

Keystroke recovery using mobile phone accelerometers

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ABSTRACT

[to - fill]

1. INTRODUCTION

Mobile phones [1] are becoming increasingly powerful devices. In addition to being able to run applications ranging from email clients to web browsers, a progressively sophisticated set of sensors are enabling these devices to more actively interface with the world around them. From gestures captured by accelerometers for games to augmented reality applications displaying metadata tags on video from the camera in real-time, mobile phones are becoming adept at capturing and harnessing rich features and data from their surroundings. Unfortunately, the array of sensors in these devices can also be used in unintended ways. As many have suggested, malware could potentially gain access to a mobile phone's camera to take photos or video of the owner and their surroundings [2]. In cases where the camera may not be pointed at an interesting target, a malicious application could instead attempt to activate the device's microphone and record ambient sounds or syphon GPS data to track the target's location [3, 4, 5, 6]. Recognizing the potential for the leakage of sensitive information, many modern mobile phone operating systems provide mechanisms by which access to such sensors is protected by explicit permission from the user. For instance, the manifest files included with every Android application provide an unambiguous list of all of permissions an application may ever request at installation time. Should an application not request access to these resources or the user deny the application such rights, the application will not be able to potentially abuse these resources. However, access to all of the sensors contained in these devices are not so tightly controlled.

In this paper, we demonstrate that unfettered access to the accelerometers available on many mobile phones can allow for significant unintended leakage of information from a user's environment. We show that a malicious application with access to the accelerometer feed can record and re-

construct the keypresses made on a nearby keyboard based solely on the observed vibrations. We develop profiles for keypress events using boosted Random Forests, which creates an abstract representation of the relationship between the keystroke signal and the alphabet typed. We then recover the typed content by translating from our intermediary form to English words using a number of different dictionaries. Such tasks are not a trivial application of standard techniques, especially when compared to previous efforts in this space. Specifically, we must overcome much lower sensor sampling rates than has been experienced in the related acoustic and electromagnetic-based eavesdropping attacks, which makes deciphering individual keypresses extremely difficult.

Through this, we make the following contributions in this paper:

1. **Develop an infrastructure for characterizing keypress vibrations:** We capture, analyze and develop profiles of keypress events on a nearby keyboard based on the vibrations created when they are pressed. Our inputs are then processed using a set boosted Random Forests to create an intermediary representation, which is combined with candidate dictionaries to successfully recover words at rates as high as —
2. **Dataset made publicly available:** To the best of our knowledge, there does not exist a dataset with the keystrokes for the vibrations recorded using an accelerometer. In this paper, we demonstrate we construct the dataset of keystroke vibrations, recorded using the accelerometer, present in a smartphone and make the dataset publicly available to enhance further research on this topic. Given the widespread about security breaches and email leaks, we perceive this to be of great importance in motivating the mobile operating system manufacturers to restrict the usage of accelerometers to permitted applications only.

Note that our approach is greatly influenced by the work of Marquardt *et. al* [1] and we present key differences with our approach.

2. RELATED WORK

Researchers have studied malicious code on mobile devices that learn information about the device owner using other

embedded sensors. In the most closely related work to our paper, Marquardt *et. al* [1] propose *(sp)iPhone* which uses motion sensors in the iPhone 4 to infer keystrokes of nearby laptop users. *(sp)iPhone* uses 3 labels for each pair of keystrokes in order to determine the correct identification for the letters of the word. The location of the key is modelled using a neural network trained on 150 keystrokes for each letter of the English alphabet. A profile is then constructed for each pair using the neural network and determines and models the distance between the two events. The predictions of the neural network are matched against a dictionary to determine the top matches. The accuracy achieved is roughly 80% but this decreases to 40% as the size of the dictionary increases.

In a very similar, but orthogonal, use case, Owusu *et. al* [7] present the threat of applications which extract the keystrokes of the user's typing on the smartphone screen itself. Again, due to no restrictions on the usage of the accelerometer, they are able to extract 6-character passwords in as few as 4.5 trials (median). TouchLogger [8] uses orientation of the smartphone device to infer the keystrokes.

3. THREAT MODEL

4. FRAMEWORK DESCRIPTION

5. IMPLEMENTATION

6. EXPERIMENTAL RESULTS

7. CONCLUSIONS

8. ACKNOWLEDGMENTS

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APPENDIX

A. APPENDIX SECTION

A.1 Appendix Subsection