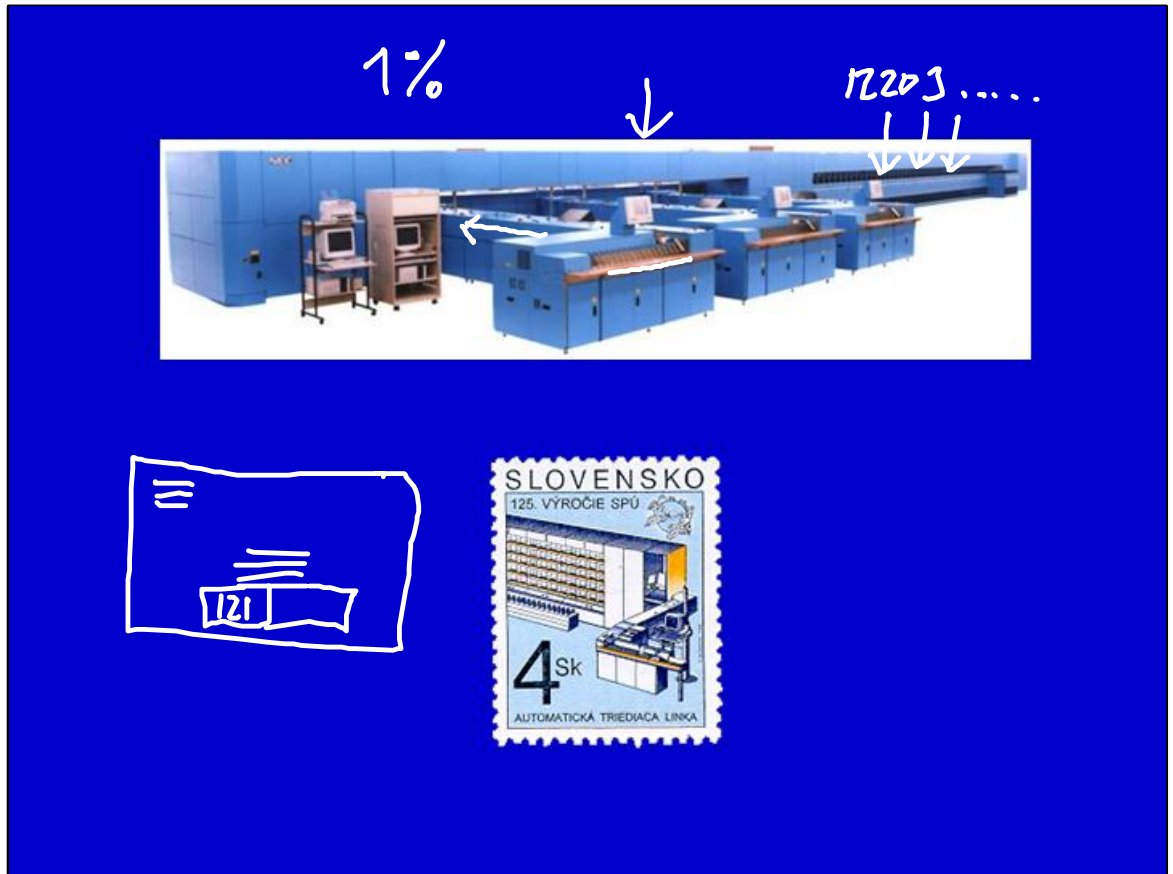
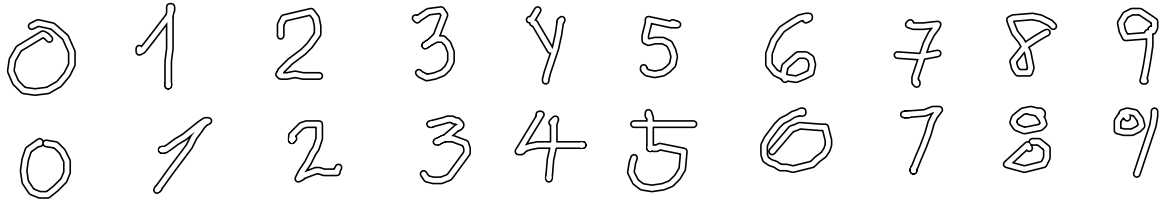
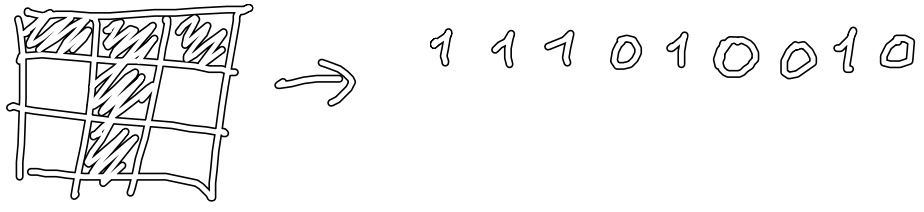


