

Perception of Short Tactile Pulses Generated by a Vibration Motor in a Mobile Phone

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Abstract

This paper describes an experimental setup and results of user tests focusing on the perception of temporal characteristics of vibration of a mobile device. The experiment consisted of six vibration stimuli of different length. We asked the subjects to score the subjective perception level in a five point Lickert scale. The results suggest that the optimal duration of the control signal should be between 50 and 200 ms in this specific case. Longer durations were perceived as being irritating.

1. Introduction

Today, basically all mobile phones have a vibration alert. The vibration actuator is a small DC motor with eccentric weight on its shaft (Figure 1). A DC control signal causes the rotation of the vibration motor that in turn generates the vibration pulses (Figure 3).

Sometimes we might want to make the vibration pulses shorter. However, this will rise some questions: 1) What is the shortest control pulse that generates a perceived vibration pulse? 2) What is the optimal length of the control signal? 3) How does the location of the device in the body affect to the perception of the vibration?

This paper describes an experimental setup, introduces experiments for finding answers for these research questions, and finally presents the results from the experiments.

1.1 Earlier work

Very good summary of earlier work can be found in [1]. Gescheider et al have studied the threshold of a vibrotactile stimulus [2] and found out that the threshold can be even 0.2 μm in displacement. They also found out that there are other affecting factors as well, such as duration of the stimulus. Sherrick and

Cholewiak [3] present figures about the effect of the body location to the threshold of a vibratory stimuli. Still another aspect is the temporal summation. Verrillo and Green [4, 5] have found out that the length of the stimulus can have an effect on the perceived intensity.

Compared to the earlier work, our experiment can be considered as a traditional usability study rather than psychophysical research. This is because of the limitations of the actuator used in our experiments. In [6] we studied perception of continuous vibration stimuli, and this paper extends the scope towards temporal attributes of phone vibration.

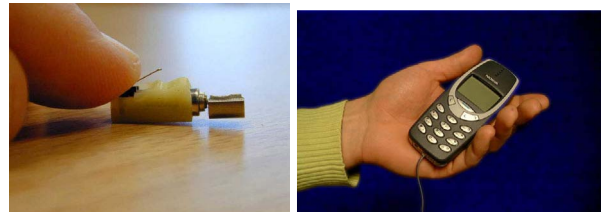


Figure 1 A typical vibration motor and a mobile phone mockup used as an experimental device.

2. Equipment

Our test device was a mockup of a widely used mobile phone (Figure 1). The weight of the device was 105 grams. It had a vibration motor inside as a vibration generator (See Figure 1). We built a special hardware for controlling the vibration. The vibration motor was driven at the nominal voltage (1.3 V) that generated the rotation speed of approximately 11000-RPM. That means 180 Hz vibration of the phone with peak amplitude 22 mm/s (or 20 μm in displacement) when the motor has accelerated to its full speed.

3. Method

We selected 6 different lengths of control signal: 12.5, 25, 50, 100, 200, and 500 ms. We used a five-

point Lickert scale for judging the perception of the vibration pulses caused by these control signals.

We tested the vibration pulses in three different body sites: Hand, trouser front pocket and belt case (see Figure 1 and Figure 2). We asked the subjects wear headphones where we played pink noise to mask the possible resonance sound.

In the experiment we played 30 pulse sequences for each body location. Each sequence consisted of 3 equal pulses. All the vibration pulses of the different lengths were counterbalanced, and played five times.



Figure 2. Mobile phone mockup locations “pocket” and “belt holder” in the experiment.

There were 18 participants (9 male and 9 female) that were 19 to 39 years old in the experiment.

4. Results

Figure 4 shows the results from the subjective scoring of the perception in the case pocket. The results from the other locations follow the same pattern. However, the two shortest pulses were slightly better perceived in hand. When the pulse length is 100 ms, none of the subjects scored the vibration as too strong, irritating, whereas when the pulse length is 500 ms, about 35% of the cases subjects scored the vibration as too strong, irritating. Our results suggest that we should use vibration control pulses longer than 50 ms, but shorter than 200 ms in order to be in the safe side.

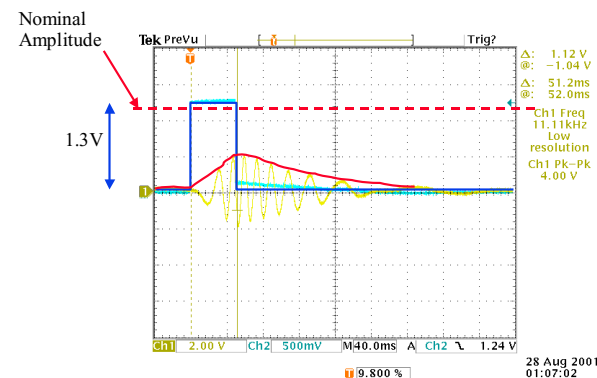


Figure 3. The measured vibration velocity response (yellow) of 50 ms control pulse (blue). Red solid

line: envelope of the vibration pulse. Red dashed line: nominal velocity level of the vibration.

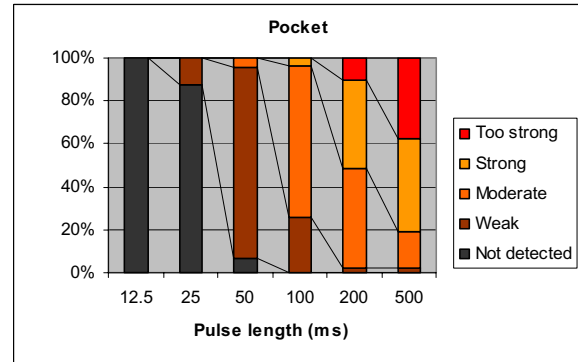


Figure 4. The results from subjective scoring of perception of vibration pulses in the pocket.

5. Conclusion

Experimental study of using short vibration pulses in a mobile device was described. The results suggest that the duration of the control signal should be between 50 and 200 ms. If the control signal is shorter, the perception of the generated vibration pulse is not guaranteed. If the control signal is longer than 200 ms the subjective feeling starts to be irritating.

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