Tactful Calling: Urgency-Augmented Phone Calls through High-Resolution Pressure Input on Mobile Phones

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Abstract
In this paper we present a system that simulates urgency-augmented phone calls on mobile phones. Different scenarios and interaction techniques are discussed. We report a user study that indicates a general need for such a system and explored the applicability of using a force sensor as a way of intuitive call urgency articulation. The proposed system allows trying out urgency-augmented phone calls hands-on.

Keywords
Urgency, mobile phone, ethics, tactile input, force-sensitivity, disturbance, interruption

ACM Classification Keywords
H5.2. User Interfaces: Interaction Styles

Introduction
Currently, in mobile phones, phone calls are of binary nature – a call is made by the caller, and the connection is established as soon as the callee picks up the phone: All responsibility to notice, ignore, answer or reject a call is in the hands of the called person.

Fig. 1a,b: Callee phone (filter setup); Caller phone (call urgency selection, faceplate removed for illustrative purposes)

On the caller's side, it appears to be problematic that the decision whether to place a call is based on speculation about its appropriateness: a tradeoff between what the callee *might* be doing, and the importance and urgency of the matter.

The callee, on the other hand, has to decide about the notification style (i.e. *ringer*, *vibration*, *off*) based only on speculation about incoming calls that *might* occur. Some phones provide caller-dependent notification modes, so that special persons can be treated differently. However, these systems are bound to fail whenever the importance of a call does not match the assumed importance of person, and is especially problematic for unknown callers.

Whether or not to interrupt an ongoing activity for an incoming call is a choice that is currently often based on speculation. Interestingly, interrupting a conversation for an incoming call is gaining increasing social acceptance [9].

At the same time, the widespread presence of *unlimited calls* plans has lead to the circumstance that no longer every call is of particular importance or necessity. It therefore appears to be worthwhile to investigate ways of adding more maneuvering room to mobile phone calls. An added dimension of importance seems to be a simple and plausible means. This paper is concerned with the general need for such a system and possible user interaction styles. It was of our interest to investigate the applicability of a *force-sensitive system*, in order to literally add *pressure* to a call.

Related Work

Adding urgency to phone calls has been in the focus of previous research, including IDEO's Knocking Mobile [1] and the SenSay project [11]. The former, a project of rather experimental nature, is a phone that can be knocked to place an outgoing call – the urgency of the call is articulated through the intensity of the knocking. The latter is an activity-sensing phone that will inform the caller if the callee is currently busy. Acknowledging this, the caller is then given the choice to call again immediately, which will let the call pass through.

With regard to the proposed force-sensitive input, several projects of this research field should be mentioned. Research in this area goes back to Herot and Weinzapfel, who originally equipped a CRT screen with a force- and torque-sensitive surface in 1978 [5]. More recently, various interaction styles for mice [2, 8, 12] and styli [10] have been proposed to be augmented pressure-sensitivity. Also, pressure-augmented mobile phones have been the focus of recent research, including Holleis' work [7] involving capacitive sensors and Clarkson's [3] work, augmenting the numerical keypad with force-sensitive resistors. The applications mentioned by Holleis mostly include navigation issues and metadata-augmentation [7], while Clarkson, besides describing other applications (including text input and 3-D navigation), points out that [3] pressure might be used as a means of affective input. Tactile feedback, as Hoggan et al. recently demonstrated [6], can be a helpful addition for interactions with mobile devices.

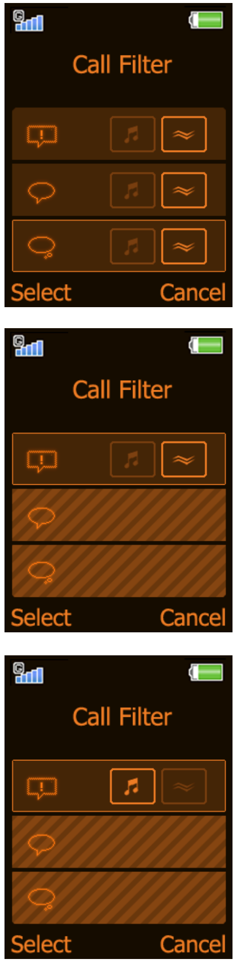

Fig. 2a-c: Urgency filter setup, configuration of threshold and notification styles for different call urgencies.

