

# Process-Centered Design in Co-creative Support Tools for 2D Art

Dagmar Lofts

University of Alberta, Alberta Machine Intelligence Institute. Edmonton, Alberta, Canada  
lofts@ualberta.ca

## Abstract

In 2D illustration an artist makes a series of decisions throughout the process, with those choices becoming more granular over time. These decisions vary in scope and impact. Given this formulation of a creative process, I observe that there exist portions of common workflows where an artist is largely following through on the logical conclusions of prior decisions. These are the specific areas of these creative workflows where I believe that co-creative tools can be implemented while retaining creative control over the completed artifact. My work so far has been in implementing such tools for steps in illustration and frame-by-frame animation. I intend to design further process-centered co-creative systems and study their usability and impact in the context of existing workflows.

## Introduction

Co-creative systems are creativity support tools where a user collaborates with an AI system to produce an artifact (Guzdial and Riedl 2019). Many such systems have been developed in recent years in the space of 2D illustration (Cetinic and She 2021). The application of machine learning to co-creative systems can allow for time-saving automation without significant hand-authoring. The majority of creativity support tools for 2D illustration have used text-based prompting, which is not naturally part of most artist's workflows (Cetinic and She 2021). While other modalities have been explored, adoption of these tools by artists is limited. A majority of systems cannot be slotted into existing workflows and therefore require new workflows designed around them.

Existing workflows consist of a series of steps and are hierarchical in nature. An artist makes decisions throughout the entire process of creation. Some of these decisions are large, such as deciding on subjects and composition, while others are small and less impactful, such as deciding where to place a particular brush stroke. While some work exists based on common workflows (Yao and Budthimedhee 2024; Wang et al. 2025; Singh et al. 2025), automating multiple steps or steps where more critical decisions are made strips the human of creative control over the final artifact. There are a number of frameworks and taxonomies to guide the

design of such tools (Rezwana and Maher 2023; Singh et al. 2025; Guzdial and Riedl 2019; Chung, He, and Adar 2021; Kreminski and Chung 2024). An analysis of intent and interaction in co-creative systems is valuable in understanding how to best design co-creative systems. Kreminski et al. identify the issues of underexpression and uncertainty as reasons a co-creative system may fail to grasp user intent. They note that the user's uncertainty is sometimes because the user does not have a fully-formed idea in mind. In 2D art this is true in a majority of cases and workflows are iterative in nature as a result. I want to study the 2D art workflow as a series of hierarchical decisions, how co-creative systems can best be applied and whether process-driven design of such systems produces more agreeable tools for artists.

The proposed topic of my thesis is therefore to design and study systems that are centered around artists and the portions of existing workflows where artists make fewer and less impactful creative decisions, retaining maximum creative control. Further, I want to study the adaptation of such systems to artists through interaction such that the small decisions deferred to the system are as consistent with the artist's intent as possible. I am additionally interested in co-creative systems in the context of design processes as a series of hierarchical decisions, and the effects of automating more impactful decisions on feelings of control and ownership. I have previously designed a system, SketchBetween, for use in frame-by-frame animation. Currently I am working on similar texture synthesis and a designer-led colorization tool through industry collaboration. I will be designing and implementing an adaptive co-creative system for inking sketches via two modalities that encapsulate two different decision scopes. It is my hope that by designing process-driven tools, the final artifacts will be of use to the 2D illustration community. Moreover, I believe that studying process-driven design of such systems could lead to a paradigm shift in how automation tools for designers are studied, designed and developed.

## Related Work

### 2D image processing

There has been a meteoric rise in the application of machine learning to the arts in recent years, with several new technologies paving the way for more high-fidelity images than

before. Large text-to-image diffusion models are among the most popular (Ramesh et al. 2021; Rombach et al. 2022). In addition, there are a variety of different modalities of image generation that have been investigated in recent years (Cetinic and She 2021). Notably, the majority of image generation research focuses on the final generated artifact as opposed to the process of interacting with the tools, and is not intentionally created to be used in an artist’s process. Some recent work in other modalities may be more relevant to artistic processes, such as lineart colorization models (Yao and Budthimedhee 2024; Wang et al. 2025), although those often encapsulate large steps of a process and are non-iterative. There are a number of mixed-initiative co-creative drawing tools (Davis and Rafner 2025), and while they offer a range of interaction modalities they are similarly not designed with existing artistic processes in mind.

There is existing research on modeling the artistic process, such as ProcessPainter (Song et al. 2024) which uses simulated data to learn a text-to-video model that generates a video of a simulated painting process. There was additional fine-tuning on artist process videos, but this work does not provide a co-creative tool.

