

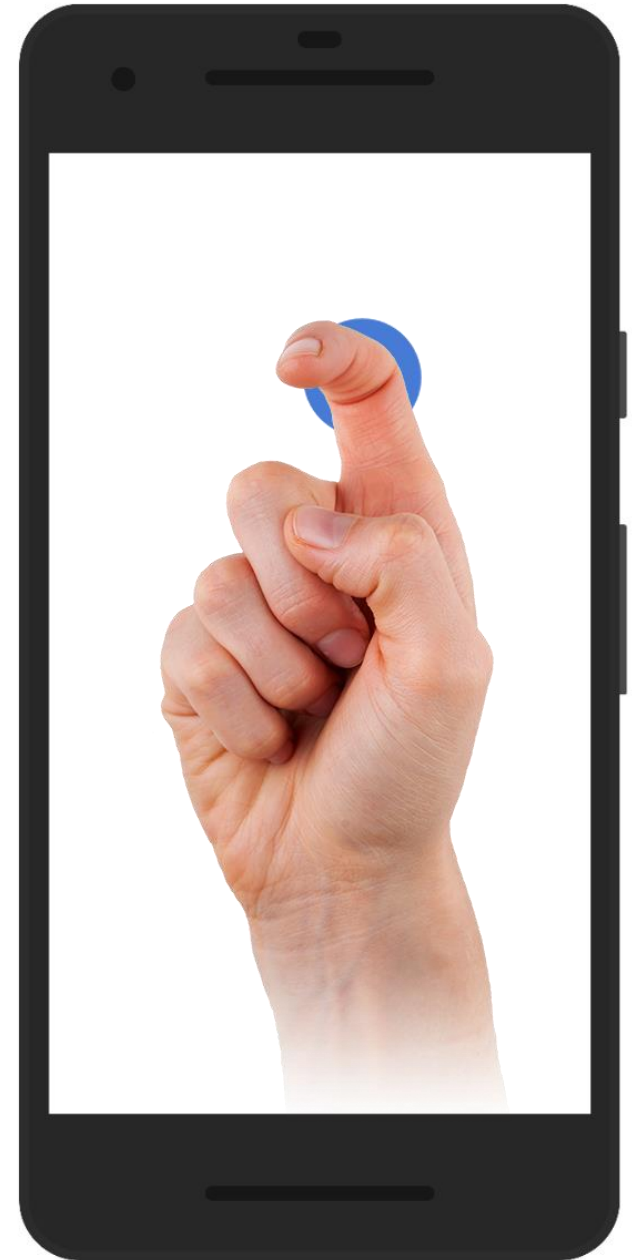
University of Stuttgart
Germany

Knuckle Input

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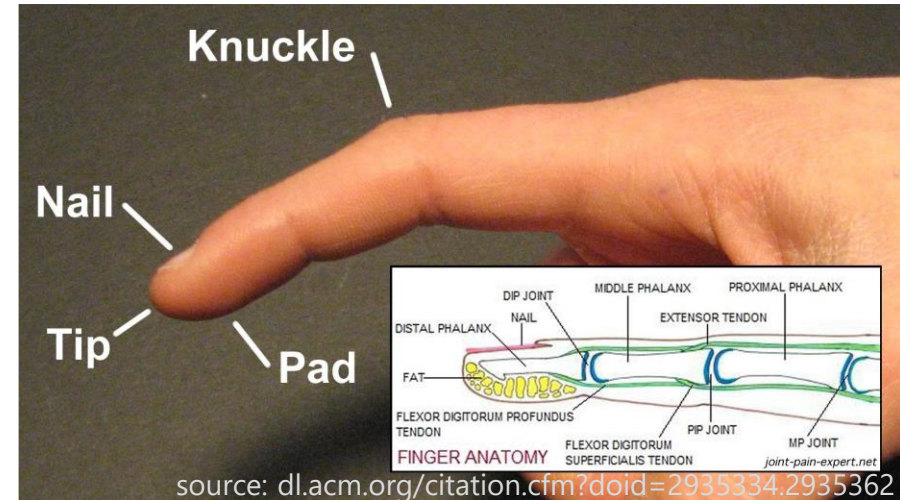
Motivation

- Extend current options for input on a touchscreen
- Recognize if touch input is finger or knuckle
- Differentiate between 17 different gestures



Related Work

- TapSense
 - Sound-based
 - Differentiate between four different finger inputs
 - SVM: 86% accuracy
- Nail+
 - 3x3 grid of strain sensors, worn on the fingernail
 - Different levels of applied finger-force can be detected
 - 85% accuracy
- Qeexo FingerSense
 - Different inputs can be detected through their vibration on the touchscreen
 - Implemented in Huawei Smartphones



Study

- Only right-handed, no movement impaired
- Two-handed interaction only
- 17 Gestures
- 20 repetitions per gesture
 - Both knuckle and finger
- Within-Subject design
- 17 participants
- Study-length: 60 minutes



