Toward More Sensitive Mobile Phones

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ABSTRACT
Although cell phones are extremely useful, they can be annoying and distracting to owners and others nearby. We describe sensing techniques intended to help make mobile phones more polite and less distracting. For example, our phone's ringing quiets as soon as the user responds to an incoming call, and the ring mutes if the user glances at the caller ID and decides not to answer. We also eliminate the need to press a TALK button to answer an incoming call by recognizing if the user picks up the phone and listens to it.

Keywords
Input, sensors, context-aware, mobile devices, cell phones

INTRODUCTION

Mobile phones have become ubiquitous communication devices, but they often employ naïve alerting policies that can transform them into nuisances. In particular, cell phones typically are unaware of how they are being used. Thus, they may act in a way that is disruptive to others or embarrassing to the owner. Many cell phones support *profiles* that allow the user to manually set an appropriate response for different contexts. However, the user must remember to turn on the correct profile, and the user must again remember to turn off the profile when it is no longer relevant or appropriate. For example, a device erroneously left in a meeting profile may lead to missed calls in a subsequent outdoor context. Automatic sensing techniques may help eliminate these kinds of problems [5].

Furthermore, many interactions with cell phones can be demanding of cognitive and visual attention. Machinery and perceptual apparatus endowing cell phones to recognize explicit, but natural and minimally demanding gestures of use, offers a set of strategies that promises to limit the attentional demands of commonly used features.

We have prototyped several interaction techniques by augmenting a Cassiopeia E105 PocketPC with three extra sensors (as detailed in [2]): a two-axis linear accelerometer (tilt sensor), a capacitive touch sensor that detects when the user is holding the device, and an infrared proximity sensor that detects range to nearby objects. Our device has no cellular connectivity, but we prototype the interaction by ringing in response to simulated phone calls.

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CHOOSING A NOTIFICATION MODALITY

The first set of interaction techniques addresses the issue of choosing an appropriate notification modality for an incoming call. Cell phones typically provide some combination of audio alerting (ringing, playing music), vibrotactile feedback (vibrating battery), and a visual indication on the display that there is an incoming call, often with caller ID information to help decide whether or not to take the call. When the phone knows if it is being held, and if it is likely that the user may actually be looking at the display, one can make a better choice of the notification modality (possibly including *silence*).

Quiet Ringing. When the phone starts ringing, if the user is not already holding the phone, then simply touching the phone automatically lowers the volume of the ring. Hence, once the phone attracts your attention, and realizes that it has done so, it is no longer necessary to "shout" and the interaction transitions to a more private, one-on-one setting by softening the volume. We also explored muting the ring, but this can lead to an ambiguous situation where the user cannot distinguish *muting* from a caller being disconnected.

Acknowledging and Ignoring Calls. Once the user has grabbed the phone, the next step is often to look at the display and see who the caller is. This is a naturally occurring "gesture" that can be recognized by our sensors. As soon as (1) the user is holding the device and (2) the device is moved so that it is tilted towards the user, it is very likely that the user has just looked at the display. At this point, the software flags that the user has acknowledged the call—it is aware that the user has received the notification. If the user is already holding the phone at the time the call arrives, this acknowledgment gesture triggers the *quiet ringing* behavior as above (if the user is already holding the phone, the fact that he is holding it does not indicate that he has noticed the incoming call).

The user can then accept the call using the *call answering gesture* described below. However, if the user chooses not to take the call, the natural response is to put the phone back in one's pocket, or back on a nearby table, for example. In all of these cases after an acknowledgment, the tilt angles change, or the user is no longer holding the device, allowing the software to infer that the user is no longer looking at the display. Once the software senses that the user is ignoring the call, it mutes the ring, but leaves a visual indication that there is an incoming call. This way, the user can still change his or her mind and decide to take the call before the caller hangs up or drops into voice mail.

