# Magnetic Table Interface and Magnetic Foods

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## ABSTRACT

In this article, we discuss the design for magnetic table interface and magnetic foods. This interface allows new interactions for the food and utensils such as modifying weight, levitation, movement, and dynamic textures. We implement these interactions by manipulating a strong magnetic field formed by an array of Bitter electromagnets placed under the table. We also proposed magnetic food by adding edible magnetic materials to the foods, and make them interactive and controllable.

## ACM Classification Keywords

H.5.m. Information Interfaces and Presentation

## Author Keywords

Multisensory Experiences; Magnetic User Interfaces; Magnetic Table; Magnetic Foods; Levitation

## INTRODUCTION

Food is a basic human needs. It creates interactions and food cultures are one of the fascinating cultural aspect around the worlds. Recent advancement in the field of multimodal intrefaces and multisensory communication allow us to build new interaction based on food and it is becoming a hot topic in HCI [8], [10].Magnetic fields and materials were used in HCI to improve multimodal interfaces to offer rich interactions like changing weight of an object, vibration, levitation, and etc. [9], [11]. We attempt to bring these interactions into food dining where users can appreciate their food better and enjoy the foods more. The users can interact with utensils that can change weights and edible foods with magnetic properties.The proposed platform is as shown in Figure 1.

## LITERATURE REVIEW

For the proposed interface, we need to produce a strong and dynamic magnetic flux near the surface area. However, the magnetic flux generated by traditional electromagnet is limited to 2T only [1] while super conductor electromagnets needs use of liquid helium [3]. Thus, we choose Bitter electromagnets for our interface because it has ability to produce strong magnetic field up to 45T [1]. We also surveying on finding edible magnetic materials that can be used for magnetic foods. Among lots of vitamins that contain in our food, there are some ferromagnetic material they used for completing the nutrient in man-made food such as iron or iron oxides.

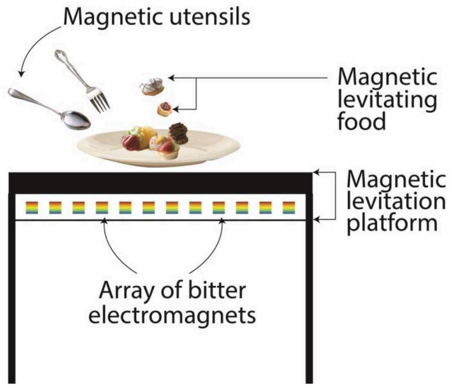

**Figure 1. A conceptual image of the 'Magnetic Dining Table and Magnetic Food' Interface: This interface will introduce new interactions for food or utensils such as modify weight, levitation, movement, and dynamic textures.**

## METHOD

### Magnetic Field Control Platform

Magnetic table will be developed by placing an array of electromagnet underneath the table. The controller circuit connected to it will drive the magnets and modifies the shape of the generated magnetic field. Figure 2 show the proposed design for a single Bitter electromagnet. The Bitter electromagnet is designed based on Francis Bitter's classic paper on Bitter electromagnets [4]. The estimated Magnetic Flux produced by our first Bitter electromagnet prototype is 0.5T. We will make this electromagnet either by using the multilayer PCB or metal stamping technology.

Analytical calculation for a Bitter electromagnet was modelled using a spread sheet software. Copper thickness was chosen less than or equal to 1mm [5] because copper thickness does affect the total magnetic flux generated by the electromagnets.Less magnetic field will be produced if we use thicker copper plate. The height of the Bitter electromagnet is set to be 10cm, outer radius to be 3cm, hollow section inner radius to be 1cm, and the supply current is 100A. We did an analysis for

