ECE 445: Senior Design

Team 65: Electric Paintbrush Cleaner

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1 Introduction

1.1 Objective

When painting, it is commonplace to have a cup of water used to clean the paintbrush when switching between colors. However, after only a handful of times of dipping the paintbrush in the water to clean it, the water becomes heavily stained with residual paint. This is problematic, as the unclean water will start seeping into the brush and lead to the unwanted mixing of colors on the canvas. Although having a designated cup of water to clean the paintbrush is a simple way to mitigate the degree of which the mixing of colors occurs, as the painter progresses in the painting process and continues to use the same cup of water, the effectiveness of the cleaning water only worsens, meaning that this solution isn't one that is fit for long-term painting sessions that require a diverse palette of colors.

Our proposed solution is to create a device that aims to clean the brush while eliminating the contamination of the cleaning water. This will be achieved by having a receptacle of clean water that will be sprayed onto the paintbrush upon its insertion, with any dirty water dripping into a separate receptacle to hold the dirty water. Furthermore, in order to address the buildup of paint particles that get caught between paintbrush bristles, we are also proposing a cleaning mechanism that consists of a motorized brush to clean between the paintbrush fibers. This will allow the painter to keep from getting their hands dirty as they usually would by using their fingers to rub off any residual paint stuck in the brush. In order to accomplish this task, our project will need to sense when the paintbrush has been inserted for cleaning, distribute the water to rinse the paintbrush, and then move the motorized cleaning brush through the paintbrush.

1.2 Background

The usual technique that painters resort to in order to correct the problem of contaminated water interfering with the quality of a painting is to either use two separate containers of water (one for getting most of the paint off the brush, and the other for rinsing the brush after the first clean), or to use a very large tupperware/bucket such that any paint that is rinsed into the water will achieve a higher degree of dilution due to the larger area of water. However, neither of these solutions actually fix the problem of the cleaning water getting contaminated - they instead only serve to slow down the process. Eventually, the painter will have to get up and change the water, which only interrupts their workflow.

It is because of these inconveniences that our solution aims to completely separate the clean water reservoir from the paintbrush during cleaning. Instead, clean water will be delivered to the brush via a waterpump and the resulting dirty water will be collected in a separate container. While this can also be achieved by running a paintbrush under the faucet, the problem is that it is not always convenient to have to paint in a kitchen where food is present or within the confines of a bathroom. Thus, our solution is one that doesn't restrict the painter to a particular area of the house that may be unfavorable.

