

Image Analysis

DIGIT RECOGNITION

Milestones of digit recognition

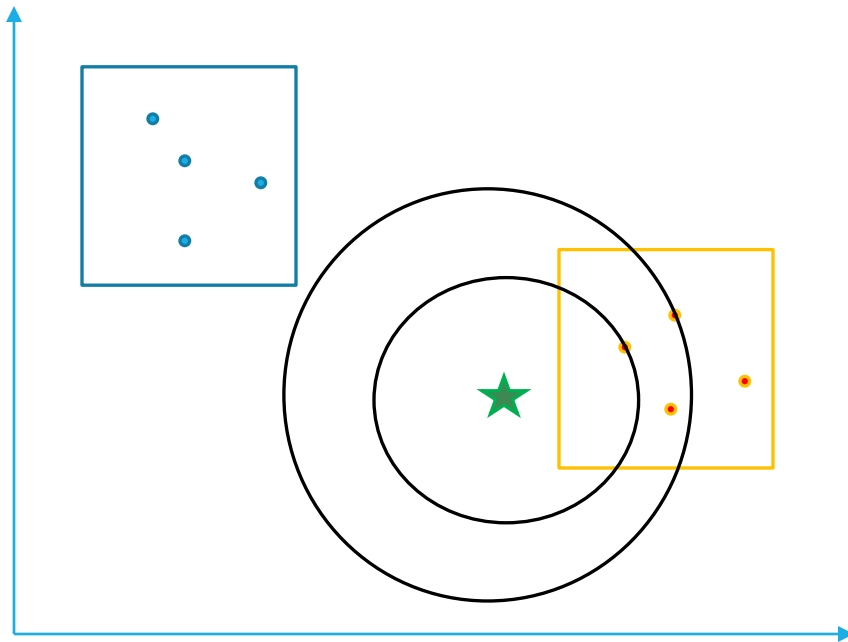
Must-have Project

- Preparations: self-written parser
- Main Algorithm – KNN: self-written → Scikit-learn function
- Further optimization of KNN via PCA, best parameters for PCA (n-number of PCs used) and KNN (k-neighbors)
- Meta-digits: mean, median, best neighbored
- Analysis of falsely recognized digits

Drawing canvas

- Drawing environment
- Centering
- Evaluation

K-Nearest Neighbours (KNN)



Which K training vectors are the nearest to our test-vector (euclidian distance)

-> Which k training images are the most similar to our test image.

In this example with 2 dimensions
(our case has 784 dimensions)

