A Half-Implant Device on Fingernails

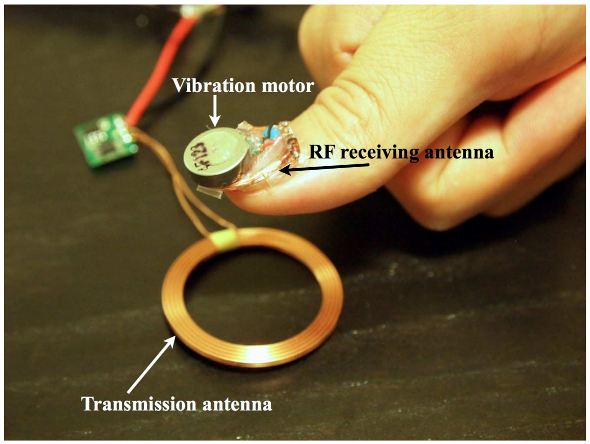

Figure 1. Prototype of the half-implant device on the nail.

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Abstract

Hand gesture feedback systems using tactile or visual information can only be used in given situations because of the limitations of the device features such as the need for a battery. In this paper, we propose a half-implant device located on the fingernail. The half-implant device consists of a radio frequency (RF) receiving antenna, small electronic parts, and UV gel. The UV gel is used to glue the parts onto the user's nail and cover the parts meant to be waterproof. The device receives power from the RF antenna; therefore, it does not require a battery to function. It notifies whether the finger is in a target site by lighting an LED or activating a vibration motor. The primary benefit of this device is that the user can feel hand gesture feedback, anytime and anywhere. The device can be placed on the users' fingernail for approximately three weeks. To verify the devices' influence on the users' pointing task, we conducted a preliminary user study. The task success rate was 100% over the sessions with tactile and visual feedback and 97% without feedback. The experiment revealed that the tactile notification reduced the task time by 12.3 % compared to that of the test with no feedback.

CHI 2014, Apr 26 - May 01, 2014, Toronto, ON, Canada.
ACM 978-1-4503-2474-8/14/04.
http://dx.doi.org/10.1145/2559206.2581293

Author Keywords

Half implant; Nail; Fingertip; RF (Radio Frequency); Tactile; Haptic; Tangible; Wearable; Design

ACM Classification Keywords

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

Introduction

Many hand gesture input systems have been suggested in HCI (Human-Computer Interaction) and Ubiquitous Computing. Hand gesture input systems must be adapted to anytime and anywhere. Can we use tactile feedback anytime and anywhere without touchable hand gesture devices? In this paper, we focus on a feedback device that can be used anytime and anywhere. Feedback devices for hand gesture input are classified as touch panel, room-mounted, and wearable type. These three device-types are described in the following:

Touch panel-type devices: Touch panel-type devices [1-4] generate sound, visual, and tactile feedback through the touch panel by recognizing a user's hand gesture on the panel. They can be used without the learning of consistent pointing because the input sensors and feedback actuators are set in the same place. User can only perform hand gesture input when they place their hand on the panel. Moreover, there can only be limited hand gesture variations because it requires the user's hand to be in constant contact with the panel. Finally, the device can only be used in 2D space.

Room-mounted-type devices: Room-mounted-type devices give the user sound and visual feedback using a speaker and projector [5, 6]. There are few tactile feedback devices in this group. As an exception, a room-mounted-type device can include tactile feedback using airborne ultrasound [7, 8]. The device can give a user a tactile feeling anywhere. However, the device only generates a maximum 0.8 gf (gram-force) [7]. This is too weak to notify the user if he is doing other things.

