Dynamic Ferrofluid Lamp

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1. Introduction

1.1. Objective

Invented in 1963, ferrofluid was originally intended to be used to allow liquid rocket fuel to be drawn toward a pump inlet in a weightless environment. It is only in the recent two years that the properties of ferrofluid have been explored and taken advantage of in fields of display and art. However, due to the relatively new concept of using ferrofluid for art, currently existing methods of displaying and manipulating ferrofluid remain somewhat crude and unrefined. Current ferrofluid only uses large and bulky ferrofluid pixels, and artistic pieces that showcase the ferrofluid properties nearly all fall into one of three categories: depending on human interaction, utilizing only one fixed sculpture base, or being too bulky and impractical for the average consumer.

Our project aims to refine the design of the artistic display of ferrofluid. In particular, our goal is to create a programmable ferrofluid lamp that enables the manipulation of ferrofluid in artistic ways via both permanent magnets and electromagnets. The magnets will be arranged such that ferrofluid can be channeled in all three axes the three dimensional space, allowing potential for numerous display patterns.

1.2. Background

'The Inspiration' Ferrofluid Motion Lamp, while able to manipulate vertical motion, only does so in an uncontrolled manner mimicking a traditional lava lamp with further variety of display requiring the participation of a person with an external magnet. Even the successful Kickstarter project 'RIZE Spinning Ferrofluid Display', raising over 140,000 dollars in crowdfunding, only uses a fixed sculpture as a base, limiting the diversity of ferrofluid appearance.

Our dynamic ferrofluid lamp combines the lava lamp and the ferrofluid display such that users can not only use it as a lighting source, but also enjoy the amazing visual effects simultaneously. User-level interactions are also included such that users may modify the lighting intensity along with the ferrofluid with respect to some outside music.

