Shape Changing Device to Inform of Notification based on Peripheral Cognition Technology

Kazuki Kobayashi[1] and Seiji Yamada[2]

[1] Graduate School of Science and Technology, Shinshu University
4-17-1 Wakasato, Nagano City, Nagano 380-8553, Japan
[2] National Institute of Informatics, Sokendai, Tokyo Institute of Technology
101-8430 2-1-2 Hitotsubashi, Chiyoda, Tokyo 101-8430, Japan

Abstract: In this paper, we propose an inconspicuous information notification method with peripheral cognition technology that uses a human cognitive characteristic, visual field narrowing. The proposed method achieves information notification without interrupting the primary task that the user is engaging in. We developed two prototype devices based on the proposed technology that change their shape to notify the arrival of new information. Such behavior enables a user to easily find and accept notifications without interruption when their attention on the primary task decreases. The result of an experiment with one of the developed devices showed that the successful notification rate was 45.5%.

1 Introduction

There are many digital devices such as smart phones and tablet PCs that notify us of fresh information. However, frequent notification from such devices often breaks users' attention and interrupts their work. Some research on ubiquitous computing deals with unobtrusive notification by electronic devices. One approach with a user model [1, 2] collects sensor data and estimates the user's status to determine the appropriate timing for notification. Another approach without a user model develops effective visual notifications that adjust the levels of interruption by using a transitional illustration [3, 4] and an animated picture [5, 6].

In this paper, we propose an information notification method with peripheral cognition technology (PCT) [7, 8] that uses a human cognitive characteristic called "visual field narrowing" [9]. The proposed method achieves information notification without interrupting the task that a user is engaging in. We developed two prototype devices based on PCT that change their shape to notify of the arrival of fresh information [10]. The behavior of the device enables a user to maintain attention on his or her work and to accept notifications without interruption when his or her attention on a task decreases because the device can move itself quietly and without causing a distraction.

2 Peripheral Cognition Technology

Peripheral cognition technology (PCT) is an information and communication technology that uses human cognitive characteristics for sensing the peripheral environment, which include the peripheral visual field and sense of ambient atmosphere [7]. Basically, PCT non-intrusively shows information in the peripheral visual field and quietly changes the peripheral user environment to notify the arrival of information. Users then notice the notification when their concentration level is naturally decreased instead of having their attention distracted from their primary work. Therefore, information notification without interruption can be achieved without monitoring the user and estimating his or her status.

PCT deals with non-urgent information such as RSSs for web sites, Twitter timelines, Facebook notifications, and update information for software. PCT always begins to show notifications regardless of the user's status as soon as it finds new information because it does not estimate the user's status. It requires its behavior to be modified so that users do not notice the notifications. For example, notifications can be set to be executed with a slow and quiet motion that the peripheral visual field cannot detect. Additionally, for devices that use PCT, the appropriate position for a device that makes the device easily noticed by users when their concentration level on

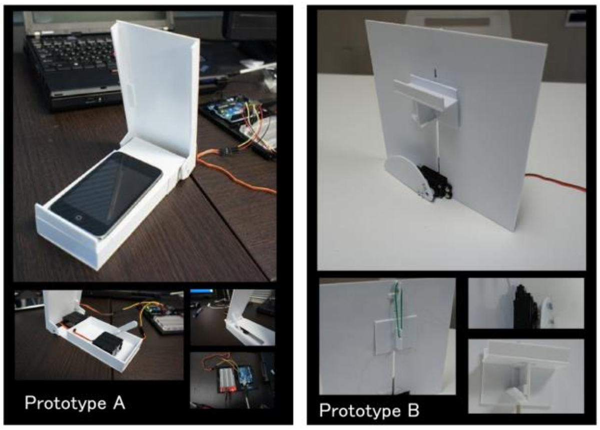

Fig. 1. Prototypes of shape changing devices

their work decreases. When applying PCT, the appropriate behavior needs to be set in accordance with the given problem.

3 Shape Changing Device

We propose a shape changing device that notifies users of the arrival of new information as an application of PCT. The device slowly and quietly changes its shape. The basic idea of our proposed method is based on the human cognitive characteristics of narrowing the peripheral vision field when concentrating on a certain target (visual field narrowing) and having difficulty with detecting subtle changes in a target (change blindness). The designed changing behavior is too slow and quiet for users to notice the movements. Information notification is achieved when users happen to see that the device has changed its shape when their concentration level on a target naturally decreases.

In our research, smart phones are assumed as the notification device. We developed a device that notifies users of delivered information without interrupting them. The developed shape changing device un-intrusively alters its shape by making the smart phone stand up, making it is easy for users to notice the change.

Figure 1 shows our prototypes of the shape changing devices. Prototype A is a pedestal type device that slowly raises the smart phone when obtaining new information to notify. Prototype B is a slot-in type device that slowly elevates the smart phone. It requires exterior casing to hide the phone; the photo of prototype B shows only its

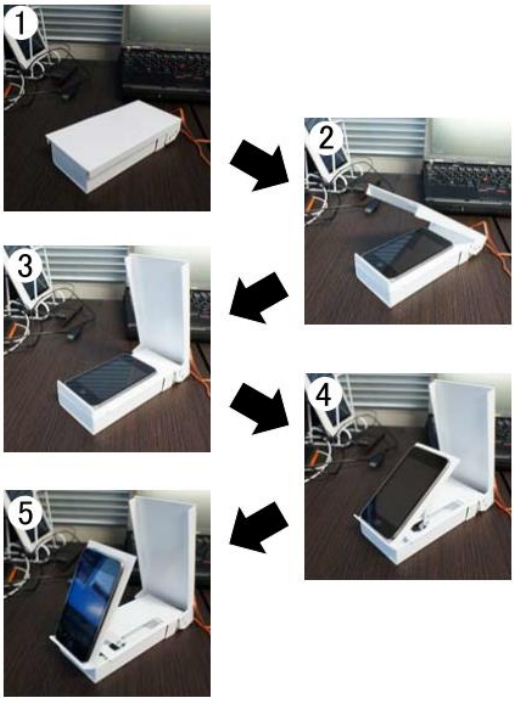

Fig. 2. Shape changing behavior

internal structure. Prototype A is focused on in this paper because prototype B requires more motor power to move the smart phone than does prototype A, and a high power motor that makes a large noise is inadequate for our proposed method.