KNN accuracy analysis

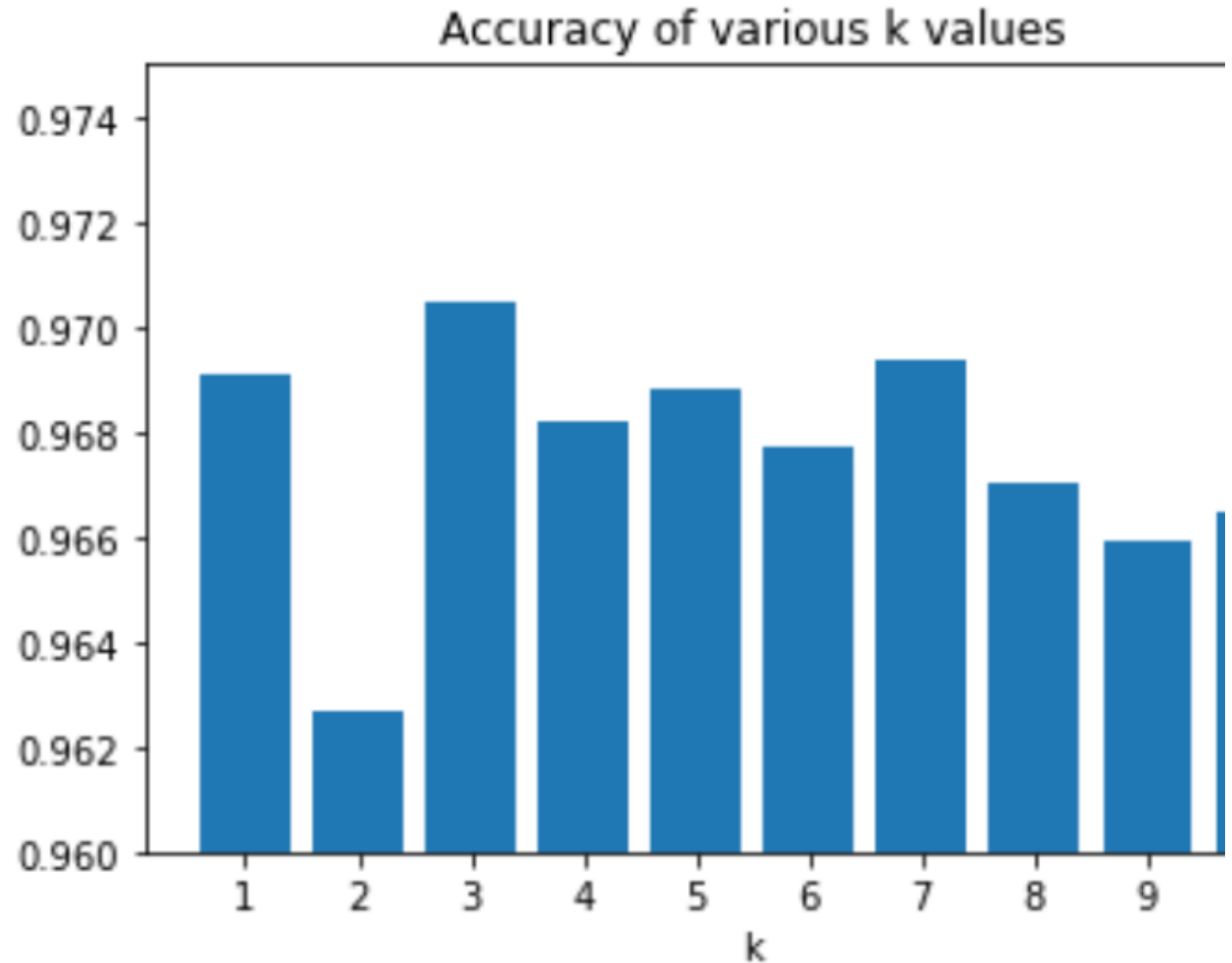
Best number of nearest neighbors: $n=3$

- Around 97% accuracy

Conflict with even values for k

