Towards a General Video-based Keystroke Inference Attack

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*denotes equal contribution

SAND Lab
security, algorithms, networks and data

THE UNIVERSITY OF CHICAGO

Remote Work

We work and type in public, e.g., lounges, cafés, airports.

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Sensitive text:

Work emails,
Research proposals,
Private documents,
……

Keystroke Inference Attack

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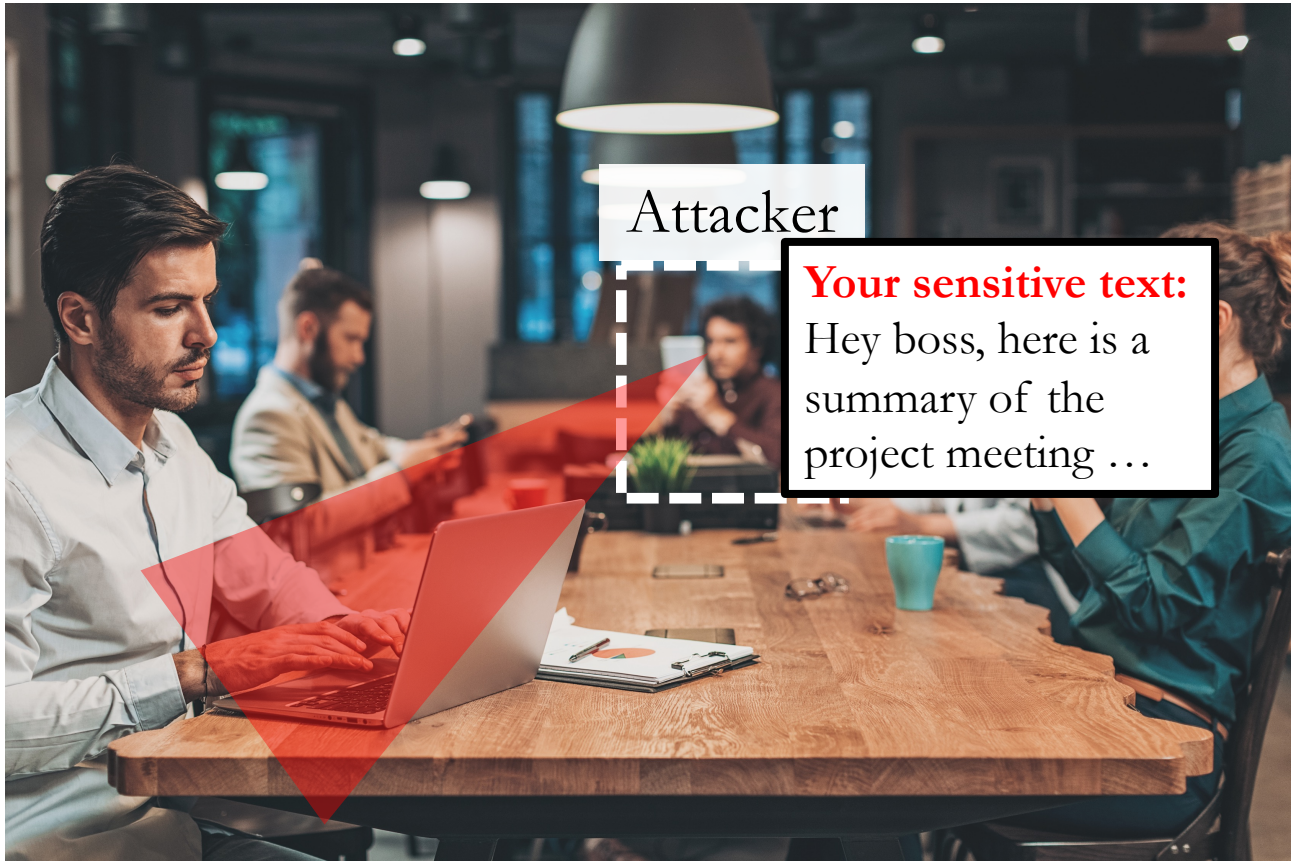
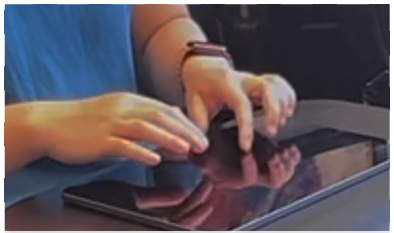


Keystroke Inference Attack

Practical Keystroke Inference Attack

Related works assume external information

- Labeled data of the target
- Keyboard size and layout
- Finger reflection
- Very close sensors (cm)



Finger reflection

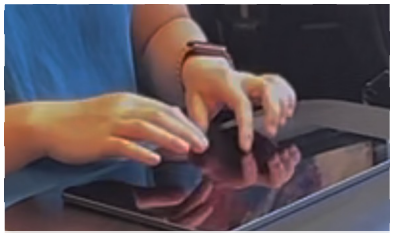
Sensor under the target's table

Practical Keystroke Inference Attack

Related works assume external information

- Labeled data of the target
- Keyboard size and layout
- Finger reflection
- Vary-to-vary sensors (vib)
- .....

No external information



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Threat Model

A general attack:
No external information

1. **The target:** types in English (10+ mins)

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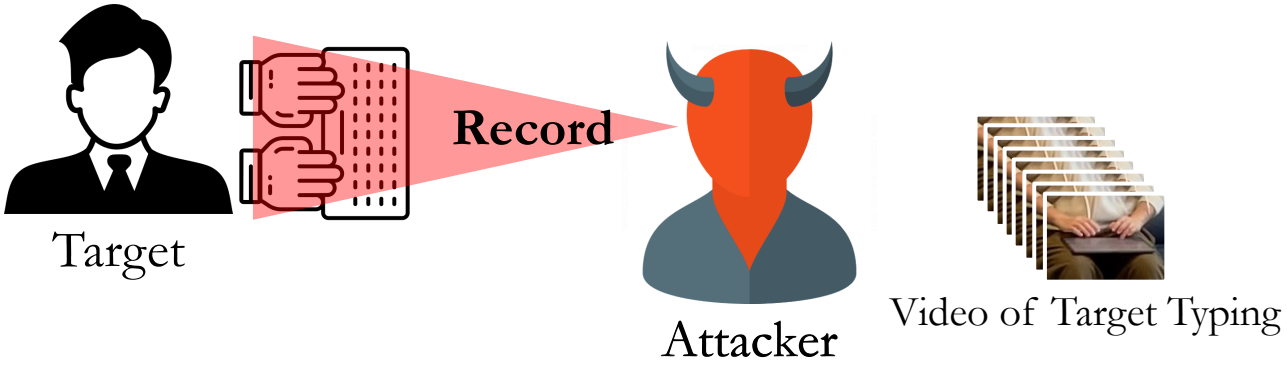
1. **The target:** types in English (10+ mins)

2. **The attacker:** 1 RGB camera
   - Unobstructive view of hands

Attack Overview



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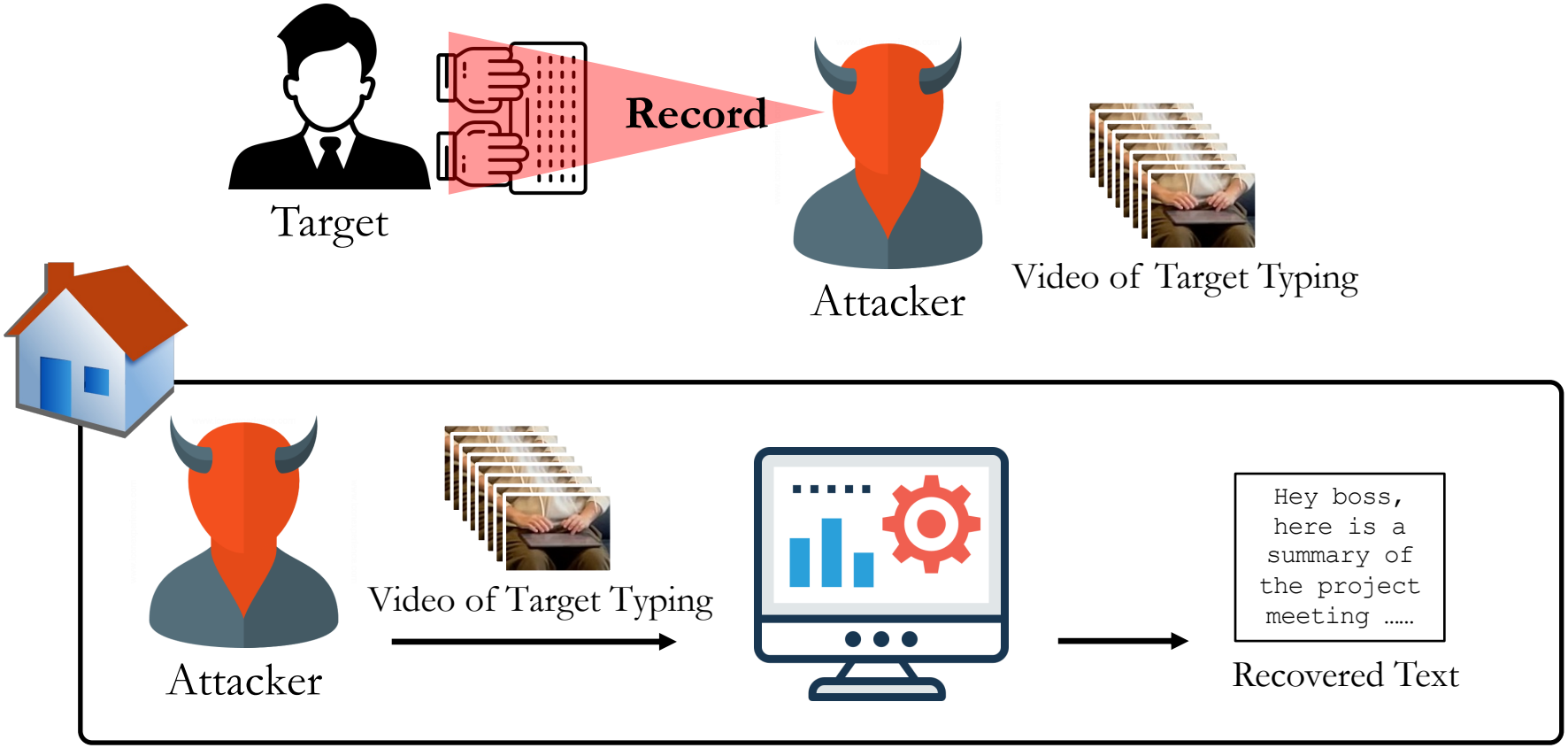

