Stroke Evolution and Co-Drawing: Exploring New Frontiers in Interactive Art

1 Project Overview

Visual art is a fundamental part of human expression, enabling us to explore, communicate, and preserve ideas, emotions, perspectives, and experiences. From drawing and painting to sculpture and photography, the visual arts encompass a diverse range of mediums that reflect the creativity and cultural richness of human existence. Masterpieces by renowned artists, often preserved in museums, are constrained by limitations that restrict tactile interaction, hinder close examination of intricate details, and limit accessibility. Such constraints highlight the need for innovative approaches that extend beyond conventional museum displays.

Recently, digital art and virtual exhibitions have emerged as powerful alternatives, breaking free from the static nature of physical displays. Yet, many digital representations remain static images, lacking the dynamic, interactive qualities that truly capture the essence and evolution of artistic expression. Imagine witnessing a painting unfold in real time—each brushstroke appearing gradually, each region coming to life step by step, transforming an empty canvas into a completed masterpiece. This dynamic approach not only expands creative possibilities but also bridges the gap between traditional art experiences and modern technology

In today's rapidly evolving digital landscape, AI is reshaping the art world, unlocking new possibilities for artistic expression, collaboration, and audience engagement. AI-assisted artistic tools are revolutionizing traditional art creation while redefining how audiences interact with and experience art. The advent of digital technologies has significantly transformed the way art is created, shared, and experienced. Traditional artistic methods are now being augmented by advanced techniques in image processing, machine learning, and interactive systems. This project focuses on stroke-based rendering, a novel approach that simulates the evolution of artwork, capturing the essence of artistic creation stroke-by-stroke. Through this process, we aim to recreate the dynamic journey of an artwork's progression, offering a rich, interactive experience for both artists and audiences.

Our approach aims to combine methods from digital art, image processing, machine learning, and human-computer interaction to reconstruct the creative process in real-time. By developing a stroke-by-stroke rendering engine, this project will enable users to engage with the creation of artwork as it evolves, providing deeper insights into artistic techniques and styles. Additionally, it allows for immersive experiences in various domains, such as collaborative co-drawing, art education, and virtual art exhibitions.

The primary objective of this project is to bridge the gap between traditional and digital art, enhancing the understanding of artistic techniques while also enabling new forms of interaction. Whether it is in an art classroom, a virtual museum, or a collaborative digital space, this system has the potential to redefine how we engage with art, offering both educational value and creative empowerment. By simulating artistic evolution across diverse scenarios and collaboration, this project seeks to investigate how art is created, learned, and experienced.

To achieve these goals, our project is focused on three key objectives:

Enable Dynamic Virtual Art Experiences: It aims to transform digital art creation by enabling real-time interaction with evolving artworks. It explores advanced stroke extraction, construction, and sequencing techniques to analyze and reconstruct masterpieces while simulating artistic processes. Machine learning and image processing methods will optimize individual strokes for visual accuracy, ensuring structured, context-aware rendering that effectively captures an artist's style and intent. With this, museums and galleries can utilize stroke-by-stroke rendering to showcase the creation process of famous artworks, and virtual museum environments will be developed to enhance engagement with historical and contemporary artworks, providing immersive learning experiences through interactive digital animation.

Additionally, educational tools will offer students and artists interactive experiences, allowing them to explore artistic evolution, receive real-time feedback, and visualize historical and contemporary artworks. The interface provides real-time stroke sequencing suggestions based on artistic strategies, assisting artists in learning and creating structured artworks. Virtual and augmented reality applications will enable users to interact with evolving digital artwork, either as an immersive experience or within games that incorporate AI-assisted stroke progression for creative expression. Further, we can also explore integrating music into stroke-based rendering for multi-sensory engagement, offering deeper artistic experiences.