source: time.com

Study App

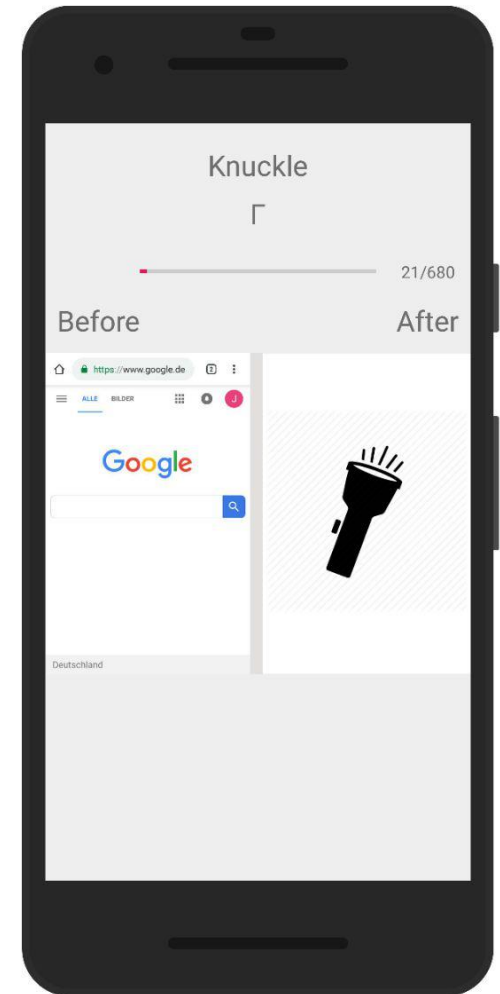
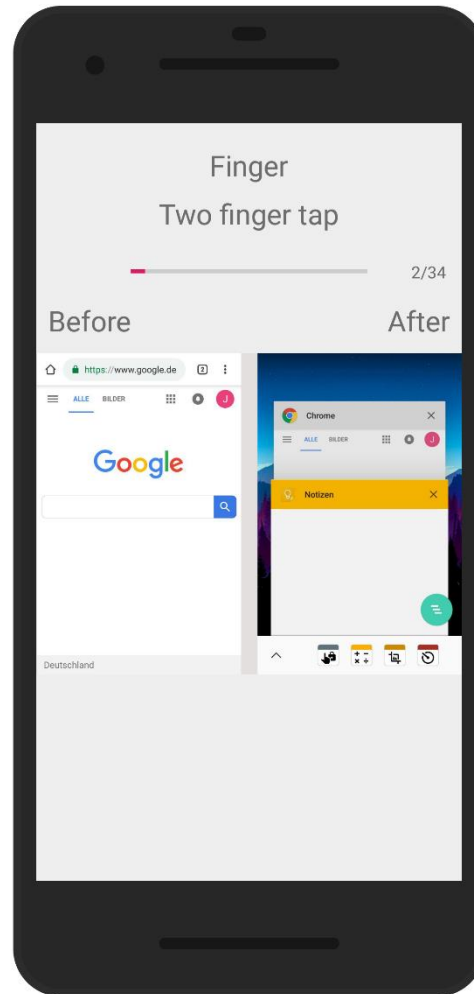
KnuckleInput

ID:
1

Age:
22

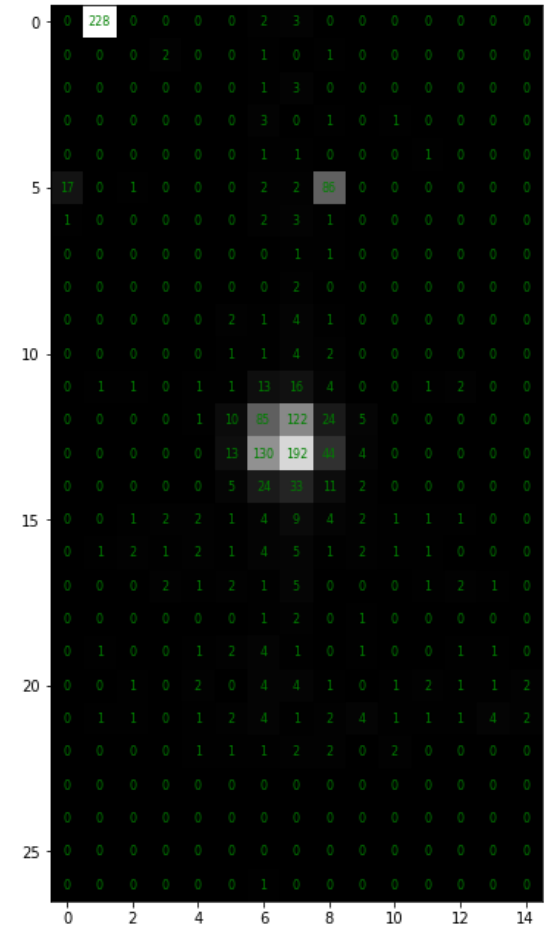
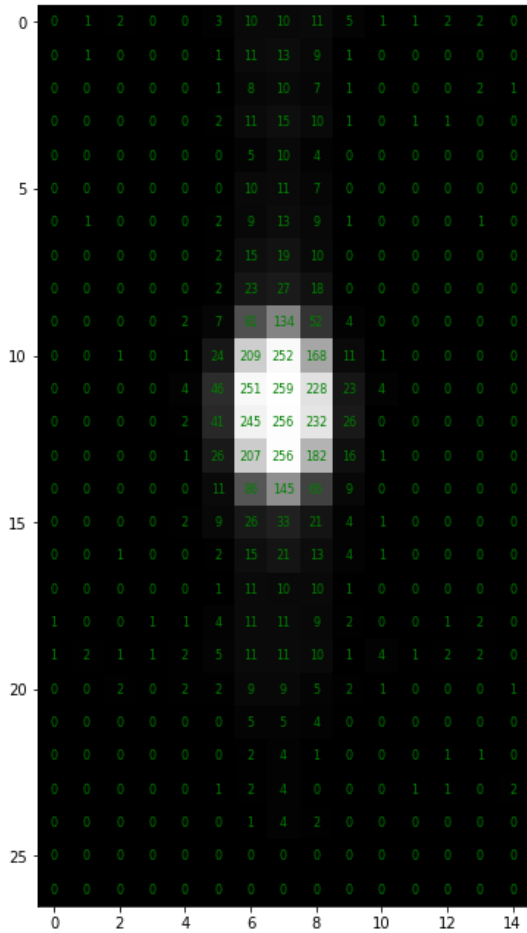
Gender:
☐ female
☒ male