Wearable-type devices: Wearable-type devices vary according to the kind of feedback. In this section, hand-gesture-input feedbacks are discussed.
For visual feedback, HMD (Head Mounted Display) devices such as Google glass [9] and AiRScouter [10] are available. The HMD devices have become small and lightweight and look like eyeglasses. However, HMD devices must be removed in some situations, for example, in bedrooms and bathrooms, for the user's safety. A small projector can also be used as a wearable feedback device. Sixth Sense [11] and BrainyHand [12] are two systems that have a battery and a small camera for detecting user hand gestures and include a small projector as the visual feedback. These devices are placed on the user's head or neck. The two systems do not hinder the user's daily gestures and the visual feedback is projected on the user's hand. Users can input hand gestures everywhere. However, the two systems require a boot command or switch because the user's daily hand gestures could be mixed with hand gesture commands if the systems are always detecting user hand gestures. Both systems require a battery that must be carried by the user, for mobile use. For these reasons, these systems are unsuitable for quick hand-gesture input in daily use.

For sound feedback, wearable, mass-consumption Bluetooth earphones [13] can be used. However, the earphones would also have to be removed in some situations, for the same reasons as the HMD devices.

For tactile feedback, Master Slave [14] and TELESAR [15] are suggested. Both devices give the user a tactile feeling using glove-type devices. Master Slave and TELESAR allow the user to control a robot hand. The tactile feeling is synchronized with the robot hand's feeling. We cannot use these devices on a daily basis because they cover the user's hand and inhibit hand motion. In order not to cover the user's hand, PossessedHand [16] is an option.

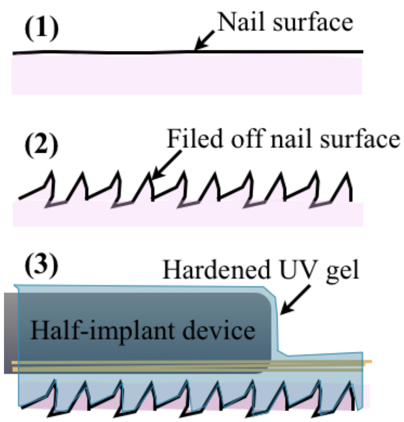

Figure 2. Implementation of the nail attach of the half-implant device.

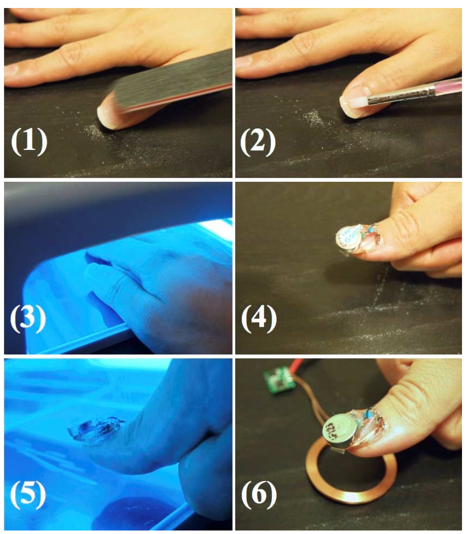

Figure 3: How to set the half-implant device on a nail. (1) File off the nail surface. (2) Coat the nail surface with the UV gel as a base coat. (3) Harden the base coat using UV light irradiation. (4) Set the half-implant device on the base coat. (5) Coat the half-implant device and the nail with UV gel as a topcoat and harden the topcoat. (6) Finish.

PossessedHand controls the user's finger-joint movements using non-invasive EMS (Electric muscle stimulation) around the user's arm. To maintain the health of the skin and muscle, PossessedHand can only be used for limited time periods.

Exceptions: Ubi-Finger [17] and Implanted User Interface [18] use the behavior of the controlled device as the feedback. Ubi-Finger is designed for inputting finger gestures in a ubiquitous environment. These devices allow users to select a target device to control using a pointing-finger gesture. They do cover the user's finger pad; however, the electric leads hinder the user's daily gestures.

Nail-mounted feedback devices have been suggested [19, 20, 21]. In these projects, feedback devices are set on the user's fingernail and do not cover the user's finger pad. These devices, however, are wired to a power supply.

Our Goal

Feedbacks that could be used as a starting point for hand gesture have been proposed. However, for anytime and anywhere usage, the following criteria are required: 1. Device must be wireless, lightweight, small, and safe. 2. Device must be usable in both dark and bright spaces. 3. Device cannot cover the hand. 4. Device cannot make noise. 5. Device must work without battery (or work with a lightweight and rapidly chargeable battery).
Our goal is to suggest a feedback device that meets the above criteria. For anytime and anywhere usage, we must be able to attach the tactile device on the user's body for 24 hours or more. In addition, the tactile device must be waterproof so it can be used anywhere.

