PIN and Password Security

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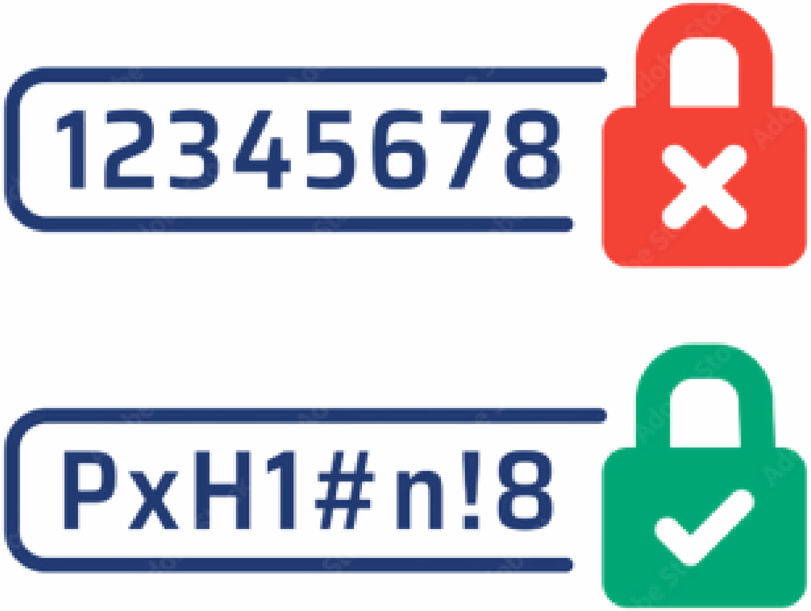
PIN sounds good... but is it?

Easy and simple...

But secure?

