Towards co-creative drawing with a robot

Chipp Jansen[1]
[1]*Dept of Engineering*
King's College London, UK
chipp.jansen@kcl.ac.uk

Elizabeth I Sklar[1,2]
[2]*Lincoln Institute for Agri-food Technology*
University of Lincoln, UK
esklar@lincoln.ac.uk

***Abstract*—This paper describes research into the development of a co-creative human-robot drawing system. Based on a pilot user study to survey the drawing practices of artists, various interaction factors have been identified that define example roles that a robot might take as a co-creative drawing partner. A research prototype system which observes an artist drawing with physical media—on paper—through the use of a drawing tablet and multiple cameras. The robotic system observes and captures data in real-time, as the artist draws. The longterm goal is to generate a data-backed model of the artist's drawing process, which in future will respond through projected visual interactions upon the drawn surface. The design and technical details of the observational system are described in this short paper.**

***Index Terms*—human-robot collaboration, co-creative drawing, user study, artist drawing process**

I. Introduction

Inspired by advances in creative AI and human-robot collaborative drawing [1], we envision a system in which physical media and non-invasive observation of an artist contributes to a co-creative mixed digital-physical workflow. Currently, drawing has a large digital tools economy, and the primary workflow for artists to create 2-D content is a digital workflow. Our longterm aim is to develop an intelligent, autonomous system that has the ability to combine active and passive sensing with sophisticated data analysis and active response, designed to help artists move forward in their creative process. Our research involves examination from two perspectives: (1) what is technically feasible through the development and evaluation of a research prototype of a real-time co-creative drawing system; and (2) what artists want with respect to a co-creative drawing partner. Here, we describe the technical design of our prototype system, the functionality of which was guided by input gathered during a pilot study conducted with drawing practitioners [2].

II. Background

Traditionally, human-robotic collaboration in the visual arts consisted of artists programming robots to draw imperatively such as AARON [3], or portraiture style through observation from an artist robot, such as PAUL [4]. Collaborative human-robotic drawing is structured around how a robot collaborates with a human. In the DOUG system [1], the robot mimics what the human is drawing and the human responds to what the robot is drawing in a simultaneous form of collaborative sketching [5]. Research into socially assistive robotics for art therapy has the robot responding to what a human is painting through contributing painting which is a visual metaphor according to a sensed emotional model [6]. In a similar approach, but outside of robotics in the creative computing area, research into co-creative sketching systems involves using visual metaphors to avoid design fixation by presenting imagery that would provide a conceptual shift in what the artist is drawing [7]. The *sketch-based* interaction research provides models of real-time drawing support, such as idealised geometric models [8], processed gradients of drawn images [9], graph-based representations of drawn stroke [10] and neural network representations [11].

To inform development of our human-robot creativity system, we conducted a mixed-methods study of drawing practitioners (e.g. professional illustrators, fine artists and art students) in Autumn 2018 [2]. Our aim was 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, technology usage and attitude, recorded three drawing exercises and participated in an interview discussing their drawing habits and thoughts about AI/robotics. Three key themes were identified: drawing with physical mediums is a traditional and preliminary way of creation for visual artists; co-creative AI is preferable to didactic AI; and artists share a general discomfort with the idea of automating creative work. Discussion of these themes has been explored elsewhere [2], as has discussion of factors for defining a co-creative drawing robot and the role(s) that robot might take in a co-creative human-robot drawing process [12].

III. Research Prototype

Figure 1 shows an early version of our prototype system (*left*) and the corresponding schematic design of its components (*right*). Each component is controlled by a dedicated Raspberry PI with communication coordinated via ROS[1]. The sensing components are (as labelled in Figure 1): three Raspberry PI cameras (**1a/$\mathbf{C_{TOP}}$**, **1b/$\mathbf{C_{LEFT}}$** and **1c/$\mathbf{C_{RIGHT}}$**), a depth camera (**2/$\mathbf{D_{FRONT}}$**) and a WACOM Bamboo Slate[2]

Research is supported through an EPSRC DTP Studentship "Collaborative Drawing Systems", Grant Reference EP/N509498/1