START



Data Collection: Data

- 956.426 images in total
 - 27 x 15 pixels each
- 806.891 actual gesture images

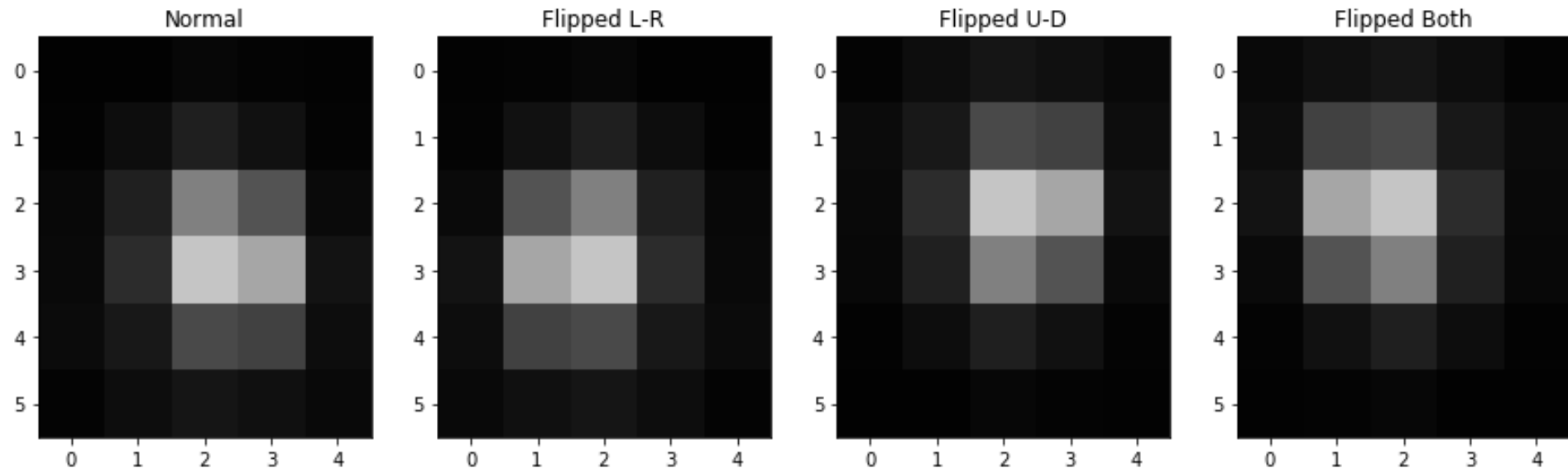


Preprocessing: First Filters

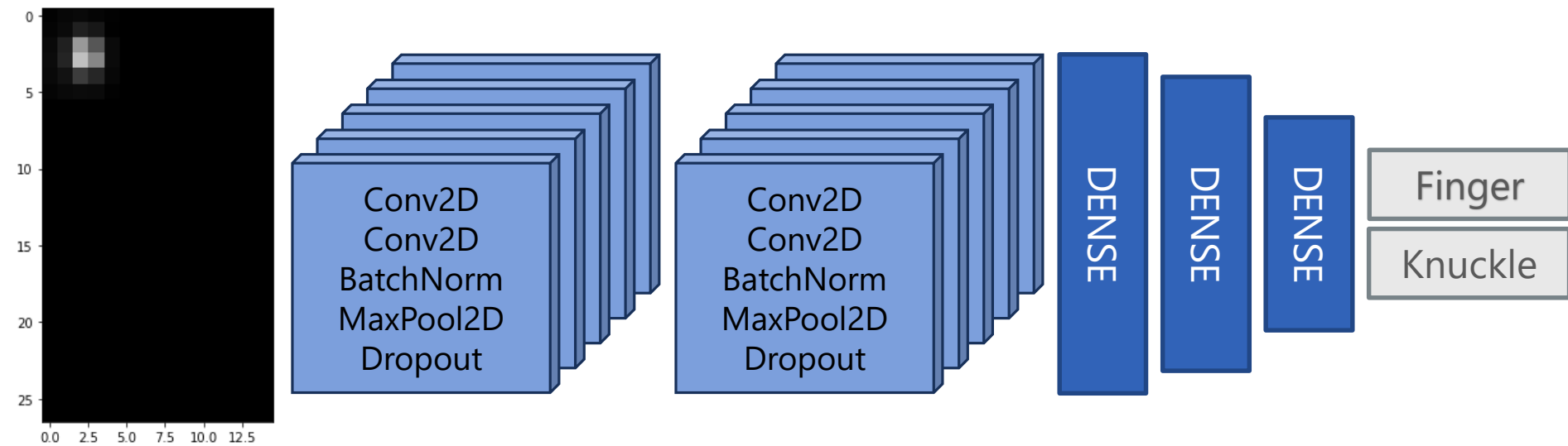
- Use highest repetition only
- Blob detection on images
 - Get rid of images without blobs
- Remaining: 155.439

Preprocessing: Data Augmentation

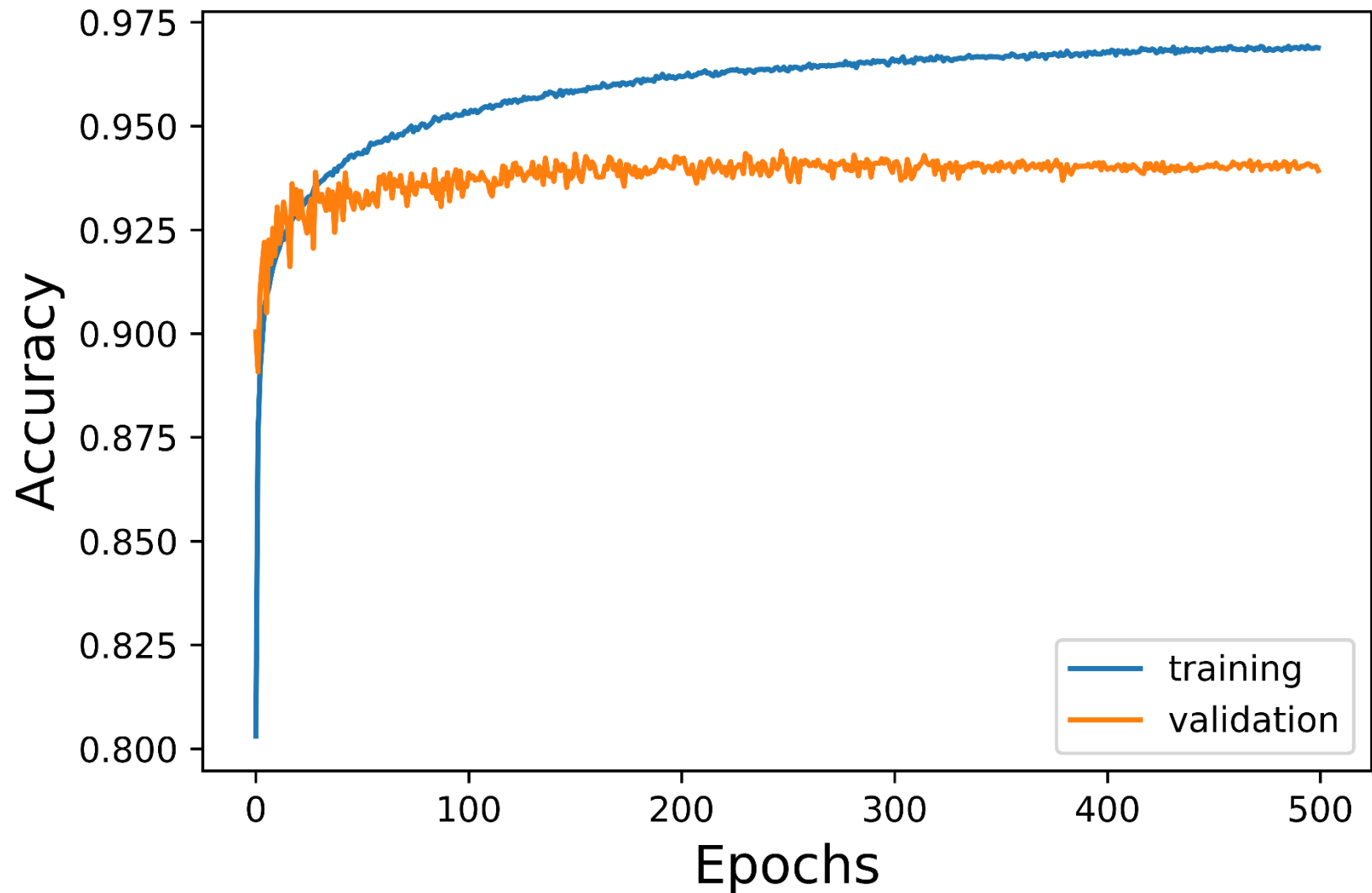
- Mirroring on both x and y-Axis
- New total images: 621.756