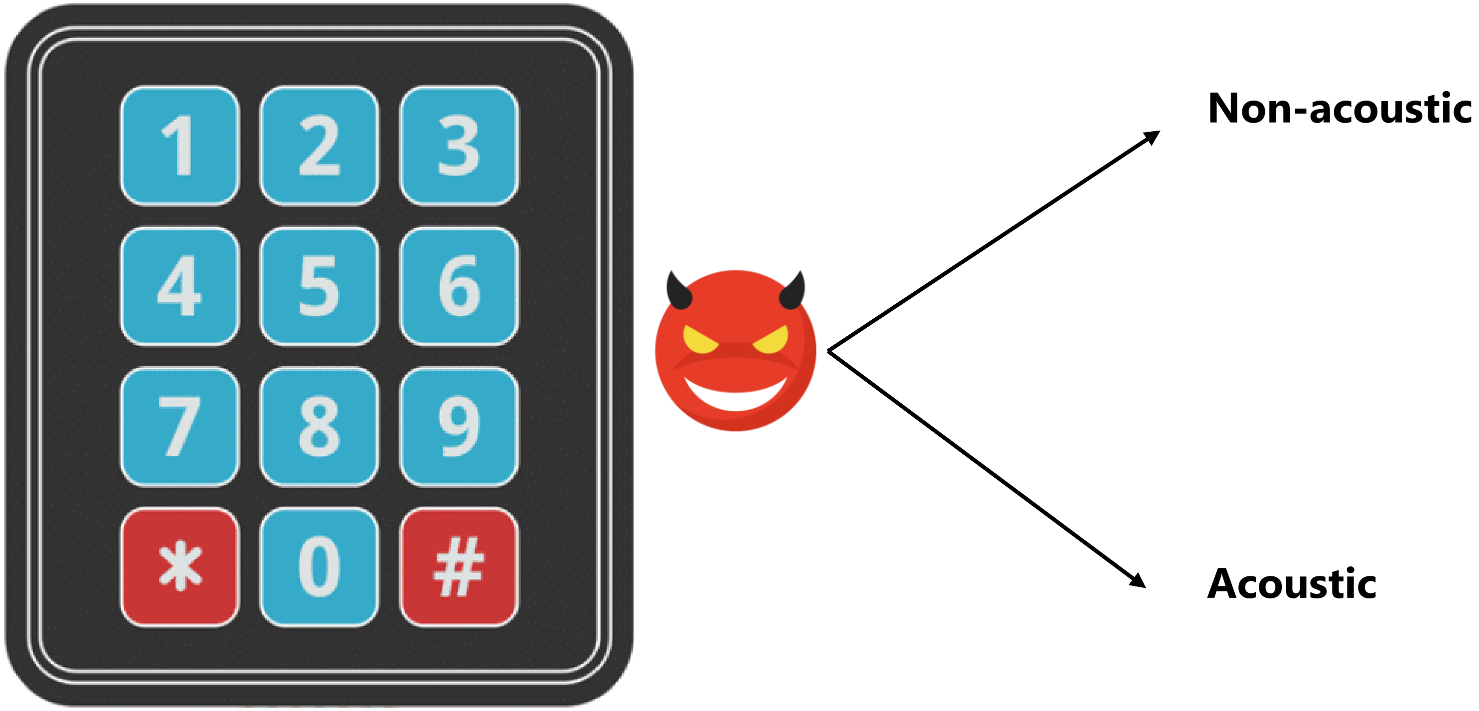


Where are PINs used?

ATMs and PoS

Smartphones

How are ATM PINs exploited?



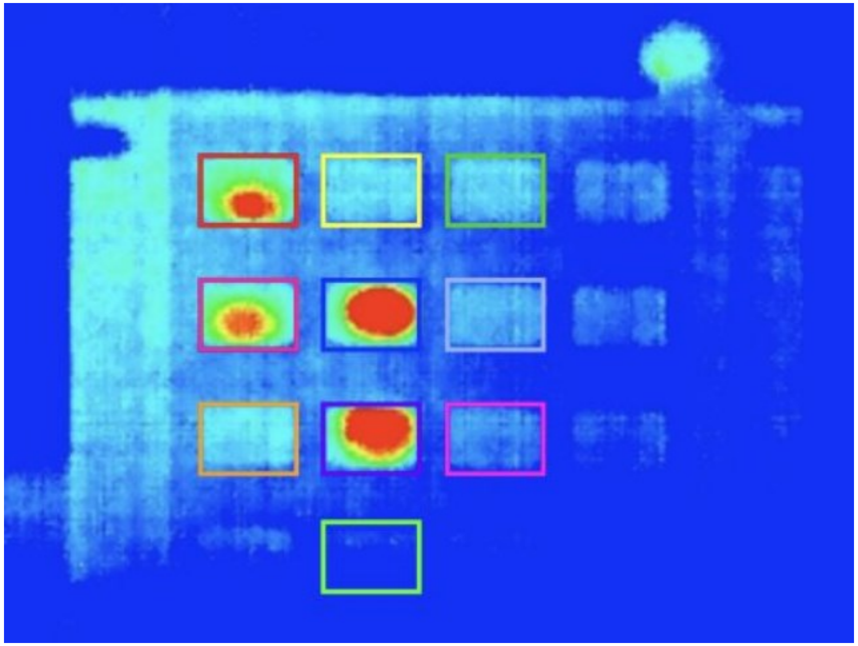
Non-acoustic

Acoustic

How to track and study PINs?

Non-acoustic

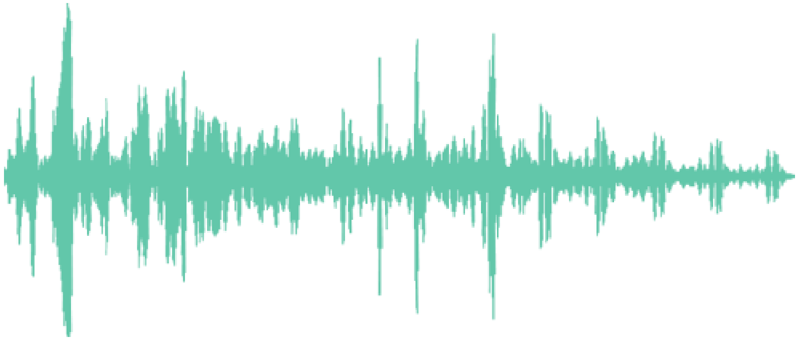
- While the user is typing the password
- Recover keystrokes by electromagnetic emanations
- Observation via a thermal camera to identify key presses on the keypad



How to track and study PINs?

