Human-Computer Co-Creativity: Blending Human and Computational Creativity

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Abstract

This paper describes a thesis exploring how computer programs can collaborate as equals in the artistic creative process. The proposed system, CoCo Sketch, encodes some rudimentary stylistic rules of abstract sketching and music theory to contribute supplemental lines and music while the user sketches. We describe a three-part research method that includes defining rudimentary stylistic rules for abstract line drawing, exploring the interaction design for artistic improvisation with a computer, and evaluating how CoCo Sketch affects the artistic creative process. We report on the initial results of early investigations into artistic style that describe cognitive, perceptual, and behavioral processes used in abstract artists making.

Introduction

Creativity is an important topic in the Human Computer Interaction (HCI) and Artificial Intelligence (AI) research communities. HCI researchers build creativity support tools (CSTs) that augment and extend the creative abilities of humans, and AI researchers develop computationally creative systems to test cognitive theories of creativity. Enormous progress has been made in the two supplemental pursuits; however, there is a gap in the research literature about blending humans and computers in a collaborative co-creative process. My thesis explores ways in which humans and computers can collaboratively improvise in the art making process. In this approach, the computer and human are viewed as a system through which a new type of human-computer co-creativity emerges.

To investigate this issue, I propose a collaborative computational sketching system called CoCo Sketch. CoCo Sketch encodes some rudimentary stylistic rules of abstract sketching and music theory to contribute supplemental lines and music while the user sketches. The system investigates a new type of artistic creativity where a human and computer both make creative contributions to an artwork. This new type of human-computer co-creativity enables a computer to contribute as a partner in the creative process.

The interaction design of CoCo Sketch is motivated by two creative collaboration domains: (1) The exquisite corpse drawing game where multiple collaborators each add to the same drawing, and (2) Jazz improvisation during which each collaborator responds to and builds on the other party's contributions. I hypothesize that CoCo Sketch will support creativity by pushing artists to explore new and unexpected line combinations. Additionally, I hypothesize that CoCo Sketch's dynamic musical accompaniment will increase creative engagement by reducing creative inhibitions and helping users attain a state of creative flow.

I ask the following research questions.

- **RQ1:** What are the basic stylistic elements of the abstract line drawing genre that can be encoded in an AI system to enable meaningful artistic collaboration?
- **RQ2:** How does improvisational human-computer co-creativity affect the artistic creative *process* and *product*?
- **RQ3:** How does creative engagement change when a system generates musical accompaniment based on the user's sketching behavior?

The primary contribution of this thesis is addressing a gap in the CST research literature on how computer colleagues can contribute to the creative process. Furthermore, the thesis paves a new path for the field of computational creativity in AI by exploring how computationally creative systems can be seamlessly blended into the human creative process. Finally, the thesis introduces a new systems view of creativity that describes how creativity can emerge from real-time human-computer improvisation and collaboration. As a new concept, human-computer co-creativity can be useful for understanding how to augment creativity across domains.

Related Work

Creativity Support Tools

Creativity Support Tools (CSTs) enhance and augment the user's existing creative skills. The precise functionality of CSTs change based on creative domain, but they generally allow users to rapidly generate multiple alternatives, explore and simulate choices, and revert to earlier stages of an idea (Schneiderman 2007). Currently, most CSTs allow users to perform operations on their creative product and support decision-making about that product. Lubart (2005) enumerates four categories that describe how computers can support creativity. A computer *nanny* provides tools to schedule and maintain creative activities. A computer *pen-pal* supports collaboration within teams. Computer *coaches* stimulate creative thinking by suggesting creative activity based on expert knowledge in the domain. Computer *colleagues* may meaningfully contribute to tasks so a human-computer team becomes a contributor to a domain. This last category of CSTs, computer colleagues, offers interesting opportunities for creative expression, but it has not been researched very deeply.

There are several artistic and sketching related CSTs that teach technical skills or stimulate creative thinking. For example, iCanDraw helps users draw realistic portraits by providing feedback about the accuracy of user's lines according to an expertly drawn portrait that serves as the ground truth (Dixon et al. 2010). iCanDraw and other similar systems improve the user's technical artistic ability, but none of these types of computational systems make creative contributions to the artwork itself.

Computational Creativity

Creativity is generally defined as a product that is novel, valuable, and surprising (Sternberg 2006). The field of computational creativity develops computer programs that autonomously produce works of art that are classified as creative. Harold Cohen (McCorduck 1990) developed a computer program called Aaron that creates brightly colored digital artworks containing abstract shapes and human figures. Aaron's algorithms are non-deterministic, which means the initial conditions and subsequent decisions of the system greatly influence the product. The product cannot be predicted because it does not follow a linear path, which means the artworks that Aaron produces are both novel and surprising. Furthermore, these artworks have demonstrated value through their acceptance as art that is displayed in galleries.

