(sp)iPhone: Decoding Vibrations From Nearby Keyboards Using Mobile Phone Accelerometers

Philip Marquardt et al.

ACM Computer and Communications Security 2011

y Ren-Jay Wang

CS598 - COMPUTER SECURITY IN THE PHYSICAL

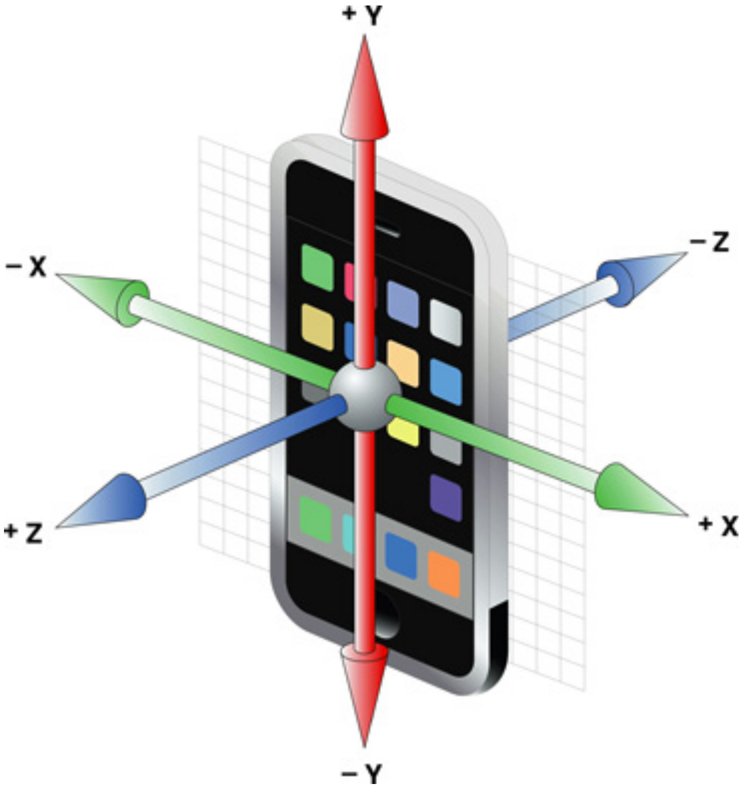
n old kind of attack

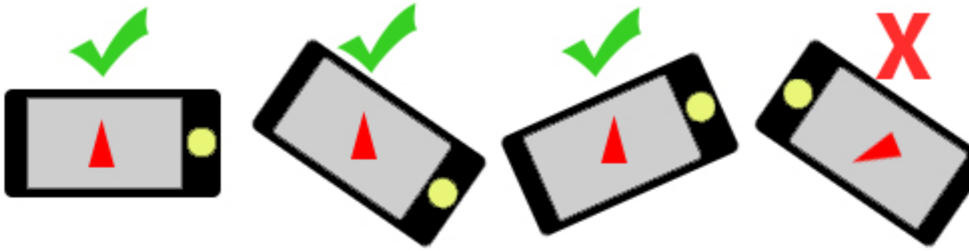
ow do we fix this problem?