Acoustic

- Each key emits a characteristic sound



- Able to construct a dictionary attack to bruteforce and reconstruct words
- Multiple microphones to triangulate the keys positions
- Alternatives: SSH traffic and video → **measure the timing between presses works better!**

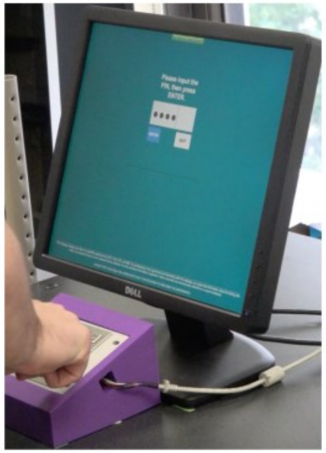
Keystroke Timing

- Measures the distance between consecutive keystrokes of subsequent keys

- The adversary can infer keystroke timings by using audio when the user is typing the PIN

- Filter timestamps of keys pressed from keypad sound normalizing the samples

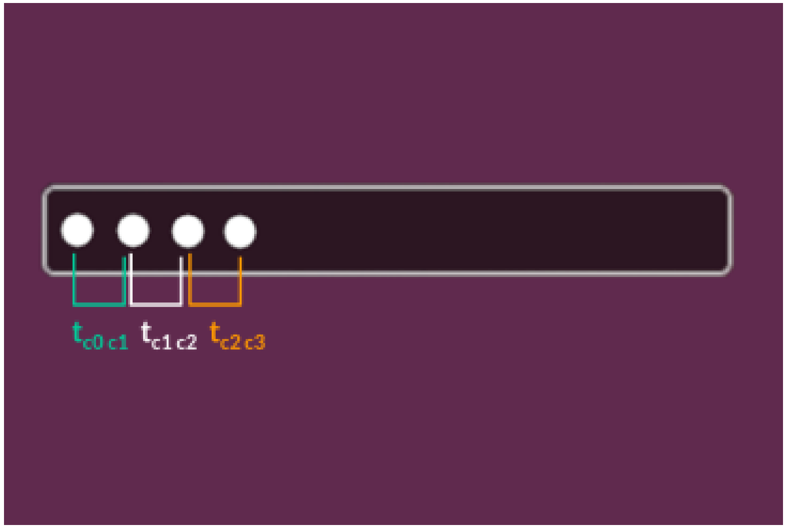
- Timing is also based on *observation (video)*



Keystroke Timing

- Ranking PINs based on the Euclidean distance between subsequent keys in each PIN (but *how many are they typed?*)

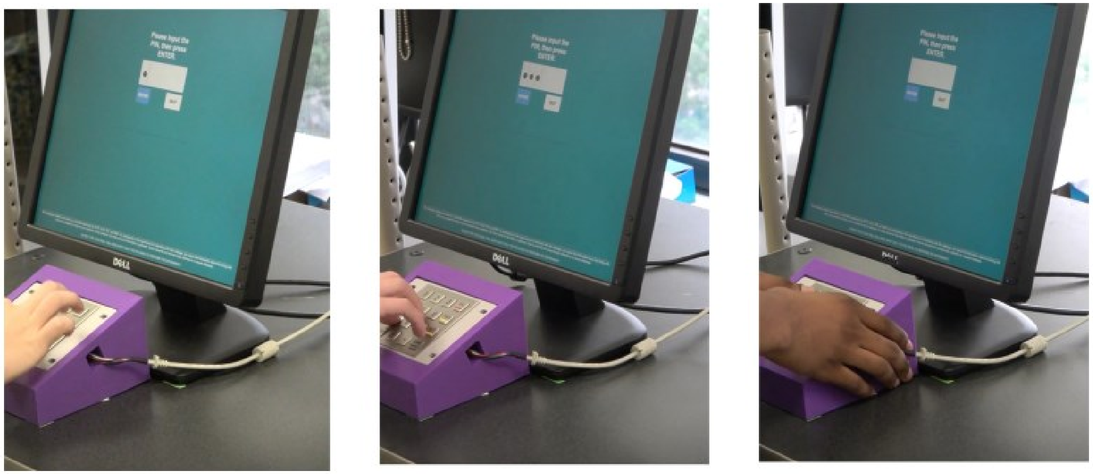
- Distance vector from a sequence of inter-keystroke timings inferred from audio feedback