1.3 Physical Design

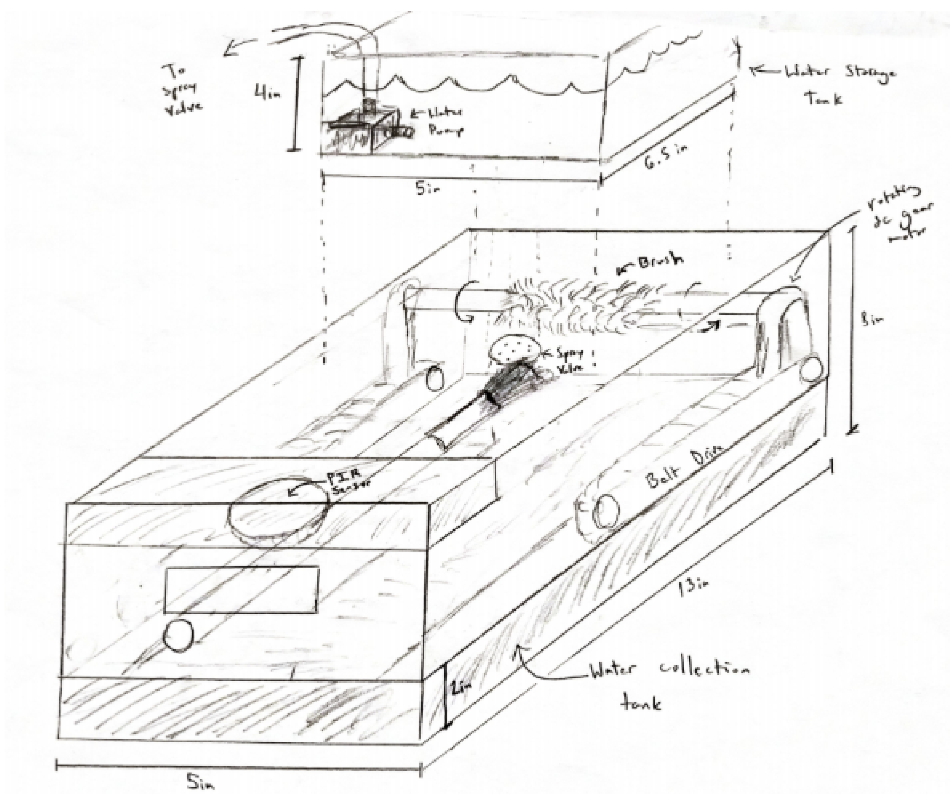

Figure 1: Pictorial Representation of Project

1.4 High-level Requirements

- The water from the cleaning tank should be successfully routed to the paintbrush to rinse it clean via the water pump and tube system, with the used water being collected in a separate removable receptacle.
- The motorized brush cleaning mechanism should be able to clean the paintbrush by rotating a brush parallel to the paintbrush bristles, and should be able to demonstrate a range of movement that allows it to move back and forth via the belt drive system.
- The microcontroller must be able to process the incoming sensor data from the PIR sensor, while also sending the correct signals to the motor drivers and the dc water pump switch at the appropriate times.

