Water Aliasing

Project Proposal

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1. Introduction

1.1 Objective

An optical illusion is an illusion caused by the visual system and characterized by visually perceived images that differ from objective reality. The information gathered by the eye is processed in the brain to give a percept that does not tally with a physical measurement of the stimulus source. In the case of aliasing water, this illusion is achieved by means of a stroboscopic light. The concept involves altering the frequency of the vibrating water with respect to the frequency of the light. Today, these Gravity Defying Water products, at a small scale, are available in the market for as high as $500-$600 [1] and cost more money than we would like to spend for entertainment. Our goal is to bring this magic to households at a lower price, with the added benefits of physically controlling these water patterns. The overall aim is to provide an enjoyable experience of "waterbending".

1.2 Background

Our project is one born out of the want for aesthetic pleasure. Humans are creatures of habit and hence, our brain makes many assumptions about our surroundings without us actually consciously thinking about them. Our minds are trained from a very young age to understand and interpret things about the universe, one of which is gravity. When we see logic being outright defied without any rational explanation that our brain can come up with, we tend to be amazed and intrigued. Water aliasing is something that most people on this planet aren't aware of. Hence, the illusion of water rising or levitating instead of falling without the help of any device, like a suction or a pump, baffles the mind. It generates what is nowadays called the "wow factor". For a good water aliasing device, people pay hundreds of dollars out of their amazement of it. So far, the devices that exist on the market have little to no user interaction. We plan on changing this.

1.3 High Level Requirements

- The entire system must be compact and mostly waterproof, so that it is safe for operation.
- It should cost less than the commercial models available in the market today.
- It must be aesthetically pleasing to look at.
- It must be easily controllable by the user and glitch free.
- The water droplets produced must be clean and distinct i.e. well spaced for the human eye to register the illusion. [2]

2. Design

Our design works on a very simple principle: the frequency of the strobe light we build must match the frequency of the vibration of water for us to see floating droplets. Every time the light is on, an image of a different drop at the same position is visible. Similarly, if the frequencies of the light and that of the vibrating stream of water differ, we see the water moving up or down. In the case of water frequency being lower than the frequency of light, the next drop of water is slightly higher than the previous drop when light falls on it. The brain interprets this illusion as water "moving up". If the next drop appears lower, water is "moving down".

2.1 Block Diagram

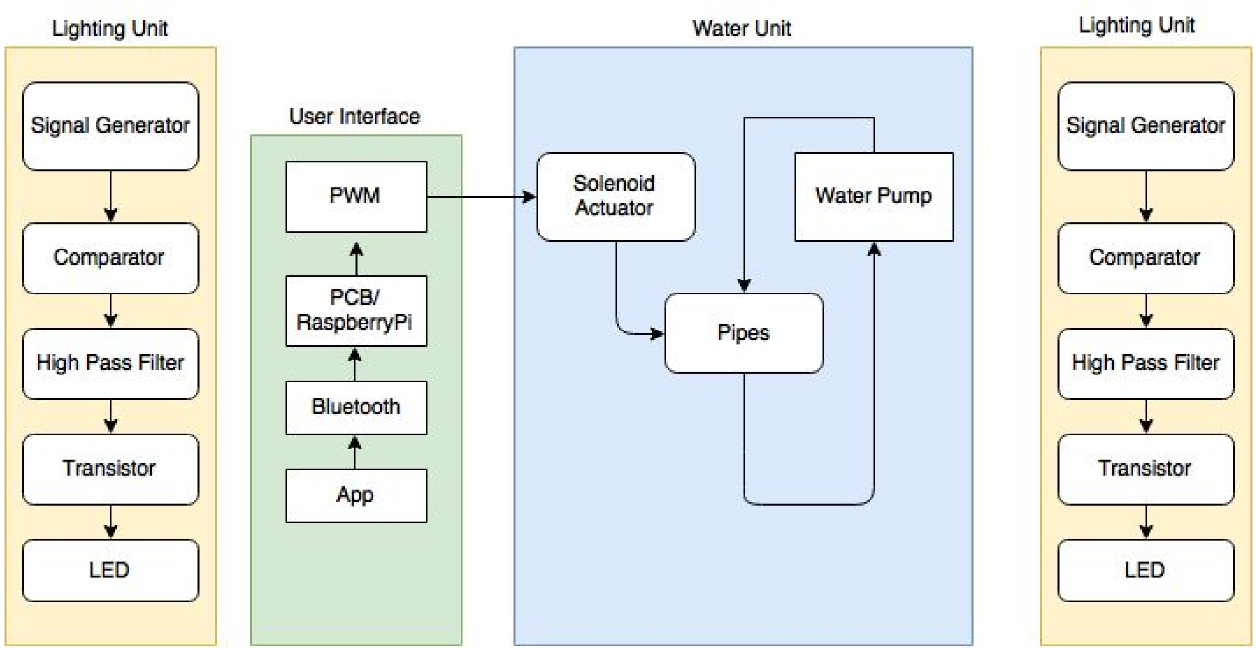

Figure 1: Block Diagram describing our component layout, as well as our physical arrangement of modules