- Example: PIN 5566 is [0,1,0]

Typing Behavior

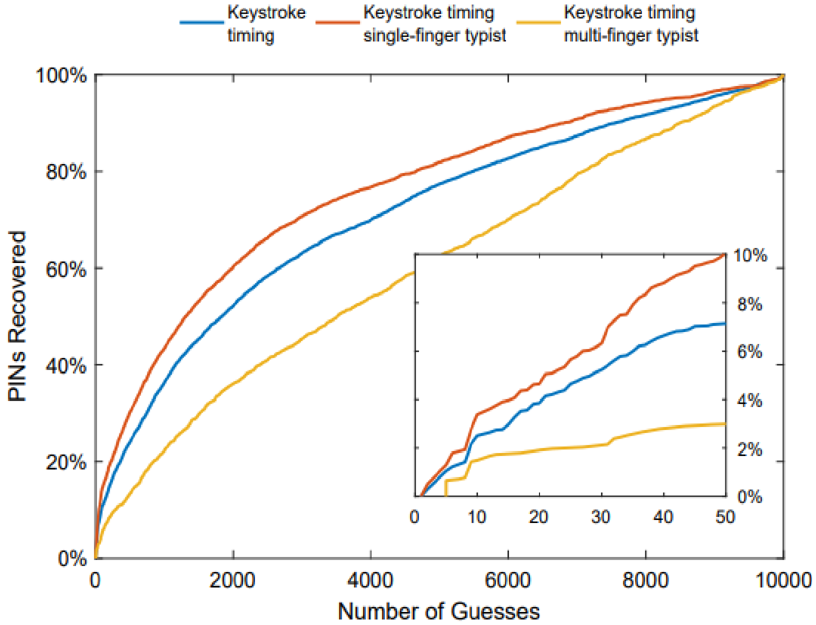
- The adversary can typically observe (video) whether the user is typing with:
  - one finger (*single* typists)
  - more fingers (*multi-finger* typists)



- We can combine thermal camera (*video*) with keystroke timing (*audio*)

Typing Behavior + Keystroke Timing

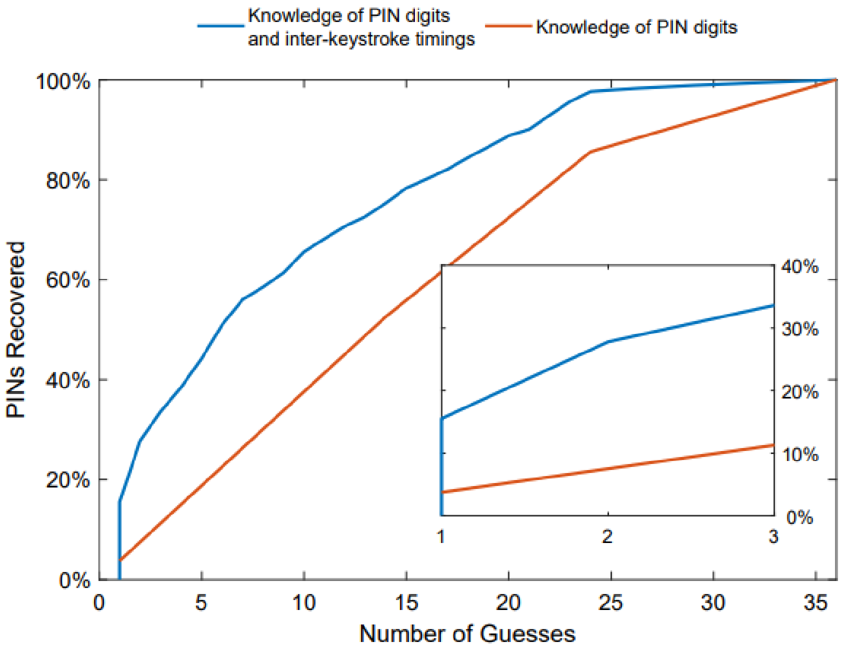
- Single-finger typists:
  - less PINs – more timing
- Two-finger typists:
  - more PINs – less timing
- and so on…