[1]http://ros.org
[2]https://www.wacom.com/en-cl/products/smartpads/bamboo-slate

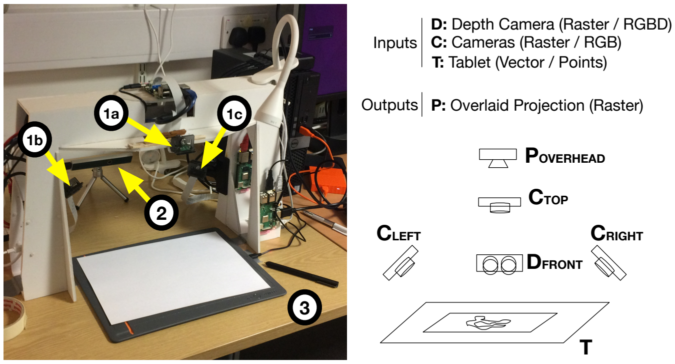


Fig. 1. Design of prototype system: *(left)* the hardware setup, *(right)* schematic of the design

digital "sketchpad" (**3/T**), which uses a pressure sensitive pen that tracks movement and produces marks on physical paper. The cameras observe the drawing area at multiple angles and records the textural aspects of the drawing, while the digital sketchpad records a vector representation of the pen's movements. Our design includes a projector (**P**$_{\textbf{OVERHEAD}}$) which overlays the robot's interaction upon the drawing surface; this component will be implemented in our next generation prototype. Through the use of projection, the artist has the sole physical agency to manipulate the drawing in progress.

Recently, we completed a data-gathering drawing study ($n = 13$) involving full-time drawing practitioners (professionals and students) to test our prototype system and collect an initial set for modelling. Participants did two drawing exercises, each lasting about 10 minutes: draw from *observation* of a still-life, and draw freely from *imagination*.

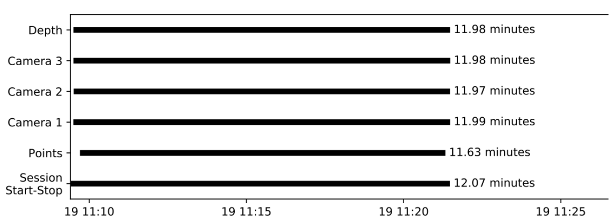


Fig. 2. Example inventory of datasets gathered for a drawing exercise.

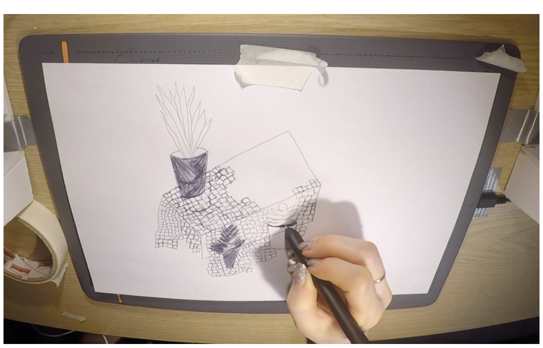


Fig. 3. Drawing in progress.

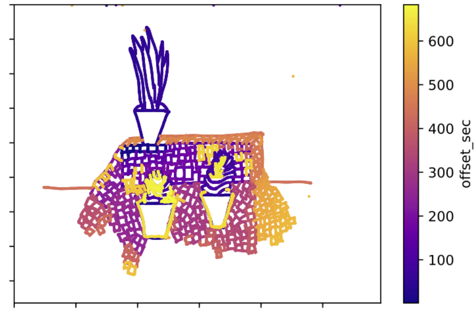
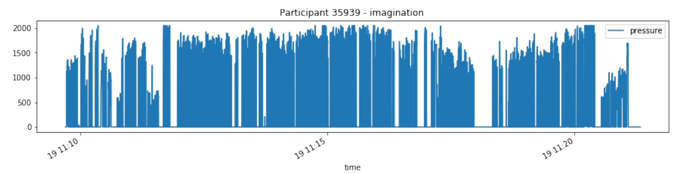
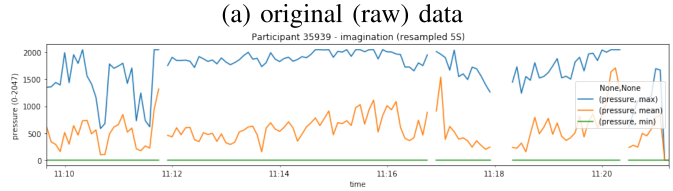


Fig. 4. Example drawing with time of drawing visualised through color.