2.2 Physical Design

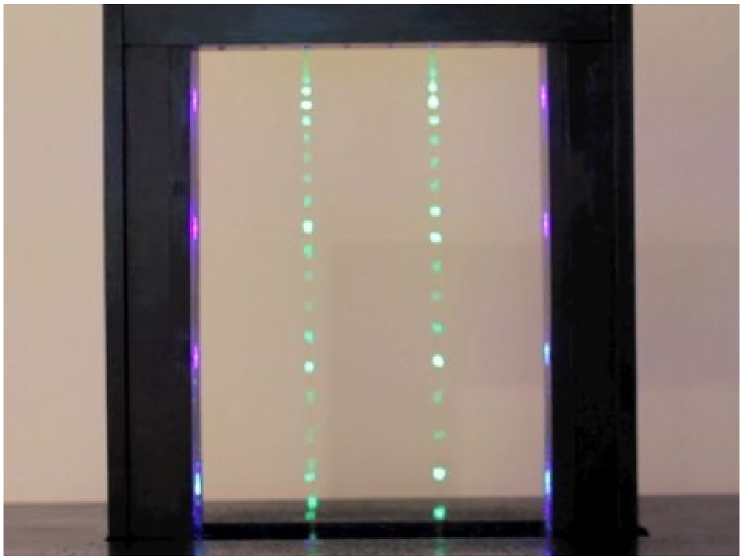

Figure 2: Proposed physical design

2.3. Lighting Unit

The lighting unit will be present on either side of our model to illuminate the water droplets as shown in *Figures 1* and *2*. The strobe light needs to be on for a very short period of time to create very clear droplets. The light will sample less movement of water in a shorter period of time. For achieving this, we will drive our own strobe light. The frequency we wish to achieve for our light is 100 Hz, the period being 10 mS. [3][4]

2.3.1 LED

We need the LEDs to be on for only 10 percent of the time. We can drive the LEDs 10 times its nominal current rating, which will provide more light. The brighter the LED is, the better the effect.

Requirement 1: *The overall project has to be performed in a dark environment, or at least have the droplets only illuminated by the strobe light. If not, we can see the complete stream of water and the illusion will not be complete.*

Requirement 2: *We need the LED panels to be on either of the array of streams so that they can be lit equally.*

Requirement 3: *The frequency of the light will never change.*

2.3.2 Comparator

The first part of our circuit design includes a comparator. A capacitor gets rid of the DC component of the signal coming from the signal generator (AC) and this resulting signal will be compared to a DC 2.5V signal to give a 0V-5V square wave.

Requirement 1: *This part of the circuit must be able to output a square wave of amplitude 5 Volts.*

2.3.3 High Pass Filter

The function of the high pass filter is to obtain signal widths much thinner than what we have originally. To mould our input analog signal into a proper digital wave, we pass the output of the high pass filter through another comparator.

Requirement 1: *The filter must ensure that the signal is high for a very short period of time. This is required for the bursts of high frequency light.*

2.3.4 Transistor

The last stage is a power FET transistor. A high at the gate will turn the transistor on like a switch. It has to be strong enough to handle the high currents running through the LEDs.

Requirement 1: *Average currents running through the FET should be able to handle maximum currents up to 1A (~10 A pulse currents).*

2.4 Water Unit

2.4.1 Water Pump

The water pump will be used to recycle the water we plan to use in this project, so we minimise wastage of water. The water is pumped upwards through a pipe so we can move the water cyclically.