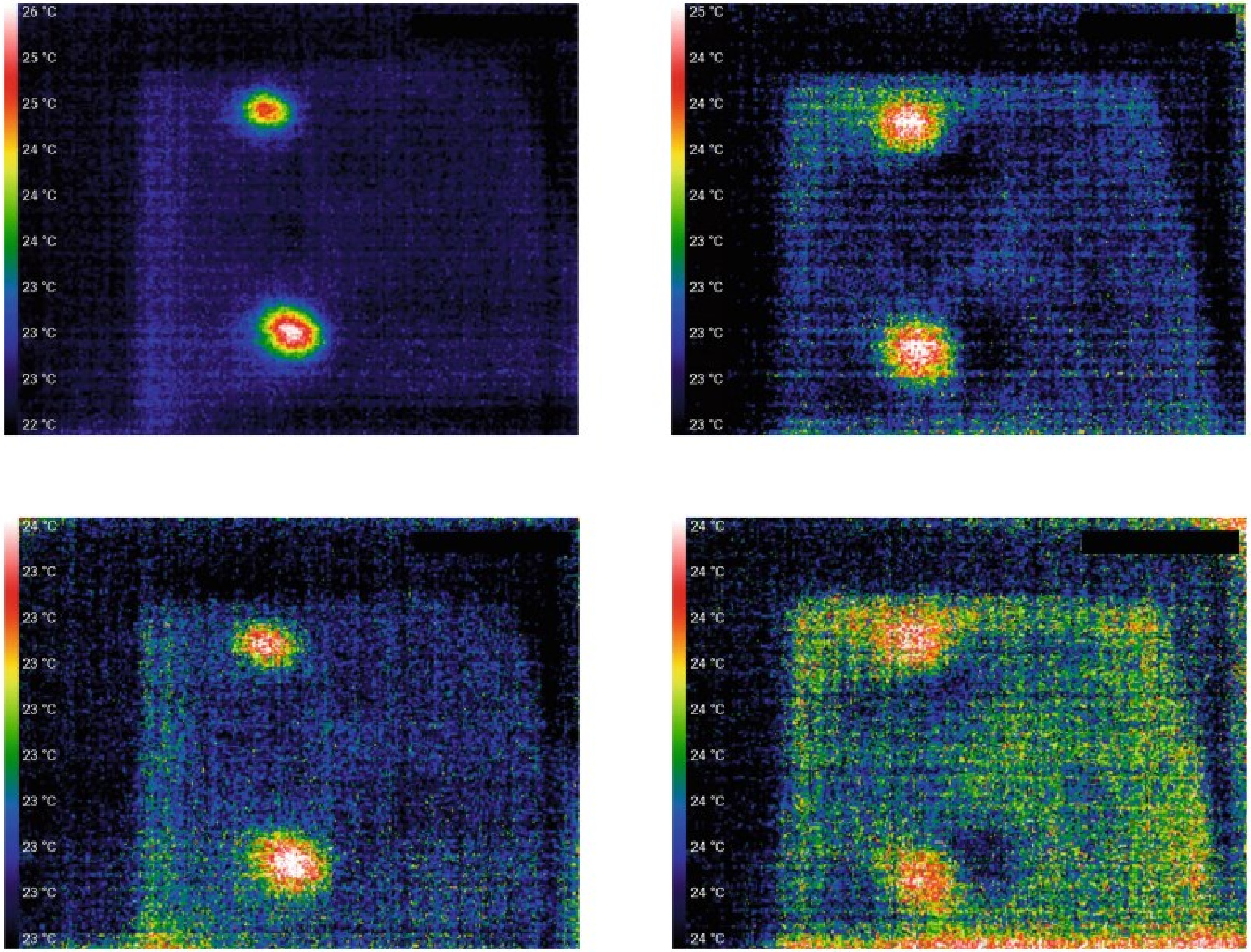
- The inter-keystroke timing (when) is not representative of the Euclidean distance (how many)….
- …which means higher guesses over single-finger compared to multi-finger!

