AffectPhone: A Handset Device to Present User's Emotional State with Warmth/Coolness

Ken Iwasaki[1], Takashi Miyaki[2] and Jun Rekimoto[2,3]

[1] Graduate School of Interdisciplinary Information Studies, The University of Tokyo
7-3-1 Hongo, Bunkyo-ku Tokyo, Japan

[2] Interfaculty Initiative in Information Studies, The University of Tokyo
7-3-1 Hongo, Bunkyo-ku Tokyo, Japan

[3] Sony Computer Science Laboratory, 3-14-3 Gotanda, Shinagawa-ku Tokyo, Japan

Abstract. We developed AffectPhone, a system that detects a user's emotional state using the GSR, and conveys this state via changes in the temperature (wamrth or coolness) of the back panel of the other handset. Since GSR is a good measure of a user's level of arousal, we detect the GSR using electrodes attached to the sides of the handset. When the user's level of arousal increases or decreases, a Peltier module in the back panel of the other device generates warmth or coolness. This system does not require special sensors to be attached to the user's body, and therefore, it does not interrupt the user's daily use of the mobile phone. Moreover, this system is designed to convey non-verbal information in an ambient manner, and therefore, it would be more efficient than displays or speakers. This system is expected to help enhance existing telecommunication.

1 Introduction

During face-to-face communication, non-verbal cues convey as much information as do the verbal ones.[1] However, when using a computer for communication, it is difficult to convey non-verbal information. We believe that conveying such non-verbal information would improve existing telecommunication, and therefore, we have developed a system to facilitate the same.

1.1 Non-verbal Communication Channel

We aimed to develop a system that provides non-verbal communication channel in addition to the existing telecommunication. A communication channel generally includes the information to be output and a sense as the input. For example, when we communicate over a telephone, our voice is the output, and auditory sense is the input (Figure 1(a)). In this system, we selected the galvanic skin response (GSR) as the output, and temperature sensation as the input (Figure 1(b)).

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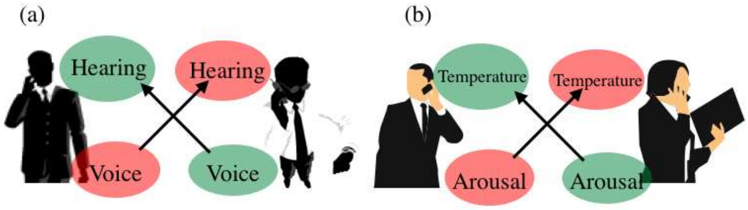

Fig. 1. Communication channels. (a) Normal telephone channel (Voice and Hearing). (b) Proposed non-verbal communication channel (Arousal and Temperature).

1.2 Selection of Input and Output

Humans use many non-verbal cues in their day-to-day communication. These cues include apparent ones such as body language, tone of voice, and facial expressions. However, we focus on non-verbal information that is not apparent, such as physiological information in this study.

We selected GSR as the output information, because Picard *et al*. suggested that GSR is a good measure of a user's arousal[2]. Moreover, the GSR can be acquired by using only two electrodes on the user's fingertip, and no special sensors need to be attached to the user's body.

We selected temperature sensation as the output, because warmth or coolness is often indicative of ones emotions, as borne out by expressions such as, "he is a cold man" or "a heart-warming story." Moreover, such haptic feedback does not interfere with user's hearing or sight. In other words, the user can convey his/her emotional state in an ambient manner.

2 Related Work

Wang *et al*. used physiological sensors and animated text to develop a system that helps in communicating emotions in an online chat.[3] This system detects a user's level of arousal from the GSR, and presents the user's emotional state as animated text. This system uses GSR as non-verbal information, but it also presents it as an attribute of the text. The objective of this system is to make text chat more efficient; however, verbal information is mainly used in text chats. Therefore, we focus on telephonic communication.

Brave *et al*. proposed inTouch, a medium for haptic interpersonal communication.[4] inTouch introduces haptic sensations in interpersonal communication and serves to enrich the communication. However, haptic sensations cannot be generated unless a user voluntarily moves the device, and therefore, this method does not suitably mimic typical day-to-day interactions. In contrast, our system can determine a user's emotional state from physiological information that the user cannot control voluntarily. Moreover, our system is integrated in a mobile phone we usually use, and therefore, it does not interrupt a user's daily use of the phone.

