PIN ART PRO

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1. Introduction

1.1 Objective

When it comes to art, both artists and art enthusiasts strive to create and find unique pieces that invoke human emotion. For this reason, the role of technology in art is largely focused on computer assistance in creating art as opposed to generating pieces based solely on algorithmic means [1]. In the medium of pin art, technology such as image processing is used to create on-the-spot contours of live image feeds. This style of pin art is limited by a lack of readily available and easy-to-use machinery to automatically generate contours of static images. Artists who wish to create amazing pieces of pin art that amaze crowds must spend many hours or dollars overcoming a technical knowledge barrier that prevents mechanical pin-art masterpieces from becoming a mainstream art medium.

Our solution is a pin-art board that uses a motorized pin-displacer to take static digital images using file formats such as PNG and JPG to create pin-art contours using the grayscale equivalents of those images. The displacer allows artists to focus on the pin material and color rather than mechanical engineering issues, and the physical contour also has the side effect of allowing visually impaired persons to use the pin-art to get an idea of what the image may have looked like.

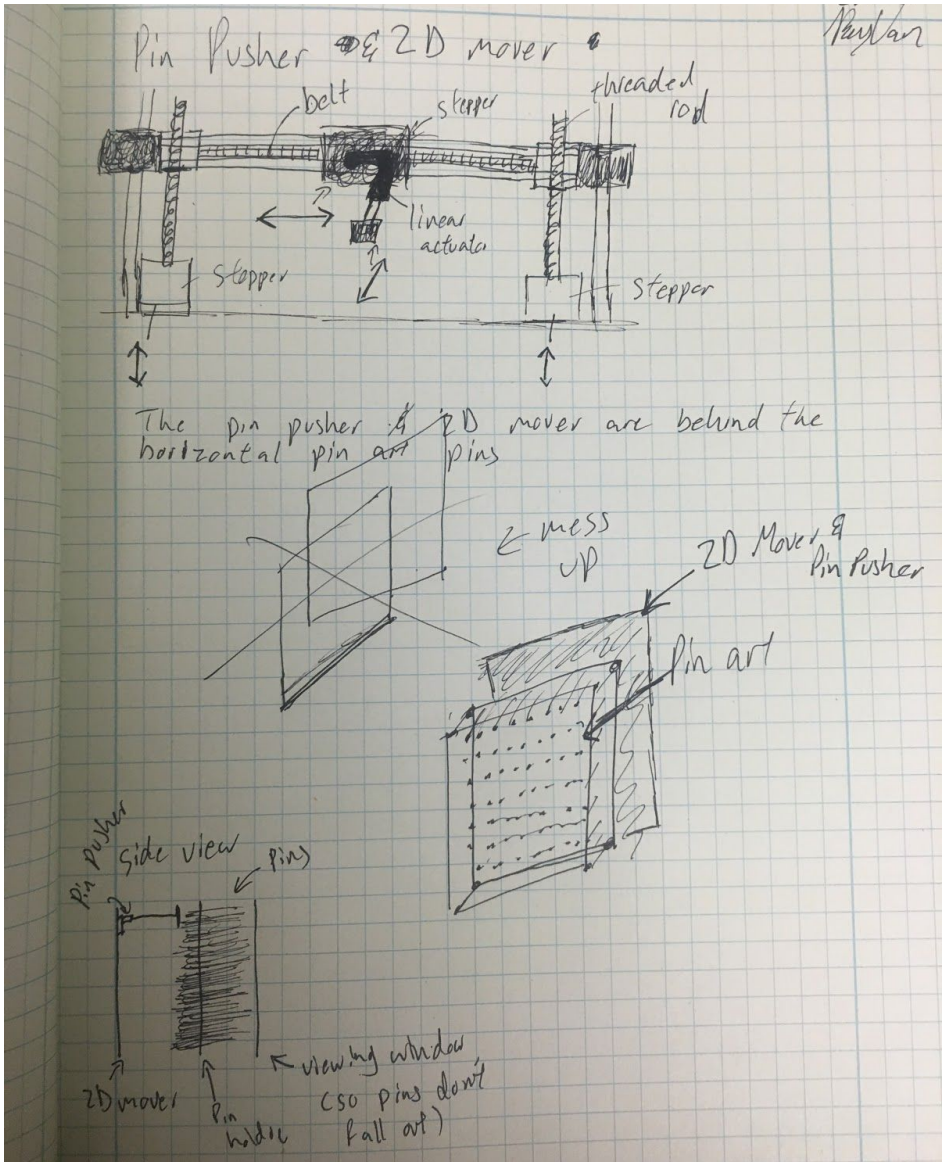
1.2 Background

The idea of the “Pin Art Pro”, a pin-displacing physical display, has existed and been worked on before in different forms with varying degrees of success. Stanford has created a high tech and expensive version which is used to quickly give side views of objects from files representing 3-dimensional objects [7]. Designer Sean Follmer has created a table top with a pin display used to show 3 dimensional math formals and gives people the ability to interact with objects by having a camera feedback loop that tracks the displacements of objects in front of the camera [2]. Even though pin-displacing physical displays exist there are some major drawbacks with those that exist.

