Demo: Augmenting Force-Sensing Interface to Mobile Devices with Sound

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ABSTRACT

We present ForcePhone, a novel system of enabling commodity phones to recognize the force applied to their touch screen and body. Researchers have shown the usefulness and importance of this expressive input interface (especially for the one-hand operation), but this advanced function has not yet been realized and deployed in most state-of-the-art smartphones. Instead of augmenting specialized/proprietary sensors, ForcePhone uses only the phone's built-in sensors to measure the applied force via a physical property called *structure-borne sound propagation*. ForcePhone has been implemented and evaluated on both iOS and Android phones. Multiple demo applications based on ForcePhone have been implemented and tested. The estimated force is shown highly correlated to the real applied force and the estimation error is low enough to support various applications. Most participants in our usability study were able to master the ForcePhone-based apps and find them very useful.

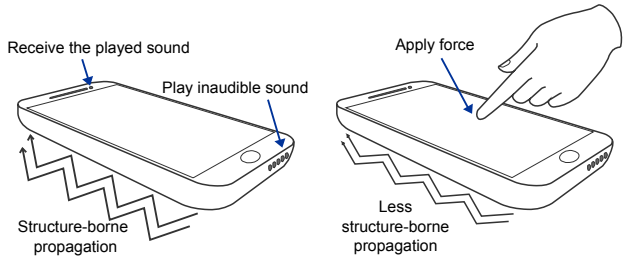
Keywords

Force sensing, Sound, Structure-borne sound, Mobile Phones

1. INTRODUCTION

Recently, force-sensitive, deformable, or squeezable input have been shown to be able to enrich the input capability of mobile devices significantly, especially for the one-hand operations. However, most of these extended input interfaces have not yet been fully developed nor deployed in commodity phones for two reasons. First, they usually require additional hardware not yet available in commodity phones, thus making them less attractive to phone users and manufacturers. Second, systems based only on built-in sensors usually impose unnatural/inconvenient usage restrictions, such as requiring users to touch the microphone reception hole or block the camera flash light source for sensing a touch interaction, thus limiting the usability of this additional sensing. In contrast to these systems, we propose a new, inexpensive solution, called ForcePhone, which provides a force-sensitive input interface to commodity phones without any additional hardware.

ForcePhone estimates the user-applied force by utilizing the structure-borne sound propagation, i.e., the sound transmitted through subtle vibrations of the device body [2]. As shown in Fig. 1, when the phone is left free to vibrate, the sound sent from the phone's speakers can easily travel through its body to its microphone. However, when force is applied to the phone, it restricts the phone body's vibration with the sound, thus degrading the sound traveling through this structure-borne pathway. ForcePhone estimates the touch force by monitoring the change of this degradation.



(a) No force (b) Force applied

Figure 1—Structure-borne propagation and the applied force. When no force is applied to the phone, the frame and internal components of the phone can vibrate freely, and hence the played inaudible sound can easily propagate through the phone's body.

ForcePhone also utilizes the information of other sensing materials to enhance sensing accuracy and reduce the false detection rate. For example, the location and the start time of a touch are inferred from the touch screen, and the phone's movement is inferred from accelerometer readings, which are then used to *filter* out unexpected audio signal changes. By integrating these sensors, ForcePhone can achieve high force-sensing accuracy while limiting the false positive rate. Our controlled experiments have shown that participants are able to use ForcePhone for applying force at 2 different levels with higher than 97% accuracy. Most test participants also think our current design comparable to state-of-the-art proprietary sensors in accomplishing simple tasks like hard-pressing of a button.

2. DEMONSTRATION

In this demo, we will show how users can effectively control mobile devices by ForcePhone. Specifically, we will prepare Android and iOS devices with the demo app of ForcePhone installed. The demo app will allow participants to call app options by hard-pressing a button (similar to the 3D Touch on iPhone 6s) and control the ball movement based on the applied force. We will also prepare different accessories, such as the car phone holder or phone bumper, to demonstrate the performance of ForcePhone in different scenarios and its current constraints. A demo video of ForcePhone can be found from [1].

3. REFERENCES

[1] ForcePhone Demo Video. https://youtu.be/cYxr2wnQVMU.
[2] Y.-C. Tung and K. G. Shin. Expansion of human-phone interface by sensing structure-borne sound propagation. In *Proceedings of ACM MobiSys '16*.

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