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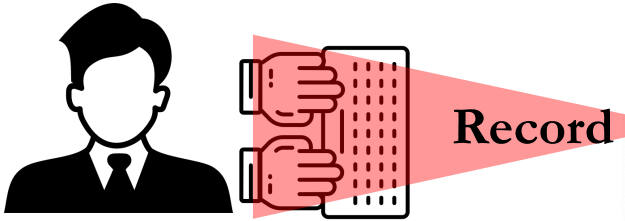
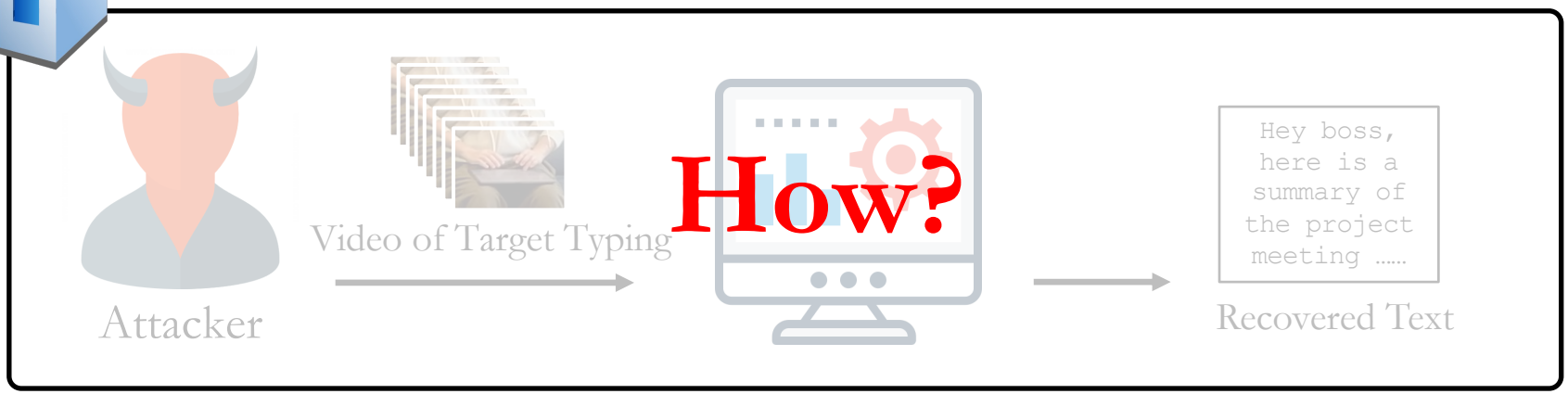
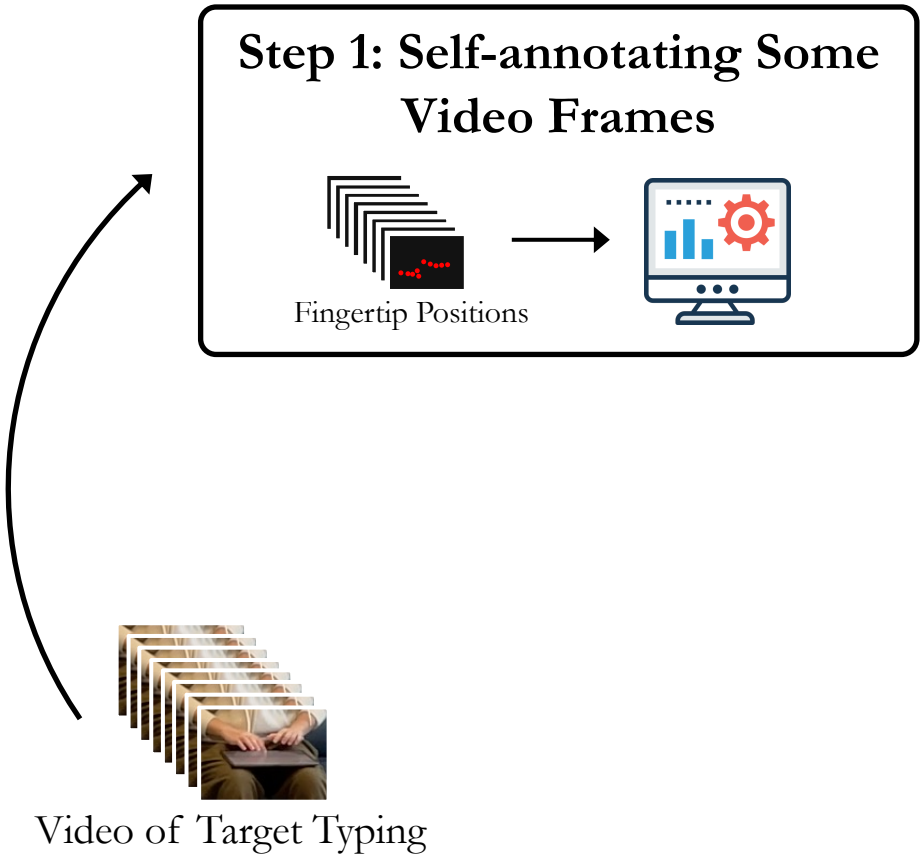




Design Intuition: Self-Supervised Learning



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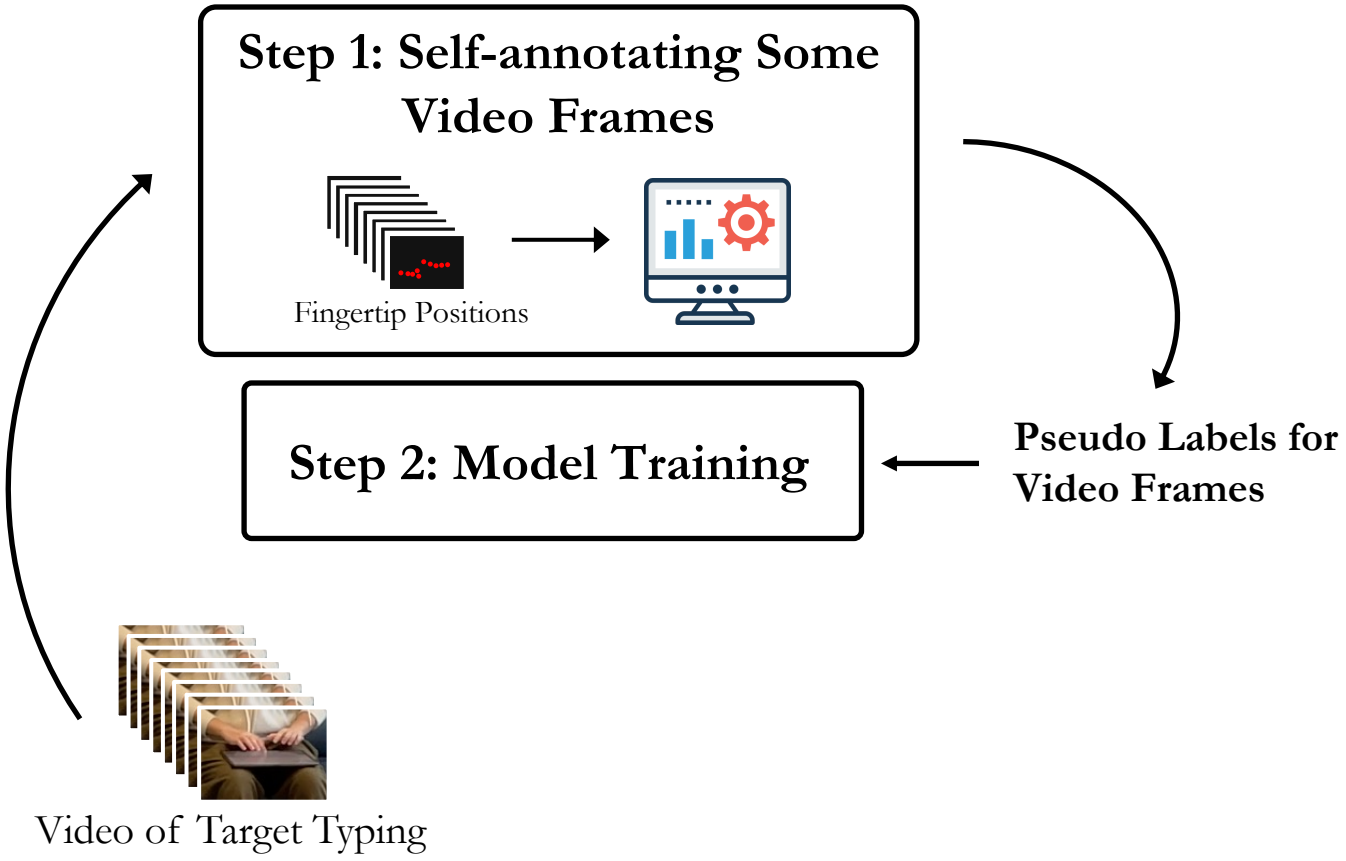

