MagNail:
User Interaction with Smart Device through Magnet Attached to Fingernail

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Abstract
Nowadays, people can walk around sporting wearable devices owing to the advancements in wearable computing. Our objective is to develop wearable computing technology that allows a user to sport a device in a natural manner at all times. We then focus on the fingernail, which is accepted as a body part that is decorated, and a magnet that does not require batteries. In this study, we use MagNail, which is nail art that uses a magnet as the decorative material. It is attached to the user's nail and detects the status of the user's finger while operating a smartphone, via the magnetic sensor inherent in the device.

Author Keywords
Fingernail; Finger status; Magnet; Smart device.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

Introduction
Wearable devices have become increasingly prevalent and devices, for detecting users' behaviors have been commercialized. We focus on placements such as the nails, teeth, and hair where device location is painless. Of these locations, fingernails are the most promising sites because they are easily accessible for installation

and maintenance and they can be used to indicate important human gestures. Moreover, nail art and care have recently become popular with both genders.

For a device, we focus on a magnet that does not require batteries and then develop the MagNail (nail art that uses a magnet as the decorative material) system. This recognizes the status of the user's finger while operating smart devices such as smartphones and tablet PCs, using the magnetic sensor for measuring the Earth's magnetism inherent in the device. The majority of smart devices can be operated via this integrated magnetic sensor.

Magnets are featured in recent studies [1, 2, 3, 4, 5], and some studies also interact with smart devices. MagiTact [4] introduced an interaction method using a magnet. MagPen [5] uses a pen-type device with a built-in magnet. Although we use the magnetic sensor of smart devices, MagNail is a type of wearable device used to detect gestures or postures of the user's fingers. Users are not required to hold any physical devices.

In this paper, we omit the details of the detection method for a finger equipped with MagNail and basic experiments because we have discussed these results in a previous paper [6]; however, we report on the overview of this system, new application examples, and their performance evaluations.

System Overview

Considering the thickness of ordinary nail art, a very small magnet was used for MagNail. To recognize the hand (finger) status, the system detects the magnetic field generated by the magnet on the fingernail using the magnetic sensor's X, Y, and Z value (this study uses the Nexus 5 smartphone). We conducted basic experiments to investigate if the magnetic information generated by a magnet attached to a fingernail could be used to detect the finger status, and then explored whether the statuses illustrated in Figure 1 could be recognized successfully. When the magnet (MagNail) was placed on the user's right middle fingernail, the following finger and hand statuses could be detected.

- **Finger status**: The right middle finger is bent in (a), whereas the finger is stretched in (b).

- **Holding status**: A user holds a smart device with the right hand in (c), with the left hand in (d), and with both hands in (e).

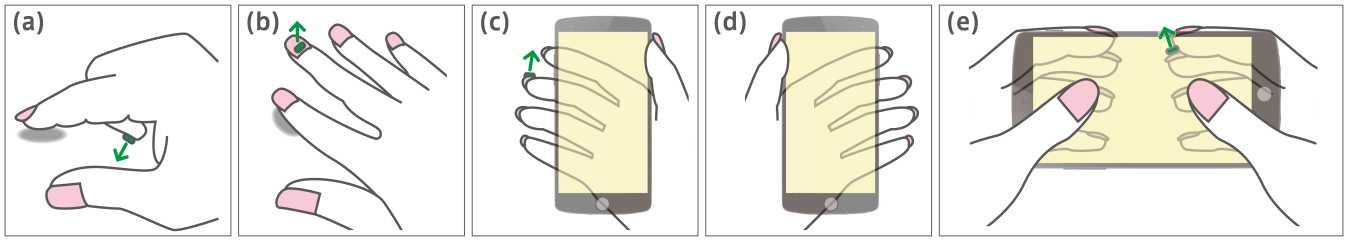

Figure 1: Interaction with MagNail on the right middle fingernail. The arrows indicate the magnetic lines.

