Sound-Responsive Magnetic Fluid Display

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Abstract: A new magnetic fluid device is developed in which the magnetic fluid is manipulated in sync with sound. The magnetic fluid moves due to changes in a magnetic field produced by several electromagnets installed above and below a shallow, horizontal acrylic panel in which the magnetic fluid is held. The voltage to each electromagnet is controlled according to sound input by computer processing, making the fluid pulsate like a living thing. In this paper, we propose the concept and design of the magnetic fluid display, and discuss the results of a demonstration of a trial wide-screen projection of the working device.

Keywords: Magnetic fluid, display, sound-response, interactive art

1 Introduction

In this paper, we propose and construct a prototype magnetic fluid display in which the magnetic fluid exhibits peculiar shape and motion. The responsive behavior of a magnetic fluid to an applied magnetic field, producing interesting shapes with many protrusions, is widely known, however there have been few studies that apply magnetic fluid as a display.

2 Concept

The shapes that magnetic fluids take can be likened to animals such as sea urchins and hedgehogs. We propose a project that utilizes this ability of a magnetic fluid to move like a living thing. The basic concept is (1) a display that uses a magnetic fluid, (2) changing the shape of the magnetic fluid continuously, and (3) manipulating the magnetic fluid in sync with sound.

As an extension of Takeno's device (Takeno, 1999), we increased the number of electromagnets and used a computer to control the voltage applied to each electromagnet synchronously with sound input. We observed the behavior of the magnetic fluid under a variety of conditions and constructed a digitized database of the shape.

3 Basic System Components

3.1 Hardware

Magnetic fluid was placed in a shallow, open acrylic panel. One electromagnet was installed above the panel, and five electromagnets were used as base. Initially, the same poles of the two electromagnets faced inward (Figure 1). A gap between the fluid and the upper electromagnet was provided to allow the magnetic fluid to move freely. The current supplied to the electromagnet was controlled within the range where the relation between the electric and magnetic fields is linear. The voltage to the electromagnets was controlled by a personal computer, with a sound level meter for input.

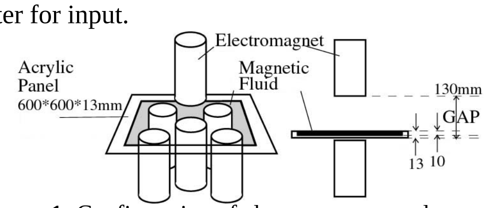

Figure 1: Configuration of electromagnets and magnetic fluid

3.2 Software

A sound level meter and microphone were employed to measure environmental sound levels (including the voices of observers), and the data sent to a personal computer at a sampling rate of 5 Hz. The software analyzed the sound level input, and generated voltages for each electromagnet according to the software's processing and distribution algorithm. (Figure 2) As a result, the shape of the magnetic fluid responded to the sound level of the sampled environment.

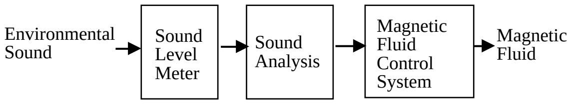

Figure 2: Software components

4 New Methods to Control Shape and Movement of Magnetic Fluid

4.1 Variety of Shapes

We initially observed the shape of the magnetic fluid while controlling the voltage of each electromagnet manually, and selected several specific shapes for display (Figure 3).

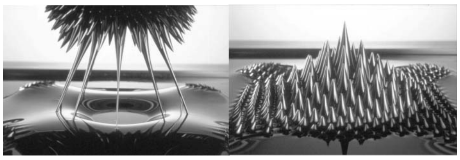

Figure 3: Example of shapes

We then constructed a voltage database to reproduce the shapes using the software. New methods for controlling the magnetic fluid are explained in the following:

4.2 Swirls

With the polarity of one electromagnet (A) reversed, positioned parallel to another (B), and with electromagnet A weak, by turning electromagnet B up quickly, two swirls appear in the shape of sea urchin above electromagnet B. The direction of the swirls depends on the relative position of the electromagnets.

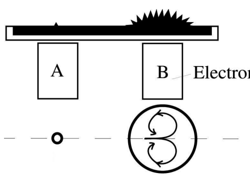

Figure 4: Arrangement of electromagnets to produce swirls

4.3 Jellyfish

The magnetic field can be adjusted such that the magnetic fluid extends up to the upper electromagnet. By adjusting the magnetic field in this situation the shape of a jellyfish can be made, and its size and shape can be changed depending on the magnetic power of the lower electromagnet.

4.4 Fuzzy Control Synthesizing to the Environmental Sound

The magnetic fluid moved up and down in sync with environmental sound, allowing the display to be used to visualize sound amplitude. This makes it possible to create a fuzzy condition of shape of magnetic fluid by means of environmental sound. In this mode, the power of the upper electromagnet is inversely proportional to the sound amplitude.

5 Demonstration

The panel in which the magnetic fluid is held is small, allowing only a few people to observe the display at any one time. We used a digital video camera and a wide-screen projection display to present the motion of the magnetic fluid to a greater audience in real time. Environmental sounds may be weak, so we played music through two loudspeakers.

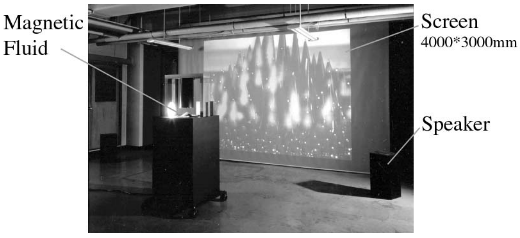

Figure 3: Demonstration of wide-screen magnetic fluid display with two loudspeakers

6 Discussion

From the demonstration, several spectators commented that "It was very interesting to watch," and "It made some very amusing animal shapes." To make practical use of this display, we have to solve several problems. (1) Reducing the size of the electromagnets, (2) examining better arrangements of electromagnets, (3) avoiding splashing of the magnetic fluid, (4) giving the system a degaussing function, (5) reducing the delay between sound and magnetic fluid motion caused by the slow speed of software processing, and (6) increasing sampling rate of the software.

7 Conclusion

In this study, we developed a novel display using magnetic fluid based on a rather simple mechanism. We expect that this will serve as an entertaining visual display in the future. We hope to re-examine the display design, and explore other methods of sound interaction.

References

Takeno, M. (1999), Appearance of Magnetism 3, Experiment of shape using magnetic fluid, *FORMA*, 14(4), 363-364.