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| Copper Thickness | Insulation Thickness | Cross-sectional $m^2$ | Area $cm^2$ | No of Turn | Field (T) | Space Factor | Power,P Watt | Resistance,R Ω |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1.73E-5 | 1.73E-1 | 50 | 0.0941 | 0.999913 | 38.9061 | 0.0024 |
| 0.9 | 0.9 | 1.55E-5 | 1.55E-1 | 56 | 0.1045 | 0.999893 | 48.0316 | 0.00297 |
| 0.8 | 0.8 | 1.38E-5 | 1.38E-1 | 63 | 0.1176 | 0.999865 | 60.0789 | 0.00375 |
| 0.7 | 0.7 | 1.21E-5 | 1.21E-1 | 72 | 0.1344 | 0.999823 | 79.39608 | 0.0049 |
| 0.6 | 0.6 | 1.04E-5 | 1.04E-1 | 84 | 0.1568 | 0.999759 | 108.0628 | 0.00667 |
| 0.5 | 0.5 | 8.63E-6 | 8.63E-2 | 100 | 0.1882 | 0.999654 | 155.6008 | 0.00961 |
| 0.4 | 0.4 | 6.91E-6 | 6.91E-2 | 125 | 0.2352 | 0.999459 | 243.0987 | 0.01501 |
| 0.3 | 0.3 | 5.18E-6 | 5.18E-2 | 167 | 0.3135 | 0.999038 | 432.0696 | 0.02669 |
| 0.2 | 0.2 | 3.45E-6 | 3.45E-2 | 250 | 0.4699 | 0.997839 | 971.4765 | 0.06005 |
| 0.1 | 0.1 | 1.73E-6 | 1.73E-2 | 500 | 0.9363 | 0.991412 | 3871.3077 | 0.24021 |

**Table 1. Analytical calculation results for Bitter electromagnet design (100A current supply)**

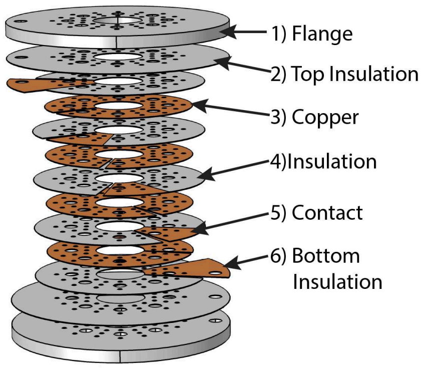

**Figure 2. Bitter Electromagnet Design**

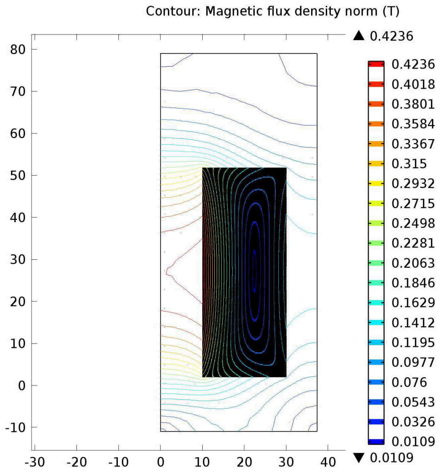

**Figure 3. Software simulation in 2D-axisymmetry format. This represents the right hand side cross-section of the Bitter electromagnet from top to the bottom. Value 0 of the X axis represents the center of the electromagnet. The maximum flux generated by this magnet would be 0.4236 T at the center.**

the thickness from 0.1mm to 1mm which changes the number of turns of the electromagnet.

Based on literature, the coil resistance need to be between 0.02Ω and 0.2Ω and the space factor must be greater than 0.7 [4].Table 1 show the analysis result for our proposed Bitter Electromagnet.The insulation thickness must be the same as the copper thickness [4]. Based on the results, copper plate with thickness of 0.1mm to 0.4mm are fit for making the bitter electromagnet. Thickness of 0.2mm is chosen for our first bitter design since it is more practical make and test in laboratory environment. The bitter electromagnet is estimated to produce 0.4699T (4699 Gauss). Next,from the best selected parameter, a software simulation has been done. The simulation results are as shown Figure 3. Since the simulation is in 2D, the copper and insulation thickness is reduced to 0.1mm to consider the hole that present in the actual electromagnet design. When supply a 250 turn bitter plate with 100A, the field produced is 0.4236T (4236 Gauss). Thus, we assume that the actual prototype may produce approximately the same result since both results show almost the same result.

