Tracking Magnetics above Portable Displays

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Abstract

We present a system of the passive magnetic tangible designs that enables 3D tangible interactions above the portable displays. When a thin magnetic sensor grid is attached to the back of the display, the 3D position and partial 3D orientation of the magnetic tangibles, *GaussBits*, can be resolved by the proposed bi-polar magnetic field tracking technique. The occlusion-free properties of this tracking method also enrich the design of tangible interactions.

1 INTRODUCTION

Tangible user interface has been developed on the prevalent mobile displays to improve the user experience[1]. However, the interactions are confined to the 2D space because of the limitations of the capacitive-based sensing technology. Although traditional vision-[2] and magnetic-based[3] approaches can track the 3D interactions, the former usually suffer occlusion problems on detection and the latter usually involve excessively heavy components for portable usage.

In this paper, we present a system of the passive magnetic tangible designs that enables 3D tangible interactions in the near-surface space of portable displays. By attaching a thin-form Hall-sensor grid to the back of an unmodified portable display, the specifically designed magnetic unit, *GaussBits* [Liang et al. 2013] allow the 3D position and partial 3D orientation (tilt or roll) of the magnetic unit to be stably resolved on or above the display, by using the proposed bipolar magnetic field tracking technology. Additionally, since the magnetic field can easily penetrate through any non-ferrous material, such as the user's hand, interaction designers can incorporate the magnetic unit into an appropriately shaped non-ferrous object to exploit metaphors from simulating the real-world tasks, and users can freely manipulate them by hands or using other non-ferrous tools without interfering with the tracking.

2 DESIGN

We implemented a grid of 32×24 = 768 Winson WSH138 Hall sensors, with an 160 (W)×120 (H) sensing area (Figure 1(a)). Each sensor element detects both N- and S-polar magnetic field intensities, in a range from 0 to 200 Gauss on a 256-point scale. The captured bi-polar magnetic field data are 16x up-sampled using the bi-cubic interpolation method, and processed by a bipolar sensing algorithm. The 3D position of a magnetic unit can be resolved by analyzing the distribution and the maximum strength of the sensed magnetic field. The tilt of a magnetic unit can be resolved in any direction without ambiguity if an axially magnetized cylindrical or ring magnet is used (Figure 1(c)). The roll of a magnetic unit can be resolved if a laid axially magnetized cylindrical magnet or a bi-polar magnet pair is used (Figure 1(d)).

Four applications (Figure 2) are presented to demonstrate how the enabling technology can enrich the mobile interaction experience.

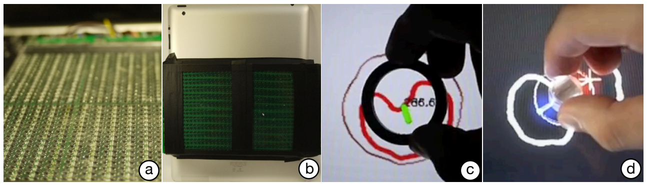

Figure 1: *Our system tracks magnetic tangibles above a portable display by attaching a (a) Hall-sensor grid to (b) the back. The (c) tilt or (d) roll information of the magnetic units can be resolved as well as the 3D position.*

In all applications, magnetic tangibles are tracked by a Hall-sensor grid attached to the back of a portable display (Figure 1(b)).

Going 3D. As a clock widget (Figure 2(a)), a user can lift it to a different height to select a hand to adjust, then rotate it (in the air) to adjust the selected hand. As a map navigator (Figure 2(b)), a user can tilt it to navigate around the map, lift it to zoom-out at the where it hovers, and flip it to switch the function to zoom-in.

Providing favorable form factors. In the flight simulation (Figure 2(c)), a user can pinch an magnetic toy aircraft to control it above the display. Therefore, the user can avoid the obstacles by moving and/or tilting it, climb or dive by raising or lowering its nose, and pick up the bonus by landing it.

Playing with non-ferrous instruments. In the fish-frying simulation (Figure 2(d)), a user can place the magnetic fish on the plastic pan, flip the fish using the wooden chopsticks, hold and shake the pan to fry the fish, and then pour the fried fish onto the display.

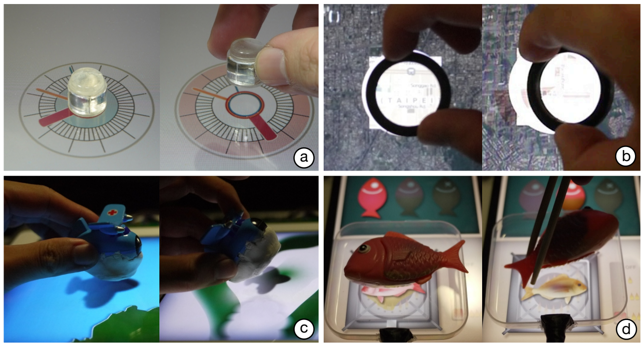

Figure 2: *Sample applications. (a) Clock widget. (b) Map navigator. (c) Flight simulation. (d) Fish-frying simulation.*

References

LIANG, R.-H., CHENG, K.-Y., CHAN, L., PENG, C.-X., CHEN, M. Y., LIANG, R.-H., YANG, D.-N., AND CHEN, B.-Y. 2013. GaussBits: Magnetic tangible bits for portable and occlusion-free near-surface tangible interactions. In *Proc. ACM CHI 2013*.

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[1] http://www.appmatestoys.com/
[2] http://www.vicon.com/
[3] http://www.polhemus.com/

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