- Algorithm chooses randomly

If k is too big, there is a risk that distances that are too far are included



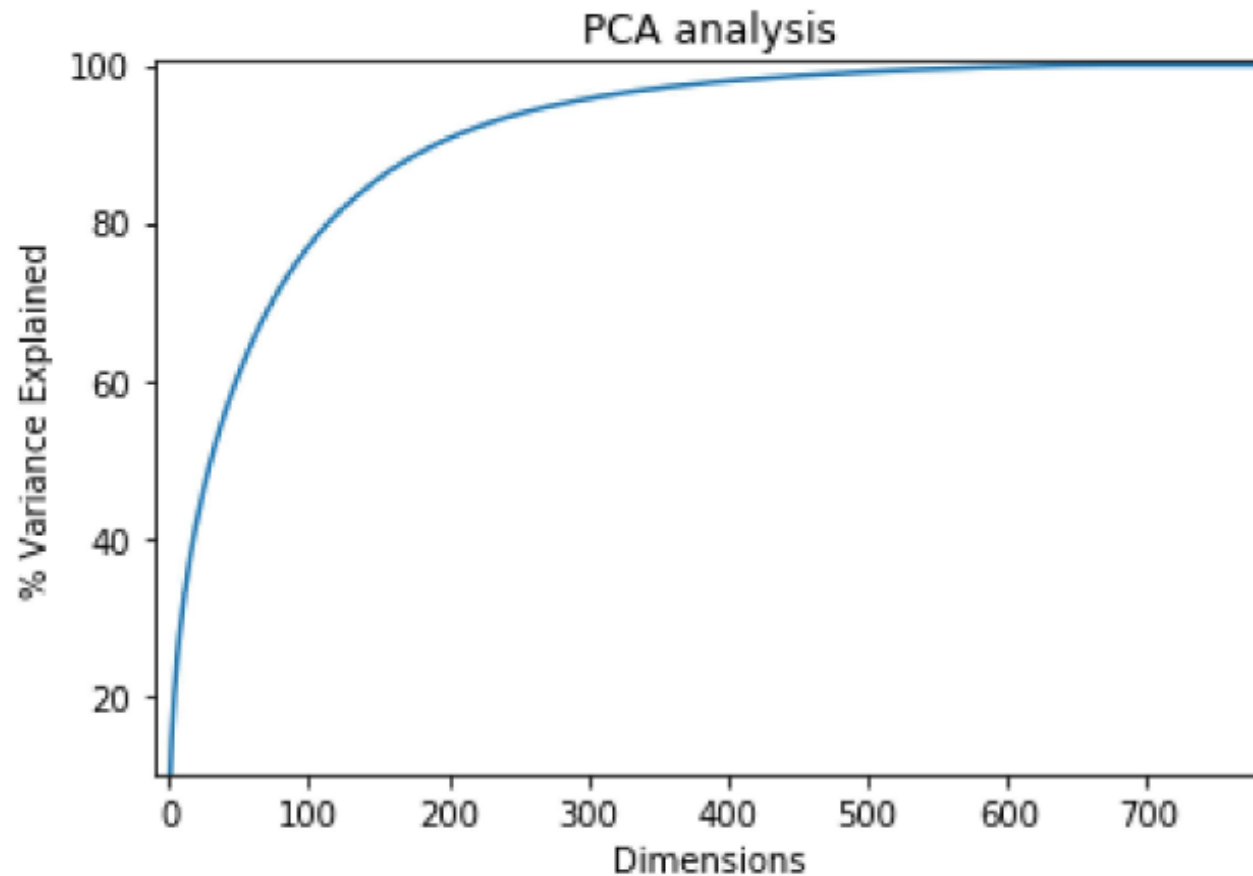
Principal Component Analysis (PCA)