Vaucelle *et al*. designed haptic interfaces for therapeutic purposes.[5] A part of their research, called the *Cool Me Down* project uses temperature sensations for therapy.

The device developed by them can be discretely worn by the user and only activated when necessary; this would help patients self-administer soothing sensory grounding treatment. Their paper discusses the design concepts of haptic interfaces for therapeutic purposes, but not for communication. In contrast, we focus on enhancing existing telecommunication.

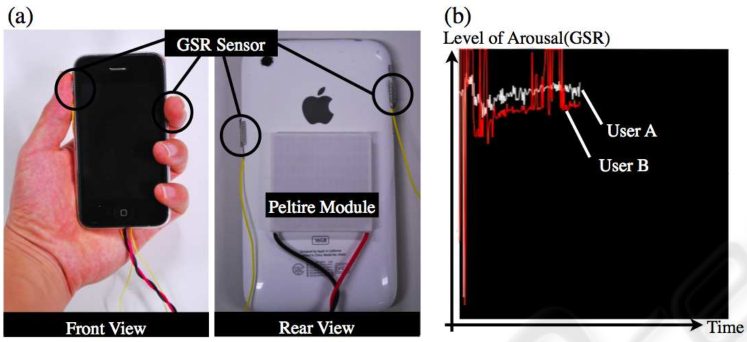

Fig. 2. AffectPhone. (a) Front and rear view of the system. (b) GSR window.

3 AffectPhone

3.1 Concept

GSR has been stated to be a good measure of a user's level of arousal, which indicates the user's level of excitement. We selected temperature sensation as the input because temperature changes are generally reflective of ones emotions. In this system, a user can feel changes in the emotional state of the person he/she is conversing with in the following manner:

– When a user's level of arousal increases, the system makes the back panel of the other device warm.
– When a user's level of arousal gradually decreases for approximately 30 seconds, the system makes the back panel of the other device cool.

3.2 System Configuration

AffectPhone consists of two electrodes for detecting the GSR and a Peltier module for providing information on temperature change (Figure 2(a)). This system provides a non-verbal communication channel in addition to the existing telecommunication channel in a normal mobile phone. In other words, a user can convey his/her level of arousal to the person he/she is conversing with in an ambient manner. The user's GSR can be detected from the two fingers in contact with the phone, and temperature changes can be sensed by the palm. This system does not require special sensors to be attached to the users body, and therefore, it does not interrupt the user's daily use of the mobile phone.

AffectPhone is designed to convey a users arousal in an ambient manner. Moreover, the user can be aware of the arousal level of the person he/she is talking to, by viewing the GSRs in the GSR window (Figure 2(b)).

3.3 Feasibility Test

In order to study the feasibility of AffectPhone, we conducted preliminary experiments. We made a subject listen to music for approximately 4 minutes, and acquired the GSR signal using AffectPhone.

Figure 3 shows the GSR signal acquired using AffectPhone. The sampling rate was 5 Hz. Because the skin resistance decreases with an increase in the level of arousal, we calculated a user's level of arousal ($a(t)$) as follows:

$$a(t) = 1000 - R \tag{1}$$

where R is resistance of the skin. (k Ohm)

A GSR signal consists of three elements—rise time, amplitude, and half recovery time (Figure 4). As shown in Figure 3 and Figure 4, the rise time, amplitude, and half recovery time are 5-10 s, 60-90, and 20-25 s, respectively. In comparison to Gasperi's web cite[6], we concluded that this system successfully acquires GSR signal.