Knowledge of which keys have been pressed

- The adversary may have visibility of the keypad in how the user moves his hand via a thermal camera
- Knowledge of one digit alone reduces the search space by a linear factor (**first** or **last**) over the remaining digits
- The keystroke timing combined with knowledge of keys lead to a higher PIN recover rate



How much time to get the keys pressed?



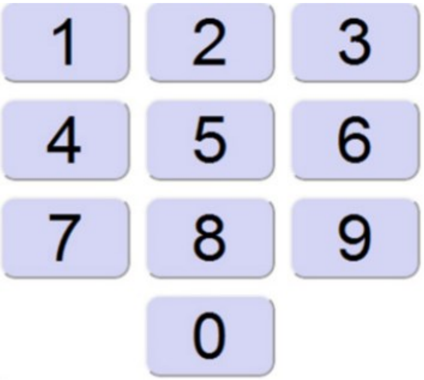
Analysis of PINs Guessing Probability

- Choosing PINs uniformly at random from the entire PIN space is not the best strategy

- The inter-keystroke timing, combined with other sources of information, can lead to higher PINs recovery rate even with same guessing probability thank to audio feedback
  - Keystroke timing + knowledge of first/last digit = x14
  - Keystroke timing + observation of keys = +15%

- Strong correlation between Euclidean distance (which keys) and inter-keystroke timings (how many) lead, combined with previous ones, to better results

PIN Selection Policies



- We said that PINs must be easy to remember....
- ....but how much can we trust users?

- We must combine:
  - **usability** – easy to remember
  - **security** – randomly distributed and difficult to guess

- PINs should have:
  - *totally different* numbers and using last numerical digits (e.g., 7,8,9)
  - different from things *easy-to-remember* (e.g., birthdays, events, etc.)
  - *security-by-design* (a policy which improves the safety without forcing the user to remember something difficult)

How PINs are distributed in the real world

- Occurrence frequency of the PINs (Power law distribution)
  - First digits are pressed more than others
  - Easier for an attacker to guess the first digit than the other digits

- PINs generated from *dates and years*
  - A good portion of selected PINs are made like this

- PINs generated from *arithmetic operations*
  - Some users combine simple things (e.g., addition/multiplication, etc.)
  - Just a minority over the others

- PINs *with close proximity*
  - Consecutive numbers are more selected given they're easy to use
  - Another good portion of PINs are like this

How PINs can be more effectively chosen

- How to balance *easy-to-remember/hard-to-master* in PINs?
  - **Enforce selection policies** (secure but not too strict)
  - Application of said policies in everyday life (e.g., locking mobiles)
  - PINs usable safely and simply in all real-life contexts

- How to balance *easy-to-remember/hard-to-master* in PINs?
  - *4-free*: 4-digit PIN without any restriction
  - *4-short*: 4-digit PIN where the 200 most popular PINs were not allowed
  - *4-long*: same rules as 4-short + without any consecutive number
  - *6-free:* 6-digit PIN without any restriction
  - *6-long:* 6-digit PIN without any consecutive number

- Scale of easy-to-remember (1 = "very easy" up to 5 = "very difficult")

How PINs can be chosen and selected

- The study gave the following results:
  - PINs tend to be chosen between the most popular ones
    - remembrance is worse (*4-short* vs *4-free*)
  - PINs tend to be chosen with consecutive numbers more
    - *4-long* (more secure) vs *4-short* (less secure) = harder for users
  - This holds even In longer PINs
    - remembrance is worse (*6-free* vs *6-long*)
  - **Good compromise**: choose *4-short* PINs over *4-free*

How PINs can be chosen and selected

- In conclusion:
  - Entropy is higher on longer PINs or longer subsequences
  - Odd numbers are usually less frequent
  - It can be useful to analyze more geographical areas and PINs databases

- It would be better to:
  - Useful to enforce a PIN blacklists policy (e.g. avoiding popular PINs)
  - Impose more different chars, easy length and easy words without enforcing the users

Thanks for the attention… but now it’s your turn!

ANY Questions?