Magnetic Plotter: A Macrotexture Design Method Using Magnetic Rubber Sheets

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ABSTRACT

This paper [1] presents a method for designing tactile macrotextures with magnetic rubber sheets. In the method, named "Magnetic Plotter", a desktop digital plotting machine combined with a tiny neodymium magnet writes fine magnetic patterns on the surface of the magnetic rubber sheets. This method enables users to design magnetic fields freely with inexpensive commercially available materials as if they are drawing pictures. Moreover, when the magnetic sheets are rubbed together, unique haptic stimuli are displayed on the fingers. The haptic stimuli can be designed by the magnetic patterns plotted on the rubber sheets. We demonstrated several applications with the prototype and discussed the possibilities.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *Interactive systems and tools*; User interface toolkits

KEYWORDS

Magnets; DIY; haptic; tactile; rapid prototyping; home

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1 INTRODUCTION

Magnetic forces have been used in various interactive techniques, especially in tangible and tactile interfaces. This is because magnets are convenient elements that can generate strong attraction/repulsion forces. Moreover, magnetic forces can pass through most everyday materials, such as paper, cloth, wood, and plastic. Though, it has been difficult to construct magnetic displays as a DIY (do it yourself) project. Electric magnets are very useful actuators with dynamic controllability. However, there are still technical barriers to constructing an electromagnetic array because an electromagnet array requires a current control processor, complicated wiring, high-voltage electricity, and a number of coils.

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2 MAGNETIC PLOTTER

As a solution for easy-to-design magnetic functions, we present Magnetic Plotter, a home-use magnetic field editing system. It uses thin magnetic rubber sheets as media for magnetic fields, and a tiny neodymium magnet placed at the top of the plotting head of the desktop-sized cutting machine magnetizes the magnetic rubber sheet exactly as designed. When the magnetic field of the neodymium magnet is applied to a magnetic rubber sheet, the atomic dipoles of the surface of the rubber sheet align with the magnetic field, and the alignment will remain even after it is removed. Plus, the plotting file can be designed by drawing software like Adobe® Illustrator. Thus, designers can create plotting files as if they are drawing pictures, without coding programs.

In addition, just a pair of magnetic-plotted rubber sheets can provide unique haptic textures when they are rubbed together (see Fig. 1). The haptic phenomenon is called a lateral-force-based haptic illusion [Minsky et al. 1990]. The intensity of the haptic stimuli depends on the magnetic force between the magnetic sheets.

Based on the phenomenon, we focused on the area ratio of the two magnetic sheets which is generating attractive and repulsive force. Using the area ratio, the total magnetic force between the two magnetic sheets can be estimated (see Fig. 2). The intensity and spatial resolution of the macrotexture generated between two sheets can be controlled by changing the magnetic patterns of the two rubber sheets.

Moreover, we implemented a one-to-one correspondent texture on the magnet sheet. A piece of magnetic rubber sheet plotting a checker pattern of polarity generates a macrotexture only where the checker pattern with the same pitch is plotted.

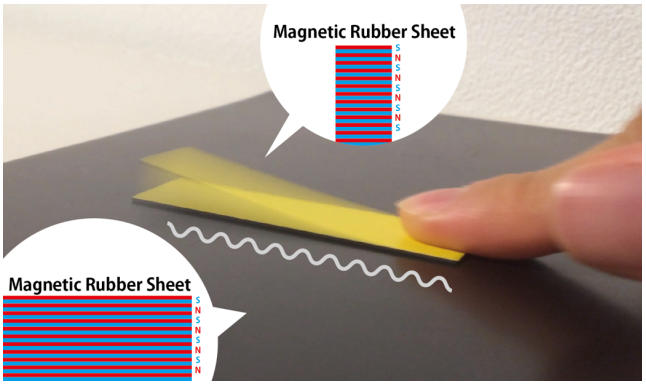

Figure 1: Magnetic Plotter can plot precise magnetic polarities on magnetic rubber sheets, and the magnetic sheets can display unique haptic stimuli on the surface of the sheet.

2.1 Applications

Using the design method, we created several examples of Magnetic Plotter applications.

Magnetic Stamp shows that the magnetic fields can be designed freely by using common drawing software (see Fig. 3 (a)).

Texture Book is an example of designing multiple haptic stimuli without an energy source (see Fig. 3 (b)). Since the book does not require a battery, it is easy to carry, just like a normal picture book. Moreover, this technique can be applied on the touch screen of the tablet device. Thanks to the thinness of the magnetic sheet, the capacitor sensors can detect the position of the finger on the magnetic sheets.

When a tiny magnet is put on the bottom of the robot, it can run only in the path and field determined by the magnetic pattern of the sheet. The effect is like an invisible cage (see Fig. 3 (c)). This method of making an enclosure without a physical barrier can be applied to other physical things, such as a safety stopper or a passage for blind people.