### **Co-creative system design**

Co-creativity has been formalized and studied through a variety of lenses. Rezwana et al. proposed COFI (Rezwana and Maher 2023), which provides a framework for modeling interactions with a co-creative system through categorizing interaction possibilities. Guzdial et al. additionally put forward an interaction framework for Co-creative Systems (Guzdial and Riedl 2019) in the form of reflections for different parts of the co-creative systems design. Chung et al. propose a taxonomy of Creativity Support Tools based on a review of existing literature on both learning and non-learning tools (Chung, He, and Adar 2021), of which co-creative tools are a subset. Further, Kreminski et al. have researched how to elicit intent in co-creative systems (Kreminski and Chung 2024). They propose three design patterns with the goal of better achieving user intent. Examining co-creative system design through the lens of iterative and hierarchical decision making in existing designer workflows may provide further insights that are not captured by existing research.

### **Work so Far**

My work to date has focused largely on creativity support tools for digital artists, with my goal being for the artist to retain creative control and ownership over the finished artifact.

### **SketchBetween: Video-to-Video Synthesis for Sprite Animation via Sketches**

In this work we used a VQ-VAE (van den Oord, Vinyals, and Kavukcuoglu 2018) to automate the process of inking, flat coloring and rendering in-between frames given fully finished keyframes and sketches of the in-betweens (Lofts-dottir and Guzdial 2022). We showed that for this task that our method outperformed a baseline of warping the image

via learned keypoints based on another animation. We performed an informal user study where artists used this tool and were able to render their in-betweens using it.

### **Neurosymbolic Texture Generation**

I am in the final stages of evaluating a system which performs wave function collapse (Gumin 2016) on the latent representation of a texture derived through a VQ-VAE (van den Oord, Vinyals, and Kavukcuoglu 2018). Initial results show a larger neighborhood of coherence than a baseline of texture synthesis via neural cellular automata (Mordvintsev, Niklasson, and Randazzo 2021).

### **Lineart to Flat Colors Conditioned on Palettes**

I am currently collaborating with the game studio Hyper Hippo to design a designer-led tool for adding flat colors to an illustration conditioned on lineart and a color palette. This project is in progress and was formulated through discussions with Hyper Hippo’s art team who identified this step in their workflow as consisting of smaller, less meaningful decisions.

### **Future Work**

The proposed topic for the remainder of my PhD is to design and study co-creative tools for portions of established illustration workflows that allow an artist to retain creative control. I will do this by leveraging my own experience with illustration and the experience of artist collaborators to identify areas where co-creative tools are welcome. Additionally, I want to apply human-in-the-loop methods to mixed-initiative co-creation such that the tools can adapt to the designer in such a way as to make the automated decisions align better with the artist’s intent. I believe that through viewing the creative process as a series of hierarchical decisions allows for an analysis of what kinds of interactions with co-creative tools can best retain creative control in 2D art. Through designing and studying tools for low-stakes decision-making parts of the process I hope to build a greater understanding of process-centered co-creative tool design.

### **Co-Creative Lineart Tool**

As an example of the sort of system I want to build, I propose a co-creative tool for inking a sketch. Once a sketch has been made, the form of the subject matter is roughly established, and the creation of lineart serves to clarify and “clean up” the sketch. I have identified that for many artists, including myself, inking a sketch often consists of following previous decisions (the sketch) to their logical conclusion. That is to say, this step contains fewer and less impactful decisions. I hypothesize that a co-creative tool would be useful in speeding up this process without sacrificing much creative control. I am interested in implementing a mixed-initiative co-creative tool where an artist and an agent both produce lineart strokes. The agent provides suggestions of lineart strokes which a user can choose to accept or reject. The user’s decision and the user’s own strokes serve as a signal to a human-in-the-loop reinforcement learning model which adapts its internal model to produce more preferred

lineart stroke suggestions. In addition to this mixed-initiative system, I want to create an alternative version which given a sketch suggests variations of completed lineart, of which the user then selects a favorite which biases the system towards their preferences by updating an internal model. I plan to evaluate the effects of the two interaction modalities and the scope of the co-creative system's actions on perceived creative control. Additionally I will study each modality's efficiency in adapting its internal model of the artist's preferences. This could offer valuable insight for future research on co-creative design tools.

### Study of Process-Driven Co-Creative System Design

Using the systems I develop as well as an analysis of existing co-creative systems I want to study the design of process-driven co-creative systems and produce insights to drive future research and development. Currently my concept of 2D illustration processes is derived from personal experience and collaboration with artists. Studying process-driven design may require these processes to be established more formally, using methods which have been used in other creative fields (Ma et al. 2024). I want to test my hypothesis that focusing on existing processes and considering the scale and impact of the decisions being automated produces tools that give designers better creative control.

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