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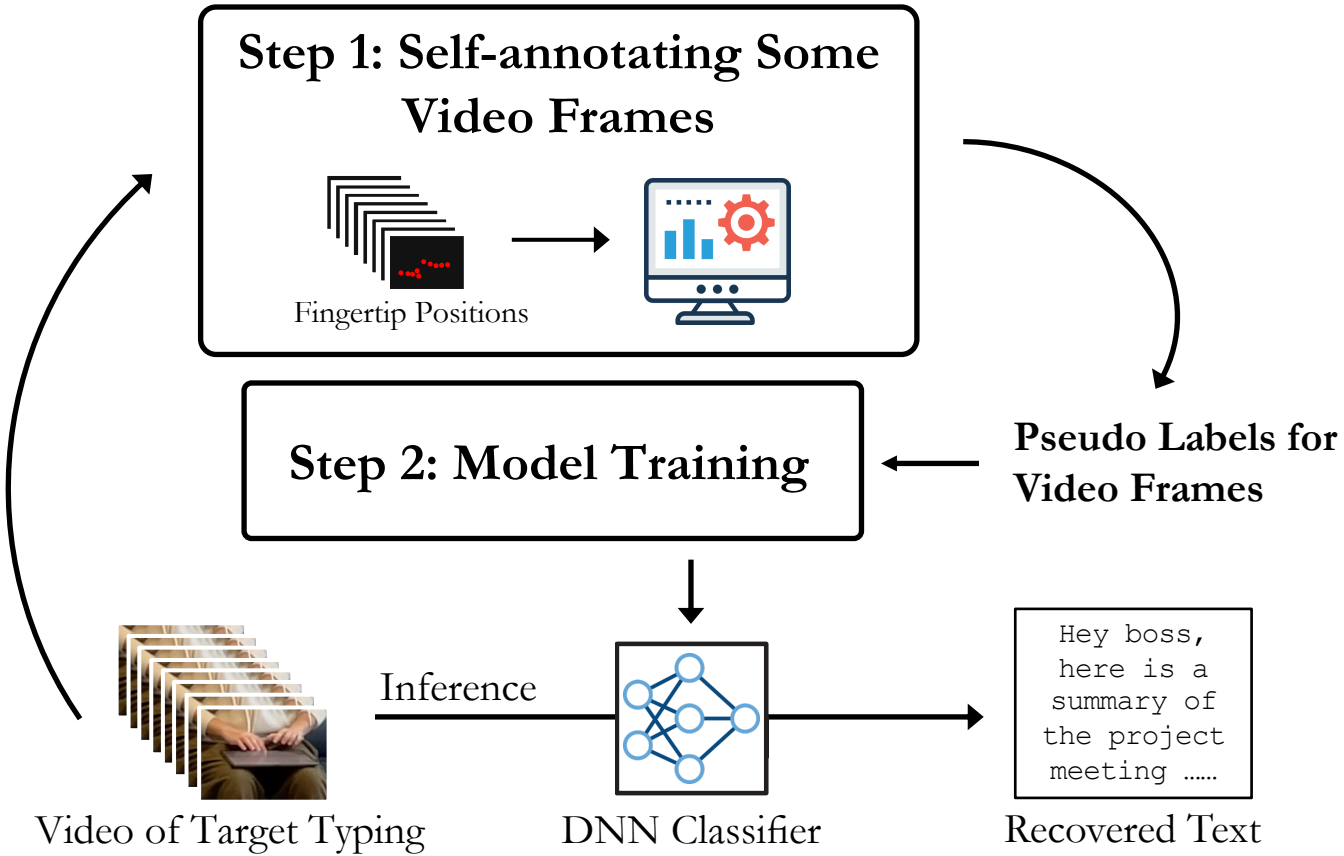

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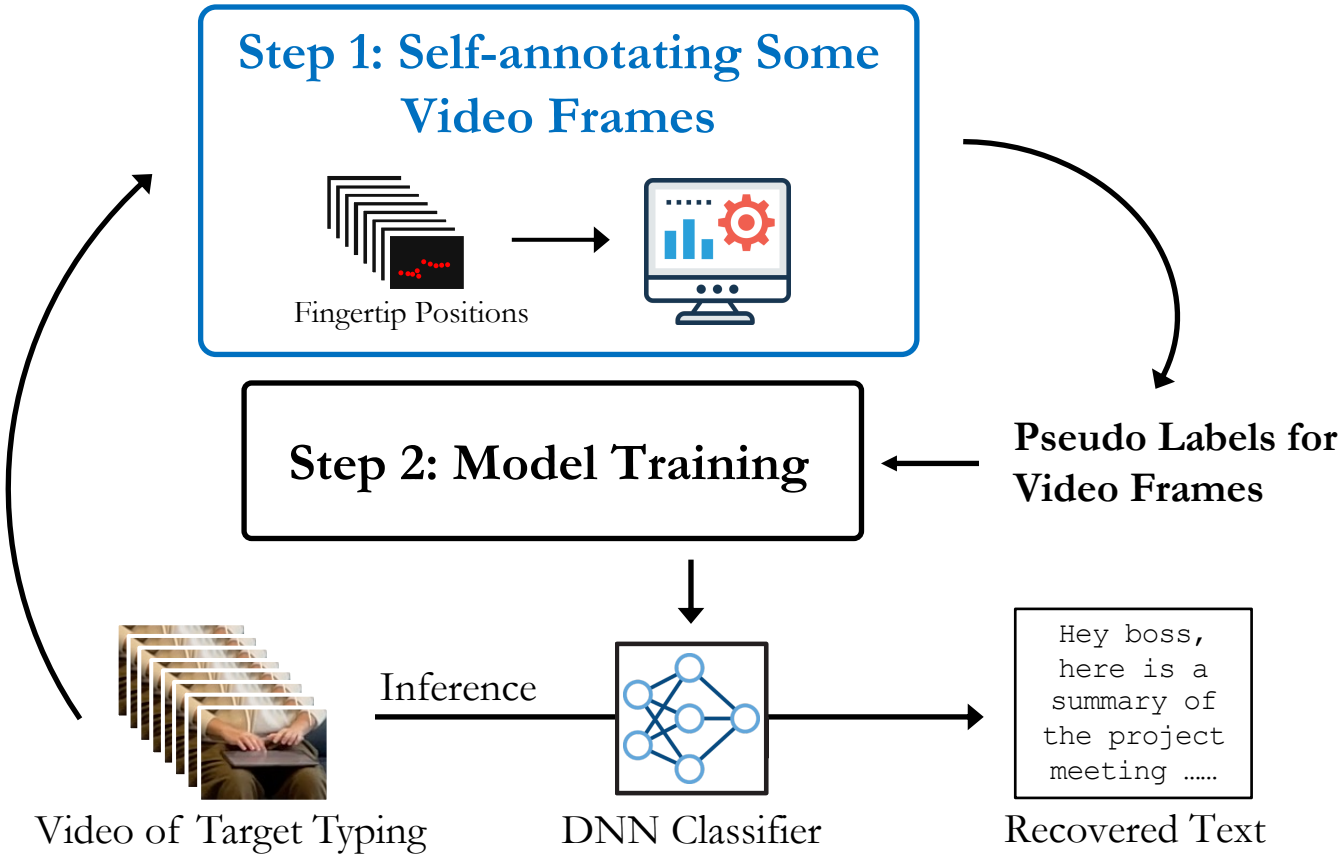
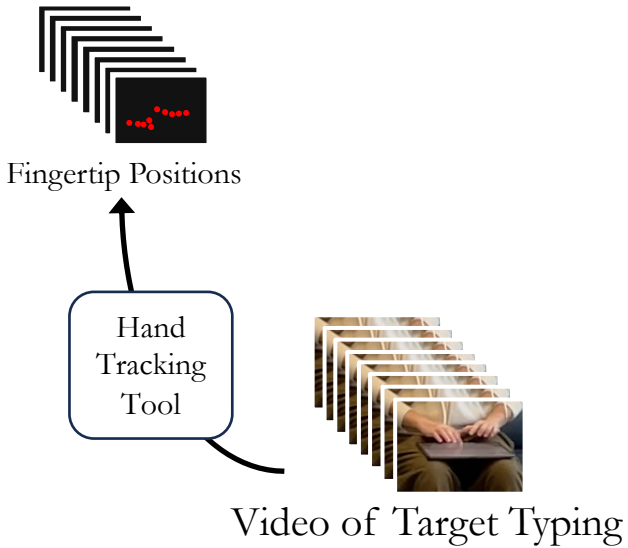


Step 1 – Self-annotating Some Video Frames



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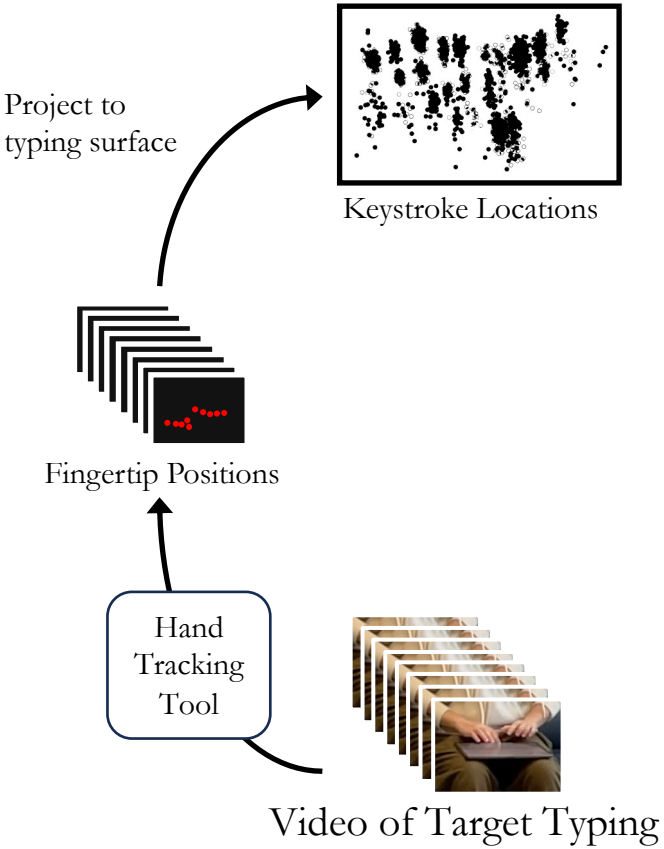