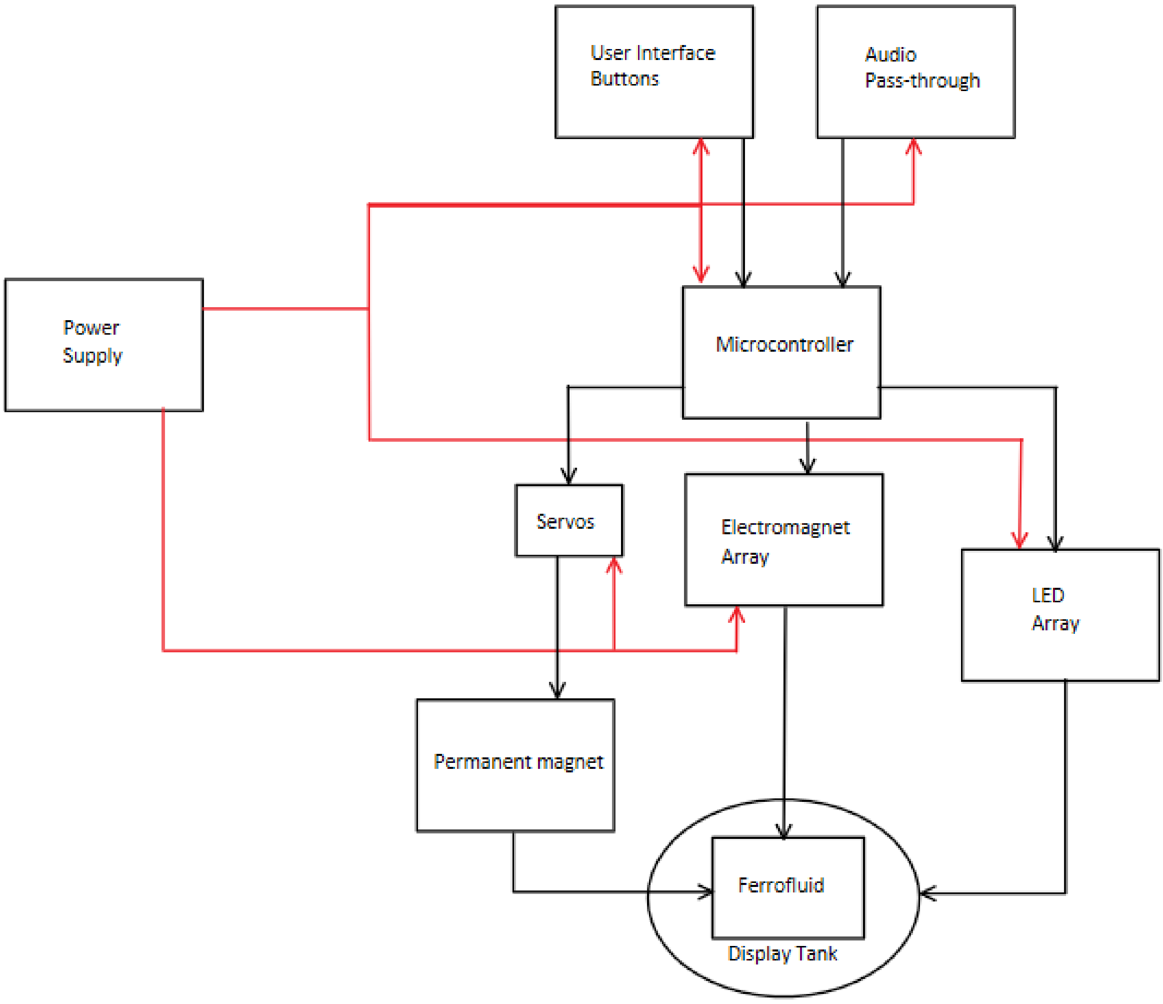
1.3. High-Level Requirements

- The lamp must be able to manipulate ferrofluid in all three axis of the a cylindrical coordinate system in three dimensional space.
- Power consumption must be lower than the 25W power consumption of an average traditional lava lamp.
- The cost of all parts must be lower than 200 dollars.

2. Design

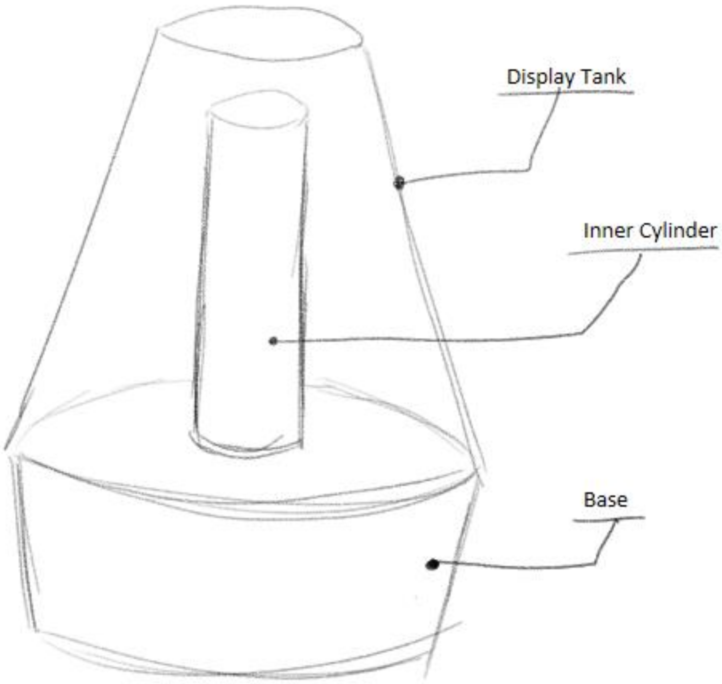
2.1. Block Diragram

To achieve the high level requirements of this project, we use a power supply to draw power from a wall outlet. The microcontroller will control the actuators for the permanent magnet, electromagnet, and LED array. The permanent magnet and electromagnet array will provide the magnetic field to manipulate the ferrofluid and the LED array will provide lighting for a more effective display. The user interface buttons allow users to interact with the ferrofluid even without an external magnet. The audio pass-through module collects audio data to provide the potential to dynamically alter the display depending on audio input.



2.2. Physical Design

The physical design consists of the display tank, the inner cylinder, and the base. The base is the compartment that contains the microcontroller. Also, audio pass-through and the user interface buttons will be located on the base. The display tank is the holder of the ferrofluid. The electromagnet array will be attached on the outer casing of the display tank. The inner casing will be the hold the permanent magnet and servos that drive the magnet's movement.



2.3. Functional Overview

2.3.1. Power Supply

A power supply is required to provide power for the electromagnets and microcontroller. The power line to the electromagnet array and servos that control the permanent magnets will be relatively isolated with respect to the power line to the other components due to the large difference in power draw.