Colton (2008) pushed the field of computational creativity forward when he suggested that creativity should be measured through process as well as product. For example, Aaron's software architecture uses distributed processing where many different models analyze the each other's decisions and reacts to them in unique ways. These modules all interact to yield an emergent artwork that was not completely dictated by the programmer, which makes its process more creative.

The proposed project injects human creativity into the algorithms of a computationally creative system. Instead of random number generators introducing noise in the system to drive unpredictable results, the system will leverage the human's creative contributions as input to the system. In this context, the focus is not on building a sufficiently creative computational system, but rather by enabling a creative system that includes both a human actor and distributed algorithms that process input independently.

Co-Creativity

Co-creativity is classified as multiple parties contributing to the creative process in a blended manner (Candy et al. 2002). In alternative creative situations, tasks can be accomplished through a distribution of labor, but the result only represents the sum of each individual contribution. Co-creativity goes beyond this division of labor model and allows all individuals to contribute collaboratively and synthetically. In this situation, ideas can be fused, combined, merged, and added onto in ways that stem from the unique mix of personalities and motivations of the team members (Candy et al. 2002). It can yield more creative solutions than if each party completed an isolated task and then added them together, i.e. the sum is greater than the parts.

I introduce a new term called *human-computer co-creativity* that introduces a computer into this collaborative environment as an equal in the creative process. Depending on the implementation details, the computer can potentially collaborate with the user in a variety of ways. The crucial point here is that the computer does not follow a pre-defined script to guide the interaction. The program is adapting to the input of the user and generating responses to that input based on computationally creative algorithms.

Human-computer co-creativity describes a situation in which the human and computer improvise in real time to generate a creative product. Here, creativity emerges through the interaction of both the human and the computer. This model of interaction is not a distribution of labor where each party performs different and independent tasks. The contributions of human and computer are mutually influential, which is the nature of collaboration and improvisation.

Research Method

The method for this thesis is threefold. (1) Perform qualitative empirical studies to begin to understand rudimentary stylistic elements of abstract drawings. (2) Encode those stylistic rules into algorithms and work to define the proper interaction design for CoCo Sketch through iterative prototyping and user testing. (3) Evaluate whether the prototype answers the hypotheses by measuring its effect on the creative process of artists. The next sections will explain these three components in more detail.

Encoding Artistic Style

Defining general rules that describe artistic style is a complex pursuit. Scoping the aim of this task significantly simplifies it. For the purposes of this project, I will focus exclusively on abstract line drawings. Complex shapes, such as people and animals, add a significant amount of difficulty due to the complexity of computer vision and object recognition. By focusing on abstract line drawing, the rules only need to deal with the visual features of lines and their spatial relations. Furthermore, an exhaustive and generalized catalog of artistic style in this domain is not necessary because the system only needs enough domain knowledge to make meaningful contributions. Fortunately, abstract art is forgiving in the sense that contributions from the computer will not be 'wrong' in the same way that they would be in representational art, i.e. putting an ear where a nose should be.

Three methods will be used to collect data about artistic style. The first step is making video records of abstract artists creating line drawings. After the artist is finished, they will be complete a retrospective protocol analysis describing their thoughts and motivations that guided their stylistic decisions. Performing a qualitative data analysis of this footage will help determine patterns and themes that can be used to describe the decision making process of artists. For example, does the artist have a certain strategy for making contributions, such as defining major lines and then adding details to those lines later? Does this strategy change as the artwork progresses?

Next, the artists will engage in a more controlled task where they create response lines to a pre-determined set of inputs consisting of simple shapes, such as vertical and horizontal lines, circles, and squares in different positions on a piece of paper (Davis et al. 2011). Asking the artist to draw response lines and explain their reasoning will help isolate factors that influence their decision making process.

Finally, the artists will play a collaborative art game (Hsiao et al 2013). In this game, the artist has to teach an 'apprentice' how to draw in a way that looks like the artist's style. Interaction will occur through turn taking, and the artist will be asked to provide feedback to about the apprentice's contributions, such as what was done right or wrong. This exercise will force the artist to be explicit about the rules and procedures s/he uses to make artistic decisions and help codify elements of artistic style.

Preliminary analysis of the abstract art creative process reveals two fundamental types of contributions in an abstract artwork—contributions that *elaborate* and refine an existing structure, and contributions that *catalyze* the artwork (Davis et al. 2011). Elaborations build on existing lines and patterns, whereas catalysts introduce completely new themes and structures into the piece.

