Robotic Caricature Artist

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1 Introduction

1.1 Objective

A caricature is a style of portrait that exaggerates certain features of the subject for comedic effect. Modern caricature artists typically work as street vendors or at social events, creating caricatures of patrons for a small fee. We wish to create an automated system that replicates the caricature artist experience as closely as possible. Caricature artists are able to take a mental snapshot of the subject and draw a simple portrait in a few minutes. Thus, our system should be able to capture an image of a patron, apply effects to the image, and use a motorized system to draw the image onto a sheet of paper.

1.2 Background

Image processing is ubiquitous in entertainment -- applications such as Snapchat allow for one to immediately apply filters to an image, which has proved to be tremendously popular. One feature nearly all apps of this nature share is instant gratification; in some cases, filters can be previewed before the image is captured. The entertainment value of certain art, however, is being able to experience the process of creation as much as the end result. Listening to music at a concert, for example, is completely different from listening to a pre-recorded track. This motivated our decision to have our project replicate the excitement and anticipation of watching an artist work rather than just receiving the final product.

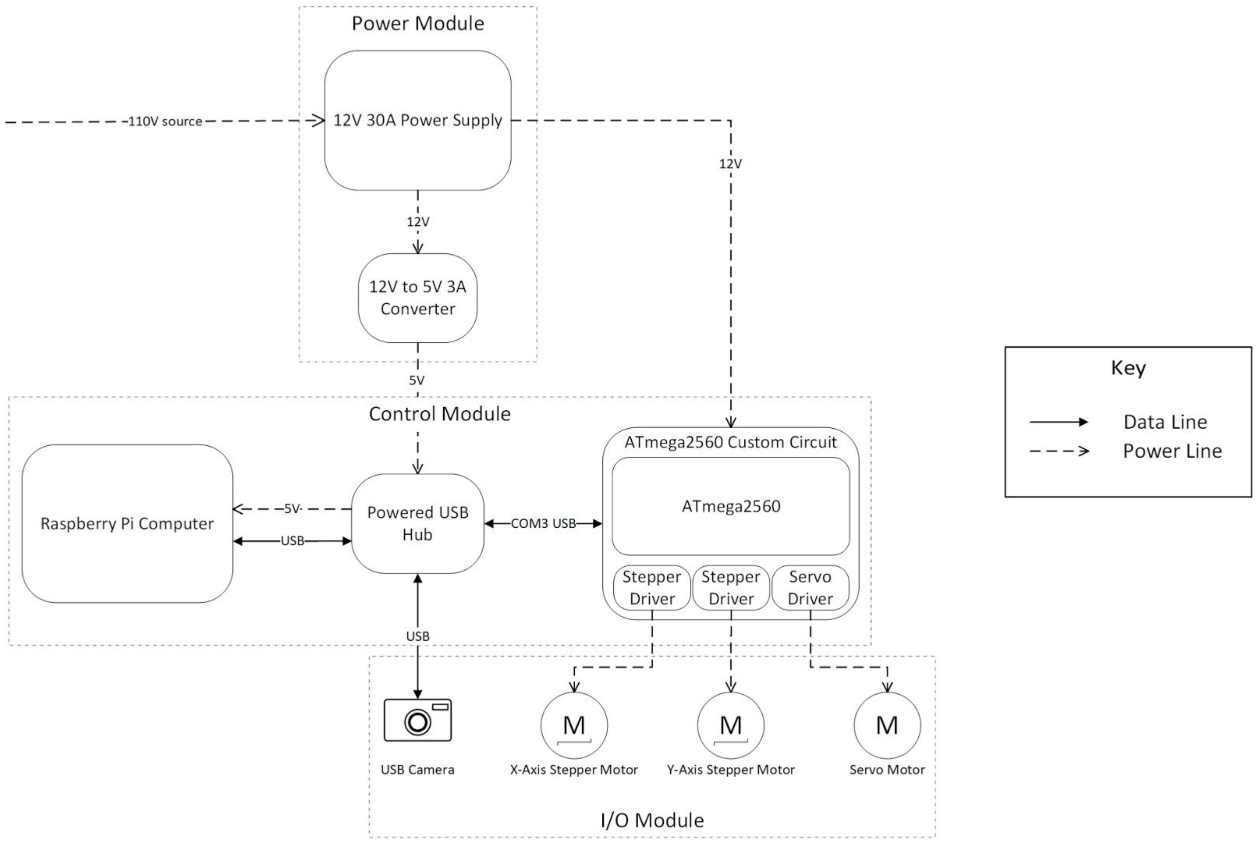
Although our system also uses a camera for image capture, the audience will not receive a preview of the applied transformations before the drawing is completed. Next, rather than use a printer to create the drawing, we want to use a v-plotter system mounted to an easel, as this approach has many advantages. First, the illustration process is bared to the user, as the paper is exposed during the process. Further, the toolpath of a v-plotter will more closely mimic that of a human, as the machine will draw each discrete stroke rather than sweep the page along an axis. Finally, the drawing is also done with a pen, which adds a natural variation that a desktop printer lacks.