2 Design

2.1 Block Diagram

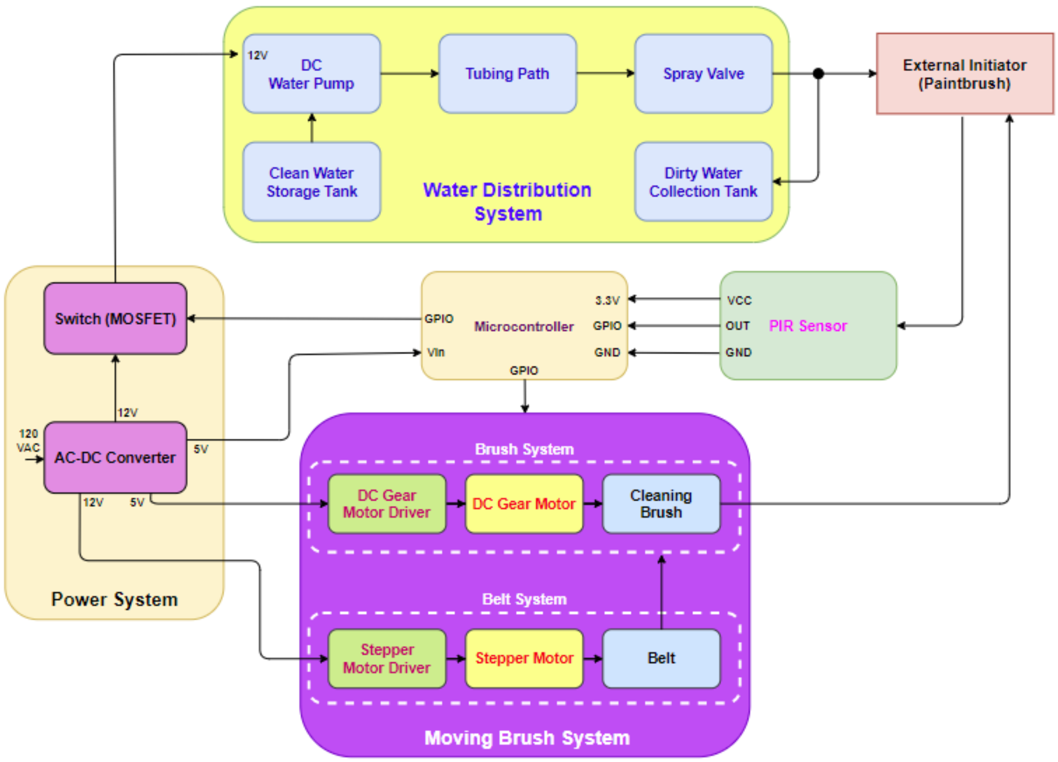

Figure 2: Block Diagram

The electric paintbrush cleaner will begin its cleaning cycle once the PIR sensor detects movement from an inserted paintbrush. At this point, the microcontroller will process the data coming from the triggered PIR sensor and begin to initiate the cleaning cycle. The microcontroller will first switch on the MOSFET to allow the dc water pump to turn on and begin pulling clean water from the designated clean water storage tank. This water is then routed through a tubing path and exits through a spray valve to rinse the paintbrush, with the dirty water being collected in a separate tank below. Once the rinsing portion of the cycle is over, the microcontroller will then send the appropriate signals over to the stepper motor driver to move the brush system forward such that the cleaning brush will be able to start cleaning the paintbrush bristles. Once the belt has moved the cleaning brush system forward, the microcontroller then starts to rotate the cleaning brush attached to the dc gear motor via its corresponding driver. Once this process is over, the microcontroller will retract the brush system further back by driving the belt system once again, signaling the end of the cleaning cycle.

2.2 Functional Overview

2.2.1 Microcontroller & PIR Sensor System

PIR Sensor

The PIR sensor is used to sense the insertion of a paintbrush into the cleaning device, which triggers the start of the device's cleaning cycle by sending a signal to the microcontroller.

Requirement 1: Sensor properly triggers when motion is detected (sends a 4-second signal pulse to microcontroller) regardless of lighting conditions.

Microcontroller

The microcontroller controls the operation of the paintbrush cleaner, sending the proper signals to the other systems to control the sequence of distributing the water, moving the belt system back and forth, and turning the motor for the brush cleaner mechanism at the appropriate times. The microcontroller is also responsible for keeping track of the timing of a cleaning cycle such that any triggering from the PIR sensor while the cleaning cycle is in progress won't restart the cycle.

Requirement 1: Must receive data from the PIR Sensor.

Requirement 2: Must send control signals to MOSFET, dc gear motor driver, and stepper motor driver.

2.2.2 Power System

MOSFET

Since the microcontroller can only source a limited amount of current, the MOSFET will be used as a switch in order to drive the dc water pump by switching on via a signal from the microcontroller, allowing the dc water pump to receive power from one of the ac-dc converter outputs.

Requirement 1: Rated for a drain-source voltage of 12V.

Requirement 2: Rated for a drain-source current of 375mA.

AC-DC Converter

The device should be able to run off ac power so that it can be plugged into a wall outlet. Dc power will need to be supplied to the microcontroller, the dc gear motor driver, the stepper motor driver, and the dc water pump.

Requirement 1: Can supply 5V to microcontroller and dc gear motor driver.

Requirement 2: Can supply 12V to dc water pump and stepper motor driver.

2.2.3 Water Distribution System

Water Storage Tanks

The clean water storage tank holds the water that will be used to rinse off the paintbrush. This tank will sit on top of the physical cleaning compartment where the brush is inserted into. Meanwhile, the dirty water collection tank is responsible for collecting the used water that is being sprayed down onto the paintbrush. This compartment will sit at the bottom of the device.

Requirement 1: Tanks are secured such that it is practically impossible for water to leak out.

Requirement 2: Should be able to hold enough water for at least 30 rinses.

Requirement 3: User should be able to attach and de-attach the clean water storage tank to the top of the device to make filling up with new water easier.

Requirement 4: User should be able to pull out the dirty water collection tank separately from underneath the cleaning mechanism, similar to sliding a drawer out.

DC Water Pump, Tubing Path, and Spray Valve

The dc water pump is responsible for taking the water from the clean water storage tank and delivering it to the paintbrush via the tubing path and spray valve. In order to make efficient use of the clean water, the dc water pump will be turned on in short bursts, with the spray valve increasing the pressure of the water delivered to the paintbrush.

Requirement 1: Dc water pump has enough power to suction water up out of the clean water tank and move it through the tubing.

Requirement 2: Tubing path should connect to clean water storage tank without creating any possible openings for water leaks.