Some abstract artists alternate their focus and perception between local features, regional patterns, and global relationships throughout their process. Local features refer to individual lines and their visual appearance. Regional patterns describe how lines and groups of lines interact and form coherent patterns. Global relationships describe the ways in which different parts of the drawing relate to each other and how to make a coherent overall composition. Local, regional, and global components all have independent and sometimes overlapping evaluation criteria. Each aspect of the artwork has what can be referred to as an aesthetic equilibrium that is reached by elaborating on the existing structures until they reach a state of stylistic 'maturity,' meaning that the lines adhere to some internal set of aesthetic or perceptual logic (Davis et al. 2011). For example, sketchy lines may need to be made smooth, or skinny lines may need to be made thick in order for aesthetic equilibrium to be reached.

Further analysis is needed to fully address RQ1 and create a more robust and detailed understanding of the creative process of abstract artists. Once some rudimentary stylistic rules exist, the improvisational structure and interaction design of CoCo Sketch needs to be developed.

Designing for Improvised Interaction

A semiotic analysis of the communication structure in improvisation will help inform the interaction dynamics and functions of the system. The most basic definition will be that of a *creative trajectory*, which is the shared understanding and intention to make creative contributions in a mutually negotiated and desired direction.

There are many ways that computers can improvise with humans in the artistic creative process. Improvisation includes understanding and relating to the contributions of another party. In successful improvisation, an individual is able to discern a pattern or theme and respond to that theme in a meaningful way. This is the basic call and response format in jazz improvisation. I will begin the analysis from this starting point.

Contributions that serve to establish a pattern or theme will be called *establishing actions*. This is similar to choosing a topic in a conversation. One party picks a creative trajectory and executes an initial action in that trajectory. The degree of expressivity, detail, or clarity of the establishing action will influence the interpretation of this action. For example, if the establishing action is too small or ambiguous, the other party may not understand how to contribute to it. When a party observes and experiences an establishing action, the choice is to accept that trajectory and align their subsequent actions with that pattern or reject it. A response action that accepts the suggested creative trajectory will be called a *verification action*, while a response that rejects a creative trajectory will be referred as a *rejection action*.

An improvisatory action that verifies a pattern shows that the party was able to successfully interpret a pattern or part of a pattern. Additionally, it encodes a value judgment on the part of the responder that shows that the party agrees with the suggested direction. Verification actions will typically align with the interpreted pattern or theme. This serves two purposes: 1) Testing whether the interpreted theme or pattern as the intended them or pattern, and 2) Indicating support for the established theme. When the initiating party experiences the verification action, they can verify that the theme was interpreted correctly and perform building actions that add to an established theme. At this point both parties are on similar creative trajectories and can perform small *elaboration actions* that push the established boundaries of the current theme.

At any point during the creative trajectory, a party can choose to break the current communication channel and open up an alternative channel of communication to establish a new theme or pattern of collaboration. This type of action is termed a *deviation action*. A deviation action serves a double purpose of notifying the other party of the intention to deviate from the current creative trajectory as well as suggesting a new direction by trying to establish a new theme. Deviation actions can serve as catalysts to the creative process because they force the other party to respond in a creative way.

Deviation actions can disturb an established equilibrium of a local area, region, or the global artwork. CoCo Sketch will separate state data for local, regional, and global information. The decision engine determining how CoCo Sketch will respond incorporates the improvisational semiotics outlined in this section as well as the rudimentary stylistic guidelines described earlier.

Evaluation

The mixed-method evaluation consists of three phases that include both quantitative and qualitative elements. To evaluate CoCo Sketch, 10 abstract artists will create three ten-minute sketches with CoCo Sketch. The first sketch will be the control condition with no assistance. The second sketch will improvise and collaborate with the user, and the third sketch will improvise as well as provide musical accompaniment.

The CoCo Sketch tool will log sketch behavior and provide quantitative data, such as the number of lines, amount of ink per second, time lapse between lines, and average line length. This quantitative data can be used as one indication of how the different interventions affect sketching behavior, which addresses part of RQ2 about the creative process. Artists will be asked to perform a retrospective protocol analysis to describe their experience and thought processes for each of the conditions to provide qualitative insight about how the tool affected their creative process.

The participants will also complete the Creativity Support Index (Carol et al. 2009), which provides measurements about creative engagement. This will help answer RQ3 about whether CoCo Sketch helps cultivate creative flow. Finally, the creative products for each three drawings will be given to an expert panel to evaluate their creativity using Amabile's Consensual Assessment Technique (1996).

Conclusions

This thesis addresses a gap in the research literature about computers colleagues that contribute as equals in the creative process. Human-computer co-creativity offers interesting possibilities in the fields of computational creativity as well as creativity support tools because it seamlessly integrates human and computational creativity. The research program that we presented included three components that deal with learning about artistic style, encoding those stylistic rules and defining the interaction, and finally evaluating the system.

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