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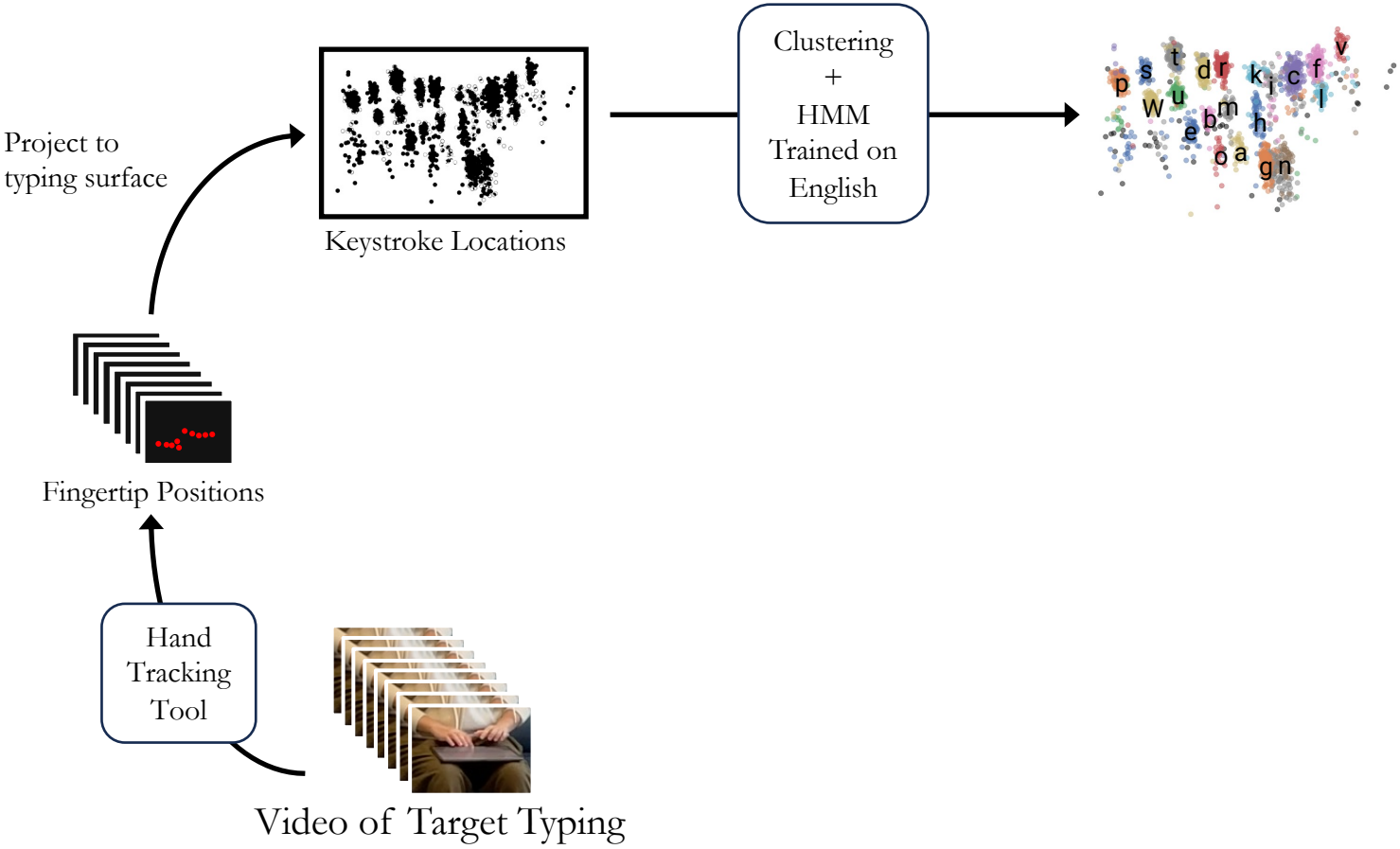

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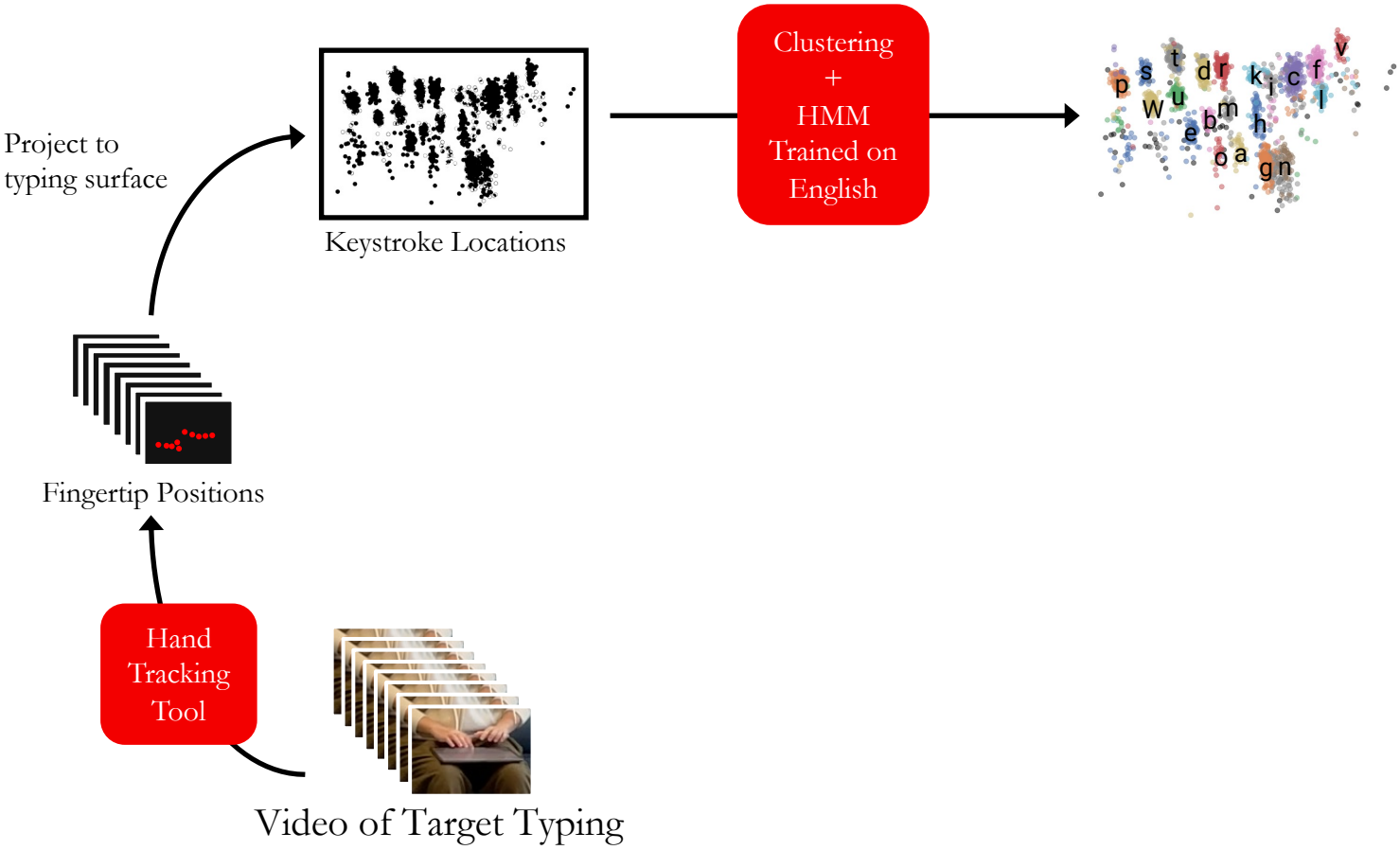

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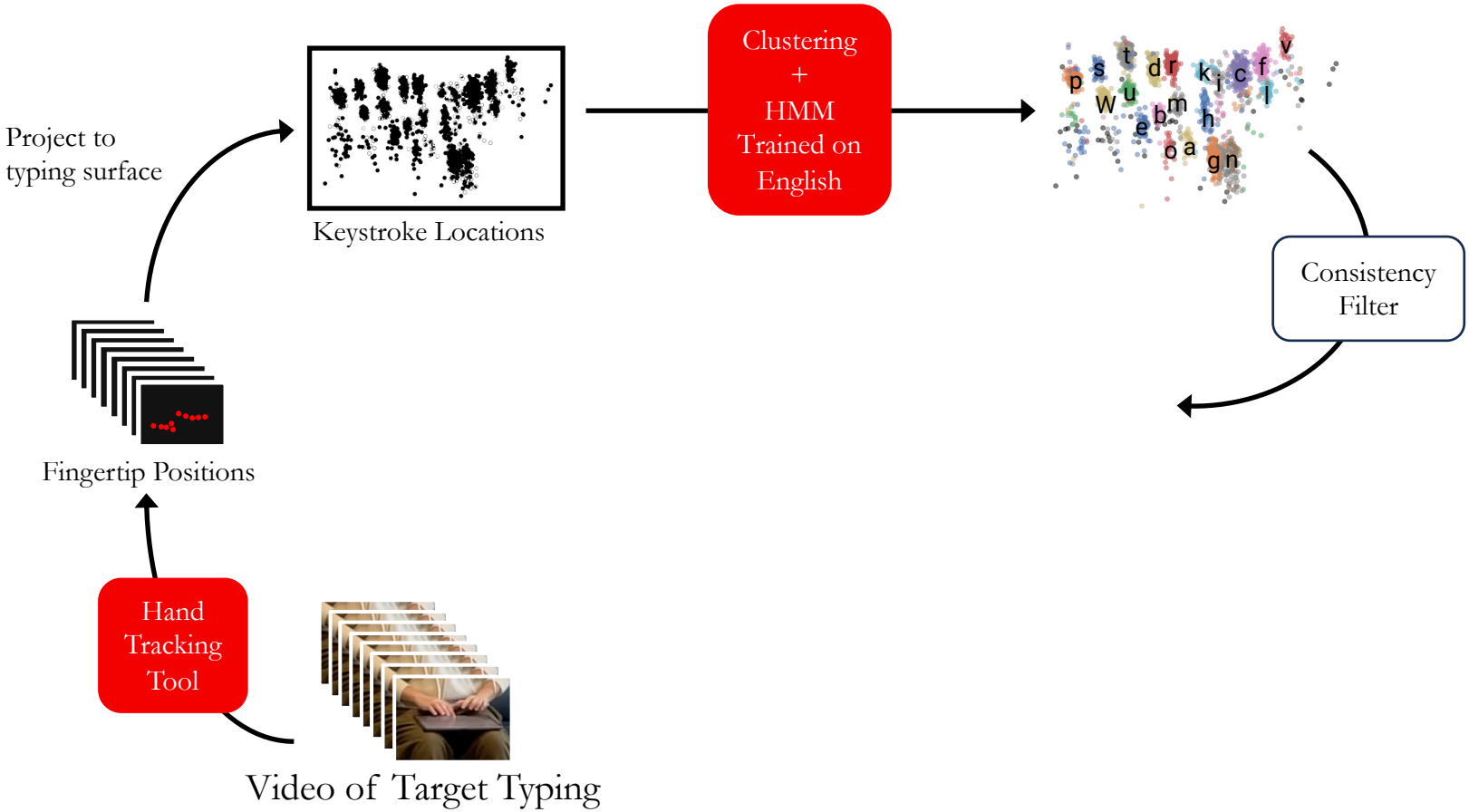