Prototype

Our prototype consists of two Bluetooth-enabled mobile phones (Fig. 1), one which is augmented with a force-sensitive resistor under each of the two softkeys. The sensors are read by a nearby Arduino board [4] and transmitted to a PC, which then sends the values back to the phone, running a Java software that implements the user interface. This circle works at a latency of less than 20ms.

The callee phone: Urgency-based filters

Our system divides the urgency scale into three distinct ranges: *thought*, *speech*, and *shouting*. The filter application on the callee phone allows a general threshold to be configured; underneath of this no calls will be passed through. Furthermore, a notification style (*ring* or *vibrate*) can be set for each of the urgency ranges. For example, all calls except highly important ones can be ignored, but those that pass through, should ring (Fig. 2c).

The caller phone: Placing a urgency-augmented call

The caller phone features a variety of input methods for urgency-augmented calls. In our study, it was of our interest how different input, selection and feedback combinations would perform compared to each other.

Firstly, three different types of visual feedback can be activated: A *discrete*, three-state visualization (Fig. 3a), a *continuous*, percentage-based alternative (Fig.3b), and a *blind* condition (Fig. 3c), in which no visual feedback about the selected call urgency is given.

Fig. 3a-c: Different visualization techniques while placing a call: *discrete*, *continuous*, and *blind.*

Secondly, three different types of selection mechanism are available: A *dwell*-based selection technique selects an urgency after holding the respective pressure level for 0.5s (Fig. 4a). This technique has been studied before, for pressure-based stylus interaction in [10] and [2]. Also similarly to these previous studies, we included a *quick-release* technique that selects a value after acquiring it through applying the target pressure and then quickly lifting the finger off the button (Fig. 4a).

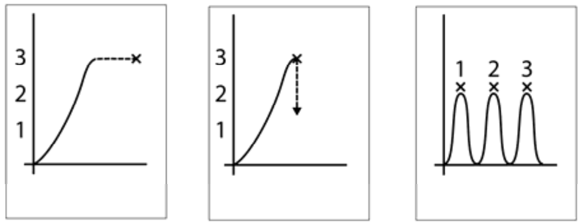

Fig. 4a-c: Different selection techniques to select a call urgency: *dwell*, *quick-release*, and *multi-dial*.

As a control technique, we implemented a *multi-dial* condition, in which the urgency of the call is articulated through repeated button presses: A *shouting* level importance call is placed through pressing the dial button thrice, a *speech* level call through pressing it twice, and a *thought* level call by pressing it just once (Fig. 4c). The force used when pressing the button is not taken into consideration in the *multi-dial* technique.

Thirdly, with regards to vibrotactile feedback, we implemented three different conditions using the phone's built-in vibration motor: A *bump* technique, with short vibration bumps between the different levels of urgency (Fig. 5a), an *increasing* condition, with a permanent, growing vibration from 0-100% of the urgency scale (Fig. 5b), and a *no-vibration* condition (Fig. 5c).

Fig. 5a-c: Different vibrotactile feedback conditions: *Bumps*, *increasing* and *no-vibration*.

User Study

We conducted a user study with 12 users (5f, 7m, aged 22-34). Our experiment consisted of: 12 users x 27 condition sets (3 tactile conditions x 3 visual conditions x 3 interaction technique conditions) x 5 subsequent trials per condition = 1620 test cycles. Each user performed once in each of the 27 randomly ordered condition sets, engaging in 5 trials for the same target range (*high*, *medium* or *low* urgency, also randomized for each of the 27 condition sets) on it. Afterwards, the subjects were asked a series of open-ended questions regarding their impressions of the system. The experiment took about 30 minutes per user. Similar to those in the studies reported in [10] and [2], we recorded the following quantitative measures: *MT* (*Movement Time*, the time elapsed between the initial touch of the button to the completion of the selection), *NC* (*Number of Crossings*, the number of times the target pressure range is entered and exited), and *ER* (*Error Rate*, the percentage of selections outside of the target range).

Results

In this section, we firstly present the outcomes of the quantitative evaluation, and secondly the results of the user interviews.