Both pin displays described above designed by others are used to represent 3 dimensional objects in 2.5 dimensions (like 3D, but only gives a side view and doesn’t show all sides of the object at the same time). These displays allow blind people to easily create 3 dimensional objects by allowing them to see all sides of an object before they print it on 3D printers. Right now, however, it is still hard for blind people to see 2D art. Most 2D art are used to represent 3D objects. With our apparatus, we can add an extra half dimension to give depth to 2 dimensional works so they can see the art by feeling it. Our project will work as one step in that direction. We do not lock the pins in place at the moment so feeling the pins may push them back. Our project will still be cheaper as instead of moving each pin individually as done in the other designs we are pushing groups of pins at a time, which will be slower but significantly cheaper.

1.3 Physical Design

On the very back of our product there is a 2D mover and pin pusher, which is given power through the regulated wall outlet. This is behind the actual pin art array of pins which get pushed by the pin pusher that is on a 2D mover. All of this is shown in Figure 1 below.



[Figure 1] Physical Design

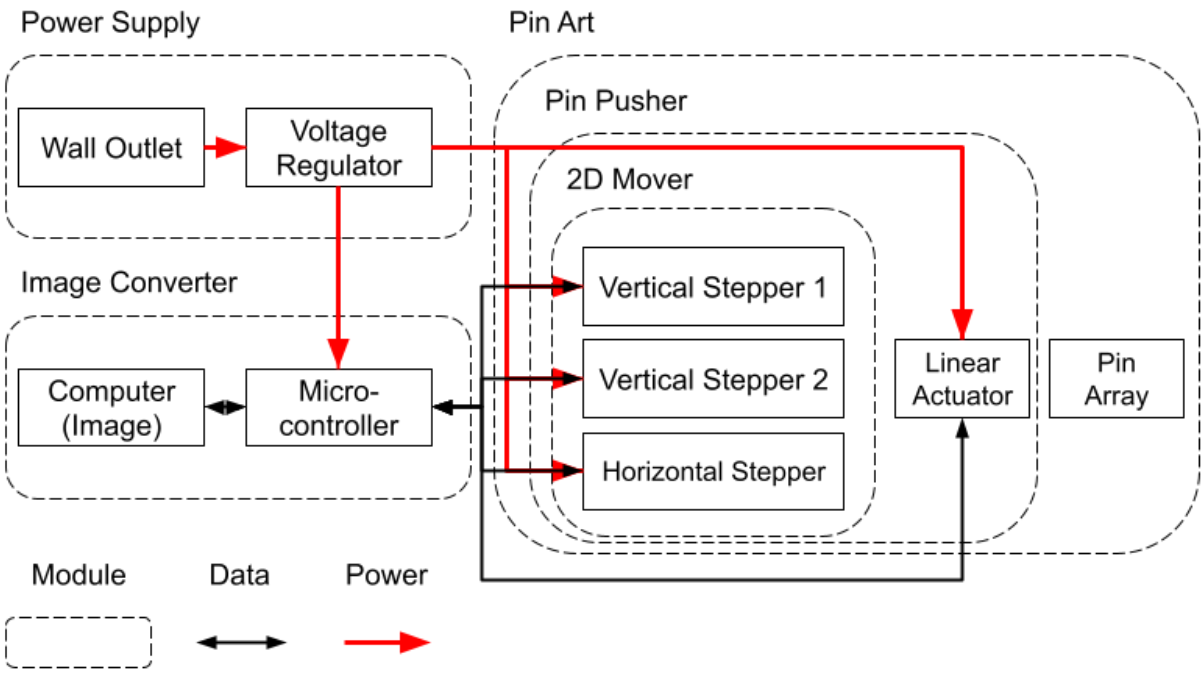
The top of Figure 1 shows the Pin Pusher and 2D Mover as one design. As shown, to move the Pin Pusher up and down it is attached to 2 stepper motors with a threaded shaft, both sides have motors to keep one side from falling down. To move the Pin pusher horizontally it has a stepper motor behind it on a belt. The middle image shows the layout of the entire product. In the front laid horizontally so the pins are parallel to the floor is the Pin Art. Behind it is the 2D mover and Pin Pusher. On the bottom left is the side view, the far left shows the 2D mover, right after (attached to the 2D mover) is the pin pusher which pushes the pins on the Pin Art board.