The image is a 784 dimensional vector. 60000 train images, 10000 test images -> KNN takes too long

Solution: **PCA**

- Reduces dimensionality by eliminating redundancy and emphasizing variances.
- We used scikit-learn function
- Not only accelerated calculations, but also increased accuracy by noise reduction

Variance explained by PCA

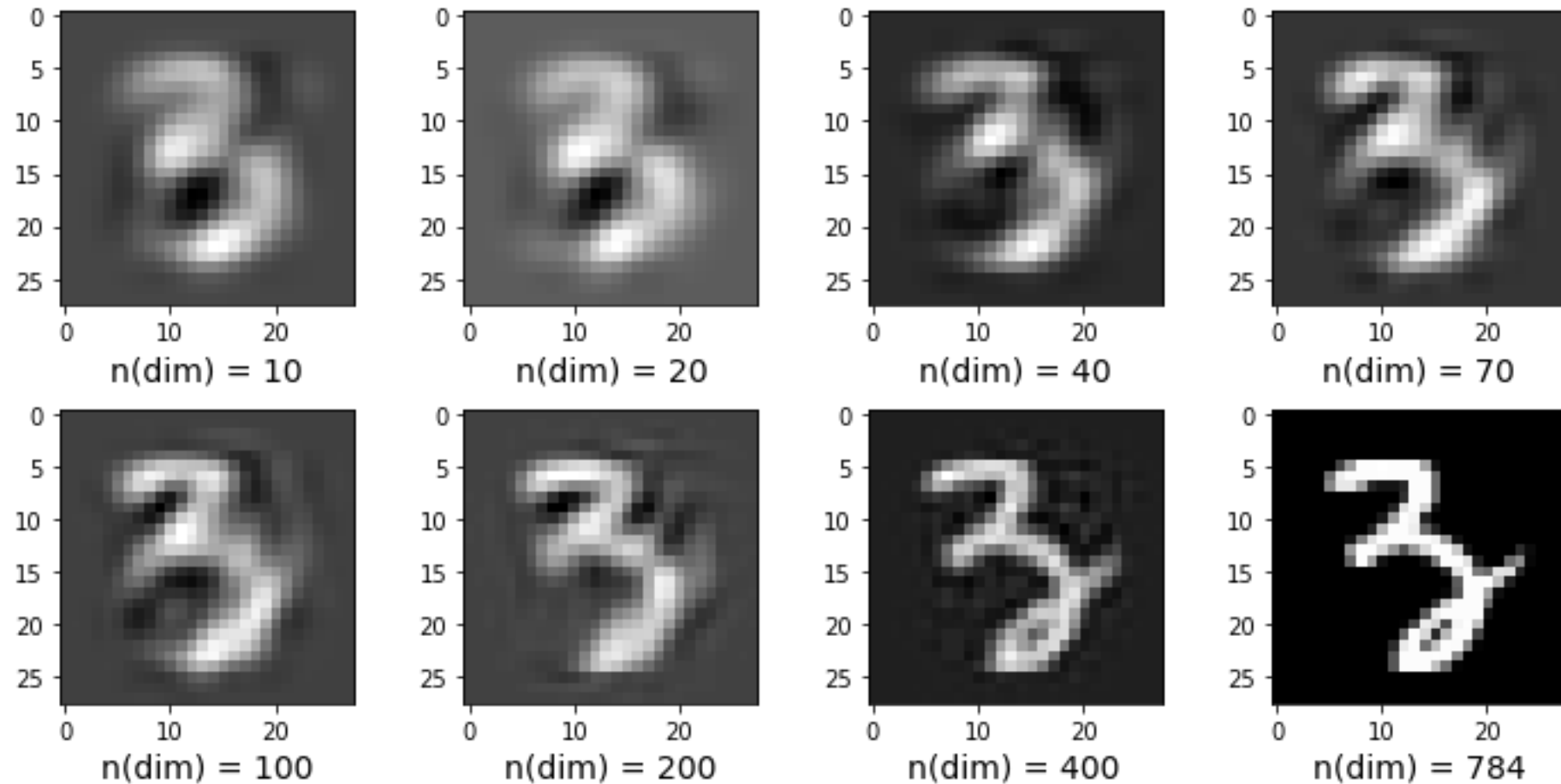


- First PCs explain the most variance due to the way the PCA works
- Idea at the beginning: to visualize the data points in 2D space and may be find some interesting tendencies