User Performance

MT negatively correlated with the increasing *trial number* (*Kendall* τ *b* = -.035, p=.024) and the increasing *set number* (*Kendall* τ *b* = -.038, p=.04): On average, the participants required less time for each trial within a set, and less time for each set during the experiment. A effect[1] of *tactile feedback* on *MT* ($F_{2,26}$=4.46, p=.012) was found through a ANOVA. We were able to determine through a Scheffé test that the *no vibration* condition (M_{NV}=1741.51, SD_{NV}=1029.94) was accompanied by *better* results than the condition of *increasing* vibration (M_{IN}=1978.20, SD_{IN}=1496.22). With regard to *NC,* the *tactile feedback* also had an

[1] Whenever we mention in the following that we found effects or differences, they are significant at a level of $p < .05$.

influence ($F_{2,26}$=3.24, p=.039): The *no-vibration* condition performed better (M_{NV}=1.32, SD_{NV}=0.84) than the condition of *increasing vibration* (M_{IN}=1.42, SD_{IN}=1.10). All *selection technique* conditions were accompanied by different findings for *NC* ($F_{2,26}$=137.40, p=.000), *multi-dial* (M_{MD}=0.97, SD_{MD}=0.23) was the most accurate, followed by *quick-release* (M_{QR}=1.22, SD_{QR}=0.86) and *dwell* (M_{DW}=1.85, SD_{DW}=1.29). Also *ER* was influenced by *selection technique* ($F_{2,26}$=47.31, p=.000). The least erroneous technique was *multi-dial* (M_{MD}=0.06, SD_{MD}=0.22), followed by *dwell* (M_{DW}=0.12, SD_{DW}=0.32) and *quick-release* (M_{QR}=0.25, SD_{QR}=0.43). *Visual feedback* led to further differences for *ER* ($F_{2,26}$= 20.40, p=.000). Here, a Scheffé test showed that the *blind* visual condition was bound to be the most erroneous (M_{BL}=0.21, SD_{BL}=0.41), while the two other visual conditions did not differ significantly (M_{CN}=0.10, SD_{CN}=0.29, M_{DS}=0.11, SD_{DS}=0.30).

User Statements

All interaction techniques had their specific strengths and limitations. The *discrete* visualization, for instance, was praised by several users for its ‘simplicity’, while others criticized its ‘lack of precision’. At the same time, some users stated for the *continuous* visualization that it was ‘hard to precisely tell the percentage of importance’ for a call, while other users particularly liked the ‘fuzziness’ of the approach. We also asked the users for their opinion about the general applicability of urgency-augmented phone calls.

In general, the users’ answers can be categorized into three types of situations:

1. Placing and ‘not missing’ calls in *emotionally or timely urgent* situations, (‘things left in the office/flat’, ‘emergencies’, which was often mentioned in combination with ‘family members’).

2. Conflicts of *etiquette* making *unimportant calls*, i.e. ‘calling late at night or during office hours, just to say hello’.

3. *Incoming calls* of unknown importance interrupting in ‘meetings or in conversations’, and the desire to ‘know in advance if it is really important’, or respectively to ‘know if it would be okay not to take this call now’.

Discussion

First of all, it should be noted that the control conditions, *no-vibration* and *multi-dial* outperformed our (force-based and with vibrotactile feedback) experimental conditions. At the same time, the differences were, considering them in a real-life scenario, negligible (e.g. a mean difference of *MT* of ca. 0.2s between the two extreme conditions). The fact that the vibrotactile feedback led to *worse* results point out that, even though it might be helpful in general, it should be handled with care.

Our results indicate two training effects: One within each set, and one across the experiment. The user statements indicate that urgency-augmented calls are desirable by mobile phone users in general. Most of the subjects stated that currently taking a call is often based on pure guess about what it might be about, and that it would be valuable to make such a decision based on their importance. Also for outgoing calls, the system was stated to be of potential value.

Conclusion

In our experiment, the circumstances were ideal for the *multi-dial* condition, and still the pressure-based techniques' performances were at least similar. This result is encouraging, as the pressure-based interaction, under its *own* ideal conditions (trained users, and an application with more than three target ranges), offers an even wider spectrum of interactions. Especially touch screen phones are sometimes considered as tactually poor – force sensitive inputs may add more expressivity to these systems. It can also be concluded that users generally appreciated the functionality, as they reported diverse situations from their own experience in which such a feature would have been desirable for them.

Future Work

Pressure based input could be a valuable addition to mobile phones – especially (being a human-to-human medium) given their often affective character. Much potential lies in urgency-augmented phone calls, but the setting of filters and notification profiles on the callee side were not part of our user study; here more work is required. Furthermore, possible social effects of such phone calls should be discussed and investigated – it is unclear whether such functionality might simply lead to inflation, or whether it would indeed help us to make calls in a more tactful way.

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