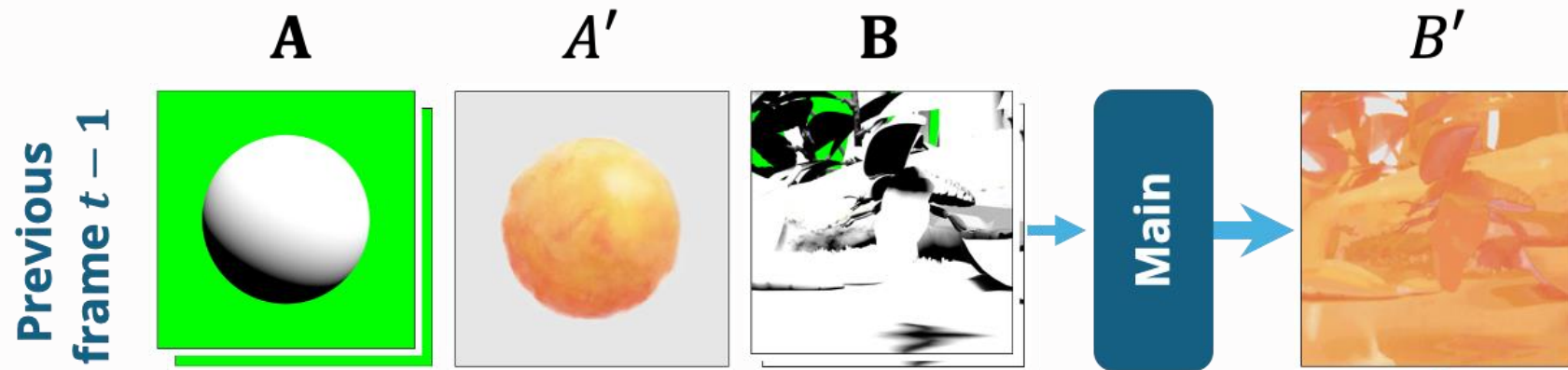# Temporal Noise Reduction: Motivation

Baseline
(without temporal guide)

Ours
(with temporal guide)

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Temporal Noise Reduction: Pipeline

Temporal Noise Reduction: Pipeline

Previous frame $t - 1$

$\mathbf{A}$ A' $\mathbf{B}$ Main B'

$$\mathbf{A} : A' \ :: \ \mathbf{B}_{t-1} : B'_{t-1}$$

Main style transfer step at previous frame $t - 1$

$$\mathbf{A}_{\text{adv}} : A'_{\text{adv}} :: \mathbf{B}_{\text{adv}} : B'_{adv}$$