CNN: Structure

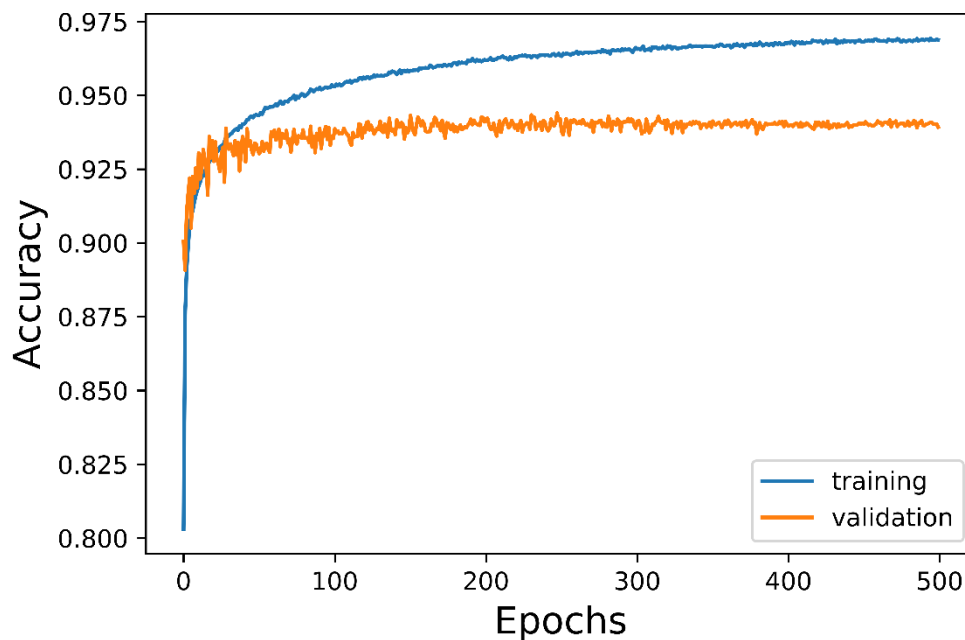


CNN: Results



CNN: Cross-Validation

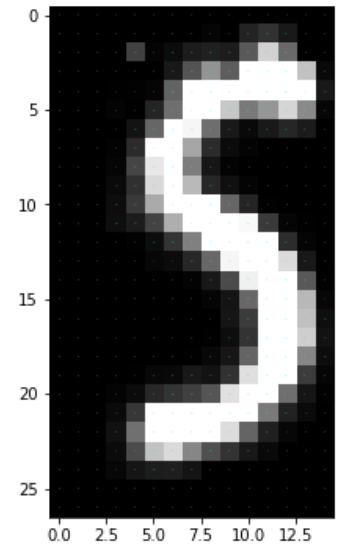
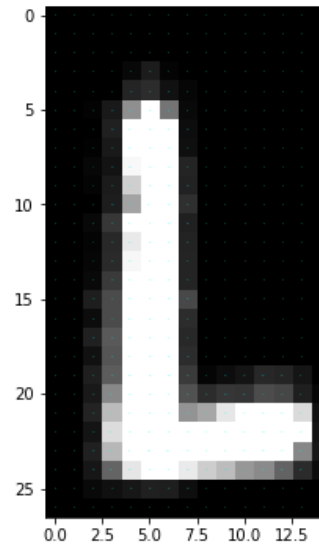
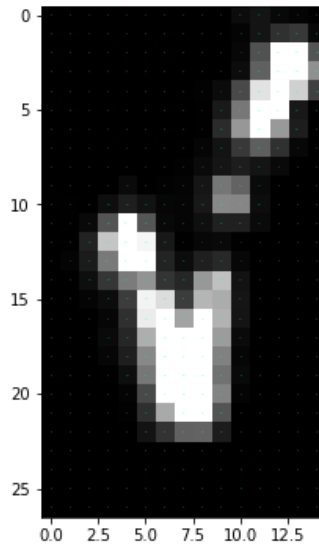
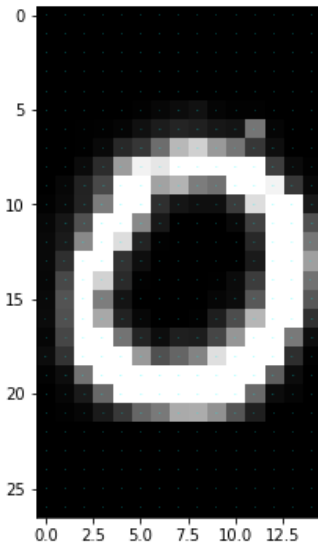
- Leave one out
- Trained for 500 epochs
- Mean values are very similar to a general trained model



TestID	ValAcc	Acc
1	0.9466	0.9596
2	0.9672	0.9577
3	0.9602	0.9533
4	0.9454	0.9612
5	0.9872	0.9571
6	0.9699	0.9562
7	0.9061	0.9625
8	0.9909	0.9560
9	0.8627	0.9613
10	0.8349	0.9636
11	0.8984	0.9586
12	0.9438	0.9596
13	0.9922	0.9589
14	0.9738	0.9568
15	0.9676	0.9569
16	0.9929	0.9543
17	0.9598	0.9545
Mean	0.9470	0.9581