Figure 2 shows the shape changing behavior of prototype A. The device changes its shape when it obtains new information from e-mail clients, Twitter, Facebook, RSS, etc. First, it softly opens the upper cover and then slowly raises the smart phone. Designing the behavior of this shape changing requires setting motor control parameters such as the moving speed and intervals so that users do not notice the changing actually taking place. In this prototype, we used two servo motors to move the cover and the smart phone. It takes about three minutes to completely raise the smart phone because any shorter and the noise from the servo motors would be rather loud, causing users to become aware of the device when they work in quiet office rooms.

4 Experiment

We performed a simple experiment for two weeks. The details of the experiment are described below.

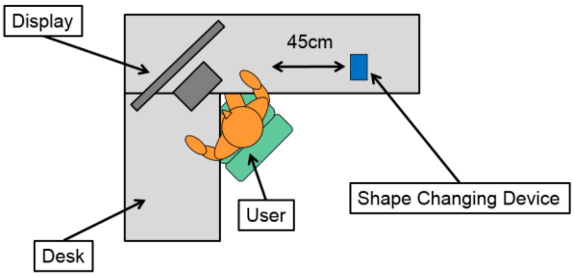

Fig. 3. Experimental environment

Fig. 4. Questionnaire page on smart phone

Table 1 Questionnaire

Timing:
I noticed it just now.
I already noticed it before.
Situation:
I suspended my work.
I just remembered the previous notification.
I noticed when I returned to my room.
No special reason.

Fig.5. Results of questionnaire

4.1 Method

The experiment was completely exploratory research done by one person who used the device for about two weeks in a real situation at his office. Figure 3 shows the experimental environment. The shape changing device was placed on the right side of the desk, which was 45 cm away from him. He spent most of his time at his desk but often left the desk.

The device informed him of the arrival of information we sent that was designed to be like the typical information sent to smart phones by changing its shape to raise the smart phone within random intervals (between one to thirty minutes). He answered a brief questionnaire whenever he noticed a notification. The questionnaire was displayed on the smart phone (Fig. 4), and he directly selected the items by touch. Table 1 shows the questionnaire, which is translated from Japanese.

We estimated the proposed method on the basis of the questionnaire results. The evaluation indexes consisted of the successful notification rate, the semi-successful notification rate, the intrusive notification rate, the neglected notification rate, and the notification received rate.

4.2 Results

The results of the questionnaire are shown in Fig. 5. In total, he answered the questionnaire 97 times within a certain time frame. The successful notification rate, selected with "I noticed it just now for no special reason," was 45.5% (44/97). The semi-successful notification rate, selected with "I noticed when I returned to my desk," was 29% (28/97). The intrusive notification rate, selected with "I suspended my work," was 19.6% (19/97). The neglected notification rate, selected with "I noticed it before," was 6.2% (6/97). The notification received rate was 37.9%.

5 Discussion

The experimental results showed that the number of successful notifications was 44 times, which exceeded that of the intrusive notification. However, there is still room for improvement because the success rate was less than 50%. The reason for this result was that the participant answered that he noticed the sound of the motor in the device. Decreasing the motor sound is one problem to solve because he delayed responding to the device only six times when hearing the sound. The participant noticed the notification when he returned from being away from his desk 28 times. This suggests that the shape changing device is useful for work in which the worker leaves and returns to his desk multiple times throughout the day.

The notification received rate was less than 40%. This result is not surprising because the proposed method contributed kept the number of times the user was interrupted from being excessive. However, since we used notifications we created, the user's behavior might have been influenced as a result. It is preferable to increase the received rate and to investigate realistic phenomenon more in depth.

Although there are many candidates for the notification method, the proposed method changed the position of the smart phone. Notification can be achieved without raising the smart phone, but the advantage of raising it is to make it easier to operate the phone. It is common for users to use their phone after they have accepted a notification. Therefore, we move the smart phone itself instead of simply changing the color of the entire phone itself or its screen.

Although we used only the shape changing device in the experiment, we need to compare other notification methods such as sound notification, which is a popular method. In addition, detailed adjustments to the shape changing parameters and consideration of the optimal device location are also future tasks.

6 Conclusion

In this paper, we proposed an information notification method with peripheral cognition technology that uses the human cognitive characteristic of visual field narrowing. The proposed method can achieve information notification without interrupting the user's primary task that he or she is engaging in. We developed two prototype devices based on the proposed technology that change their shape to notify of the arrival of new information. Such behavior enables a user to easily find and accept notifications without interruption when their attention on a primary task decreases. We performed a simple experiment in a realistic office environment. The experimental results showed that the successful notification rate was 45.5%. We need to solve the motor sound problem and to clearly identify the most effective situation for using the device as future work. The proposed method and its related knowledge will be used as elemental technology in the research field of human-agent interaction.

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