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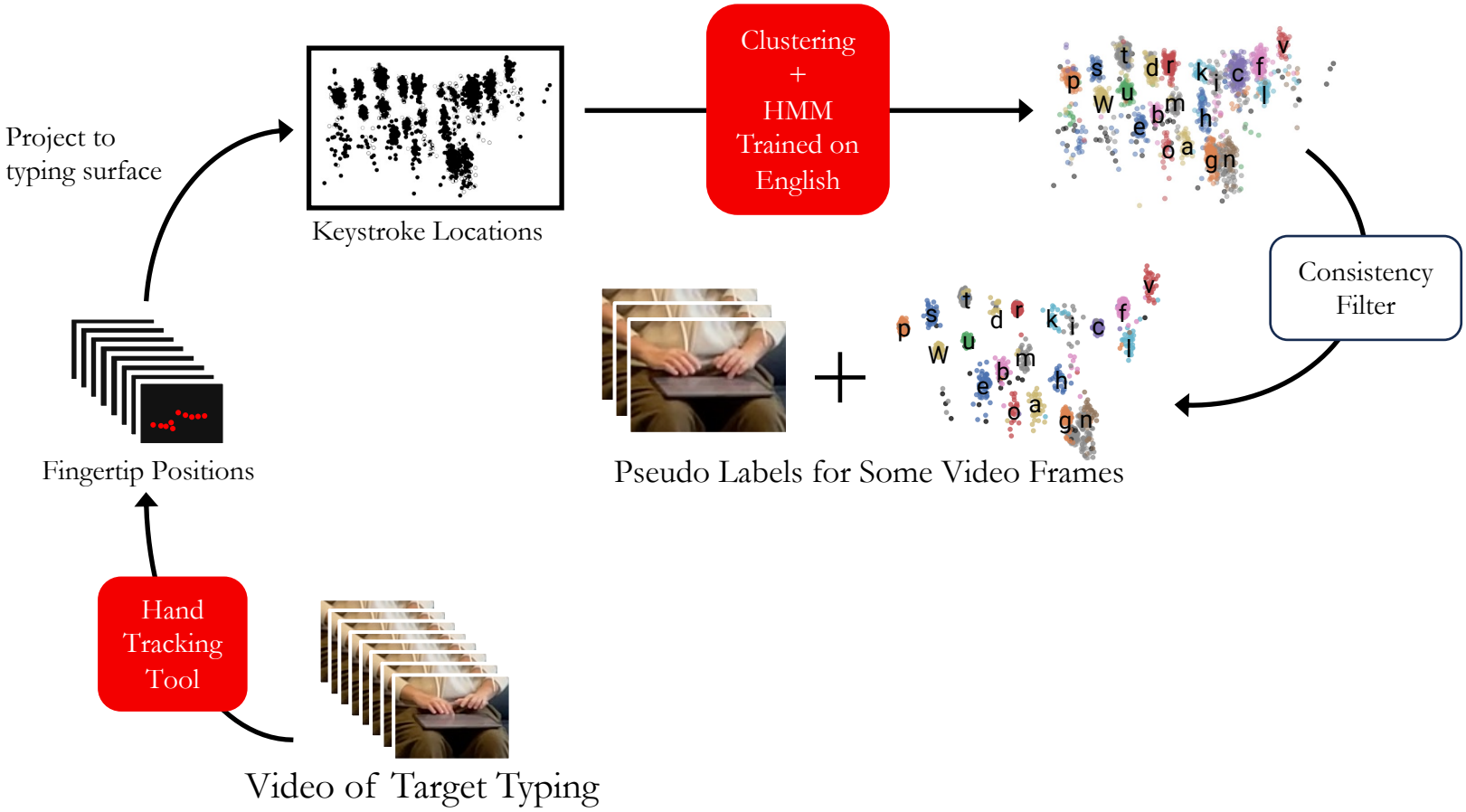

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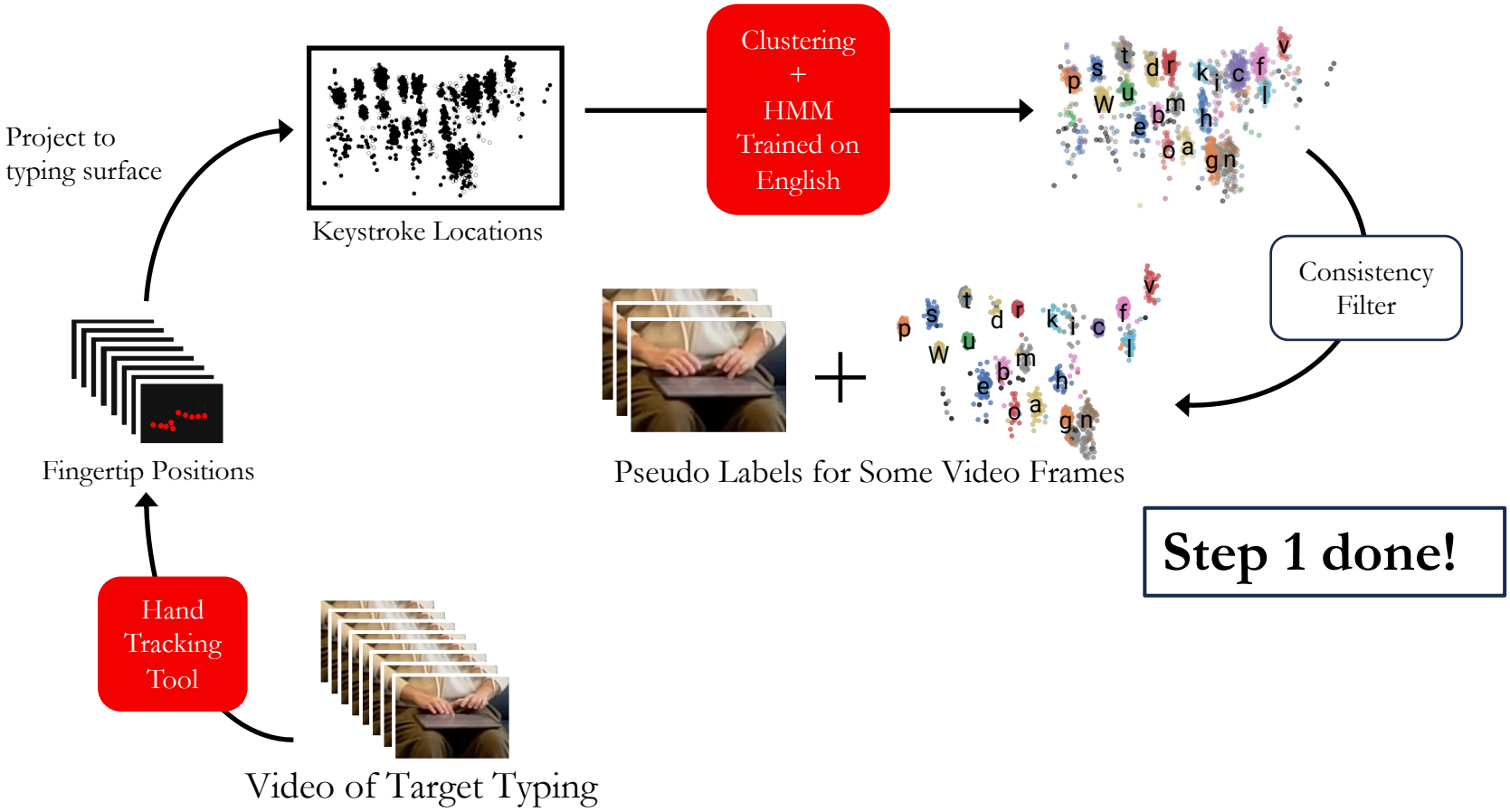
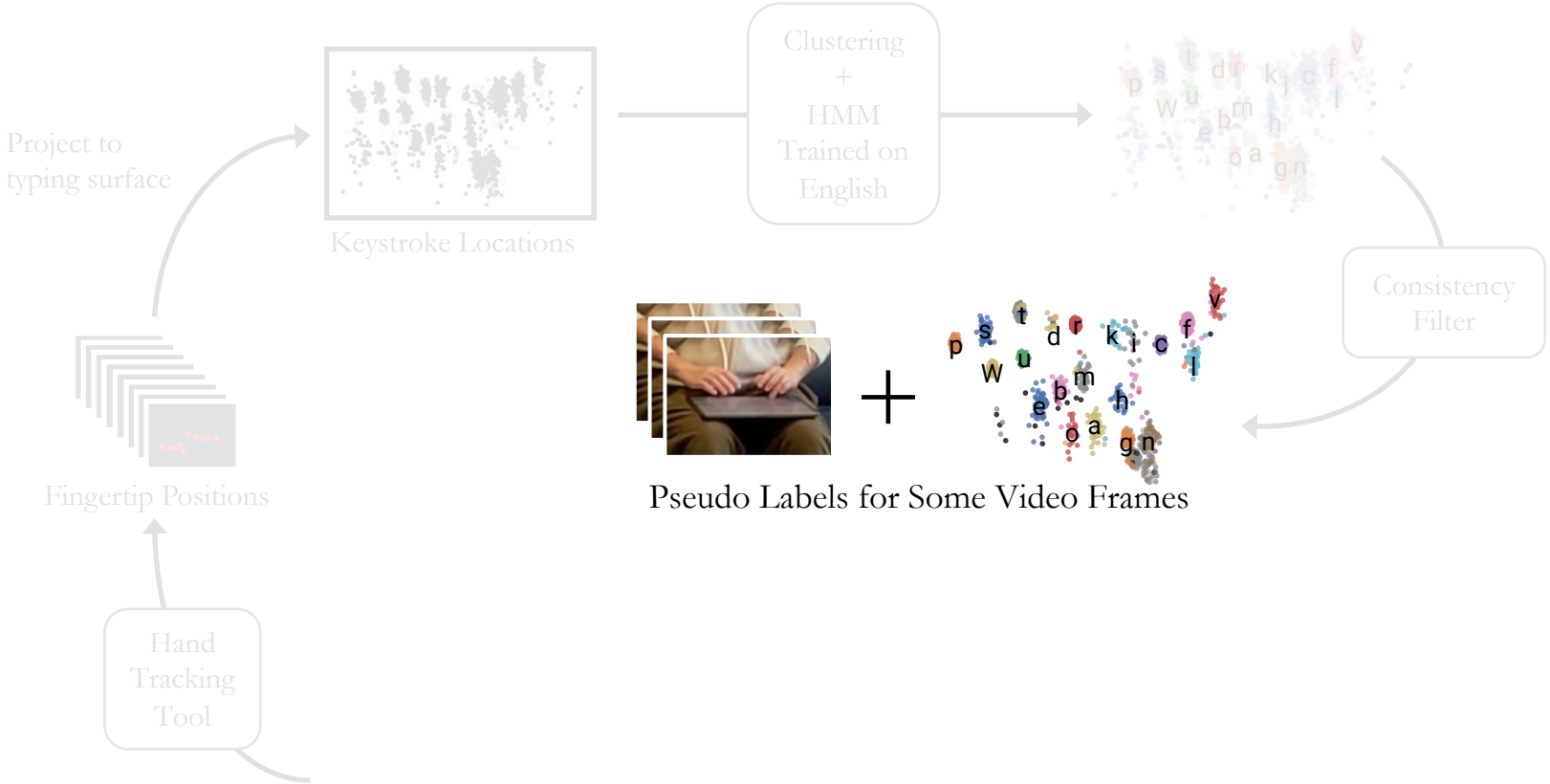