Requirement 1: The power supply must be able to provide 20 ~ 30 watts of power.
Requirement 2: The power draw of the electromagnet array and servos must not affect the power supply of the other components.

2.3.2. Microcontroller

The microcontroller controls the actuators for the permanent magnet, electromagnet array and LED array. It also be able to processes the signals from the user interface buttons and the audio pass-through so users can interact with the ferrofluid and LED array.

Requirement: The microcontroller must have over 20 GIOP pins for controlling the LED array, servos, and electromagnet array.

2.3.3. Servos

The servos are controlled by the microcontroller and provides vertical and rotational motion to the permanent magnet.

Requirement: The servo must have enough torque to rotate the permanent magnet at at least 1 revolution per second.

2.3.4. Permanent Magnet

A permanent magnet is used as the main provider of magnetic field and will serve as a way to control the ferrofluid with relatively low power consumption. The permanent magnet will be placed in the inner cylinder of the lamp, with servos controlled by the microcontroller dictating the vertical motion and rotation of the magnet. This will provide the vertical and rotational control to the ferrofluid.

Requirement: The permanent magnet must be able to hold at least 20 milliliters of ferrofluid.

2.3.5. Electromagnet Array

An electromagnet array, controlled by the microcontroller, will be placed along the outer casing of the lamp and will be perpendicular to the central axis. This placement of the electromagnets will enable them to control the ferrofluid on the radial axis. Due to the short delay time of activating electromagnets, this component will enable effects by producing pulsating magnetic fields.

Requirement 1: The electromagnet array must allow more than 5 individual electromagnets to be operating at once.
Requirement 2: When an individual electromagnet is operating, the strength of the electromagnet must be adjustable by the microcontroller, with a 5% degree of tolerance.

2.3.6. LED Array

A LED grid is placed at central cylinder for lighting purposes. It will be controlled by the microcontroller to change lighting conditions along with the display and user interaction for enhanced effects.

Requirement: The LED array must have a maximum brightness of at least 50 lumens.

2.3.7. Ferrofluid

Main display component. The ferrofluid will be controlled by the magnetic field produced by both the permanent magnet and electromagnets.

Requirement: The ferrofluid should not stick to the walls of the container.

2.3.8. User Interface Buttons

Interface buttons for power, display modes, and interacting with the display.

Requirement: The button should be resilient to mechanical fail.

2.3.9. Audio Pass-Through

An input audio jack that passes input audio unchanged to an output audio jack while at the same time passing the audio data to the microcontroller for possible effects.

Requirement: The output audio signal and input audio signal should not have a difference of more than 1%.

2.4. Risk Analysis

The close distance between the ferrofluid and the electrical coils driving the magnetic fields is the most significant risk. It would be extremely dangerous if the coils are broken and the ferrofluid leaks through the wires even when the current is low, not to say what would happen when the current goes unstable while experimenting. We must be extra careful when dealing with the ferrofluid and the electrical wires and potentially wear rubber gloves to eliminate the risk as much as possible.

3. Safety and Ethics

Because ferrofluid is a relatively new area when related to aesthetics, it still has a lot to be explored. During our experiment with the ferrofluid, we will follow closely to the IEEE Code of Ethics, #3, “to be honest and realistic in stating claims or estimates based on available data.”[1] We will not include any unrealistic data or result in our report in order for it to look good or persuasive, we will instead be honest and respectful to the data we have acquired even if it is not perfect.

We choose ferrofluid-related field as our primary research project because we are interested and excited about it, and want to dive deeper into it. Thus, we will closely follow the IEEE Code of Ethics, #5, “to improve the understanding of technology; its appropriate application, and potential consequences,”[2] as we work along with our project. Our intention is to understand more about the properties of ferrofluid and how it can be applied to further contribute to our society in the future.

Although our ferrofluid lamp is a product of aesthetics and focuses on visual effects, it unavoidably comes with several potential safety hazards. The first safety issue comes with the nature of the ferrofluid. Because ferrofluid itself is dangerous to manipulate with depending on its type, we will only select safe ferrofluid to play and test with. We will gather information about various potential ferrofluids first, then narrow down to the ones that are relatively safe, and investigate and experiment with them carefully throughout the entire project.

References:

[1] http://www.ieee.org/about/corporate/governance/p7-8.html

[2] http://www.ieee.org/about/corporate/governance/p7-8.htm