(a) original (raw) data



(b) resampled data at 5sec time periods

Fig. 5. Pressure of drawing pen as recorded by the WACOM digital "sketchpad" for the same drawing exercise.

Here we present some very preliminary analysis of the data gathered. Figures 2-5 illustrate the data gathered and preliminary modelling for one sample participant. Figure 2 illustrates the amount of data gathered from one drawing exercise completed by our sample participant. Figure 3 shows their drawing in progress. Figure 4 shows the resulting drawing and how it evolved over time. Figure 5a illustrates the level of pressure exerted, over time, by one participant for the same drawing. This data is rather dense, so we have resampled the data in an attempt to build a model of user pressure behaviour (Figure 5b).

IV. Summary

We have described the design of our robotic co-creative drawing system, informed by an initial user study (Autumn 2018) and recently tested (January 2020) to gather drawing data from full-time artists. With this dataset, we are building models of the drawing process that will incorporate dynamics of the artist's body, their tool use and textural changes to the artwork's surface. With these models, we plan to experiment by having our robotic system inhabit various roles as a co-creative partner (e.g. suggestive, predictive, referential) and evaluate these roles through a larger user study with drawing practitioners in order to measure impacts of the robot on the artist's drawing process.

References

[1] S. Chung, "Drawing Operations (DOUG)," https://sougwen.com/project/drawing-operations, 2015.

[2] C. Jansen and E. Sklar, "Co-creative Physical Drawing Systems," in *ICRA-X Robots Art Program at IEEE International Conference on Robotics and Automation (ICRA)*, Montreal QC, Canada, May 2019, p. 2.

[3] P. McCorduck, *Aaron's Code: Meta-Art, Artificial Intelligence, and the Work of Harold Cohen*. W.H. Freeman, 1991.

[4] P. Tresset and F. Fol Leymarie, "Portrait drawing by Paul the robot," *Computers & Graphics*, vol. 37, no. 5, pp. 348–363, Aug. 2013.

[5] E. Sandry, "Creative Collaborations with Machines," *Philosophy & Technology*, vol. 30, no. 3, pp. 305–319, Sep. 2017.

[6] M. Cooney and P. Berck, "Designing a Robot Which Paints With a Human: Visual Metaphors to Convey Contingency and Artistry," in *ICRA-X Robots Art Program at IEEE International Conference on Robotics and Automation (ICRA)*, Montreal QC, Canada, May 2019, p. 2.

[7] P. Karimi, M. L. Maher, N. Davis, and K. Grace, "Deep Learning in a Computational Model for Conceptual Shifts in a Co-Creative Design System," *arXiv:1906.10188 [cs, stat]*, Jun. 2019.

[8] J. Arvo and K. Novins, "Fluid sketches: Continuous recognition and morphing of simple hand-drawn shapes," in *Proceedings of the 13th Annual ACM Symposium on User Interface Software and Technology - UIST '00*. San Diego, California, United States: ACM Press, 2000, pp. 73–80.

[9] Y. J. Lee, C. L. Zitnick, and M. F. Cohen, "ShadowDraw: Real-time user guidance for freehand drawing," in *ACM SIGGRAPH 2011 Papers on - SIGGRAPH '11*. Vancouver, British Columbia, Canada: ACM Press, 2011, p. 1.

[10] J. Xing, L.-Y. Wei, T. Shiratori, and K. Yatani, "Autocomplete Hand-drawn Animations," *ACM Trans. Graph.*, vol. 34, no. 6, pp. 169:1–169:11, Oct. 2015.

[11] D. Ha and D. Eck, "A Neural Representation of Sketch Drawings," *arXiv:1704.03477 [cs, stat]*, May 2017.

[12] C. Jansen and E. I. Sklar, "Towards a HRI System for Co-creative Drawing," in *Workshop on Creative Content in HRI*, Cambridge, UK, Mar. 2020, p. 4.