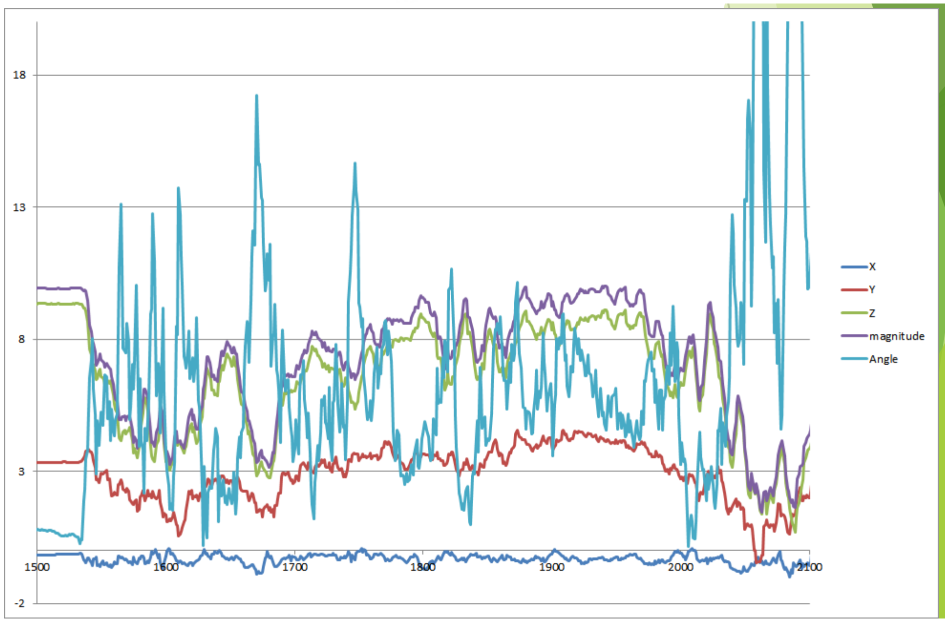
- Easy solution: users provide explicit permission

new kind of attack

e can use mobile phone accelerometers to detect vibrations







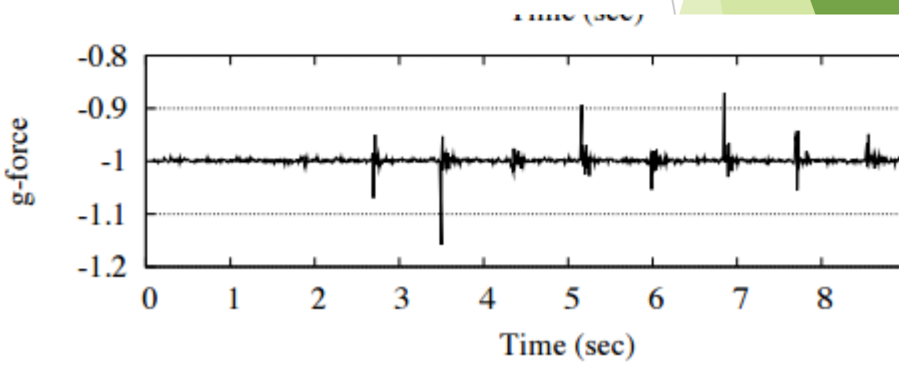
elated electrical/mechanical manation attacks

- Van Eck Phreaking (CRT electromagnetic emanations)
- Tempest in a teapot: Compromising Reflections Revisited
- Recreating key presses through a microphone

he new attack

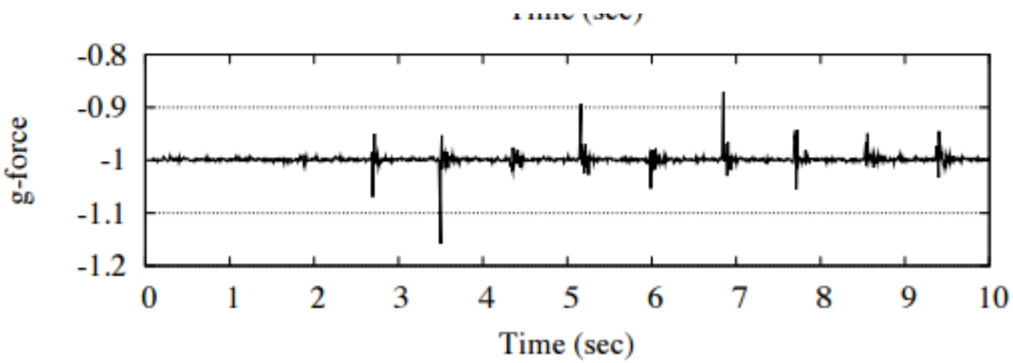
Many users place their phones nearby when working on a computer