Half-implant device

In this paper, a half-implant device (for tactile and visual-feedback) is described. We made a prototype of the device for a user's fingernail. Figure 1 shows the prototype. This device consists of a vibration motor or LED, RF (Radio frequency) receiving antenna, a capacitor, a rectifier diode, and UV gel. The power and vibration pattern are supplied from the magnetic field.

The UV gel can be applied to the user's nail to bind the other parts and cover the parts to be waterproof. To apply the UV gel, the nail surface is filed off. Then, the UV gel is spread on the roughened nail surface. The parts are then securely fixed on the user's nail (Fig. 2). Figure 3 shows the process to install the parts on the user's nail. The UV gel is hardened by UV light irradiation. "UV GEL FSM Clear" is used as the UV gel. This gel is normally sold for artificial nails. It takes approximately 20 minutes to mount the device. In our study, the half-implanted device was fixed for five weeks. However, the device should be removed before three weeks because the user's fingernail does grow out.

To supply the power, an RF (Radio frequency) receiving antenna, which is a small coil, is used. The inductance of the coil is set to 17.0~18.0 μH for the electromagnetic coupling. A 0.2 mm diameter tinned line is used. The inner diameter of the coil is set to 15.0 mm. The outside diameter of the coil is set to 18.0 mm (Fig. 4). A wireless charging module (POW01141B) by *SeeedStudio* is used. From the transmission antenna, our receiving antenna captures alternating current.

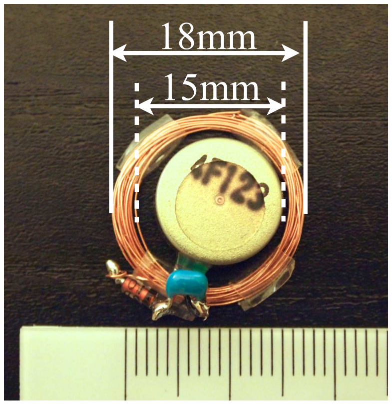

Figure 4. Close-up of the prototype device with the vibrator

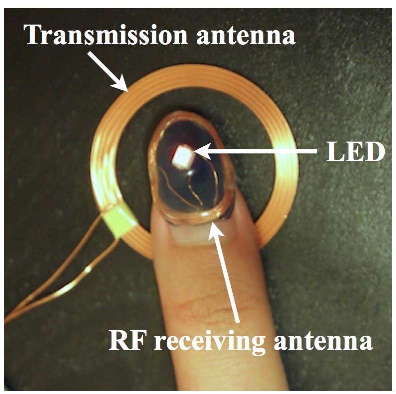

Figure 5. Close-up of the prototype device with the LED

Tactile feedback-type
The tactile feedback device activates vibration motor. We install a rectifier diode (40V, 600mA) in the circuit of our device because the vibration motor (FM34F) by *T.P.C* is designed to run on DC (Direct Current) electricity. For noise rejection, a capacitor is also included in our device. The vibration motor uses 2.5V~3V, 50~90mA through the circuit.

Visual feedback-type
The visual feedback device (Fig. 5) consists of a receiving antenna (3.0~5.0μH) and an LED. An LST676-R (20mA) is used for the LED.

Experiments

To verify the devices' influence on the users' pointing task, we conducted a preliminary user study. In our experiments, determining the kind of feedback suitable to assist users in locating the place to input information quickly and accurately, is examined. Tactile feedback with a vibration actuator and visual feedback with a LED that meet the requirements of our objective ('Our Goal') are considered. As a standard experiment, the absence of feedback is compared with tactile and visual feedback.

Hypothesis
Tactile and visual feedback will help users locate the place to input information quickly and accurately. In addition, for information input, tactile and visual feedback will be more effective than the absence of feedback.

Apparatus
Two types of half-implant devices are used, the tactile feedback-type and the visual feedback-type.