3 RELATED WOKRS

Bump Ahead [Yasu and Katsumoto 2015] is an interactive haptic interface that does not use an electromagnet for the generation of haptic textures. This method is a kind of DIY haptic, which is very well suited for prototyping or workshops. However, it is hard to re-arrange the magnets because they are fixed in a way that prevents them from attracting each other. This makes re-designing the haptic sensation difficult. Another issue is that the resolution of the magnetic field is restricted by the size of the magnets.

Meanwhile, Polymagnet [Correlated Magnetics. 2016] has developed a technology for computational magnetization of permanent magnets and FluxPaper [Ogata and Fukumoto 2015] is an ultra-thin magnetic layer on a sheet of paper using neodymium powder and resin. Their magnetizer is so strong that it can magnetize even neodymium magnets. However, such a high magnetic flux density could ruin a magnetic storage medium like a hard disc drive. Further, the strong attractive force between the two magnets might injure the fingers. Therefore, such a strong magnetizer has to be handled with care and is not suitable for personal use.

We introduced Magnetic Plotter as a digital tool for DIY magnetic functions and described a method for designing magnetic fields with inexpensive materials and equipment. It does not require strong magnetizer and heavy equipment. Plus, the magnetic sheet is a mass-produced material. Moreover, the plotter can overwrite the magnetic fields repeatedly many times and the sheet can be washed with water. This method is very well suited for workshops, rapid prototyping, and home fabrications.

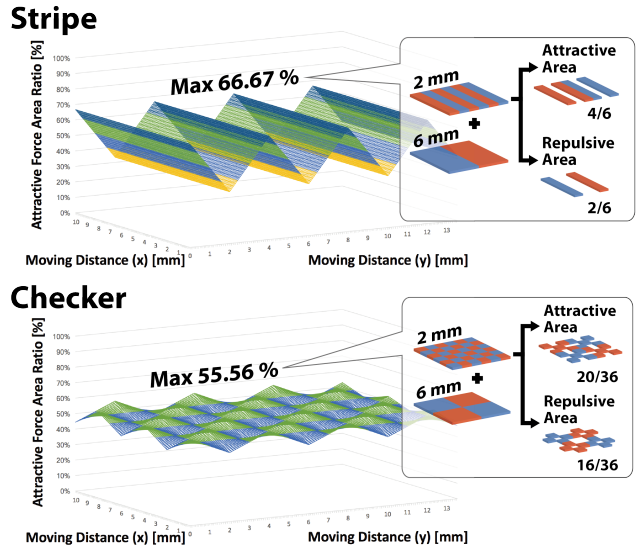

Figure 2: The haptic sensation can be estimated by the attractive force area ratio of the two magnetic sheets.

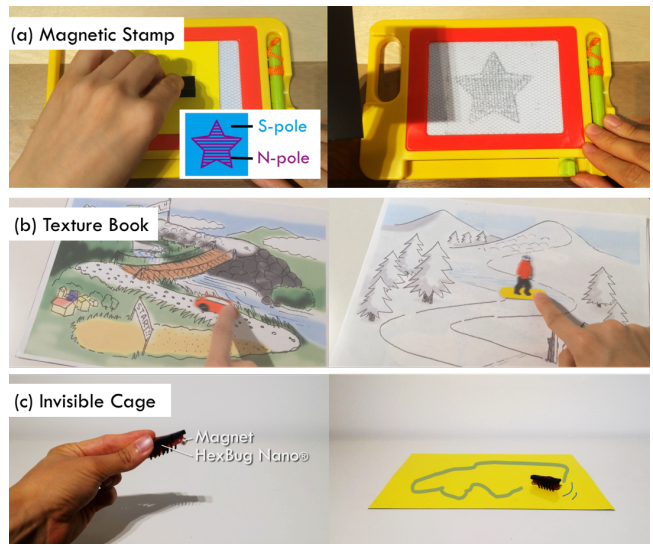

Figure 3: Application examples. (a) Magnetic Stamp. (b) Texture Book. (c) Invisible Cage.

REFERENCES

Margaret Minsky, Ouh-young Ming, Oliver Steele, Frederck P. Brooks, Jr., and Max Behensky. 1990. Feeling and seeing: issues in force display. *In Proceedings of the 1990 symposium on Interactive 3D graphics (I3D '90).* ACM, New York, NY, USA, 235-241. DOI: http://dx.doi.org/10.1145/91385.91451

Kentaro Yasu and Yuichiro Katsumoto. 2015. Bump ahead: easy-to-design haptic surface using magnet array. *In SIGGRAPH Asia 2015 Emerging Technologies (SA '15).* ACM, New York, NY, USA, Article 3, 3 pages. DOI=http://dx.doi.org/10.1145/2818466.2818478

Correlated Magnetics. Polymagnet.com. 2016. Retrieved September 16, 2016 from http://www.polymagnet.com/

Masa Ogata and Masaaki Fukumoto. 2015. FluxPaper: Reinventing Paper with Dynamic Actuation Powered by Magnetic Flux. *In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15).* ACM, New York, NY, USA, 29-38. DOI: http://dx.doi.org/10.1145/2702123.2702516