Additional style transfer step for advection $t-1 \rightarrow t$

$$\mathbf{A} : A' :: \mathbf{B}_t : B'_t$$

Main style transfer step at current frame t
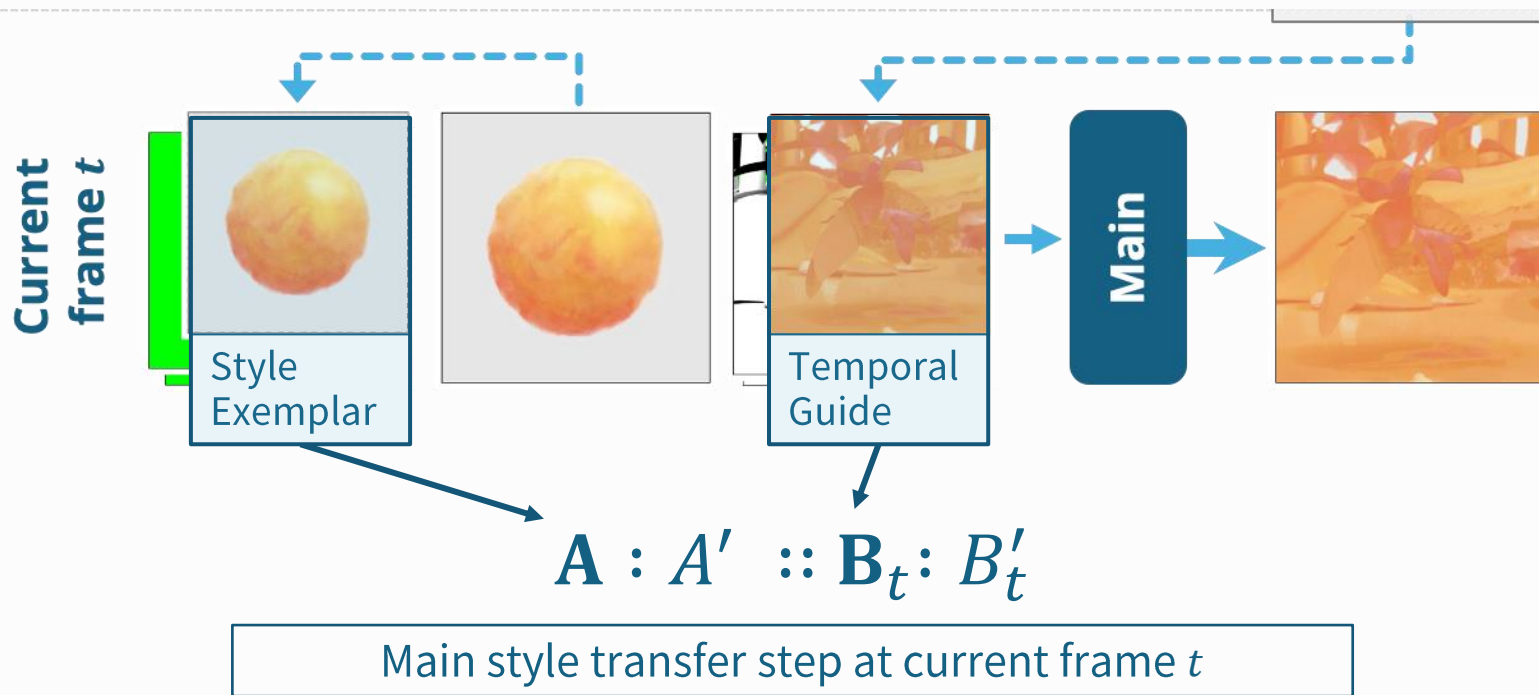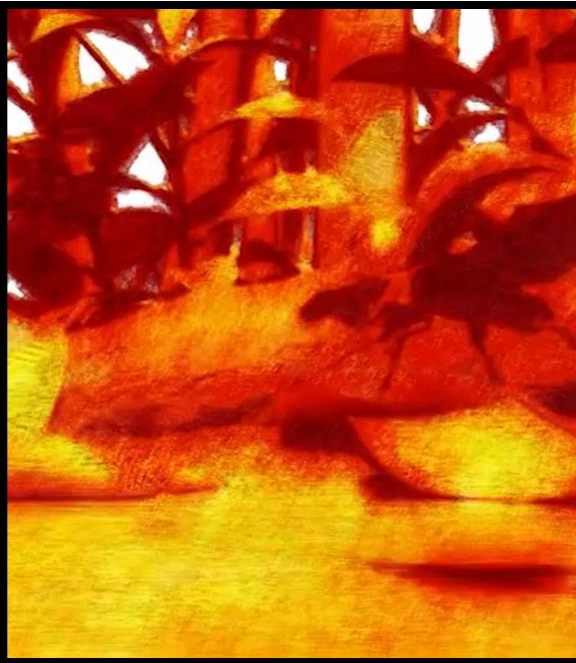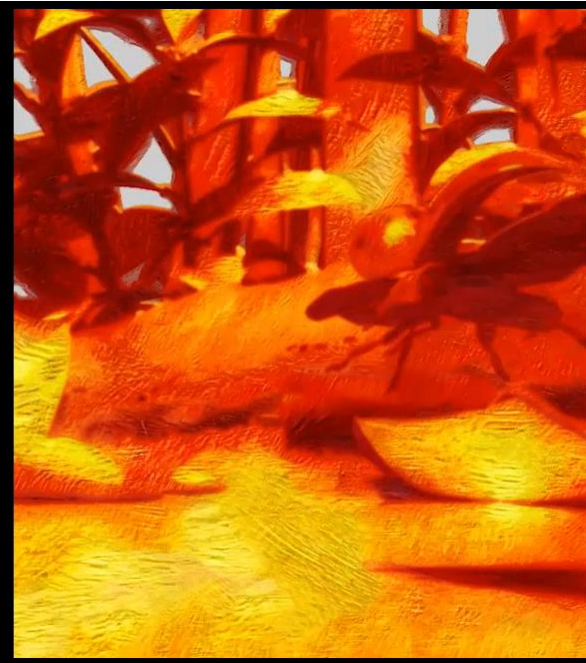
Temporal Noise Reduction: Comparison
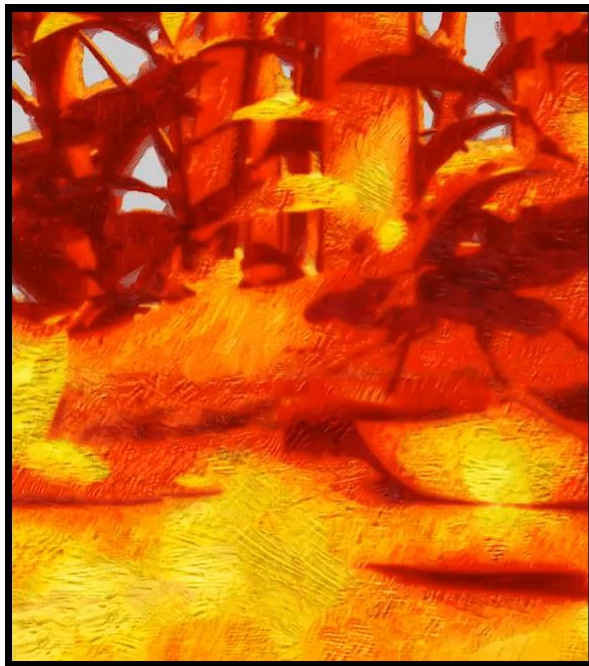
Baseline
(without temporal guide)