Requirement 3: Spray valve can disperse water over the entire area of the paintbrush bristles *with enough force to get paint out.*

2.2.4 Moving Brush System

Dc Gear Motor Driver

The dc gear motor driver is responsible for driving the dc gear motor via signals from the microcontroller, and is powered with 5V via one of the ac-dc converter outputs.

Requirement 1: Turn dc gear motor according to commands received from microcontroller.

Dc Gear Motor

The dc gear motor will be used to rotate the cleaning brush parallel to the paintbrush bristles to assist in the cleaning process and work any dried-up paint particles out of the paintbrush. This dc gear motor will be sitting on top of the belt system.

Requirement 1: Provide enough torque to allow cleaning brush to rotate through paintbrush fibers without damaging the paintbrush.

Cleaning Brush

The cleaning brush will be attached to a rod that is inserted into the dc gear motor, allowing the cleaning brush to rotate.

Requirement 1: The cleaning brush should be able to be removed by the user for cleaning after use.

Stepper Motor Driver

The stepper motor driver is responsible for driving the stepper motor via signals from the microcontroller, and is powered with 12V via one of the ac-dc converter outputs.

Requirement 1: Turn stepper motor according to commands received from microcontroller.

Stepper Motor

The stepper motor is used to rotate the belt, allowing the brush mechanism (consisting of the dc motor and cleaning brush) to move back and forth within the device.

Requirement 1: Must turn belt accurately without missing steps.

Belt

The belt sits above the dirty water tank and is rotated forward to bring the brush mechanism over to the paintbrush, and rotated backward to retract the brush mechanism to allow the clean water to make contact with the brush for rinsing.

Requirement 1: Must be built small enough to limit the space taken up within the device but strong enough to move the cleaning brush mechanism.

2.3 Risk Analysis

The block that poses the greatest risk to successful completion of the project is the water distribution system. This is mainly for two reasons. First, if any unprotected part of the circuit gets in contact with this system, it's components may be affected by the water and the entire system may not function. This also implies the potential risk of electrical shock. In addition, whatever technology that would now be ruined would have to be replaced, and considering our group is on a budget of 100 dollars since we are not bringing in any preexisting technology or funding, this would be a huge hindrance to the success of our project. The second factor is the fact that this system literally determines the success of our project. For success, we need to be able to take a paintbrush that has been cleaned how painters normally clean them (in a dirty water cup) and paint a stroke on a canvas, and then take a paintbrush that has been cleaned through our system and paint a stroke, hopefully demonstrating dramatic improvement in cleanliness. If our water system does not wash all the bristles on the paintbrush, or at least a majority of them, then our project may not be successful. In addition, if the water system is somehow not consistent or efficient in its performance, such as an inability to wash multiple paintbrushes in a given amount of time, then our system can also be seen as failing because it is designed to wash multiple brushes, rather than just one.

3 Ethics and Safety

In order to enforce the IEEE code of ethics, specifically, Section 7.8.1 [1] which pertains to ethical design and the disclosure of safety hazards, the group acknowledges that an obvious safety issue that arises with this project is the close proximity of water to electronics. The group shall take the necessary safety precautions during project development to prevent the risk of electrical shock, including the use of GFCI outlets, appropriate grounding of all electrical components, and proper isolation of all water. The group will also make sure of waterproofing all circuitry, as well as creating a design that is durable enough to prevent any spillage of water onto the electronics in the case of an accident. Furthermore, the group has decided to develop a safety manual that shall inform users of the potential risks associated with using the appliance, as well as the precautions they should take to minimize these risks. These precautions include, but are not limited to, not exceeding the max water level of the clean water tank, always emptying out the bottom collection tank before use, and always ensuring that the water system is working smoothly without any clogging. This safety manual should closely resemble those which are distributed with similar water appliances such as in-home decorative water fountains.

4 References

[1] ”IEEE Code of Ethics.” Institute of Electrical and Electronics Engineers. 2020.
https://www.ieee.org/about/corporate/governance/p7-8.html [Accessed Feb 12. 2020]