Step 2 – Model Training



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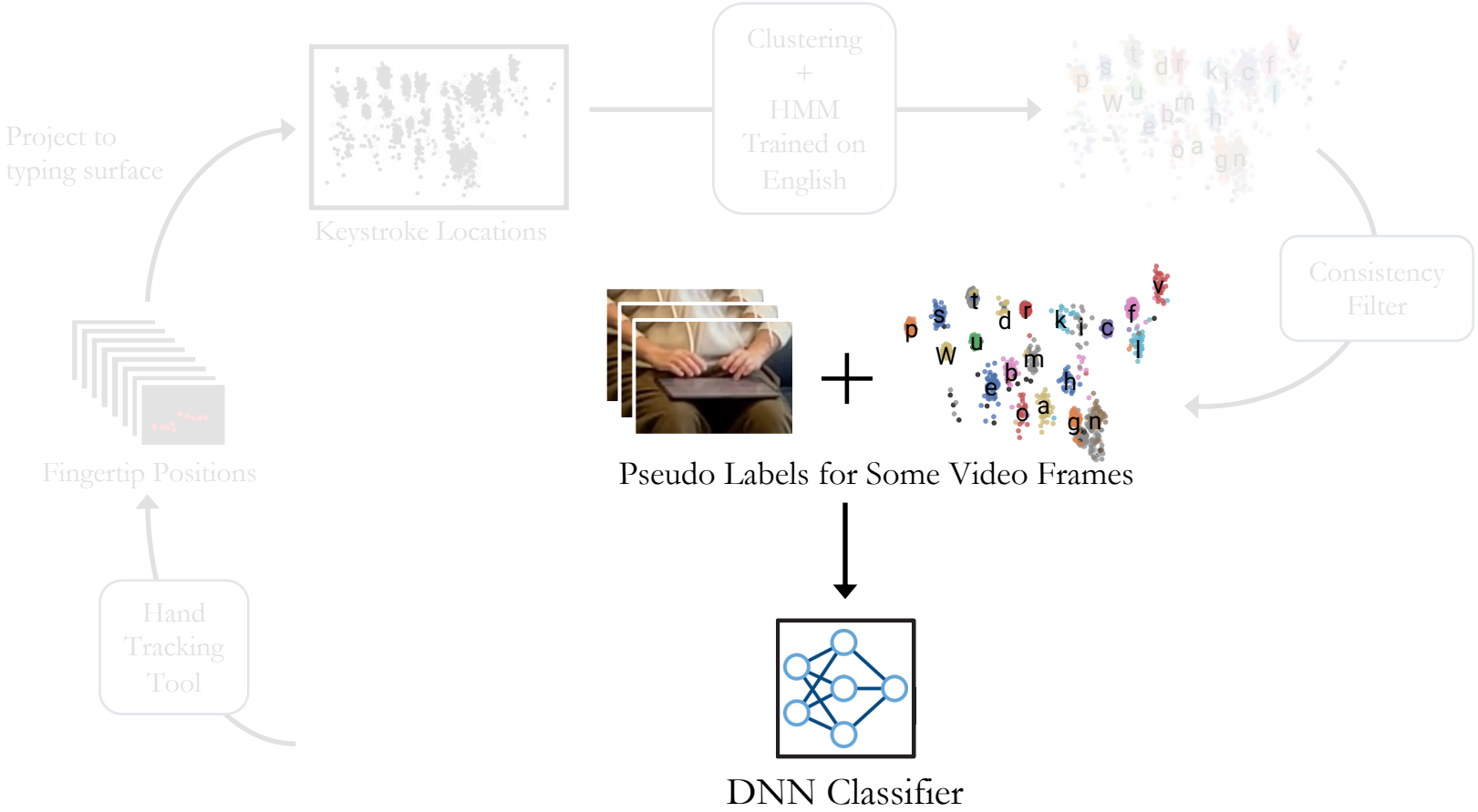


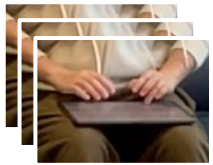
Step 2 – Model Training

Project to typing surface

Keystroke Locations

Clustering + HMM Trained on English

Consistency Filter



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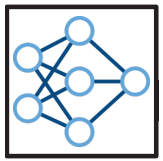
Pseudo Labels for Some Video Frames