Support Collaborative Digital Art Exhibits: It aims to develop collaborative platforms where multiple artists can draw together in real time, utilizing co-draw systems to enhance creativity and support artistic collaboration. By enabling co-creation on shared canvases, artists can collectively evolve artworks while receiving real-time feedback on their strokes or suggestions on what to paint next. AI-driven systems will analyze and evaluate user strokes, offering personalized recommendations to refine artistic techniques. Additionally, these platforms will support interactive exhibits where visitors can create or modify artwork using stroke-level tools, allowing for personalized artistic experiences. Users will have the ability to customize stroke characteristics to match their personal style or experiment with different techniques, while models suggest the next stroke, helping novices learn from professionals and innovate in a structured yet creative digital environment. Beyond co-drawing, the system can be extended to incorporate cross-cultural artistic techniques into digital rendering, enabling users to explore the evolution of diverse art styles worldwide.

Enhancing Mental Health and Rehabilitation Through Digital Art: This initiative leverages digital artistic expression to support mental health, rehabilitation, and therapeutic practices. It aims to develop art therapy tools that simulate creative engagement, providing users with a meaningful outlet for emotional expression and healing. By integrating stroke-level analysis into healthcare technology, these tools can assist patients in recovering fine motor skills through controlled drawing exercises based on artistic stroke techniques. Users will have the opportunity to experiment with different strokes and artistic styles from home, simulating professional techniques for both therapeutic and creative purposes.

2 Challenges

This project presents multiple technical challenges. Extracting and reconstructing individual strokes from diverse artworks while preserving stylistic complexity is a challenging problem. It requires accurately identifying stroke characteristics such as shape, position, and color across different artistic styles while ensuring realism in stroke sequencing to reflect the natural evolution of art. Maintaining contextual relevance during stroke placement, capturing artistic strategies like layering and composition, and optimizing strokes without compromising intricate details of artworks are key challenges. Additionally, segmenting an artwork into meaningful regions and ensuring region-based progression aligns with artistic intent further complicates the process. Developing an engine that simulates artwork evolution in a sequential manner while maintaining stylistic consistency, especially in collaborative settings, is another challenging problem. A significant drawback is the lack of task-specific datasets, as different artists perceive and create artworks uniquely—no two artists paint identically, and enforcing uniformity would diminish creativity. Furthermore, there is no standardized mechanism defining individual brush strokes or the pragmatic sequence humans follow when creating art.

Beyond technical constraints, ensuring a seamless and engaging user experience is equally critical. A robust real-time feedback system must cater to artists of all skill levels while preserving creative autonomy. Supporting cross-cultural artistic styles and maintaining educational clarity in stroke visualization are essential for accessibility and engagement. In museum applications, interactive digital reconstructions must be intuitive and immersive, allowing users to explore artwork evolution effortlessly. Integrating multi-sensory elements, such as music, into stroke-based rendering must be handled carefully to enhance engagement without overwhelming the visual experience. Ultimately, achieving a balance between artistic freedom, computational precision, and user interaction is fundamental to successfully implementing stroke-based digital art evolution.

3 Current Progress – Stroke Extraction, Construction, Sequencing, and Art Evolution

Sketch & Paint: Given an input painting, our proposed method effectively extracts individual strokes and reconstructs the stroke sequence that represents the evolution of the artwork from initial sketch to final painting. This approach lays the foundation for simulating the creative process by revealing the underlying structure and progression of artistic techniques, thereby setting the stage for further enhancements in real-time co-drawing and interactive art visualization. (Accepted in ECCV Poster Session)

Region-Driven Art Evolution: We explore an image-to-painting method that facilitates semantic guidance for vector strokes in targeted regions, computes the vector stroke parameters, and establishes a sequence among segments and strokes to sequentially render the final painting. This approach enables the transformation of an input image into a painting by strategically directing stroke placement, optimizing stroke parameters, and ensuring that each stroke builds upon the previous ones to progressively reveal the complete artwork. Figure 1 illustrates the stroke-by-stroke evolution of the artwork, demonstrating the transformation from the input to the final painting.