Gestures

- First idea: CNN for gestures with combined images
 - Val. Accuracy ~ 40%

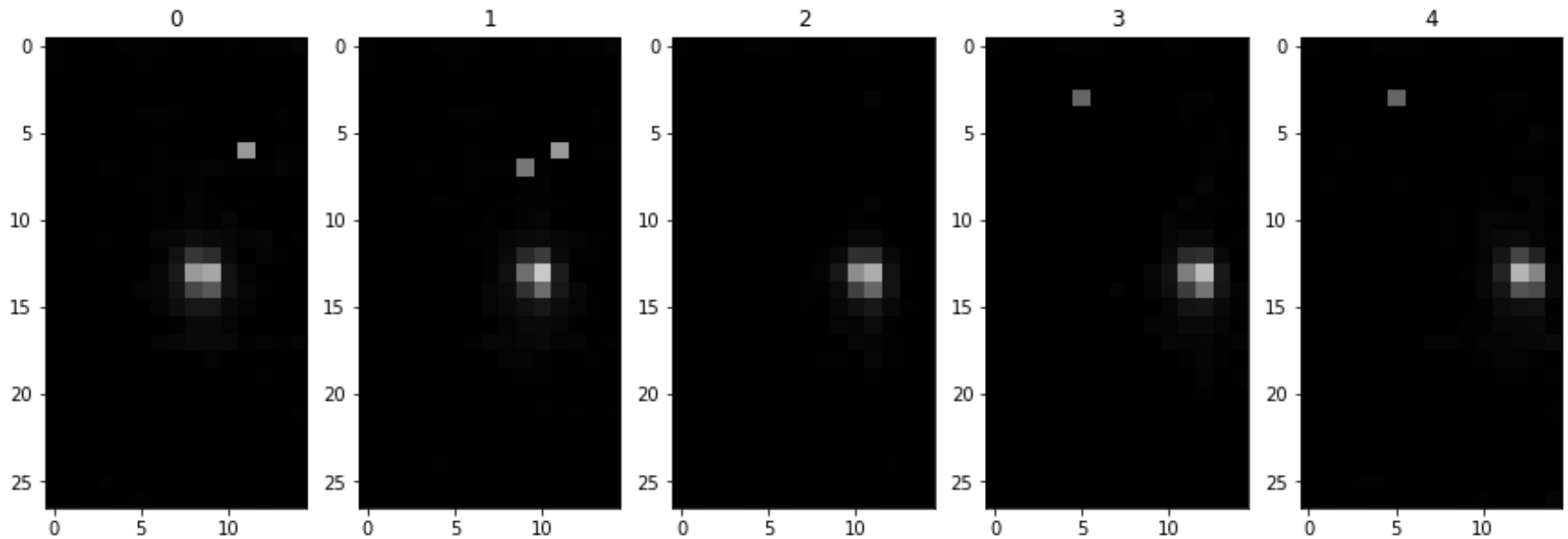


➤ LSTM

- Fixed window size (30/50)

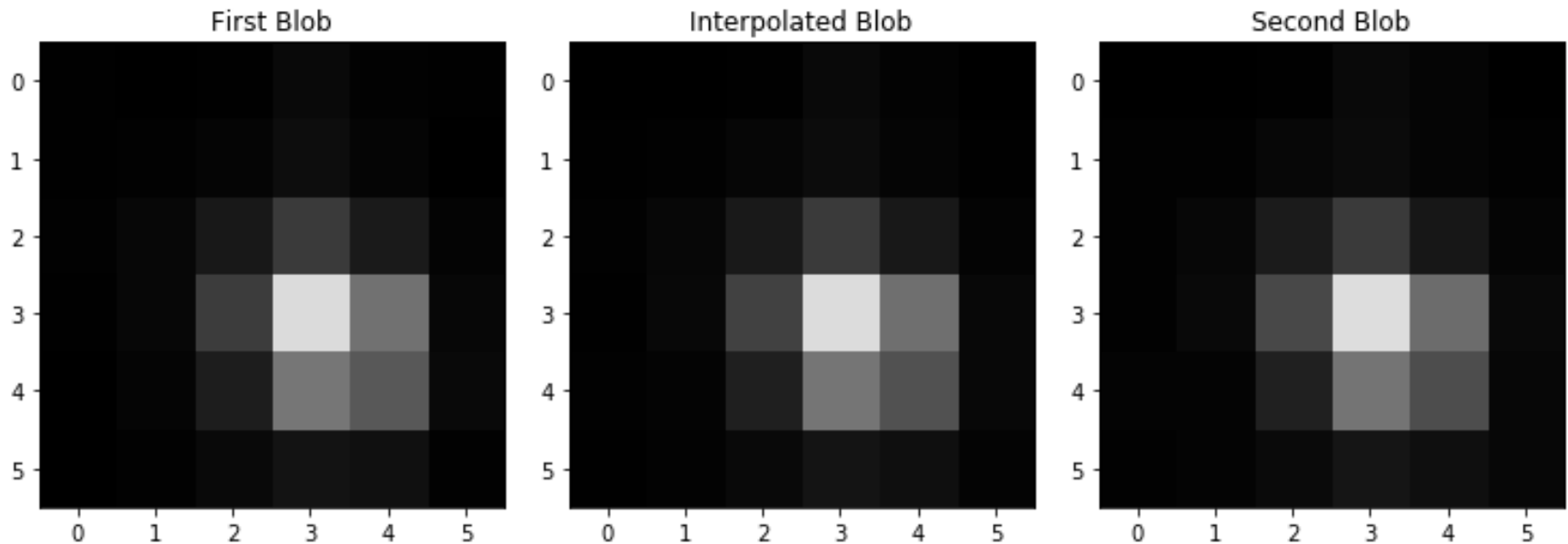
Preprocessing: LSTM

- Take images between first and last blob
- Reset gesture index
- Remaining: 8.088 gestures