1.4 High-Level Requirements

- Our motor hardware should be able to move our pin pusher to a specific pin specified by the microcontroller accurately.
- Given an image, our image analyzer should output a data file that fits within the memory of our microcontroller SoC.
- The pin pushing motor should be able to adjust the position of a pin on the board by an adjustable distance in between a range of 0ft - 0.75ft.

2. Design

2.1 Block Diagram



This whole block diagram shows how we go from image to 2.5D rendering. First, we need enough regulated power to power 4 stepper motors and 1 microcontroller. Then we need the image and a microcontroller which should be able to convert the image to a displacement map. Finally we should be able to use that displacement map to move an array of pins to the correct displacements to create the 2.5D rendering.

2.2 Functional Overview

2.2.1 Power Supply

Supplies everything that needs power with power.

- *Wall Outlet:* Connects to the electricity from the regular US Wall Outlets. This sends the voltage to the voltage regulator
- *Voltage Regulator*: Makes sure all electronics get sufficient voltage.

2.2.2 Image Converter

Assigns displacements based on an image to push the pins

- *Computer Image*: Gives the image to be converted

- *Microcontroller*: Converts the image to grayscale and assigns displacements on the array of pins based off that image

2.2.3 Pin Art

Physically moving subsystem that creates final 2.5D rendering of image.

- Pin Array: Array of pins to be pushed to create final rendering.
    - Pin Pusher: Pushes all of the pins to correct offset
        - *Linear Actuator*: Physically pushes a square grouping of the pins.
        - 2D Mover: Moves pin pusher in Z and Y axis
            - *Vertical Stepper (1 & 2)*: Uses the threaded pole to move the pin pusher up and down.
            - *Horizontal stepper*: Connects to a belt to move the pin pusher left and right.

2.3 Block Requirements

2.3.1 Power Supply

Must be able to supply three 12V (+/- .5V) motors and a single 5V (+/- .5V) microcontroller.

2.2.2 Image Converter

Must be able to create an array of displacement for each grouping of pins on the pin art.

2.2.3 Pin Art

Must be able to restart all the pins in the starting position, even if manual.

Pin array must be 1.5 ft by 1.5ft and be able to stay stable horizontally.

Linear actuator must be able to displace between 0 and 1 feet (+/-.5 ft) with 1 inch accuracy.

All stepper motors must be able to move the linear actuators 1.5 ft vertically and horizontally with a 1 inch accuracy.

2.4 Risk Analysis

The sub-module that is the biggest risk to completing this project is the Pin Pusher, which contains the linear actuator and the 3 vertical stepper motors. Being able to move the linear actuator to the correct location on the YZ-axis and displace the pins to an accurate displacement on the X-axis is going to be the

most challenging, as the team is inexperienced with stepper motors and they are physically moving so any miscalculations or significant error in the operation and control of the motor could ruin the accuracy of the pin art render.

3. Ethics & Safety

There are no concerns relating to ethics in the development process of this project. There is a concern about using our product to print inappropriate images, violating the IEEE Code of Ethics Section I.1: “to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment” [2]. To prevent unethical usage, we should educate our users on acceptable behaviors.

Our product uses electricity from a household outlet of 120V. Our power system must be compliant with UL 498 [4] and ANSI C57.3-1942 [5]. Inappropriate usage of the power system or errors might cause severe injuries. Our product uses electric motors for moving to designated locations and an actuator for pushing appropriate pins. Our pin art system must be compliant with UL 1004-1 [6]. Our product requires manually resetting the pins. Our product does not have safety checks before operating. Starting operation while resetting pin locations or positioning one’s hands on or near the surface, pins, motors, or actuator while operating might cause minor injuries.

References

[1] S. Ornes, “Science and Culture: Computers take art in new directions, challenging the meaning of ‘creativity,’” *PNAS*, 12-Mar-2019. [Online]. Available: https://www.pnas.org/content/116/11/4760. [Accessed: 16-Feb-2021].

[2] “IEEE code of ethics.” [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 15-Feb-2021].

[3] *Stanford increasing access to 3D modeling through touch-based display*. Stanford, 29-Oct-2019.

[4] *Attachment Plugs and Receptacles*, UL 498, April 28 2017.

[5] *ANSI Standards for transformers, Regulators, and Reactors*, ANSI C57.1, C57.2 C57.3-1942, Nov. 10 1942.

[6] *Rotating Electrical Machines - General Requirements*, UL 1004-1, Sept. 19, 2012.

[7] S. Follmer, J. B. Ginsburg, A. F. Siu, E. J. Gonzalez, and S. Yuan, Stanford University, rep., Apr. 2018.