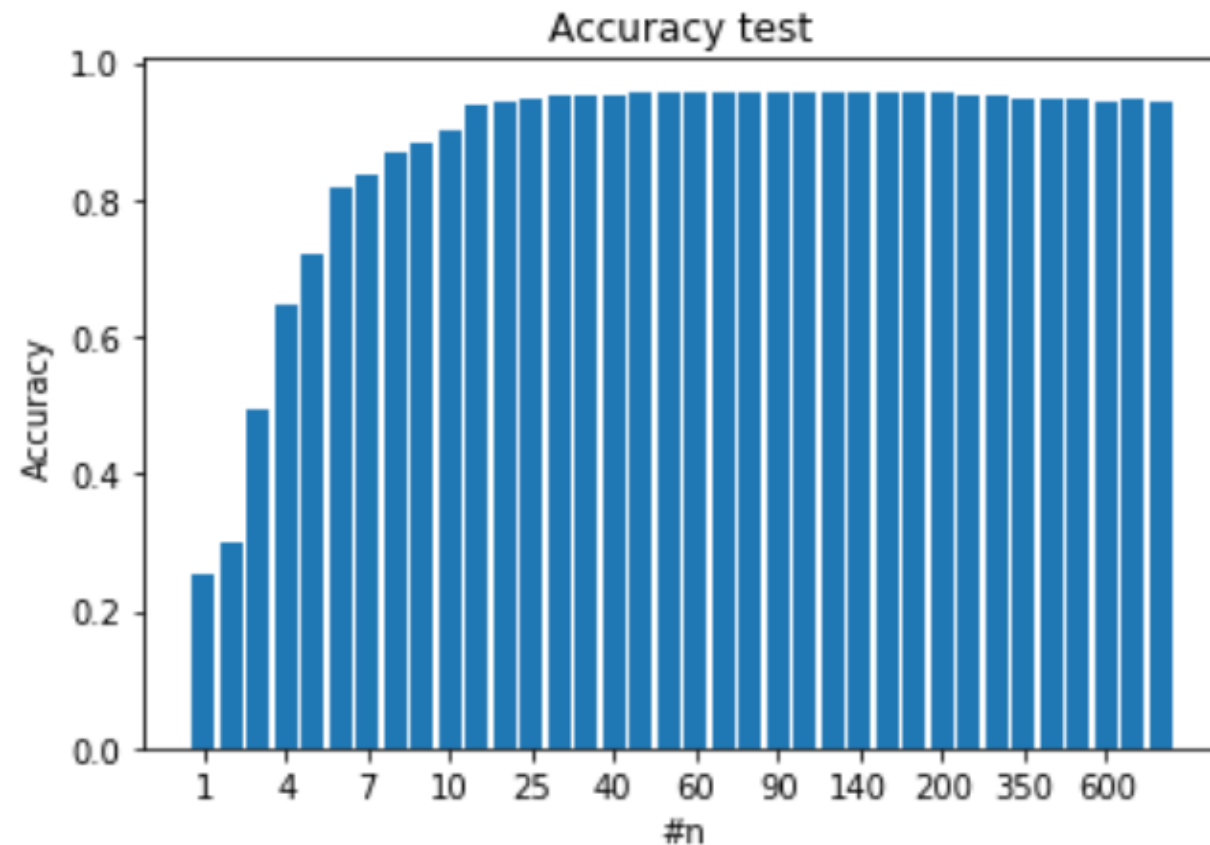
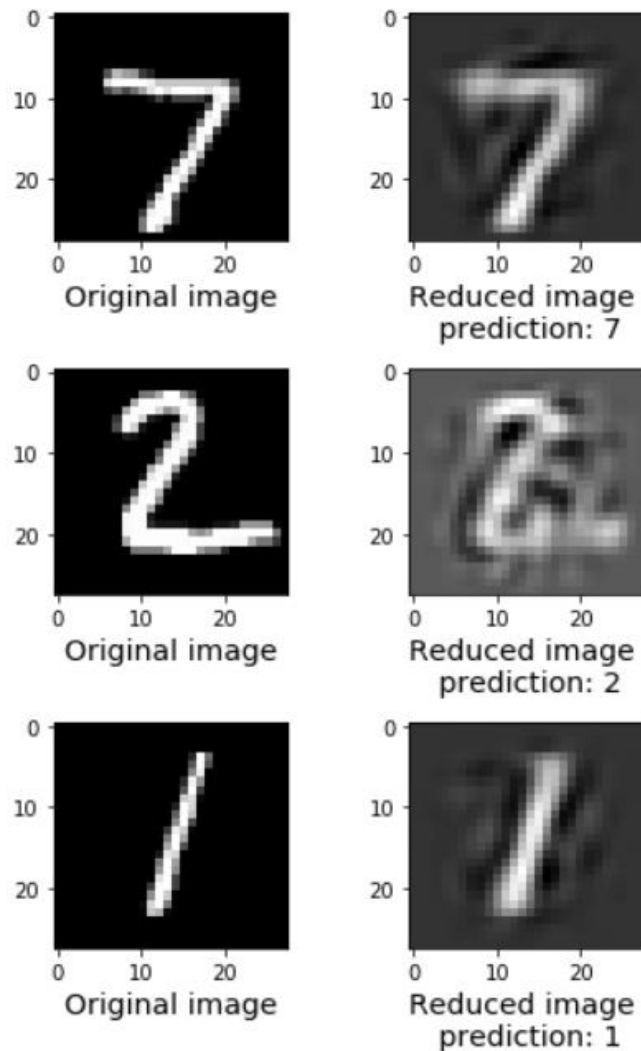


- Not possible, first two PCs explain too little variance

Recovered images




Interesting tendencies and the best parameter



- Highest accuracy with 78 dimensions
- Noise reduction
- 2 dimensions: less than 5% variance, but more than 30% accuracy
- 3 dimensions: 5% variance, the highest increase in accuracy (to 50%)

Interesting tendencies

- 2 dimensions: less than 5% variance, but more than 30% accuracy
 - 3 dimensions: 5% variance, the highest increase in accuracy (to 50%)
- 
- Are these 30% from 2 dimensions in 50% in 3 dimensions?

1) More generally, are there digits which were recognized in n dimensions, but mixed up in $n+1$?

Solution: 784 diagrams with 10 categories and accuracy of recognition for every category.

2) (Hypothesis) 30% and 50% of accuracy are not evenly spread among all digits. There are some, which can be recognized even with 2 dimensions and some, which are unrecognizable even in 10. (should be seen from the 1. diagram) With which digits are they often mixed up by different dimensions?