Together, these techniques use the naturally occurring gestures implicit in using a cell phone to help ensure that the phone quiets, and then mutes, as soon as feasible, thus minimizing potential disruption to others while also being certain that notifications get through if possible.

Target Device for Notifications. We use physical contact with the device (touch sensing) and any recent activity registered by the tilt sensor to decide if a device is being used currently, or has been used recently. The most recently used device typically will be available for subsequent notifications, in the absence of other evidence to the contrary. We have only constructed one prototype of our device, so we have not yet been able to fully explore this technique when multiple devices are present.

Vibration Notification. If the user is holding the phone, then the phone knows that the user can feel a vibrotactile response and hence it is not necessary to distract others by ringing as well. However, if the user is *not* touching the phone, the user still may be able to feel it vibrate– the phone may be in a pocket, for example, where it is not being touched but its vibration can still be felt. Hence it should both vibrate and ring in that situation (as opposed to a similar technique proposed by Schmidt [5]). Our prototype device does not have a vibrating battery, so at present we visually indicate the "vibration" notification.

REDUCING ATTENTIONAL DEMANDS

Call Answering Gesture. Current cell phones require a specific action in order to answer the call. Examples include pressing a TALK button, which requires looking at the button or searching for it by feel, or opening a flip cover, which can be awkward to achieve with one hand, especially when the user is already engaged in another real-world task. When there is an incoming call, we use lifting the phone and listening to it as an implicit gesture to answer the call. The gesture, which is the same as that used in our previous work to trigger voice recording on a PDA [2], is a combination of holding the device, tilting it in a pose typical of talking into a cell phone, and detecting the head in close proximity. We currently have no corresponding gesture to hang up the phone, as putting down the phone activates a speakerphone mode ([1], see below), and thus does not necessarily indicate that the user wants to hang up.

Voice Recognition Context. At other times, when no incoming call is pending, the "answering" gesture can be used to activate the built-in microphone for a voice recognition context. Cell phones with voice recognition capabilities are available now on the market: for example, the user can speak the name of a contact, such as "Call Jeff at home." However, the user must speak a magic word or press the TALK button to trigger the functionality. Our approach eliminates the need for these extra steps. We have not implemented voice recognition on our device; we currently only record the utterance for testing purposes.

Backlight Activation. Picking up and looking at the phone turns on the display backlight for 15 seconds, allowing the viewer to see the display without any extra action such as hitting a button. This gesture also turns on the phone if it is currently powered off [2]. Furthermore, if the user is still looking at the display when the backlight goes off, a slight readjustment (quick change in tilt angles while holding the phone) turns the backlight back on. If the phone is held in an orientation where it is unlikely the user is looking at it, the backlight is turned off to save power.

RELATED WORK

We recently reported related techniques for hand-held computers [2]. Other than location awareness, we are aware of little published work on sensing techniques specifically tailored to cell phones. Schmidt et. al. [5] describe a cell phone that switches profiles by sensing when it is sitting on a table, being held by the user, or being used outdoors, for example. One commercial product, the Ericsson R520 cell phone [1], features a speakerphone mode with a proximity switch that automatically reduces the volume if you hold the phone to your ear, but reverts to speakerphone when you put it down. We have also implemented this technique on our prototype device; it seems to work well.

There are other approaches which could be combined with our work to address the problem of notification in context as a whole. Sawhney & Schmandt [4] propose several related techniques for dynamically adapting notification modality and calculating a usage level, as well as audio processing techniques which could be used to augment the techniques reported here. Horvitz et al. [3] describe a notification architecture that uses probabilistic techniques to prioritize notifications, allowing the system to either suppress them or deliver them at an appropriate time, to an appropriate device, using evidence such as the user's calendar, or sensed events (keyboard, mouse, microphone).

CONCLUSION

We have proposed techniques to help make cell phones less intrusive to others, and less demanding of the owner's attention. Such techniques provide examples of how the coming age of ubiquitous sensors may provide a richer, more sensitive user experience for mobile phones.

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