We can use this fact to our advantage to eavesdrop

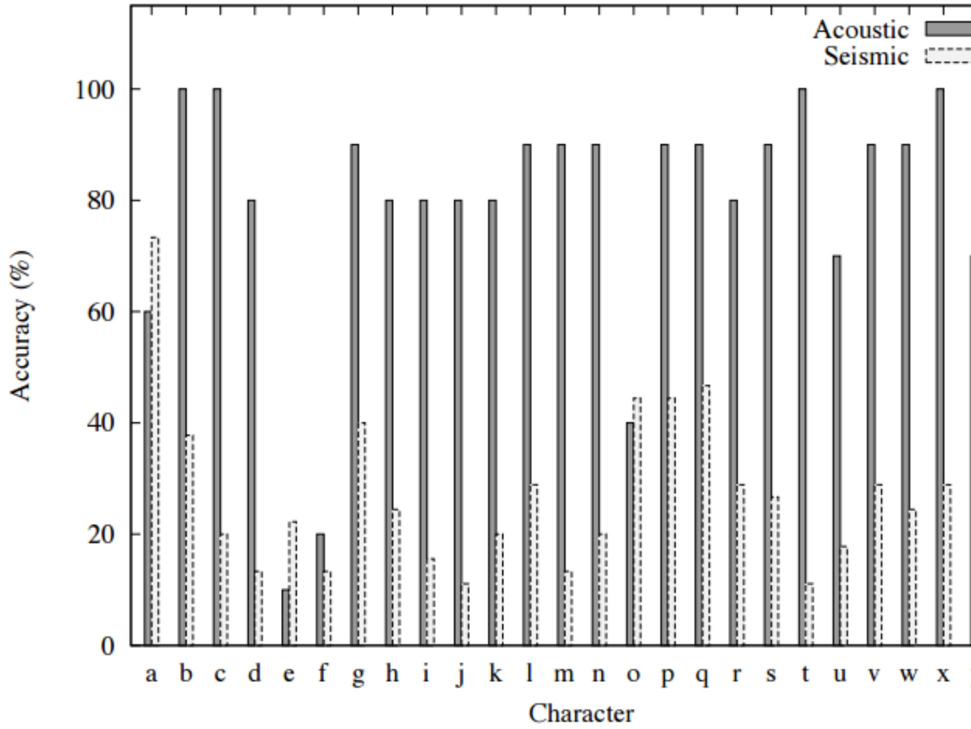


he result of trying old techniques

Ve choose to use an iPhone 4 because it has a better accelerometer & gyroscope



...doesn’t work



o what do we do next?

We choose to recognize key *pairs* instead of individual keys

We recognize whether keys are on the LEFT or RIGHT relative to a central line and if they are NEAR or FAR relative to some defined threshold distance α

For example, “Canoe” ->

LLN LRF RRF RLF

Strings of length *n* can be split into *n-1* abstract string representations

reating our own neural network model
tep 1: Learning phase

- Record each key press 150 times (total 3900 key-press events)
- Create feature vector for each key drawing from x,y,z accelerations => <mean, kurtosis, variance, min, max, energy, rms, mfccs, ftts>
- Word labeling: for each *n-1* character pairs, concatenate random feature vectors for the corresponding keys
- Can’t be too specific -> to avoid overtraining, use even distribution of left, right, near and far labels