3) There is the maximum of accuracy by 78 dimensions due to noise reduction. But what digits are better recognized by 78 than by 784.

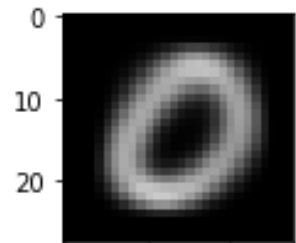
-> digits with a high noise-component

Finding meta digits

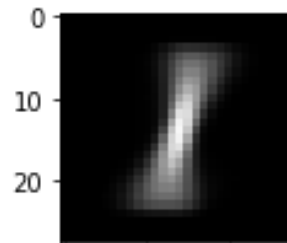
Objective: Something what describes digits with the same label.

- Reason:
- To see a cause for a wrong recognition by KNN by comparing of falsely predicted with Meta
 - We need a reference point for drawing canvas to evaluate our own hand-written digits

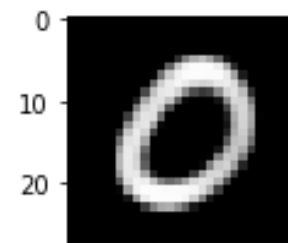
Two easiest solutions: mean and median meta digits



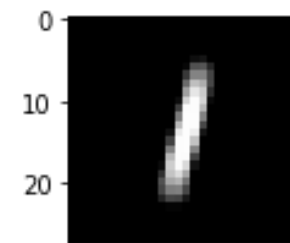
Mean of all 0's



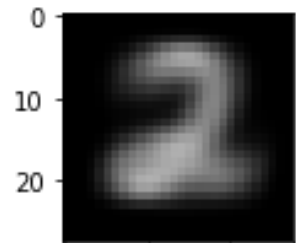
Mean of all 1's



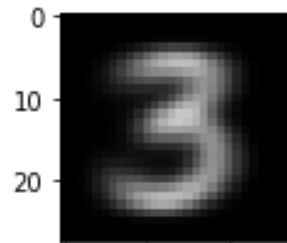