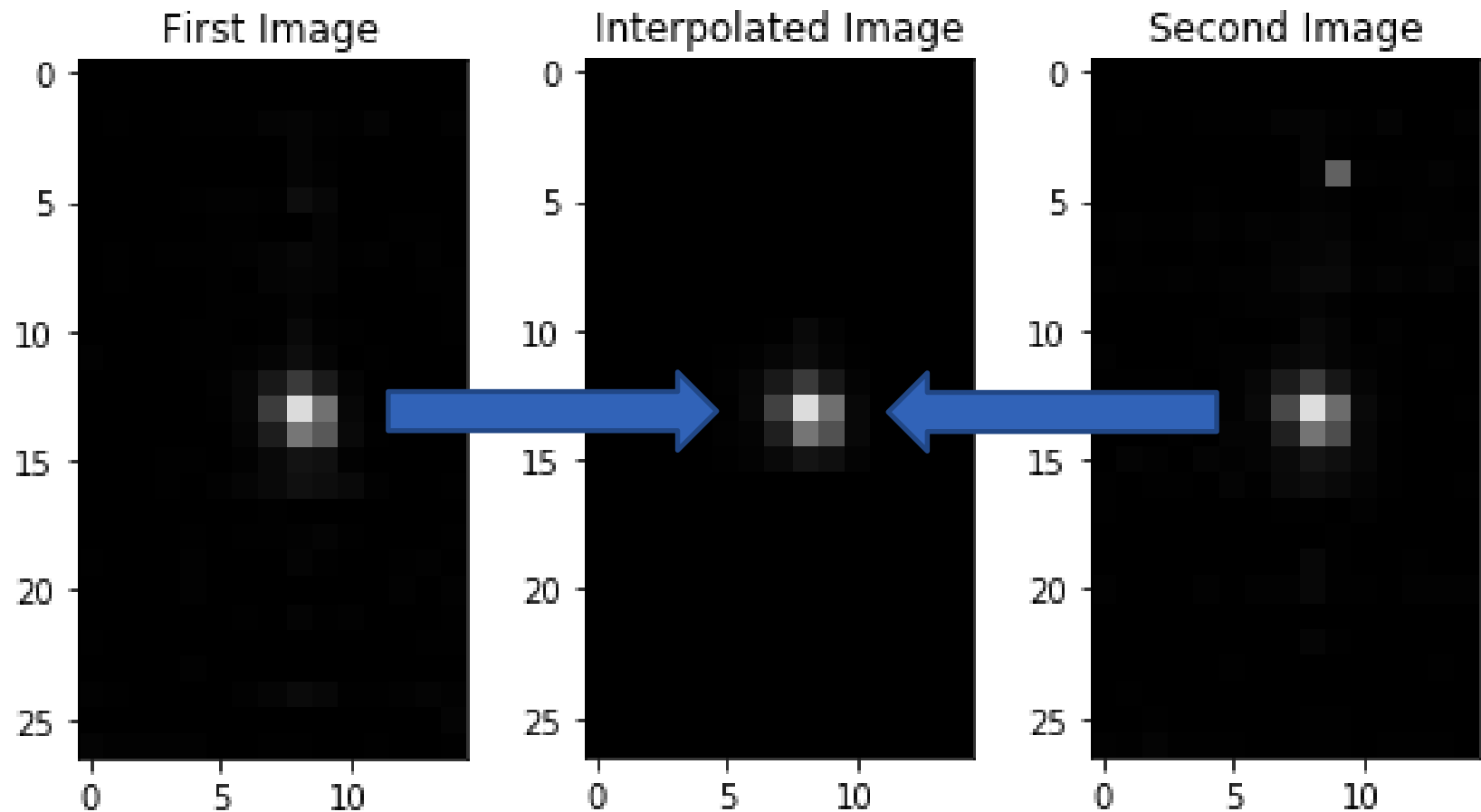


Preprocessing: Interpolation

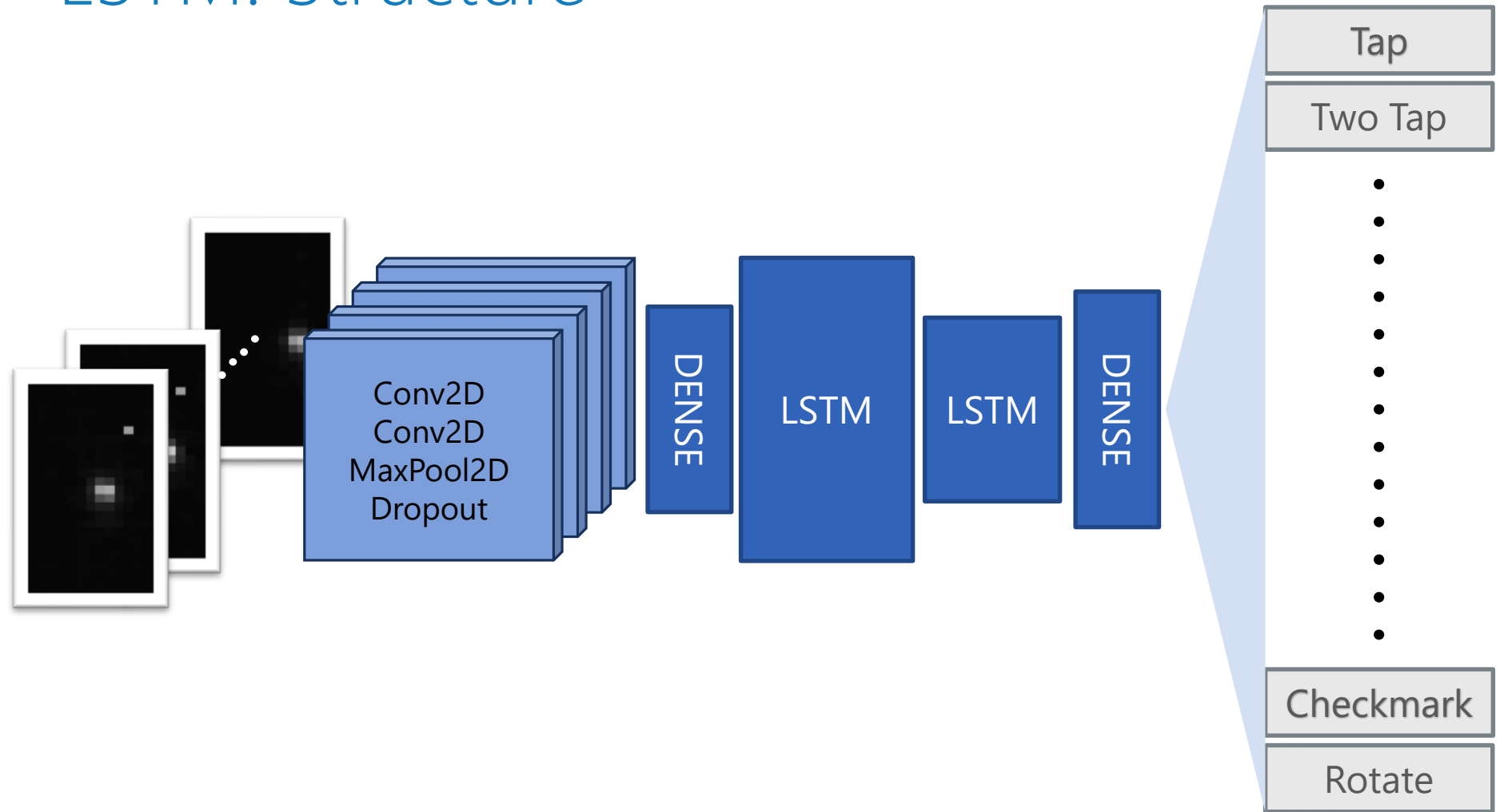
- Filter gestures by length
- Fixed window size, some gestures are longer, some shorter → Interpolation
- Detect blobs, interpolate blobs, interpolate positions