A neural method
[Texler et al. 2020]

Ours
(with temporal guide)

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Discussion

Our Pipeline Could Meet **Production Requirements**

● **Expression enhancement:**

Support various hand-drawn styles that are otherwise difficult

● **Artist control:**
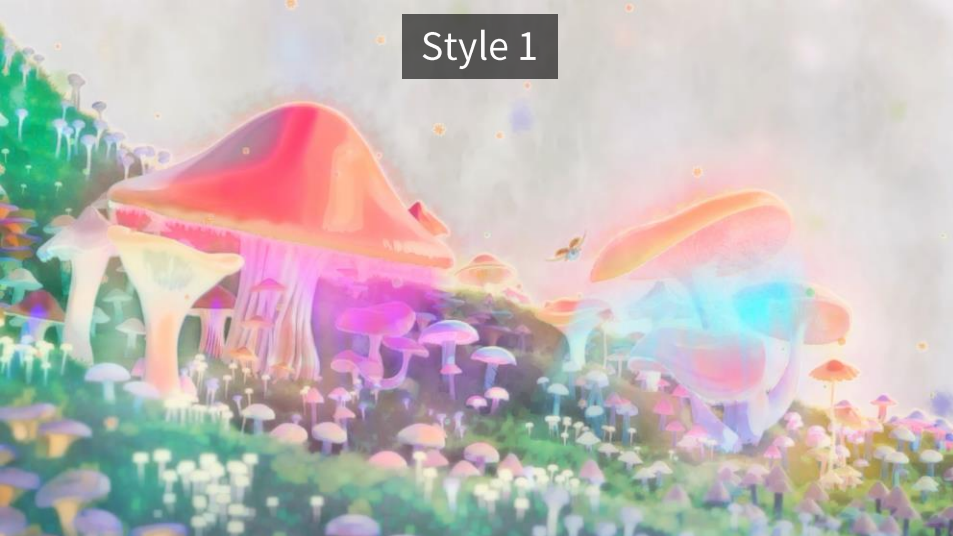
Provide fine controls at the compositing stage