Median of all 0's



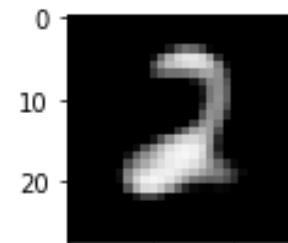
Median of all 1's



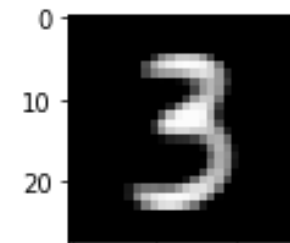
Mean of all 2's



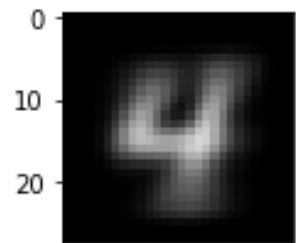
Mean of all 3's



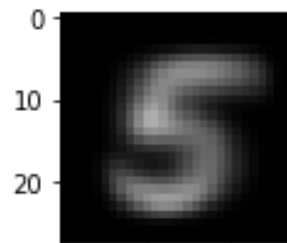
Median of all 2's



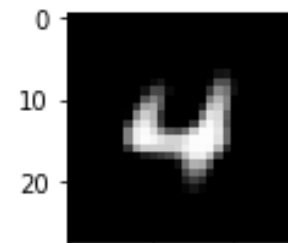
Median of all 3's



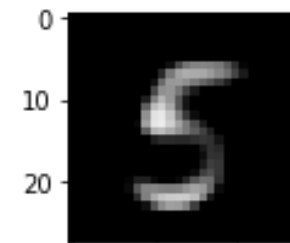
Mean of all 4's



Mean of all 5's



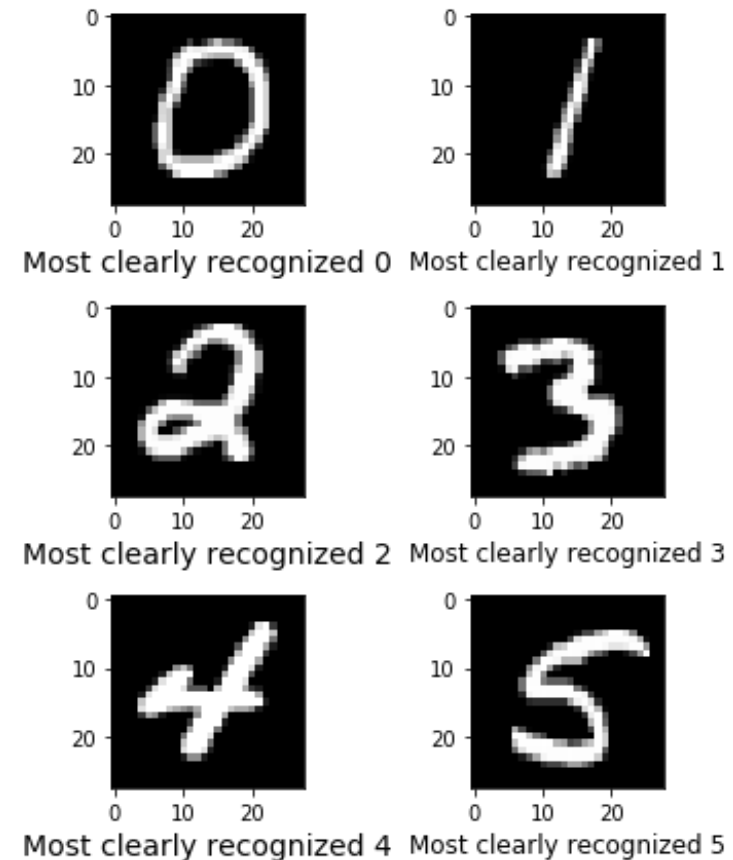
Median of all 4's



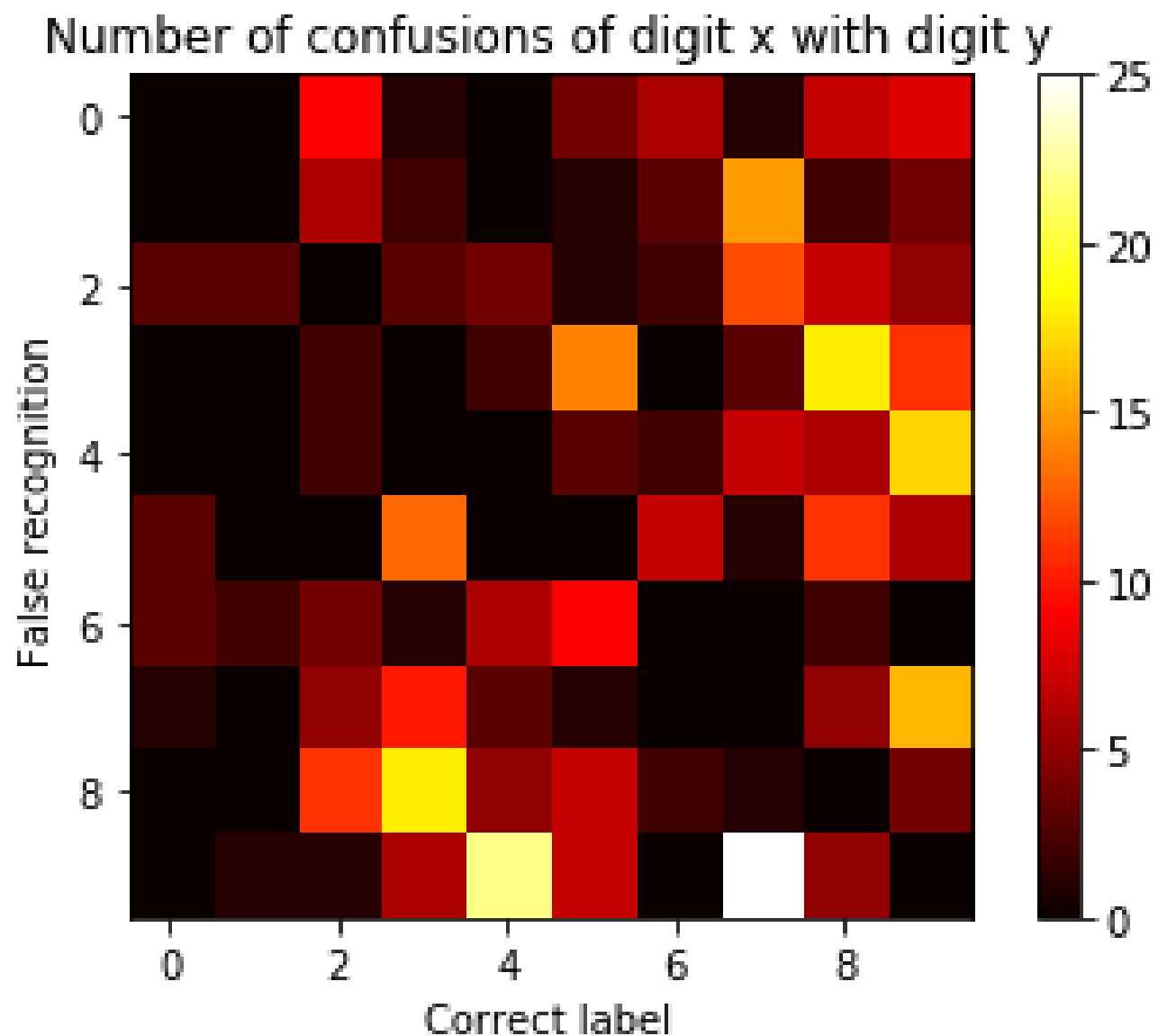
Median of all 5's

Best recognizable digit

- Image that is surrounded by the highest number of images with the same label.
- We decided to take it as meta digit.
- Reason: only this meta digit type represents the real existing data-point (image)

