



**Figure 1: Paintings created using the CATS system by Ticha Sethapakdi (top), Constance Ye (middle left), Rain Du (middle right), and Ming Lu (bottom). See [1] for more results.**

# Painting with CATS: Camera-Aided Texture Synthesis

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## ABSTRACT

We present CATS, a digital painting system that synthesizes textures from live video in real-time, short-cutting the typical brush- and texture- gathering workflow. Through the use of boundary-aware texture synthesis, CATS produces strokes that are non-repeating and blend smoothly with each other. This allows CATS to produce paintings that would be difficult to create with traditional art supplies or existing software. We evaluated the effectiveness of CATS by asking artists to integrate the tool into their creative practice for two weeks; their paintings and feedback demonstrate that CATS is an expressive tool which can be used to create richly textured paintings.

## KEYWORDS

art; creativity support; digital painting

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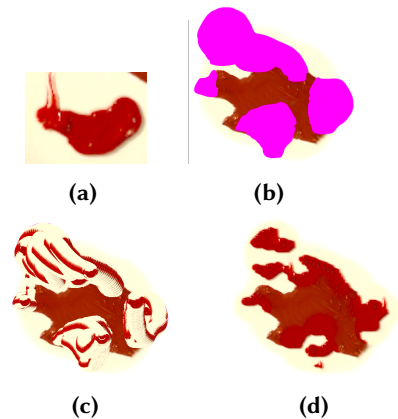
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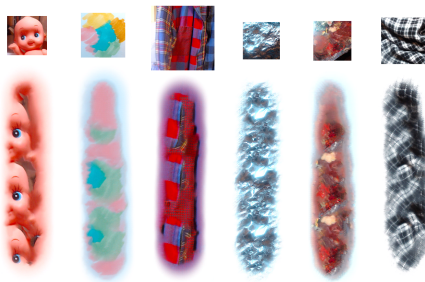
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**Figure 2: Comparison of regular stamping (c) and texture synthesis in CATS (d), for a given exemplar (a) and target (b). The target region is highlighted in pink.**



**Figure 3: Examples of brush strokes created in CATS using exemplars of varying textures and sizes.**

## INTRODUCTION

A popular approach to creating visual art is digital painting. Digital painting interfaces have evolved significantly since their inception in the 1970s. Much like in traditional media, digital painting programs now equip artists with a diverse set of tools and brushes so they can produce expressive paintings. However, unlike traditional media, digital media often requires artists to go through several steps before they can use their own materials for painting. Applications like Adobe Capture simplify this workflow by allowing users to use their phone camera to quickly make creative assets.

We wanted to take this idea further by enabling artists to paint with the rich colors, textures, and patterns of the world around them. To achieve this, we have developed a hybrid capture-and-painting system (Fig. 4) that empowers artists by allowing them to immediately paint with anything they see – without the need for specialized hardware. To do so, we needed an effective method for handling the behavior of brush strokes made from live video. Commercial painting systems commonly use a “stamping” approach, which stamps the brush image along the path the user painted. Adobe Photoshop, for example, has a ‘pattern stamp’ brush that allows the user to use any picture as a stamp image. Stamping has the advantage of being intuitive to use and produces easily controllable results. For solid colors and simple patterns, stamping is an adequate technique – however, it cannot preserve the fidelity of irregular or complex textures (Fig. 2c) and creates obvious seams at stroke boundaries which can make strokes appear artificial. Since we wish to allow artists to paint with arbitrary textures, a stamping-based solution would not suffice. Instead, we choose to use *real-time texture synthesis* for stroke creation (Fig. 2d). Texture synthesis behaves in a similar manner to watercolor, which blends strokes in a cohesive and organic way. Another unique characteristic of traditional mediums like watercolor is the potential for “happy accidents”, which can produce desirable outcomes users might not have thought of themselves. Happy accidents can be more powerful when combined with the correction capabilities, such as undoing, that digital media provides. Our system tries to strike a balance between controllability and unpredictability by making strokes both stochastic and correctable.

## Guiding Principles

CATS is a painting system that combines the strengths of digital and traditional approaches. Based on our comparisons of traditional and digital media, we prioritized the following features:

- (1) *Intuitive creation of brush assets*, through synthesizing textures from live video in real-time. This makes brush creation and modification as simple as pointing a camera.



Figure 4: The CATS system.

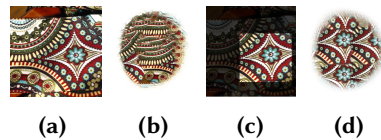


Figure 5: Demonstration of cropping. Exemplar and stroke before (a,b) and after (c,d) cropping to the desired region of interest.