Noise-Aware Training

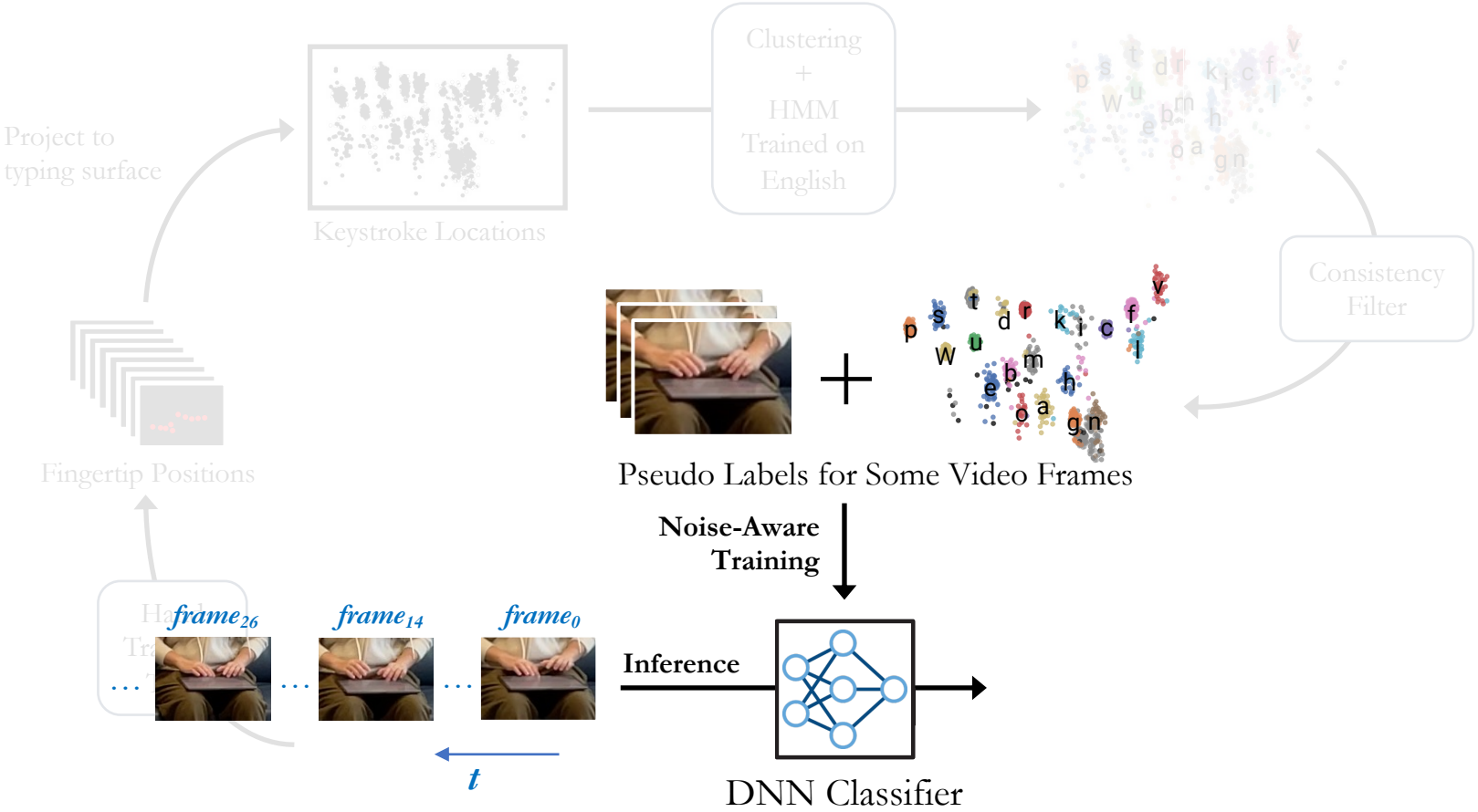


DNN Classifier

Fingertip Positions

Hand Tracking Tool

Step 2 – Model Training



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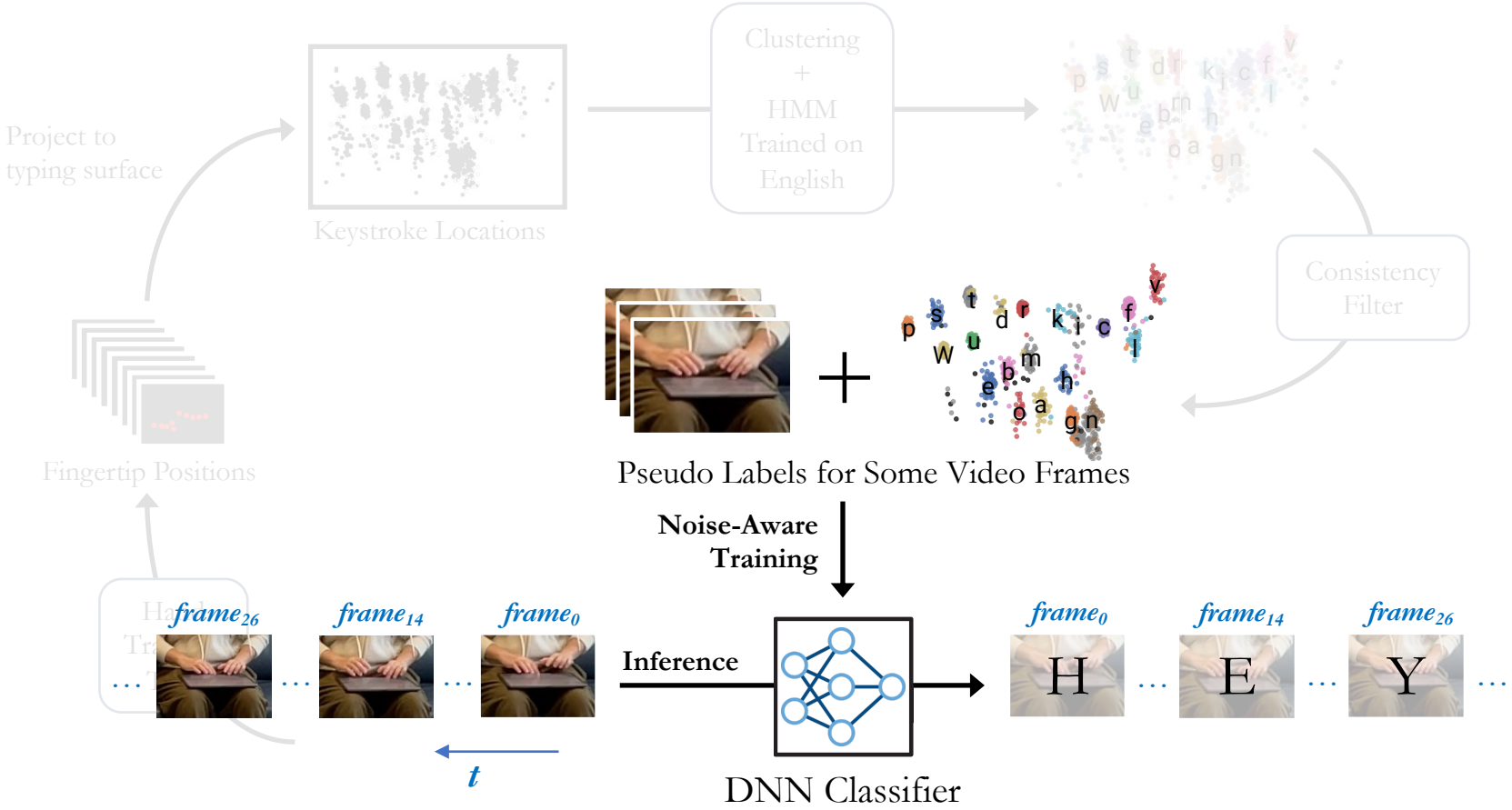

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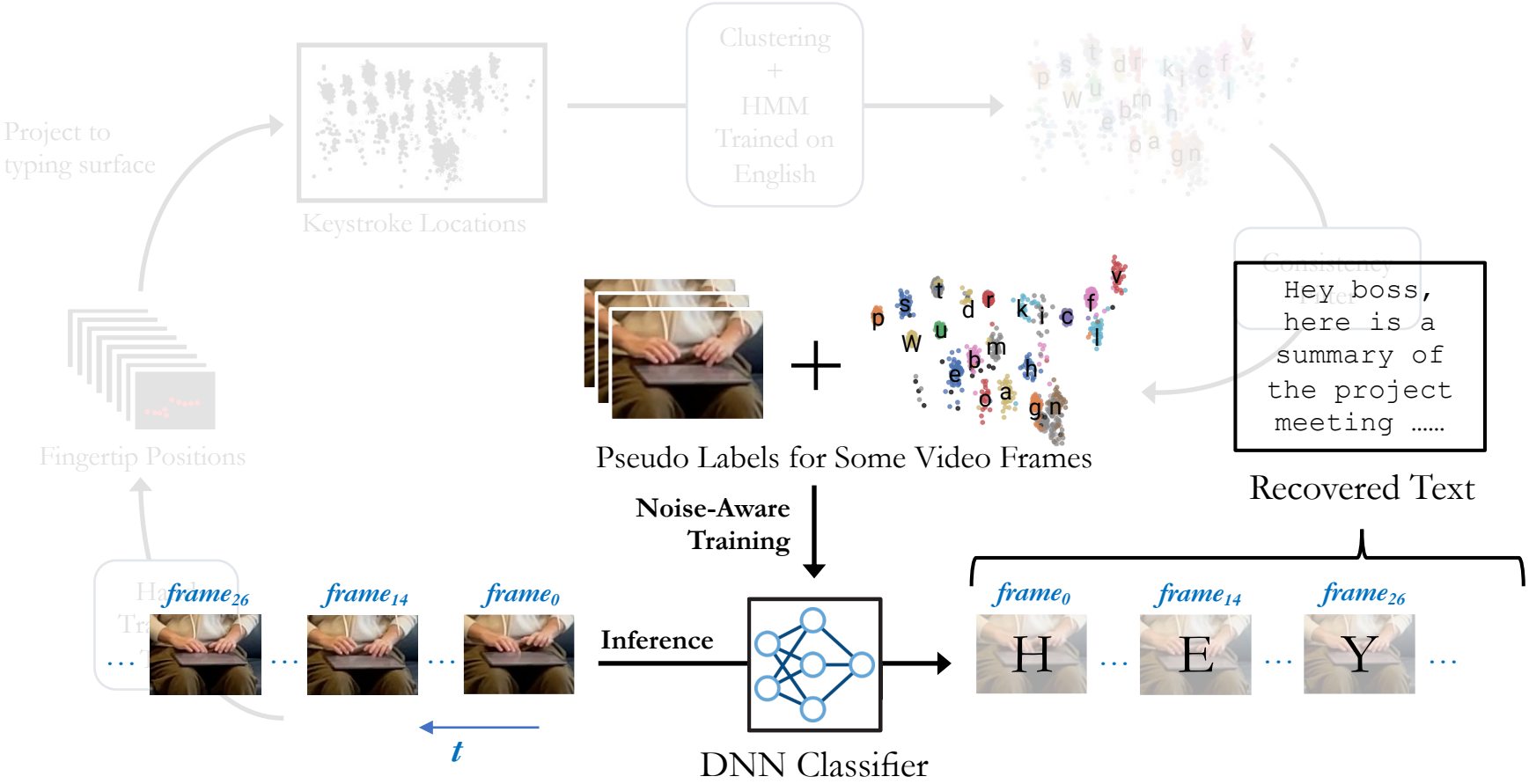
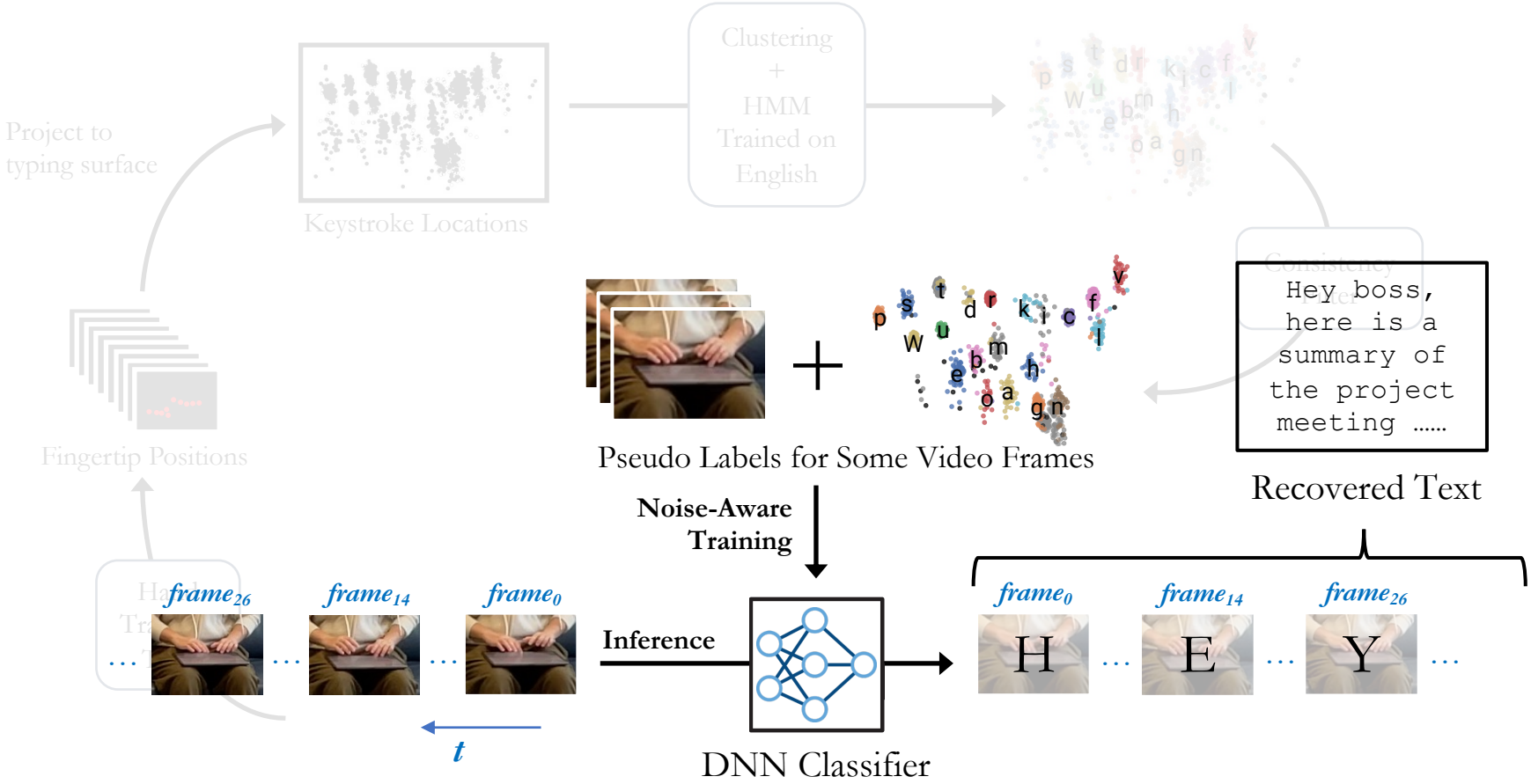


