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Application of Audiotactile Intensity Interaction on Touch-Screens

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Summary
Sound generation requires acoustical energy, which is in the most part supplied by the movement of structures. This movement is a result of the tactile interaction with the structures. Therefore, the sound pressure level and the level of force-feedback or vibration are coupled by physical laws. Our recent studies showed that the level of tactile stimulus can have a significant influence on the loudness and vice versa. The communication with touch-screen devices can be improved using tactile feedback. Small vibration actuators, such as pager motors are mostly used systems to generate tactile feedback. However, the amplitude of the feedback which can be realized by such kind of actuators is limited. In this study, different combinations of the tactile and auditory feedback signal forms were evaluated. The aim is to overcome the limitations of haptic interfaces for touch-screen applications. Our findings show that audiotactile interaction can be a useful possibility for the multimodal interface designer.

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1. Introduction

Multisensory perception can be defined as a "construction" of the brain that is derived from a weighted combination of multiple sensory inputs. During the evaluation of multi-modal events, tactile and auditory information interact and possess a substantial influence. Two modalities can be combined and the resulting multi-modal percept may be a weaker, stronger, or altogether different percept [1].

Our recent studies show that the well adjusted combination of auditory and tactile stimuli can be useful to overcome a number of technical limitations or common product design problems [1,2,3,4]. In a normal environment, force-feedback would be perceived in our hands as a consequence of beating a drum and combined with the loudness of the drum sound give us the required information about how much force we applied when playing the drum. In a former study [2], psychophysical experiments were conducted to investigate the effect of loudness on haptic force-feedback perception ("strongness") by playing a virtual drum. In the experiment, some stimulus-pairs were designed to be physically accurate (the drum sound was presented with loudness proportional to the beat-force magnitude) and in some stimulus-pairs, the drum sounds were presented with loudness greater than would be expected by the beat force. In each experiment, subjects were asked how much force they had applied when playing the virtual drum by assigning number to the test stimuli. The results show that the magnitude of strength increases with increasing loudness in spite of no change in force-feedback as generated by the virtual drum and applied to the subjects hand. Therefore it appears that participants weight loudness to a greater degree than haptic information if there is no-change in force feedback, when trying to discern information from two modalities. So in conclusion, humans do not exactly feel what the haptic sense tells them, but, rather they integrate the two modalities of hearing and touch and what they feel will be dependent upon the loudness of the stimuli and the force-feedback which it creates.

In a recent study [4], we found that there is not only an influence of loudness on the haptic force-feedback perception, but also vibration has an influence on the loudness perception. To investigate the influence of vertical whole-body vibrations on loudness perception, a loudness matching experiment was carried out. An acoustic stimulus was presented first without tactile stimulation and then together with a vibratory stimulus. The test persons' task was to adjust the level of the acoustic stimulus which was played simultaneously with a vibratory stimulus until it was perceived as equally loud as the acoustic stimulus without tactile stimulation. The statistical analysis of the results indicates that whole-body vibrations have a significant influence on loudness perception. If an acoustic stimulus is accompanied by a vibratory stimulus, the level of the acoustic stimulus is on average perceived one decibel higher.

These studies show that to overcome the technical limitations of the haptic or auditory interfaces and provide sufficient realism, audiotactile intensity interaction could be useful.

The simulation of realistic buttons or sliders with touch screens can only be realized with tactile and audio feedback [5]. Small vibration actuators, such as pager motors are mostly used systems to generate tactile feedback in most of the hand-held devices with touch screens. Hovewer the disadvantages of these systems is that the actuators cannot reproduce high amplitudes which is common for classical push-buttons, because of the restricted actuator size and the operating space [5].

In this study, psychophysical experiments were conducted to investigate if audiotactile interaction can be used to improve the quality of touch screens.

2. Experiment

In this experiment, an electrodynamic shaker was used to generate the vibratory stimulation. A touch screen was mounted on the shaker. The acoustic stimuli were presented with a Sennheiser HDA 200 closed-face dynamic headphones. 6 virtual buttons were simulated on the touch screen surface. The task of the 6 participants was the dialling telephone numbers. 64 numbers should be dialled as fast as possible. The criterions were overall quality evaluation and feedback suitability judgments. Two different vibratory signals, which are a sin^2 wave and a 50 Hz sinusoidal signal, are combined with various auditory feedback (Fig. 1). The auditory feedback had different frequency spectra, time course and the loudness. The results of the experiment for the feedback suitability are shown in Figure 2. The characteristics of the overall quality results are very similar to the feedback suitability results. Therefore only the feedback suitability results are shown.

3. Discussion and Conclusion

If both modalities are combined, there are synergy effects. The auditory signal can improve the tactile only ratings and almost all ratings get better. However wrong stimuli combination can result with a degradation of the feedback suitability. Frequency content of the auditory and tactile feedback plays an important role on the improvement of the feedback suitability.

It is not possible to clarify the role of the loudness on the quality improvement with these stimuli combinations. Therefore further experiments are planned to investigate systematically the influence of the audiotactile intensity interaction.

