Co-creative Physical Drawing Systems

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Abstract— This paper describes design research into the development of a human-AI co-creative drawing system. The artist draws with physical media (e.g. pen and ink) on paper and the AI responds through projected visual interactions upon the drawn surface while observing and modelling the artist's drawing process. Based on a preliminary user study to survey the drawing practices of artists, a design for a real-time system architecture is described along with an initial prototype. This prototype will be used for research with anticipated contributions into dynamic sketch acquisition of physical media, modelling co-creative human interaction for visual arts and development of an artist tool for artistic output to be showcased within the creative computing community.

I. INTRODUCTION

Despite wide adoption of digital drawing tools, physical media still plays an important role in the workflow of many drawing practitioners. Recent developments in creative AI for visual arts and human-robotic collaborative drawing [1] raise the proposition for research in human-AI collaboration within a drawing workflow. This motivates us to explore how such interaction might contribute to the creative work of artists. We investigate two key questions: (1) Utilising techniques from Computer Vision, can the richness of a drawing with a variety of textures and layers upon a physical surface be observed and synthesised for an AI to model? (2) Utilising techniques from Human-Robot Interaction can non-obtrusive creative collaboration be supported? In this short paper, we present preliminary work in addressing these questions, through an exploratory user study of artists' practice and a prototype system designed to capture, and eventually model, interactions between the artist and our AI system.

A. Related Work

This interdisciplinary research connects to multiple communities, and we highlight relevant activity in some of them here. *Sketch beautification*, where the intention is to enhance the drawing process and the end goal is the drawing itself [2], is a closely related area within the well-established *sketchbased* computing research literature. These systems utilise a variety of models to provide real-time drawing support to an artist, such as idealised geometric models [3], databases of drawn images [4], graph-based representations of strokes [5] and neural network representations of drawn strokes [6]. *Sketch recognition systems* provide a process of analysing a drawing for its content [7], [8]. The *drawing research* community [9], [10] documents (not necessarily technology mediated) collective and collaboration drawing practices. Other relevant work include systems built to study artists at work through techniques such as *saliency analysis* [11] and embedded sensor systems [12]. *Generative computer art* [13] and *Creative AI* [14] provides techniques for an AI to contribute towards collaborative art-making. *Robotic painting and drawing* [15], [16] and robot-artist collaborative drawing [1] are examples of art systems embodied in the physical world.

II. PRELIMINARY USER STUDY

To inform development of our human-AI creativity system, a mixed-methods study of drawing practitioners (e.g. professional illustrators, fine artists and art students) was conducted in Autumn 2018. Its aim is to discover possible roles that technology could play in observing, modelling and possibly assisting an artist with their drawing. A total of 21 participants representing a mix of professional illustrators, part-time drawing enthusiasts and illustration students were interviewed individually. Each participant completed a paper survey about their drawing habits and technology usages and attitudes. They completed 3 recorded 10 minute drawing exercises and participated in an interview discussing their drawing habits, attitudes towards AI and envisioning potential collaboration with a drawing AI.

We have identified three key themes from the user study: (1) Drawing with physical mediums is a traditional and primary way of creation for visual artists. Participants expressed the benefits of drawing with physical art media (e.g. pen, pencil, paint, paper, canvas). Physical surfaces feel immediate and direct (e.g. drawing with a pencil and then being able to smudge drawn lines with a finger). Paper provides a tactile response through friction with the drawing tool. This contrasts to the feeling of working with a digital drawing tablet, which has the haptic response of pushing a piece of plastic upon glass. Even if the final product would take a digital form, sketching with pencil and paper often are the initial steps towards embarking on a creative project. Digitising a physical drawing typically occurs once during a project, via scanning or taking a photo with one's phone, as the effort is high to switch between physical and digital drawing tools.

(2) **Co-creative AI is preferable to didactic AI.** When presented with the idea of having an AI collaborator, artists and illustrators expressed a few reservations. They were concerned with something obstructing the direct action of drawing, being stressed by having an observer of their

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Fig. 1. Prototype system with two Raspberry PI cameras (1), pico projector displaying camera calibration pattern (2) and WACOM Bamboo Slate digital "sketchpad" (comprised of a digitally enhanced pen which tracks movement and produces marks on physical paper) (3), each with a dedicated Raspberry PI 3 (RPI) communicating via ROS (http://ros.org)

drawing process (even if artificial) and being annoyed at the premise of something instructing them in what to draw. Creative autonomy is important to the artist, and having something intervene within the drawing process is seen as distracting and is not desired.

On the other hand, artists were open to idea of having an inspirational agent, or muse, to contribute towards their idea process. Sometimes, coming up with ideas of *what* to draw is difficult, especially for those who draw on a regular basis. Creative practitioners are often faced with these "artist blocks" and self-help exercises [17], suggestive prompts (e.g. *Oblique Strategies* cards [18]) and visual games (e.g. *Exquisite Corpse* [19]) are ways to *warm up* an artist towards feeling *inspiration* towards working.

(3) Artists share a general discomfort towards automation of creative work. Creativity and drawing is seen as one of the last bastions that is resistant to complete automation via AI. Artists and illustrators are aware of the output of the latest developments in visual expression by AI which reach mainstream press, such as the outputs from *style transfer* research [8]. In this case, AI appears to stand alone and apart from any human creative input, despite requiring human effort to development, train and tune.

III. SYSTEM DESIGN

Figure 1 shows our current system prototype, development of which has focused on deciding on the interfacing technologies. A *digital "sketchpad"* (comprised of a digitally enhanced pen which tracks movement and produces marks on physical paper) is utilized in tandem with a Computer Vision (CV) system to train an observation system to capture the richness of the artist's work. Dependence on a CV-based system satisfies one of our design goals which arose from our preliminary user study, which is that the drawing process is done via physical media. Another design goal is that the artist has the sole physical agency to manipulate the drawing in progress. The co-creative AI responds through projected visual interactions upon the drawn surface. This provides collaborative opportunities for the artist to then respond to the AI in whatever manner they deem appropriate.

IV. NEXT STEPS

Further development of our prototype system requires a unified representation of the drawn work. Integrating and calibrating individual sensing components (i.e. cameras, projector, digital sketchpad) is a technical challenge to guarantee coherent data collection and user interaction. Next, a model for collaboration between the artist and AI needs to be developed including further literature review of collaborative drawing practises and lab experimentation. In addition, quantitative techniques to analyze and describe changes in behaviour of an artist's drawing practises that may arise through interactions with the AI will be developed.

A second user study will be conducted with a similar cohort of drawing practitioners using the research system through a series of drawing experiments in order to test the model of collaboration between artist and AI. Using the developed analytic techniques with the results from the drawing experiments, we will be able to describe the impact collaborating with an AI has on an artist's drawing practice.

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