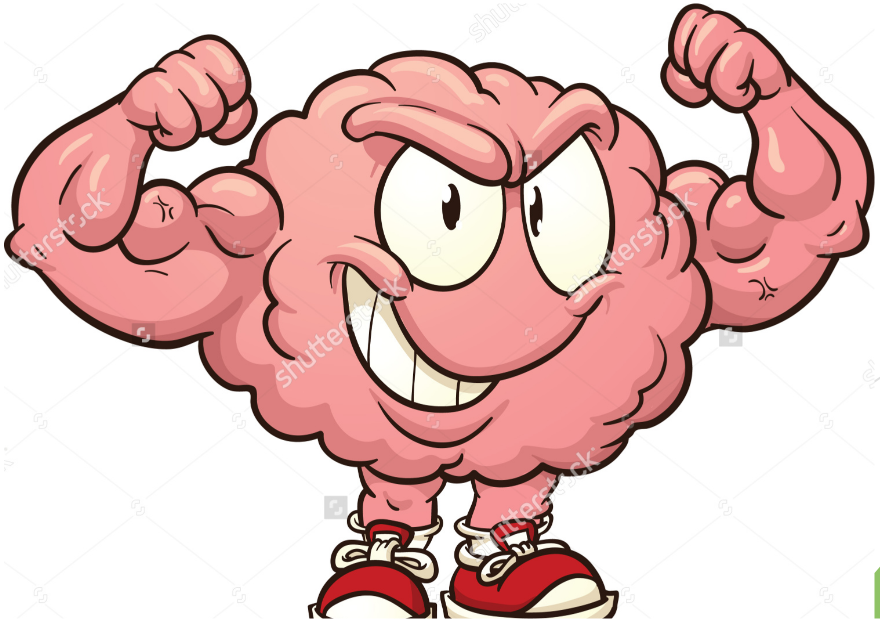
reating our own neural network model
tep 2: Attack phase

Data Collection: Raw-acceleration data is collected

Feature Extraction: Feature-vectors are calculated

Key-press Classification: L/R labels and N/F labels are classified based on the neural networks

Word Matching: Words are matched against a dictionary and sorted; top scores are candidate predictions

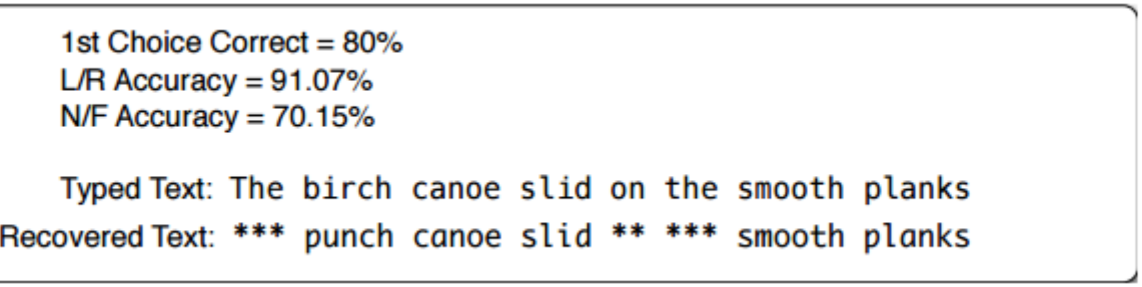


ow well does our model perform?

- L/R classifier correctly identifies 91% of the time
- N/F classifier correctly identifies 65% of the time
- These percentages drop with more keypresses, which is to be expected

xperimental Results – Tests 1 and 2

- Removed words of <= 3 characters
- Test 1: 1 sentence -> 80% accuracy using first choice
- Test 2: 10 sentences -> 46% using first choice, 73% within first two choices