Requirement 1: *The pump must not be too large or bulky in size (should be easily concealable) since our physical design is fairly small.*

Requirement 2: *3-3.5 ft. maximum pumping height is desired.*

Requirement 3: *The pump should carry out quiet operations and not be too noisy.*

2.4.2 Solenoid Actuator

For the streams of water, we require a vibration to be produced at a certain frequency, either matching or being higher/lower than the frequency of light. This vibration can be brought about by speakers, which give us slightly distorted droplets. However, we need very clean droplets of water and this can be achieved by a more refined mechanical process. We consider a linear solenoid actuator, which converts basic electrical energy into a pushing or pulling motion. [5]

Requirement 1 : *The actuators must be able to produce frequencies of the order 95Hz - 110Hz.*

Requirement 2: *Control from bluetooth via PCB must be achieved.*

Requirement 3: *It must not overheat during operation.*

2.4.3 Pulse Width Modulator

For the streams of water, we require that the frequency of water droplets be changed in response to a signal received from a phone. To achieve this flexibility, we plan to use a PWM (Pulse Width Modulator) [6]. Each stream of water will have it's own PWM, controlled by a PCB or Raspberry Pi [7], so that each stream can be controlled independently.

Requirement 1 : *The PWM must be able to change duty cycle for water droplets without adding extra noise (frequency) to the circuit.*

Requirement 2 : *The PWM must be able to operate in frequencies of the order 95Hz - 110Hz.*

2.5 User Interaction

We envision our complete system to be 5 evenly spaced vertical streams of water. Each stream can be controlled by the user through an app on the phone.

2.5.1 Mobile App

In the app, each of the 5 streams will have its own directional slider (similar to a volume slider on most smartphones). The top most point corresponds to the fastest upward motion of the droplets, the middle corresponds to them simply levitating, while the lowest point on each slider corresponds to the fastest downward motion of the droplets. The user can independently control any stream of water through the app to create any desired pattern.

Requirement 1: *The app must be glitch free and pick up where it left off last.*

2.5.2 Bluetooth

A Bluetooth transmitter (inbuilt in smartphones) will be used to send the signals from the app to the actuator via a PCB or a Raspberry Pi (using an hc-05 receiver for example).[8] The signal sent by the user can be used as a trigger to change water frequency to create the user specified illusion.

Requirement 1: *Some data/signal is transmitted to the PCB via bluetooth.*

Requirement 2: *The signal received triggers a change in the frequency of vibration of the solenoid actuator.*

2.6 Risk Analysis

We believe that the use of water poses the greatest risk in our project. We understand that the use of water in the lab is highly discouraged for fear of equipment damage. For this reason, it may be hard to demo our finished product in the lab. However, we can demo the working of individual modules of our system with the help of multimeters and oscilloscopes, by creating signals using basic function generators.

For the purpose of minimising water spillage in general, we plan to encase our entire model in a glass container. This will not be entirely problematic, since our model is small scale, ideally something the user can keep on a desk at home. Thus, we require the model to be compact. We will have to waterproof several components that may be in close proximity to water.

We need to take into consideration that once the stream of water falls to the bottom, it will splash due to coming in contact with the rest of the water that is accumulating over time. The pump action will not be instantaneous to cycle the water around the system. To mitigate this risk, we plan to have a container that is high enough to not let these drops of water spill out into the open.

We have also considered the heating of the solenoid actuators due to overuse. Longer periods involving direct power supply to the coil will make it hot and may affect operation. This, however, will not be a cause of any risk since our actuators will be using an "intermittent duty cycle", operating at the frequency we want to run our water at. This will be achieved through the pulse width modulation.

3. Ethics and Safety

Since this is predominantly water based project, our primary concern is to make sure this project is safe and does not cause any electrical mishaps during its development phase. In order to see the effects our chosen frequencies have on our system, we will need to test with water at all times. This is in conflict with the IEEE code of ethics [9] (1): " ... making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment", since our project may endanger the environment or the safety of others who may be helping us.

There is another group this semester with a very similar project dealing with water aliasing. We plan to collaborate with them during the initial research phase to choose appropriate hardware components for our designs. We keep in mind the IEEE Code of Ethics (7): "to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others" and (9): "to assist colleagues and co-workers in their professional development…". These are important factors to ensure a smooth collaboration between the two groups which can result in individual, well functioning projects.

We will also be mindful of wastage and conservation of water, since this is a water heavy project. We will use a water pump that can pump water to about 3 or 3.5 feet, which will be ideal for our project needs. This is in accordance with the IEEE code (1).

We are also aware of all the resources available to us during the entire course of this semester and adhering to the ACM Code of Ethics and Professional Conduct [10] (2.4): " Accept and provide appropriate professional review", we will perform honestly and proficiently at peer reviews and provide our views as critically as possible. We will take any and all critique pertaining to our work from our teaching assistants and professors to improve our product.

4. References

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