

Z-Drawing: A Flying Agent System for Computer-assisted Drawing

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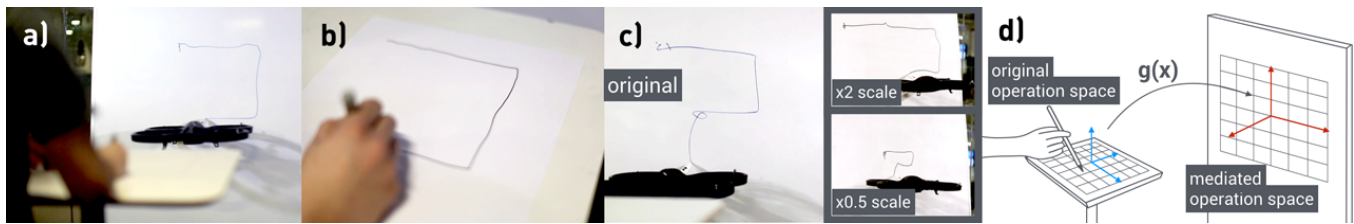


Figure 1: Our drawing application. a, b) Drawing on a regular desk canvas scales onto a larger canvas at a distance. c) The drawing can be scaled into different sizes on the go. d) $g(x)$ is the transformation describing the relation between original and mediated operation spaces.

Abstract

We present a drone-based drawing system where a user's sketch on a desk is transformed across scale and time, and transferred onto a larger canvas at a distance in real-time. Various spatio-temporal transformations like scaling, mirroring, time stretching, recording and playing back over time, and simultaneously drawing at multiple locations allow for creating various artistic effects. The unrestricted motion of the drone promises scalability and a huge potential as an artistic medium.

1 Introduction

Drawing as a means of expression has evolved over time, as, and through a means of computation: Since pre-historic time, mankind has been involved in drawings through a myriad forms of mediums that, over many years, have evolved to be increasingly computation-driven [Yamaoka and Kakehi 2014]. However, they largely continue to remain constrained in our innate motion capabilities. In this paper, we use drone technology to create a computer-powered flying agent that allows pen drawing at different scales and locations. The unrestricted motion of the agent provides unlimited possibilities of carrying out various artistic distortions of a user's hand drawing in real-time, creating a new dynamic medium of creative expression.

2 Our System

The system tracks pen movements as a user draws on a desk. These movements are captured by a computer, go through transformations pipeline, and are output through a drone's motion that draws on a larger canvas.

Pen Pose Stabilization: A pen attached to the drone creates a complex dynamic system as it comes in contact with the canvas, where the pressure applied towards the canvas induces a sideways friction. This results in a torque making it difficult for the drone to stay

in a fixed attitude (pitch angle θ). In addition, the drone has to consistently push forward for pen pressure on the canvas - with a risk of flipping. To alleviate this convoluted stabilization challenge, we PID control the pitch angle θ to be fixed. Then, we tilt the drone's yaw ϕ towards the moving direction in order to cancel out the torque induced by the friction. By denoting the vertical exertion of the drone as G and the horizontal exertion as F , the stabilization condition is expressed by the equation below. (κ is the friction of coefficient between the pen and the canvas.)

$$G \sin(\theta) \sin(\phi) \cos(\phi) = \kappa G \sin(\theta) \cos^2(\phi) + F \cos(\phi) \quad (1)$$

Flight Tracking and Position Control: A Windows desktop server controls the positions of a drone in 3D space based on the pen movements performed by the user. Retro-reflective markers on the drone and the pen are captured with the Optitrack [Optitrack] motion capture system for 6 DOF tracking. Then, the drone in space is controlled and anchored by a PID controller, thereby connecting the user's pen input to the motions of the drone. The PID control parameters were optimized to ensure smooth response of the drone to the pen input.

Transformations Possible: *Geometric Scaling* - A drawing can be scaled up or down based on the user's artistic intention or dimensions of the canvas. *Mirroring* - A drawing can be mirrored in real-time, creating a twisted geometric relation between input and output drawings. *Time Modulation* - This gives an interesting distortion to the process of drawing, allowing for the drawing act to be stretched in time, or to be recorded and redrawn later at different time speeds. *Multiplication* - More than one drone can be simultaneously used for drawing. This not only opens up the possibility of drawing at multiple locations at the same time, but also can be used to distribute controls to a number of people, creating a unique means of collaborative artistic expression.

References

OPTITRACK. <http://www.optitrack.com/>.

YAMAOKA, J., AND KAKEHI, Y. 2014. A pen-based device for sketching with multi-directional traction forces. *24th annual ACM symposium on User interface software and technology*.

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