Evaluating Transparent Liquid Screen Overlay as a Haptic Conductor

Method of enhancing touchscreen based user interaction by a transparent deformable liquid screen overlay

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Abstract— **In line with our previous work, this research focuses on a method for attenuating acoustic components (noise) while providing enhanced vibrotactile feedback signals on mobile devices using, deformable touchscreen overlays. Traditional mechanism of providing tactile feedback to the fingertip via a flat rigid touchscreen is limited due to the dampening of the mechanoreceptors which are sensitive to static deformation and lie at the tips of the intermediate ridges in the epidermal-dermal junction. This tactile mechanism becomes useless when the fingertip acts against a ridged surface (chemically strengthened alkali-aluminosilicate glass). Furthermore, the actuation provided by most devices is indirect with little or no mediation mechanism, which results in filtering various signal frequencies, loss of signal intensity as well as creating acoustic noise. The resulting haptic signal is considerably inefficient and incongruent to the applied signal, which was designed to stimulate user skin contact. To resolve these issues we developed a unique transparent screen overlay conductor which contains an oil based composition (a low viscosity inert nonconductive liquid), that acts as a soft deformable interaction point, enhancing the ratio between tactile signals and the acoustic components, provided by haptic actuators. Using surface mounted and embedded actuators to the overlay, while being attached to an ExoPC Slate, we measured haptic signal to noise correlation, as well as signal efficiency and strength over multiple frequencies and concluded that the haptic conductor was able to limit auditory noise and mediate tactile signals more efficiently than traditional rigid glass based surfaces.**

Keywords-component; Liquid transparent screen overlay; haptic signal mediation; vibrotactile mechano-transduction; haptics user interface; piezoelectric and voice coil actuators.

I. Introduction

As the functionality of portable devices increase, it becomes much more challenging to provide a dynamic user interface that can be adaptive to the various device functions. In an attempt to deliver more functionality and control, many electronic devices are being equipped with touch sensitive input mechanisms, over mechanical controls. Touchscreen can offer a more versatile UI experience that can be adapted to the various device properties. However, touchscreens lack the tactile cues needed to operate a graphical user interface effectively, hence many attempts have been made to provide tactile guidance (haptic feedback) to these systems, simulating both tactile and kinesthetic sensations (dynamic strength and force envelope) during touch-based interactions with dynamic user interfaces.

Compounding the issue of missing tactile feedback is the fact that current touchscreens are flat ridged surfaces which limit tactile signals during finger based interaction. Furthermore, most touchscreen systems are also now moving towards gesture based interaction to further increase the usability of their systems. Although gestures provide intuitive means of interaction and often act as shortcuts to common button based controls, the lack of haptic feedback hinders in the overall user experience. In turn, touchscreen based systems become more visual centric in their operation and feedback, which limits users' ability to multitask in real world environments [1]. Additionally, having no viable haptic feedback on rigid glass touchscreens limits or hinders interaction and user performance [2]. Users' attention to other modalities (i.e. visual and audio feedback) is also weakened during multimodal interaction when there is no haptic feeling associated with physical human experience and controls such as buttons, switches, and knobs [3]. Moreover, users' efficiency and performance also deteriorates since users cannot rely on previous haptic experience while interacting with these systems [4].

Vibrotactile feedback or the artificial stimulation of the human skin is the process by which mechanical energy from a source of vibration, in combination with periodic compressions and micro displacements, impacts on the human body. Mechanical energy of a stimulus is then converted by sensory receptors into feelings interpreted as tactile information associated with physical properties of the contact surface. The need for the use of tactile information channel and simulation of the tactile feedback on a touchscreen has led to the development of tactile transducers. However, neglecting the features of mechanical energy propagation from actuator to specific receptors in the skin and their functionality largely attenuates the magnitude of tactile signals rendering the signals weak and less informative [5]. There are two key factors adversely affect signal integrity. Firstly, mechanical impedance of each component involved in the mechano-transduction process (by transferring the feedback signal from actuator to the point of contact) is largely inconsistent, as different materials having different physical properties (i.e. density and mechanical impedance) that modulate energy of stimuli. And secondly, investigations into the mechanical impedance of the skin at the fingertip have shown a nonlinear increase in stiffness when pressure is produced against the contact surface until a maximum skin indentation of approximately 3 mm [6,

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