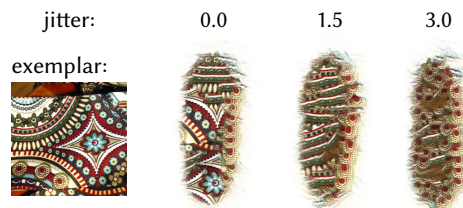


Figure 6: Jitter decreases the coherence of synthesized strokes.

- (2) *Support for correction*, through standard correction functions and a *paint-drying* mechanism, which gives users a small window of time to make adjustments to the stroke texture after it is painted.
- (3) *Production of organic strokes*, through enforcing cohesiveness between new and existing strokes.
- (4) *Support for “happy accidents”*, through incorporating elements of randomization.

## SYSTEM FEATURES

The CATS system runs on a standard computer with a connected webcam and drawing tablet (Fig. 4). The interface is equipped with a combination of familiar painting functions and functions specific to the CATS system. For implementation details, see [1].

### Exemplar Management

The *exemplar* is the texture that is used as paint for the brush (Fig. 3). By default, the exemplar is the current webcam feed, which means that the user can change the exemplar at any time by moving the camera or the objects it is observing. When capturing the exemplar, the camera exposure and white balance are typically locked to avoid video fluctuations resulting from changing lighting conditions. CATS allows users to manipulate the exemplar in various ways:

*Cropping.* The user can specify which portion of the exemplar to paint with by cropping it to a region of interest (Fig. 5).

*Eyedropping.* In standard painting programs the eyedropper tool allows users to grab the color of a specific pixel on the screen. In CATS, the eyedropper lets the user grab a small portion of the canvas to use as the exemplar.

*Texture Swatches.* CATS also allows users to save and restore exemplars from a library. Saved exemplars are referred to as ‘swatches’.

### Brush Control

Similar to normal painting systems, users have control over basic brush parameters. The brush used in CATS is a soft-edged brush.

*Brush size and opacity.* Like a standard painting program, CATS allows users to adjust the brush size and opacity. Opacity can be adjusted manually while brush size can be adjusted manually or through pen pressure.

*Brush jitter.* Strokes also have a jitter parameter that affects how much structure from the original texture is maintained (Fig. 6).

### Auxiliary Functions

CATS has support for stroke correction as well as canvas and exemplar management.

*Wet paint.* Strokes have a ‘dryness’ parameter that determines how quickly the stroke is committed to the canvas. As a stroke is ‘drying’ users can make adjustments to the exemplar. Once a stroke is completely dry, it is committed to canvas and no further adjustments can be made.

*Erase/Undo.* Users can erase strokes or undo previous actions.

*Loading/Saving Canvases.* Users may load and save canvases. The loading functionality for canvases allows users to import a sketch or photograph as a painting base.

### RESULTS AND EVALUATION

To understand how CATS would fit into an artist’s workflow, we conducted a 2 week long user study with 3 local artists with distinct artistic styles. Figure 1 shows CATS paintings created by these artists as well as the author. As with any new program, each artist had to go through an adjustment period. Artists found that CATS made it difficult to achieve very specific results due to the decisions made by the stroke matching algorithm. However, as they grew more accustomed to the tool, they enjoyed the unpredictability (Sidebar 1), liked how strokes ‘blended’ together, and felt like their CATS paintings are not easily reproducible using other means. The idea of “play” was also frequently brought up in discussions. Artists described the program as being fun to play around with and often took an exploratory approach to their paintings. They reported that much time was spent finding textures to use for their paintings – this frequently led them to experiment with many unconventional materials, such as railroad tracks and tissue boxes.

### DISCUSSION

One of the challenges many artists face when trying a new painting system is loosening their hold of familiar methods. CATS, at its core, is a rather unorthodox digital painting system: it encourages the use of textures rather than solid colors and does not give users full control over outputs. From the results of our study, it is evident that CATS breaks expectations, creates confusion, and, in the process, inspires delight. User study results demonstrate that artists could produce texture rich paintings that could not easily be made through purely digital or traditional means. This opens an exciting new avenue for using computation to facilitate the creative process and produce new materials for art creation.

### REFERENCES

- [1] Ticha Sethapakdi and James McCann. 2019. Painting with CATS: Camera-Aided Texture Synthesis. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '19)*. ACM, 8.5. <https://doi.org/10.1145/3290605.3300287>

*“I think it’s good to have some things be a little out of your control. It’s like how in watercolor you can’t control it too much so you just roll with it; this tool does what it wants so you roll with it and it’s pretty cool.”*

**Sidebar 1: Constance Ye, on the CATS system.**