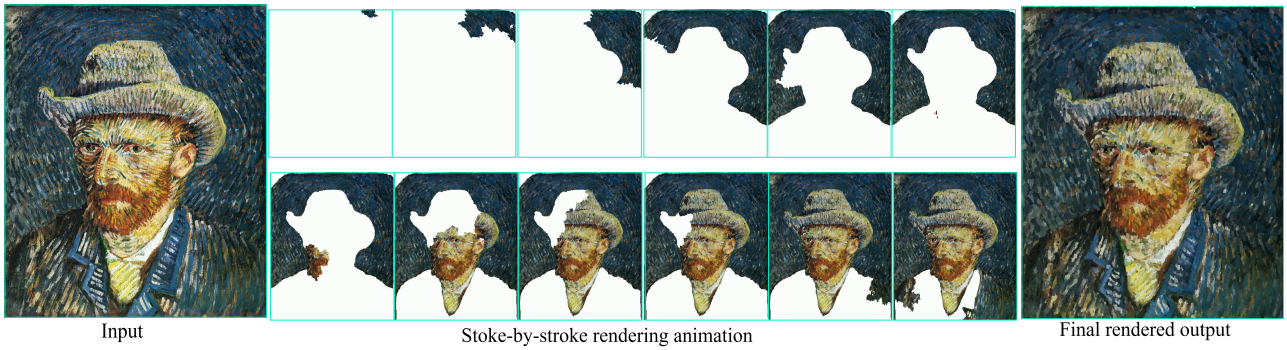

Figure 1: Our painting process begins by dividing the input image into a set of meaningful regions. Stroke parameters are then approximated and rendered sequentially, ensuring a structured progression. The image is filled stroke by stroke, region by region, and segment by segment, following a hierarchical approach to maintain coherence and artistic integrity. [Zoom in to observe stroke details closely].

4 Innovations

We introduce several key innovations in stroke-based rendering, enhancing digital art interaction and deepening the understanding of artistic processes. Our novel stroke extraction and reconstruction technique accurately segments both regions and individual strokes while preserving stylistic complexity. This enables region-by-region and stroke-by-stroke sequencing that closely mirrors the natural evolution of artistic creation. Additionally, we develop an adaptive stroke optimization system that balances computational precision with artistic intent, ensuring high-fidelity rendering while maintaining the unique characteristics of different art styles. To validate our approach, we investigate our proposed methods across diverse data sources, including portrait and cityscape/landscape paintings from WikiArt, artistic faces from MetFace, photographic faces from FFHQ, and photographic-to-painting transformations from IM2Oil and LineArt. In the future, stroke-based rendering can be extended to collaborative and educational platforms, enabling multiple users to co-create and explore artistic evolution in real-time. Integrating AI-driven real-time feedback will provide personalized suggestions for stroke placement, technique refinement, and artistic composition, making the system valuable for both novice and professional artists. Furthermore, incorporating cross-cultural artistic techniques into the rendering engine will allow users to study and experiment with diverse historical and contemporary styles. Lastly, exploring multi-sensory engagement by integrating music with stroke evolution can enhance artistic experiences while maintaining coherence between visual and auditory elements.

5 Hypothesis

This project is based on the hypothesis that stroke-based rendering can effectively model and reconstruct the evolution of artistic creation while preserving stylistic complexity and contextual coherence. By accurately extracting and sequencing individual strokes, we can approximate an artist's workflow, capturing essential artistic strategies such as layering, composition, and region-based progression. Furthermore, we hypothesize that integrating AI-driven optimization and feedback mechanisms can enhance both artistic accuracy and user engagement. Adaptive stroke refinement can balance computational precision with artistic intent, ensuring high-fidelity rendering across diverse styles. Additionally, incorporating real-time interaction, collaborative co-drawing, and cross-cultural artistic techniques will enable new forms of creative expression, making digital art evolution more immersive and accessible.

6 Conclusion

This project presents a transformative approach to digital art, merging stroke-based rendering with AI-driven insights for interactive artistic evolution. By bridging traditional and digital art, the system enhances learning, creativity, and accessibility. Its applications span art education, digital museums, and immersive experiences, providing a dynamic platform for exploring and preserving artistic techniques. The ability to simulate artistic evolution holds immense potential for future generations, ensuring a deeper engagement with art through technology.