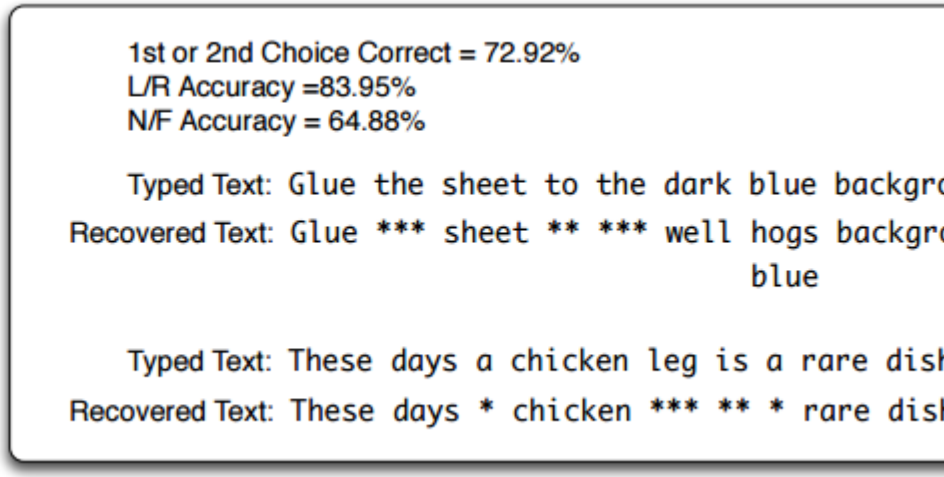


1st Choice Correct = 80%
L/R Accuracy = 91.07%
N/F Accuracy = 70.15%

```
   Typed Text: The birch canoe slid on the smooth planks
Recovered Text: *** punch canoe slid ** *** smooth planks
```

<- Test 1

Test 2 ->



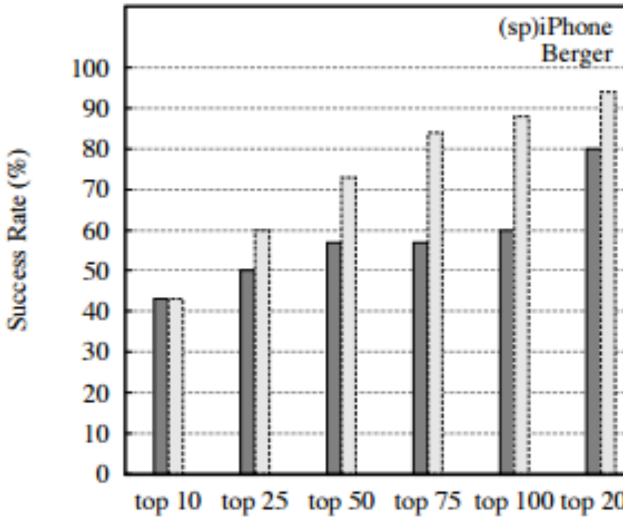
1st or 2nd Choice Correct = 72.92%
L/R Accuracy =83.95%
N/F Accuracy = 64.88%

```
   Typed Text: Glue the sheet to the dark blue backgr
Recovered Text: Glue *** sheet ** *** well hogs backgr
                                          blue

   Typed Text: These days a chicken leg is a rare dish
Recovered Text: These days * chicken *** ** * rare dis
```

xperimental Results – Test 3

- Comparison to previous work by Berger et al., using dictionary of 57,500 words and sentence with 4-9 characters per word
- Berger: 43% accuracy within top 10 word guesses
- Experimental result: 43% as well!
- Experimental results less accurate than Berger when increasing the number of guesses…limitations?