The experimental space (24.0cm x 27.0cm) is located on a desk. The transmission antenna (target site) is also placed on the desk, hidden under a cover. From the change of antenna's current caused by electromagnetic coupling, we detected whether the participants place their hand over the correct location.

Participants
Four volunteers (2 male, 2 female), ranging in age from 20 to 40 years old, participated in our experiment. (Mean (M) = 32, Standard Deviation (SD) = 5.4). All participants were right-handed and used our devices on the index fingers of their right hand.

Procedure
First, an experimenter pointed the target site (2.0cm x 2.0 cm) located in the experimental space (24.0cm x 27.0cm) to the subjects. The antennas were covered, so the subjects had to memorize the approximate position on the plain cover.
Second, the subjects set their hand in a fixed start position. They then moved their hand to the target site. Then, they returned their hand to the fixed start position. They repeated the pointing task ten times as quickly as possible. The subjects repeated this activity five times (five sessions). Before the start of each session, the experimenter changed the location of the antennas randomly. Fifty pointing trials were measured for each condition.
With these conditions, each subject performed 150 trials. In this experiment, the difference of the efficiency and speed was measured. The results are described in the following subsections.

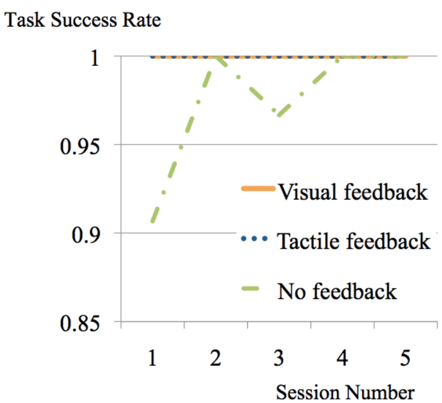

Figure 6. Results of the efficiency of each condition. With feedback, the gesture is 100% successful.

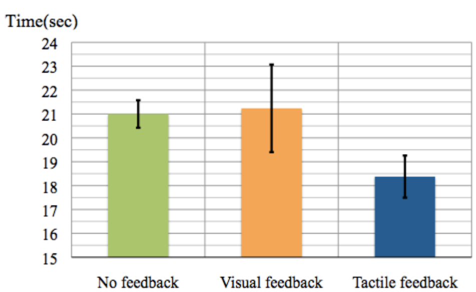

Figure 7. Results of the speed. The average speed differs only slightly over the conditions, whereas the variance differs a great deal.

Result: Accuracy

Task success rate of this experiment is shown in Figure 6. With visual feedback and tactile feedback, the task success rate is 100% over all sessions. The Task success rate lowers to 97% with no feedback condition.

Result: Speed

The average time for one task in the three conditions is shown in Figure 7. The average time shows a difference among the conditions (21.0 seconds with no feedback, 21.23 seconds with visual feedback condition, and 18.38 seconds with tactile feedback condition). In other words, the tactile notification reduced the task time by 12.3 % compared to that of the test with no feedback. The variance also shows a difference over the conditions (0.58 with no feedback, 1.83 with visual feedback condition, and 0.88 with our device).

Discussion

For accuracy, either feedback (visual or tactile) is effective for finding target site. For speed, the visual feedback does not effective for quick searching. The error bar for visual feedback is higher than other two conditions, suggesting a larger overshoot effect. However, tactile feedback reduced the task time by 12.3 % compared to that of the test with no feedback. Our experiments show that tactile and visual feedbacks are efficient for the half-implant system. Tactile feedback is particularly suitable for quick input.

Conclusion

In this abstract, we proposed a half-implant device located on the fingernail. Preliminary user study suggested that tactile feedback is effective for quick input. As a future work, we are going to build applications over this result.

The primary benefit of this device is that the user can feel hand gesture feedback, anytime and anywhere. The device can be placed on the users' fingernail for approximately three weeks. Next research interest would include surveying social acceptability of this concept. For example: 1. What size and weight is acceptable for half-implant. 2. How long do users want to attach this device. 3. How the user's feeling changes over time.

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