A microcontroller based firmware system and a computer program will be used to control the controller circuit and thus controlling the magnetic object above the table. It is necessary to decide the method of cooling first since it generates considerable amount of heat during the operation. Therefore, we are designing a water based cooling system based on the theories discussed by McAdams [6].

### Magnetic Food and Magnetic Utensils

Magnetic foods and Magnetic utensils will be placed on top of the Magnetic table interface. These special foods and utensils will be magnetized first and as a result we can make them to levitate, rotate, move, or modify weight and change the shape (only for the food). We will be testing custom-made foods that have permanent magnet(s) inside. In addition, we will also be looking in to powder like materials that can be added into the food such as iron since it is a known fact that iron enriched cereals can be movable on a smooth surface by using a weak magnetic field [2] and also other suitable ferromagnetic materials. We also aiming to introduce magnetic utensils. The magnetic utensils will be magnetized in three different methods. The first method is to make these utensils using ferromagnetic or ferrimagnetic material and use a magnetizer to magnetize them. Second, we will embed one or set of permanent magnets into the utensils. The third is to embed small battery powered electromagnets to the utensils and change the magnetic flux it generates dynamically.

## FUTURE WORKS

One of the main experiments we intend to do is to study the influence of dynamic changes in cutlery weight on the perception and enjoyment of food [7]. We will design the proposed platform as a dining table and manipulate the weight of cutlery during people's eating experience by using magnetic fields. We expect this interface able to modify taste and smell sensations, food consumption and even human-food interaction experiences. We also will be able to use this interface for collaborative dining. Serving the levitating dishes to your loved once, changing the weight and texture dynamically would add new experience and dimension into the food interactions.

## CONCLUSION

This paper discussed about the development of Magnetic Table Interface and Magnetic Foods using magnetic fields and material. In future, this technology can be used to improve the multi sensory in the fields of human- food interaction, new media, mixed reality, medicine and also entertainment computing.

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## REFERENCES

1. 2016. Bitter electromagnet. (2016). `https://en.wikipedia.org/wiki/Bitter_electromagnet`.
2. 2016. Magnetic Cereal. (2016). `https://www.kjmagnetics.com/blog.asp?p=cereal-contains-iron`.
3. SH Autler. 1960. Superconducting electromagnets. *Review of Scientific Instruments* 31, 4 (1960), 369–373.
4. F Bitter. 1936. The design of powerful electromagnets Part II. The magnetizing coil. *Review of Scientific Instruments* 7, 12 (1936), 482–488.
5. The National High Magnetic Field Laboratory. 2009. Making resistive magnets. (2009). `https://nationalmaglab.org/news-events/feature-stories/making-resistive-magnets`.
6. William H McAdams. 1954, Heat transmission. (????).
7. Charles Michel, Carlos Velasco, and Charles Spence. 2015. Cutlery matters: heavy cutlery enhances dinersâĂŹ enjoyment of the food served in a realistic dining environment. *Flavour* 4, 1 (2015), 1.
8. Takuji Narumi, Takashi Kajinami, Tomohiro Tanikawa, and Michitaka Hirose. 2010. Meta cookie. In *ACM SIGGRAPH 2010 Posters*. ACM, 143.
9. KARUNANAYAKA KA KASUN THEJITHA. 2013. *Magnetic human interfaces*. Ph.D. Dissertation.
10. Jun Wei, Adrian David Cheok, and Ryohei Nakatsu. 2012. Let's have dinner together: evaluate the mediated co-dining experience. In *Proceedings of the 14th ACM international conference on Multimodal interaction*. ACM, 225–228.
11. Malte Weiss, Chat Wacharamanotham, Simon Voelker, and Jan Borchers. 2011. FingerFlux: near-surface haptic feedback on tabletops. In *Proceedings of the 24th annual ACM symposium on User interface software and technology*. ACM, 615–620.