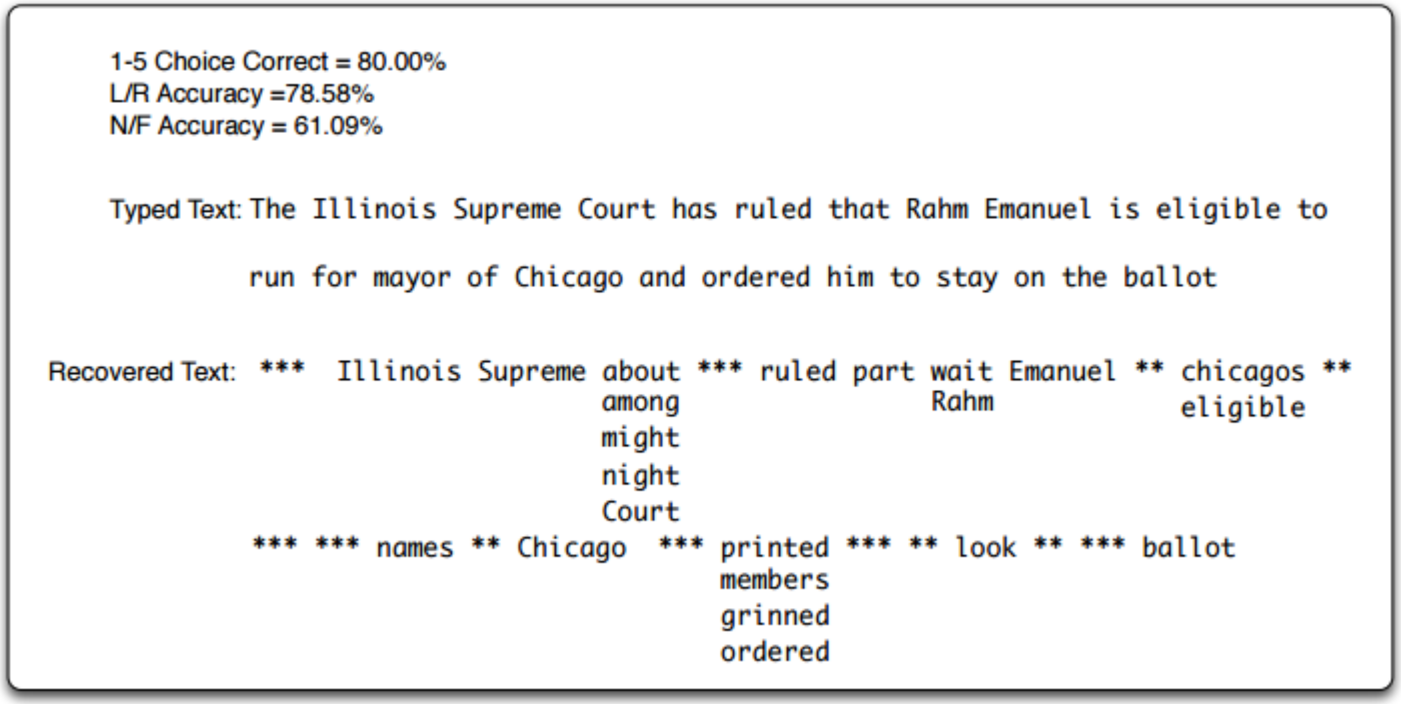


xperimental Results – Test 4

A more realistic attack – USAToday article

Dictionary constructed using seven related news articles

40% in first choice, 53% in top 2, and 80% accuracy in top 5 predictions



```
    1-5 Choice Correct = 80.00%
    L/R Accuracy =78.58%
    N/F Accuracy = 61.09%

    Typed Text: The Illinois Supreme Court has ruled that Rahm Emanuel is eligible to

                run for mayor of Chicago and ordered him to stay on the ballot

Recovered Text:  ***  Illinois Supreme about *** ruled part wait Emanuel ** chicagos **
                                       among                    Rahm              eligible
                                       might
                                       night
                                       Court
                *** *** names ** Chicago  *** printed *** ** look ** *** ballot
                                              members
                                              grinned
                                              ordered
```

hallenges and Limitations

- Distance and environmental factors – only sure to work within one foot
- Orientation of the phone
- Ambient vibration
- Typing speed
- Desk surface

ow do we fix this vulnerability

Short term solutions

- Don’t get too close!
- Permissions on accelerometer

Long term solutions

- Restricting data resolution to applications
- Being careful with all kinds of sensors in the future!

iscussion Points

- Key contributions of the paper?
- Limitations to this attack?
- Is this paper relevant to other areas of security?
- Thoughts on improving the accuracy/effectiveness of the attack?
- What are ways we can combat these kinds of attacks?