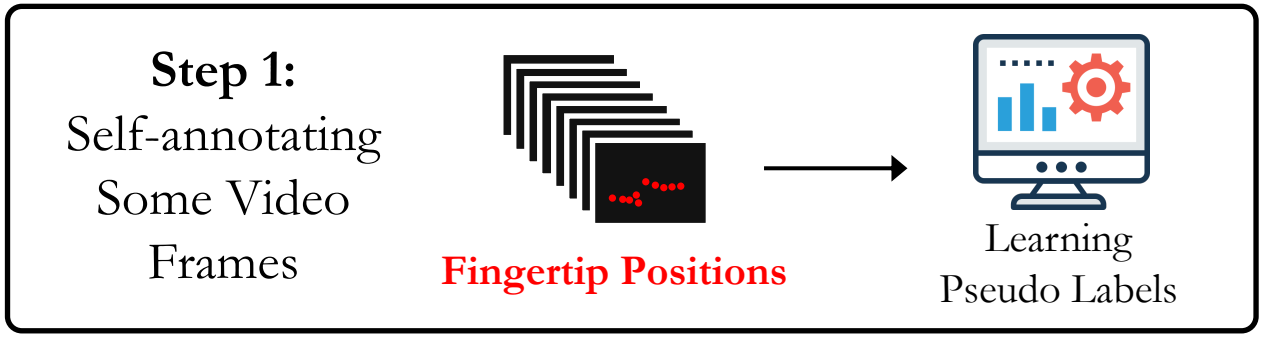
Step 2 – Model Training

See paper for more details



Design Takeaways

Step 1 & 2 use two different data modalities



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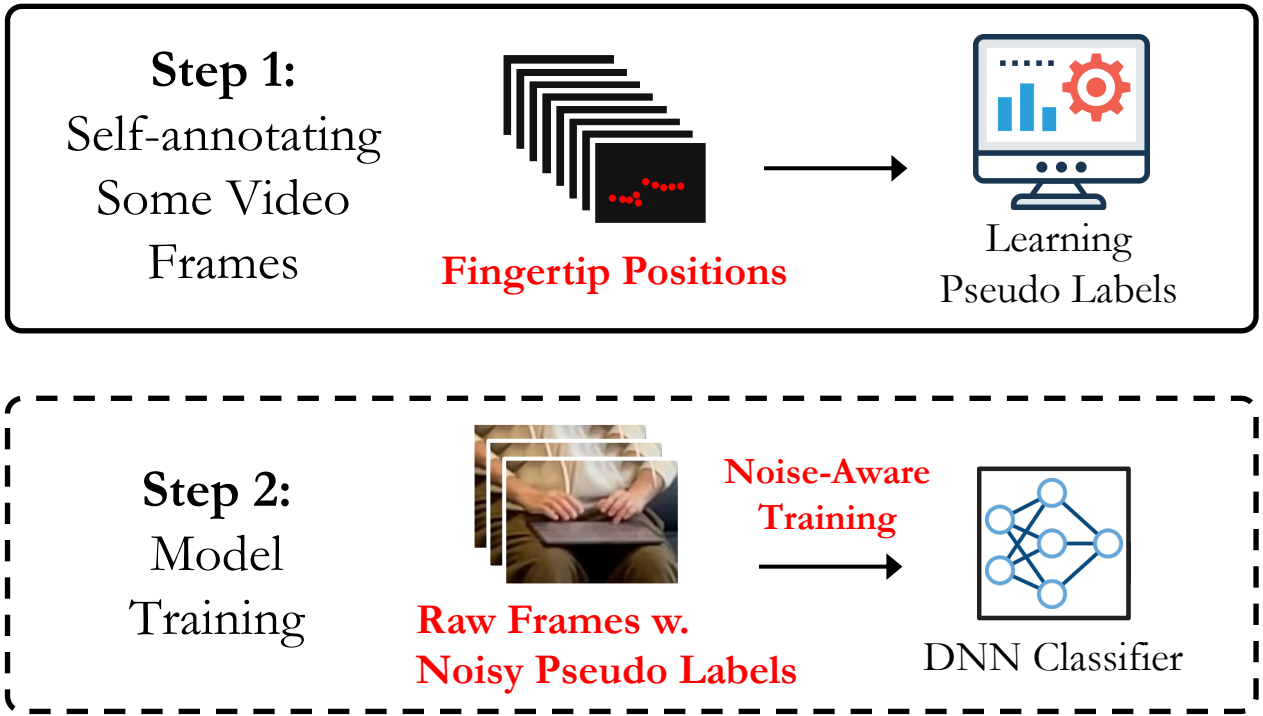

Evaluation (Across Users)

- 16 users
- Very different typing styles
- ~500 words email from Enron dataset
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User	CER (%) ⬇️	WER (%) ⬇️	Semantic Sim. (%) ⬆️
1	0.7	3.4	99.6
2	1.1	6.0	98.8
3	1.0	3.6	97.4
4	2.3	8.4	97.2
5	3.6	11.2	94.8
6	5.0	12.1	93.5
7	3.9	15.2	91.0
8	5.8	16.5	90.4
9	5.2	14.9	87.6
10	5.1	20.0	84.0
11	8.0	25.5	83.4
12	6.9	17.8	79.9
13	11.6	32.9	71.0
14	12.3	44.8	62.8
15	13.6	35.5	59.0
16	22.8	62.7	14.8

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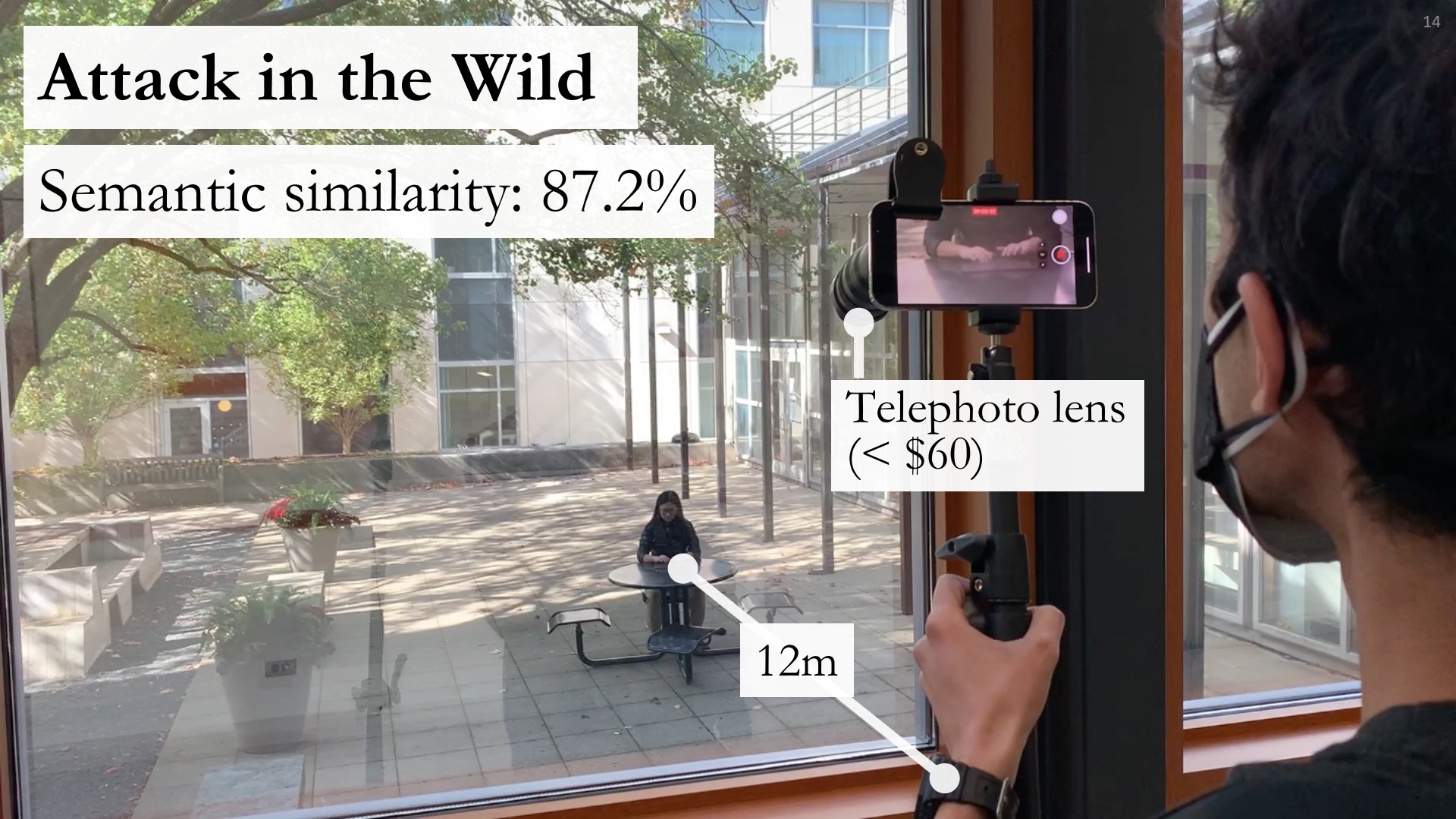
Avg: 6.8%

Avg: 20.7%

Avg: 81.6%

Attack in the Wild

Semantic similarity: 87.2%



No Visual Cue

Equally successful w/ and w/o keyboard

Defense
A physical shield

Project website:

https://sandlab.cs.uchicago.edu/keystroke/

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security, algorithms, networks and data