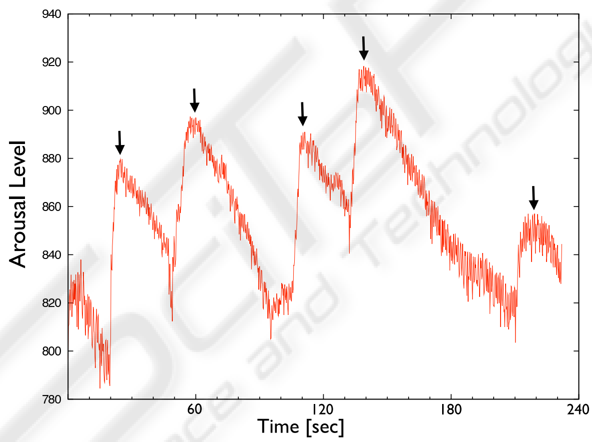

Fig. 3. GSR signal acquired from AffectPhone. Peaks indicated by arrows indicate sudden increase in the level of arousal.

3.4 GSR Signal Analysis

The above-mentioned test confirms that the proposed system can be used to acquire GSR signals. Here, we discuss how to analyze the acquired GSR signals.

The amplitude of the GSR signal indicates a change in the user's emotional state (get angry, happy, etc.). In such a situation, the system makes the back panel of the other device warm when the following condition is satisfied.

$$da/dt > d_T \tag{2}$$

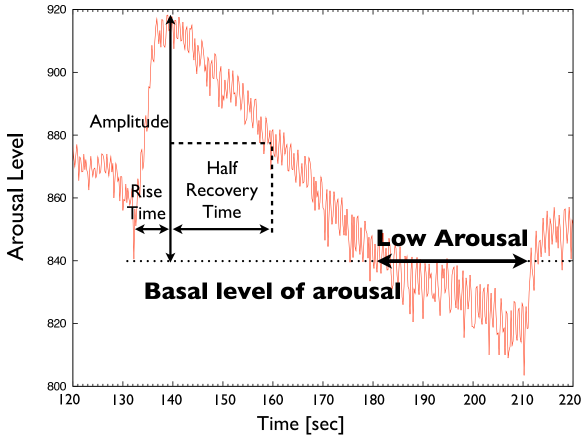

Fig. 4. Period from 120 s to 220 s shown in Figure 3. We considered the gradual decrease after the peak to correspond to a decrease in the level of arousal.

where a denotes the user's level of arousal, t, the time in seconds, and d_T, the threshold of difference, respectively.

After the half recovery time, the system turns off the Peltier module of the other device.

$$a(t) = (a_A - a_B)/2 \tag{3}$$

where a_A denotes the level of arousal in the amplitude and a_B, the basal level of arousal.

When a user's GSR gradually decreases after recovery, we consider that the user's level of arousal has decreased (Figure 4). In such a situation, the system makes the back panel of the other device cool when the following condition is satisfied:

$$a(t) - a_B < 0 \ \ (t_R < t < t_R + 30) \tag{4}$$

where a_B denotes the basal level of arousal, t_R, the time of recovery.

4 Potential Applications of AffectPhone

AffectPhone can convey a user's level of arousal in terms of changes in the temperature (warmth or coolness) of the back panel of a phone. This system is useful not only when a user is talking on the phone, but also when the phone is ringing. When the phone rings, the system determines the level of arousal of the caller. If this system finds widespread use, the following scenario might become possible. If the caller is upset, the receiver can be made aware of the same even before answering the phone. A user can detect whether or not a call is important, and thus deal with a difficult situation more effectively.

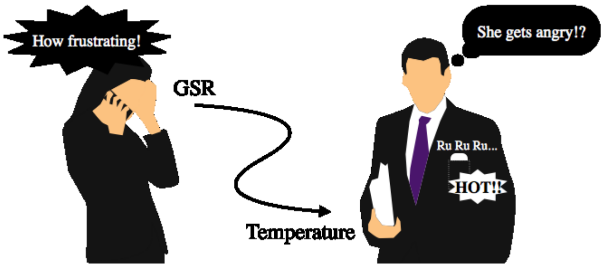

Fig. 5. Potential applications of AffectPhone

5 Conclusions and Discussion

In this study, we designed AffectPhone, a handset device that can be used to identify a user's emotional state via temperature changes (warmth or coolness). This device has been designed to provide a non-verbal communication channel in addition to the existing telecommunication channel in a normal mobile phone. However, further improvements must be made to this system. In the future, we intend to focus on user evaluations of factors such as the following:

– The extent to which a user's level of arousal changes when talking on the phone.
– The accuracy of determination of temperature changes by the user.

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