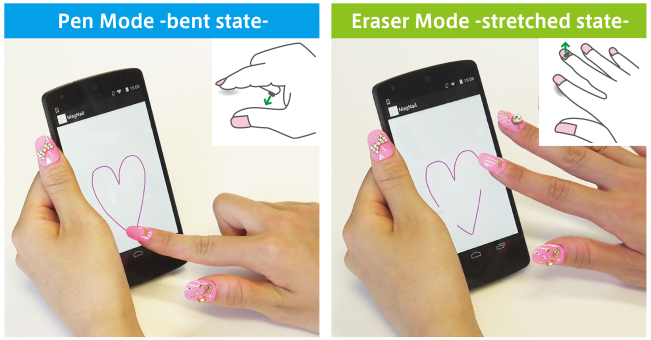

Figure 2: Paint Application: switching Pen/Eraser mode.

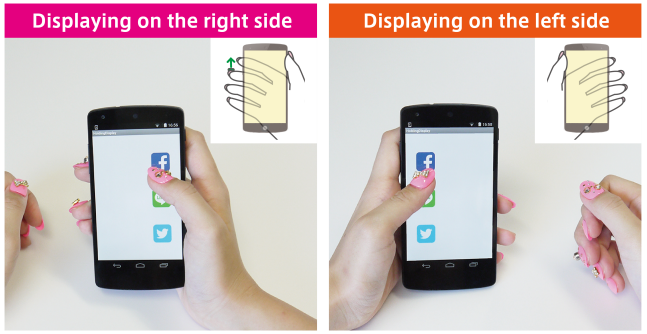

Figure 3: Display Application: switching Right/Left mode.

Application

As shown in Figure 2 and Figure 3, we propose feasible applications for MagNail attached to a user's right middle fingernail. First, **Paint Application** that performs a drag operation by the user having MagNail on the middle fingernail using the first finger as a pen and an eraser while the middle finger is bent and stretched, respectively. Second, **Display Application** that moves the menu icons to a position on the display according to the holding hand, i.e., positioning them at the right side on the display when holding the device in the right hand, and at the left when holding in the left hand. We can facilitate the select operations.

Paint Application

Implementation

First, we measured the values of the magnetic sensor with MagNail while touching with the first finger, where the middle finger was either bent or stretched. Then, we compensated for the Earth's magnetism and obtained the normalized direction vectors *gBent* and *gStretched*. Whenever a user touches the screen, the system calculates the magnetic values and determines what direction vector is being indicated by the current touch.

Performance Evaluation

We conducted a performance evaluation targeting ten women (aged 21–52 years), who experienced MagNail for the first time. We explained the basic usage of MagNail and requested each user to place MagNail on their right middle fingernail and to draw (bent status) and erase (stretched status) freely five times.

We found that the eraser mode functioned almost perfectly (average 96%). Conversely, the pen mode performed with 81% accuracy, i.e., although the user intended to operate the pen mode, it worked as the eraser mode one out of five times. For the pen mode, the manner of bending the middle finger varied depending on the user, and this possibly resulted in the lower precision. Thus, we expect that by collecting the magnetic direction vectors on each user separately, or adopting the direction vector actively via detecting the user's corrected motions, the discrimination precision would be improved.

Display Application

Implementation

We determined that even when the values included the influence of the Earth's magnetic vector, there was an observable difference in the x, y, and z values of the magnetic sensor when the user held the device in the right or left hand, compared to the changes of the other values. Therefore, when the differences of each value at the time of touching the display exceed a specific value, it can be determined as holding the device in the right hand.

Performance Evaluation

In addition to the Paint Application, we also conducted a performance evaluation of the Display Application with new eight women (aged 16–24 years). We explained the basic usage of MagNail and requested each user to place MagNail on the right middle fingernail. They were then directed to repeat the following sequence of actions five times: holding the device in the right hand, click the display with the right thumb five times; then switch to the left hand and click the display with the left thumb five times. We did not provide any direction on how to hold the smartphone or where to place the free hand. However, the identification of holding the smartphone in either hand was successfully recognized.

Conclusion

We successfully conducted performance evaluations for 2 applications using 18 women as subjects. The results suggested that, in addition to the high feasibility of this method, there were other possible interactions based on the status of a secondary finger (middle finger in this study) complementing the main input finger. In addition, this system is durable in daily life, and it requires only the magnet sensor already integrated in smart devices and magnets, which are cheap and readily available. We converted the magnet into a wearable and fashionable system by decorating it in an attractive manner as a nail art component, which was fixed to a user's fingernail.

Acknowledgement

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