● **Complex scene suitability:**

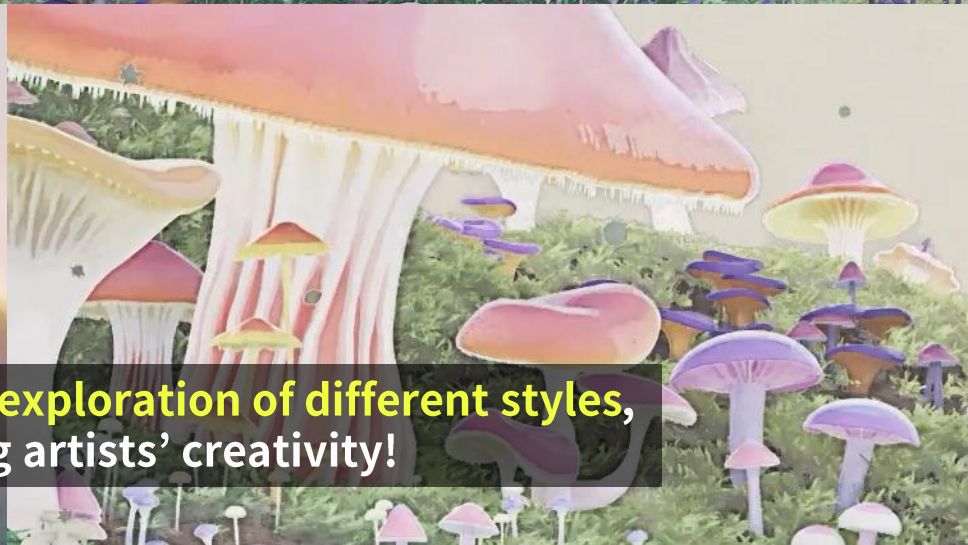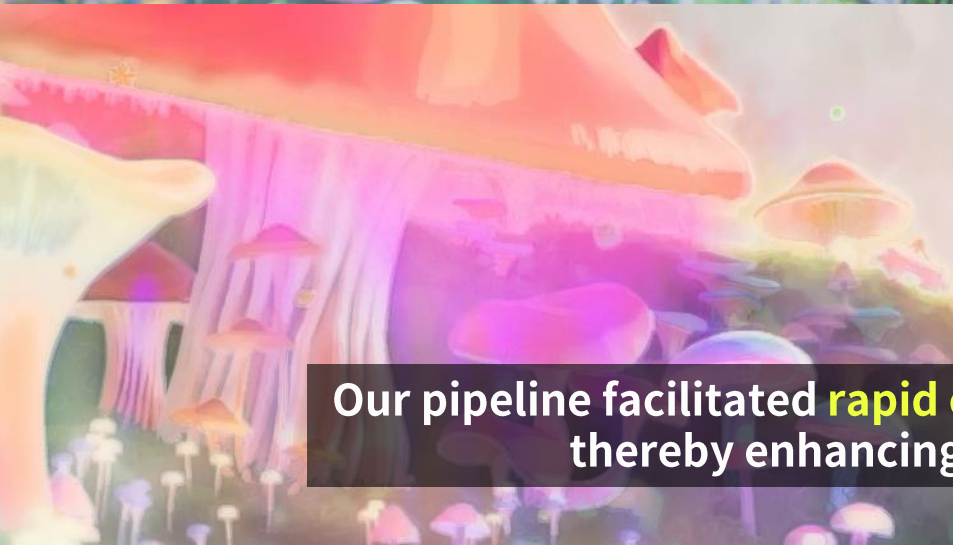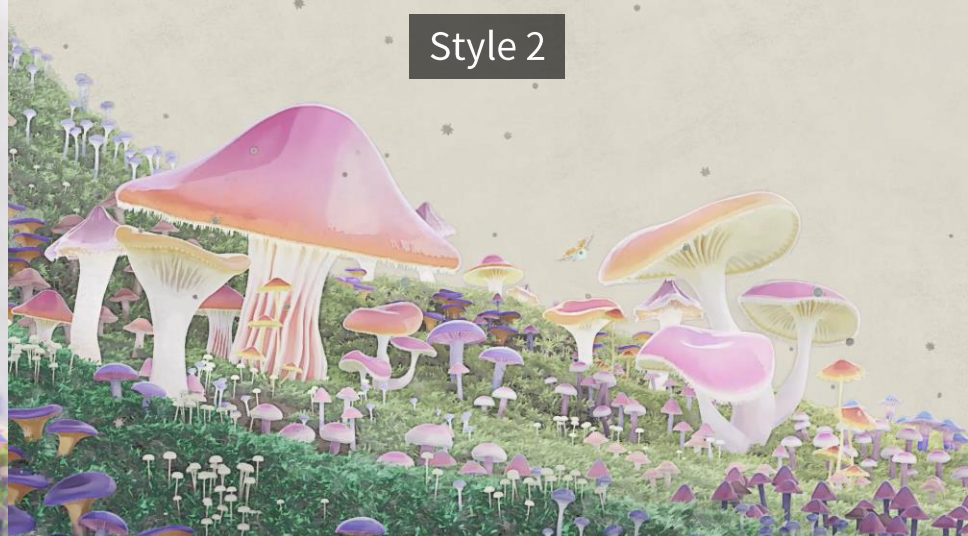Sufficiently robust for production-level complex scenes

● **Practical workload:**

Keep the workload small by avoiding cut-by-cut exemplar preparation

Style 1

Style 2

Our pipeline facilitated rapid exploration of different styles, thereby enhancing artists' creativity!
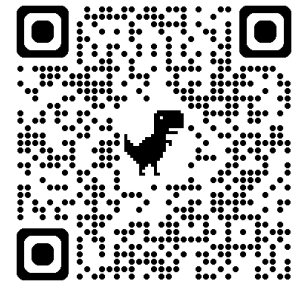
Style 1

Style 2

Our pipeline facilitated rapid exploration of different styles, thereby enhancing artists' creativity!

Summary:

● We bridge the gap between academic research and production by designing a practical style transfer pipeline

● Our pipeline enables the creation of diverse hand-drawn-style 3D animations that would otherwise be impossible

● We continue to conduct R&D to support creativity, aiming to pioneer next-generation creative anime production

Search on YouTube "Forest Tale"

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Thank you for listening!

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