While the hardware of this project is incredibly important, the software will be responsible for integrating all of the individual components into a cohesive product. The image processing component of our project will be done entirely in software; there is prior research in the area of computer-generated caricatures which we are looking to implement. [1] Additionally, lower-level software, such as firmware, will be essential for reliable communication between the computers and microcontrollers in our project.

1.3 High-Level Requirements

- Apply a caricature effect to an image and generate plotter instructions
- Plot simple geometric shapes given a G-code script
- Complete the entire process in less than 5 minutes

2. Design



2.1 Power

2.1.1 12V 30A power supply

The 12V power supply will power all the other components in our design.

Requirements: convert wall voltage (110V) to 12V 30A DC +/- 5%

2.1.2 12V to 5V converter

The 12V to 5V converter is wired to the USB hub, which supplies power to the Raspberry Pi, ATMega 2560, and any other components that need a 5V source.

Requirements: must supply steady 5V at 3A +/- 5%

2.2 Control

2.2.1 Raspberry Pi

The Raspberry Pi receives an image from the camera, applies filters to the image, vectorizes the image [2], converts the final vector drawing into machine code, and sends commands to the ATmega 2560 over a USB serial interface.

2.2.2 Powered USB hub

The USB hub is wired to the 12V to 5V converter. One of the ports on the hub is used to power the Raspberry Pi, and the data-in line is connected to one of the Raspberry Pi's USB ports. The ATmega circuit and camera receives power and communicates with the Raspberry Pi through the USB hub.

Requirements: 4 ports, externally powered; must support 5V at 3A +/- 5%

2.2.3 ATmega custom circuit (PCB)

- ATmega 2560 microcontroller

  The ATmega 2560 receives machine code over a serial interface from the Raspberry Pi, converts these commands to motor rotations, and sends information to the stepper and servo drivers.

  Requirements: communicate over USB serial interface

- Stepper motor driver (x2)

  The stepper drivers receive data from the ATMega 2560, and pulse the stepper motors accordingly.

  Requirements: support ⅛ step microstepping; operate at 12V at 350mA +/- 5%

- Servo motor driver

  The servo motor driver controls the servo that controls whether the pen makes contact with the drawing surface.

  Requirements: supply between 4.2 - 6V (servo operating range)

2.3 I/O

2.3.1 Camera

The camera takes an image upon instruction from the Raspberry Pi and sends the image back to the Pi through the USB interface.

Requirements: must allow remote capture over USB

2.3.2 Stepper motor

Each stepper motor controls an axis for the drawing mechanism.

Requirements: must have a machined flat on the shaft; 1.8 degree step size

2.3.3 Servo motor

The servo motor allows the drawing implement to retract from the drawing surface.

Requirements: minimum 1 kg-cm stall torque; motor must weigh < 50 g

2.4 Physical design

The basic design of the plotter will consist of two stepper motors mounted on the upper left and right corners of an easel, spaced roughly 24 inches apart. The drawing mechanism is suspended in the center of the easel via two pieces of string attached to sprockets on the stepper motors, forming a “V” shape. A servo motor on the drawing mechanism allows the implement to retract. The physical design will be finalized once a suitable easel design has been found.

2.5 Risk mitigation

The ATMega2560 custom circuit will pose the greatest risk to this project. We aim to integrate most of the functionality of an Arduino board with our motor drivers; this will probably be challenging because there is a considerable amount of I/O we have to accommodate, such as a USB interface and pin connections for each motor driver. Additionally, the ATMega 2560 runs at a different voltage from the stepper drivers, which requires the two voltage sources to be properly designed into the circuit and isolated from each other. Our project will also be non-functioning without successful completion of the circuit, which could introduce serious delays to other components if there are issues with our design.

3 Safety and Ethics

We have some safety concerns with this project. The power supply requires some wiring to receive a 110V input; these connections need to be robust and correct in order to ensure safe operability. The stepper motors also receive a fairly high amount of power during operation, so poor circuit design and wiring could also cause a fire or electrocution hazard. The stepper motors we plan to use are capable of producing high torque figures, which could potentially injure the audience were they to get too close.

One ethical consideration for our project are the negative externalities associated with automating the job of a caricature artist. If our machine were made available for sale, human caricature artists could suffer from reduced job opportunities. However, we believe that customers would still be willing to pay a premium for the personal touch of a human caricature artist. Additionally, we must be mindful of the ethics surrounding digital manipulation of portraits; it is important that we do not offend patrons with overly grotesque manipulations of their image.

References

[1] Brennan, Susan. *The Caricature Generator*. MIT Media Lab master's thesis, 1982.
[2] Selinger, Peter. *Potrace: a polygon-based tracing algorithm.* SourceForge, 2003.