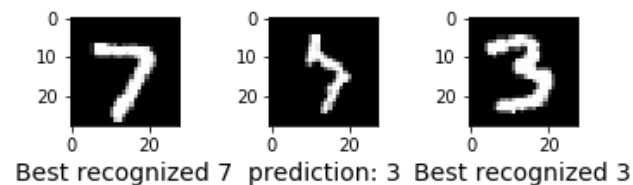
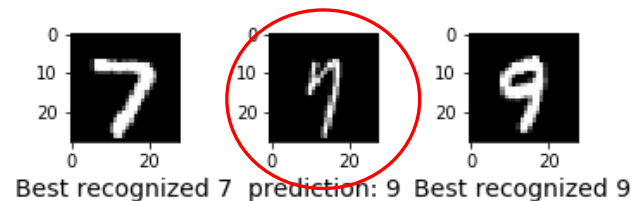
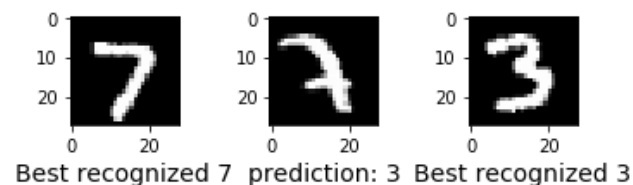
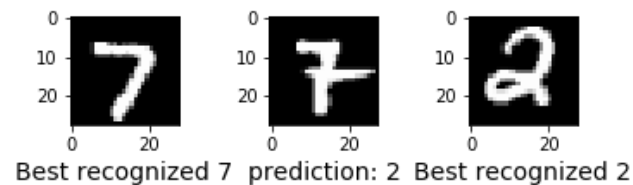
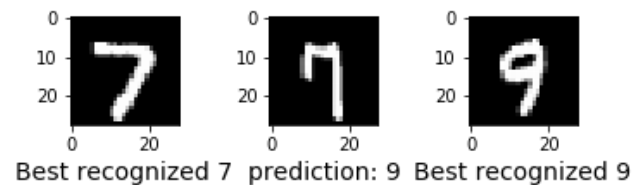


Why are there
mispredictions?



Heatmap with
confused digits

Wrong predicted digits



Exciting things to be investigated

- Cumulativity in prediction accuracy for a certain digit or even data-point
- Which digits have higher average noise component (recognized better by 78 than by 784)
- Other metrics for the distance calculation and their effect on the accuracy of recognition
- Other types of dimensionality reduction methods (f.i. kernel PCA) -> a hypothetical further increase in accuracy of recognition and noise elimination.

DRAWING CANVAS