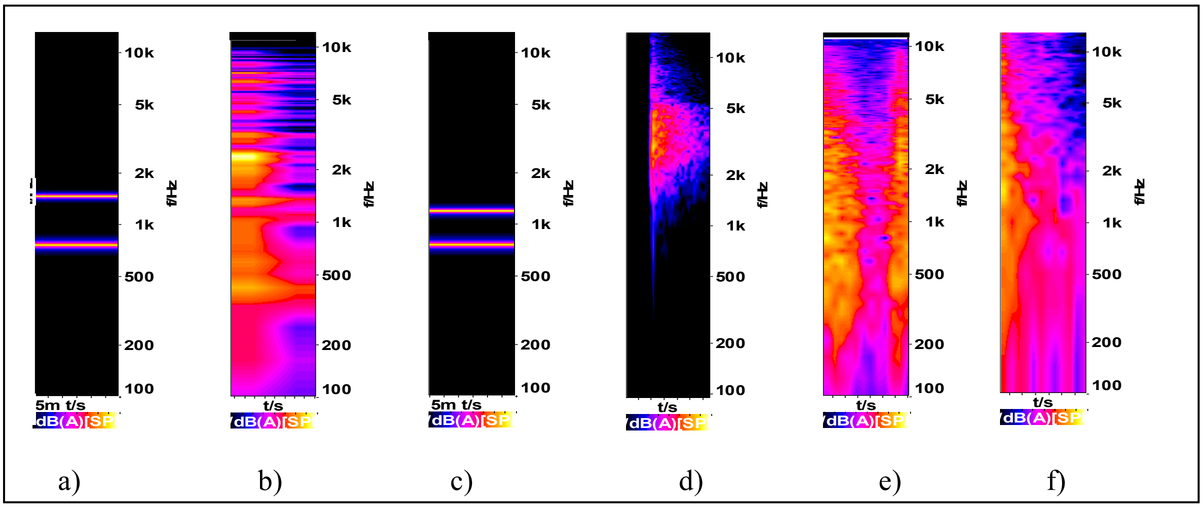

Figure 1. Acoustic stimuli.

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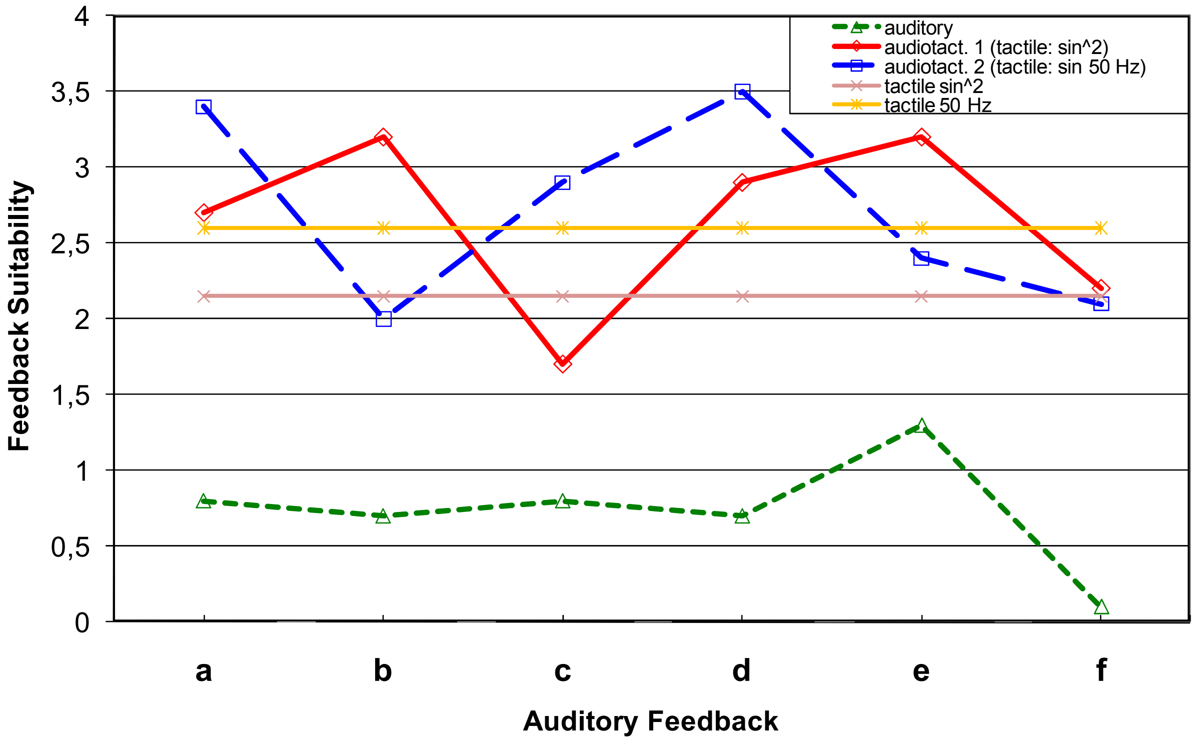

Figure 2. The feedback suitability judgments.

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References

[1] M.E. Altinsoy: Auditory-Tactile interaction in Virtual Environments. Shaker Verlag, Germany, 2006

[2] M.E. Altinsoy, J. Blauert and R.H.Y. So: Effect of loudness on the haptic force-feedback perception in virtual environments. JASA. 114 (2003), H. 4, S. 2330-2331

[3] M.E. Altinsoy and U. Jekosch: The influence of non-stationary vibrations on the quality of non-stationary product sounds: Proc. of the "CFA/DAGA'04 (Congrès Joint / Joint Congress 7ème Congrès Français d'Acoustique CFA / 30th German Annual Meeting for Acoustics DAGA)" (ISBN-10 CD-ROM: 2-9521105-3-0), March 22-25, 2004, Strasbourg, France.

[4] S. Merchel, A. Leppin, and M.E. Altinsoy: Influence of whole body vibrations on loudness perception. Proc. of the 16th Int. Congress on Sound and Vibration, ICSV 2009, Krakow, Poland (ISBN-13: 978-83-60716-71-6).

[5] M.E. Altinsoy and S. Merchel: Audiotactile Feedback Design for Touch Screens. in Altinsoy, M. E., Jekosch, U. & Brewster, S. (Eds.), Haptic and Audio Interaction Design 2009, LNCS 5763, pp. 136-144. Berlin, Germany: Springer.