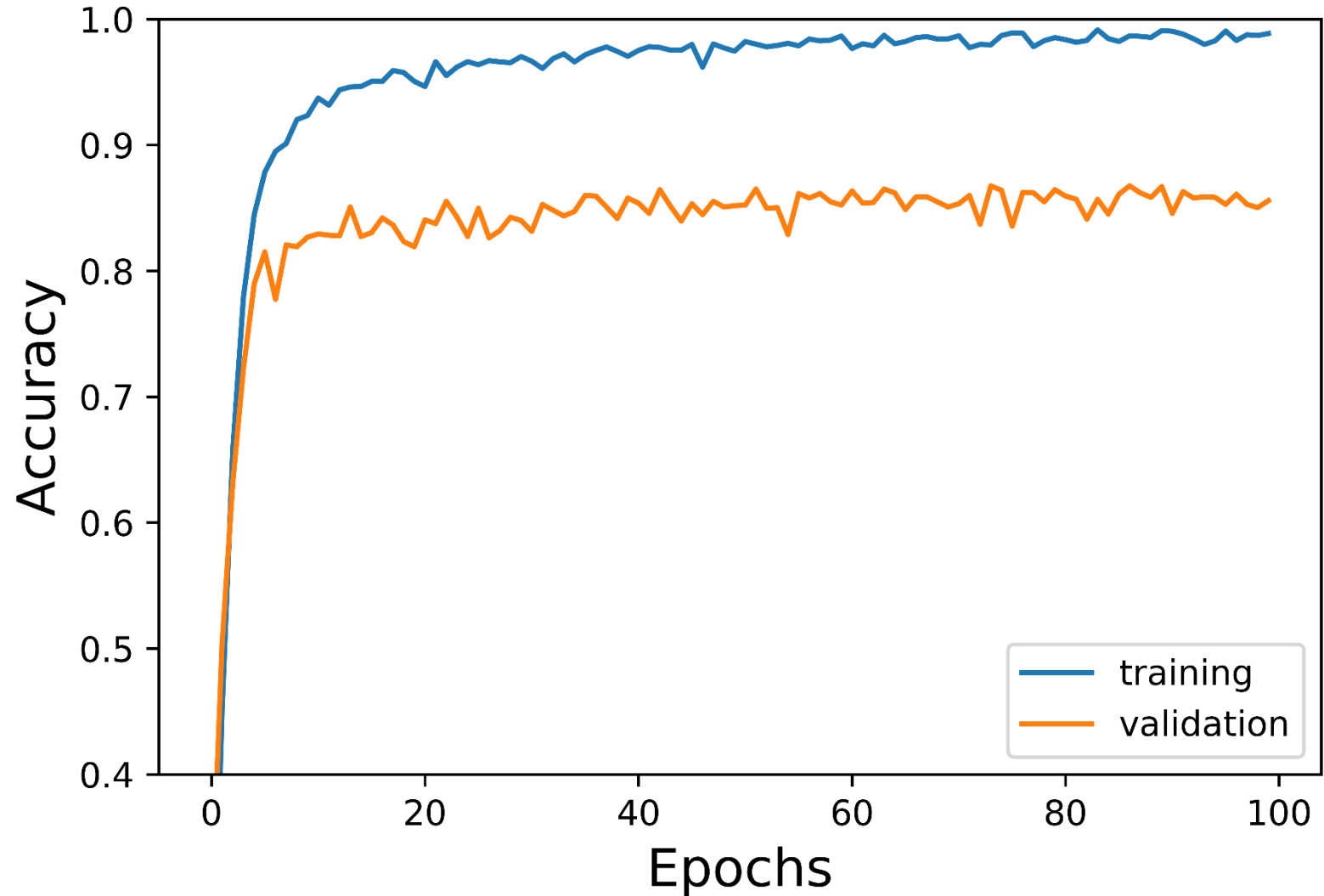
Preprocessing: Interpolation



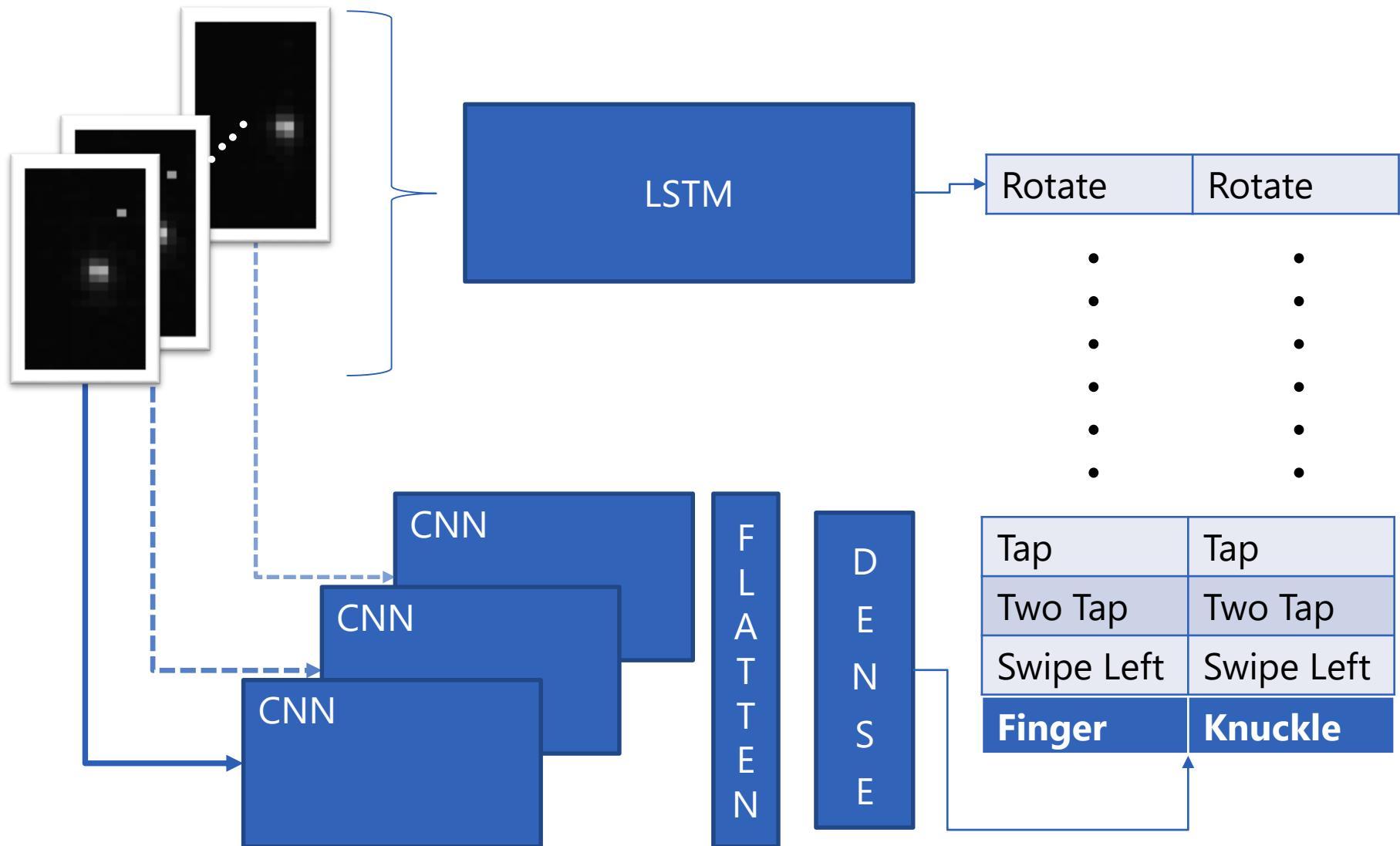
LSTM: Structure



LSTM: Results



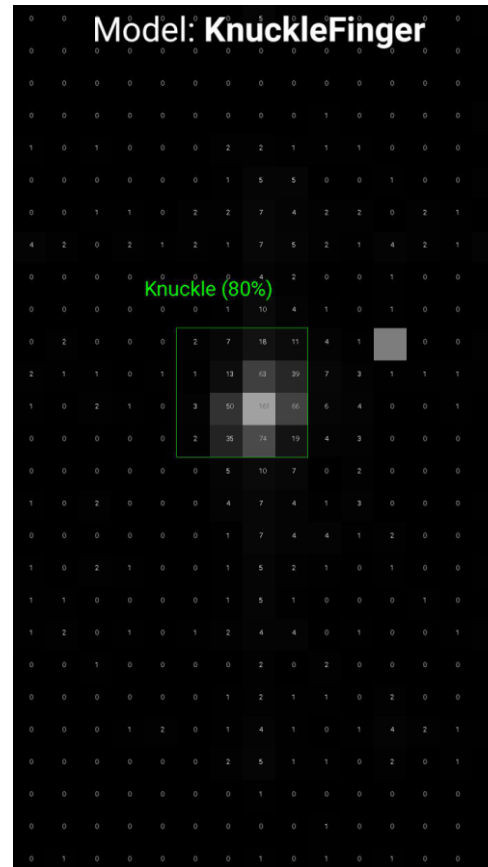
Combination



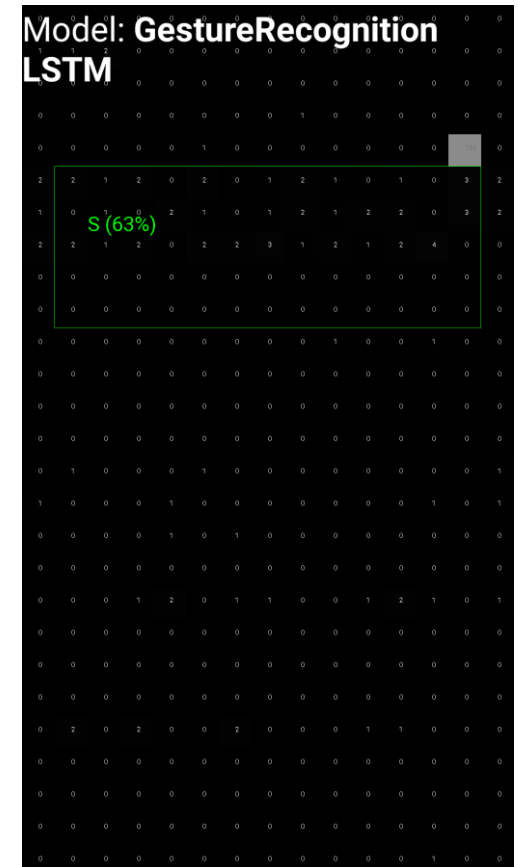
Demo App

- Visualisation:
 - Capacitive Image
 - Blob Bounding Box
 - Accuracy
- Models used:
 - CNN (Knuckle/Finger)
 - LSTM (Gesture)

CNN



LSTM



Future Work

- Another data collection: Different touch angles
- Combined gestures

Take away

- Neural networks for capacitive images work great at detecting if a touchscreen input was done by a finger or knuckle (95% accuracy)
- Gesture recognition with LSTMs for 17 different gestures also works fine (87% val. accuracy)

References

- <https://dl.acm.org/citation.cfm?id=2047279>
- <https://dl.acm.org/citation.cfm?doid=2935334.2935362>
- <https://qeexo.com/fingersense/>