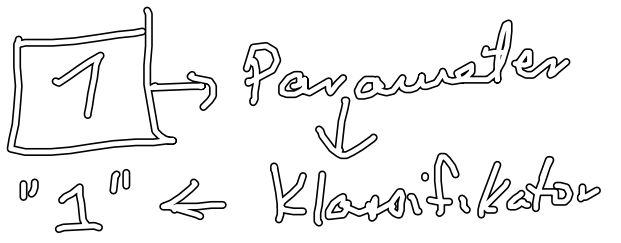
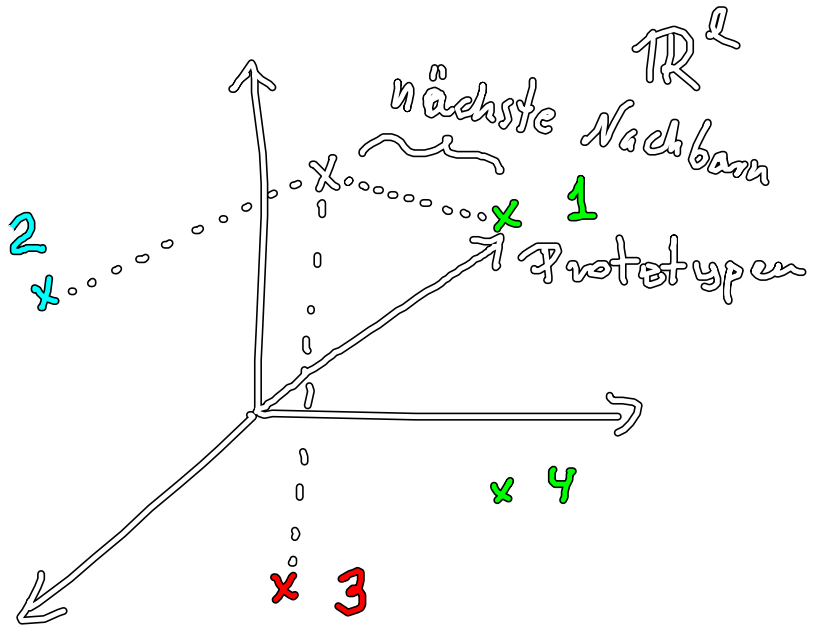
Klassifizierung

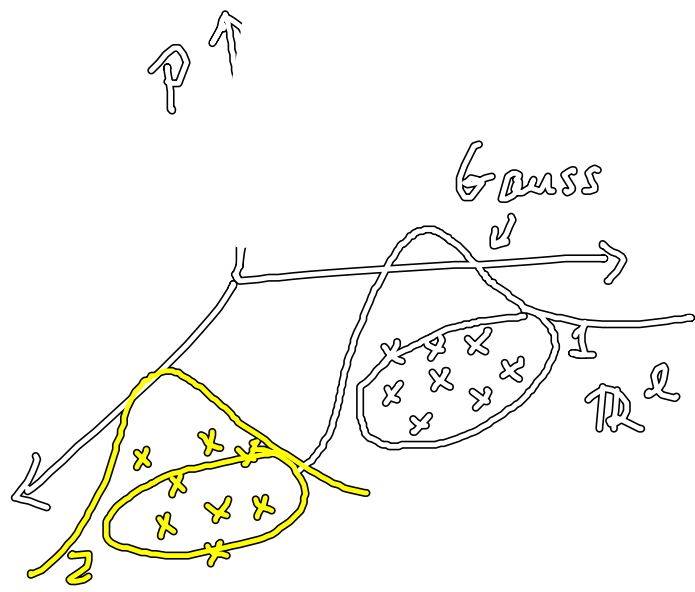
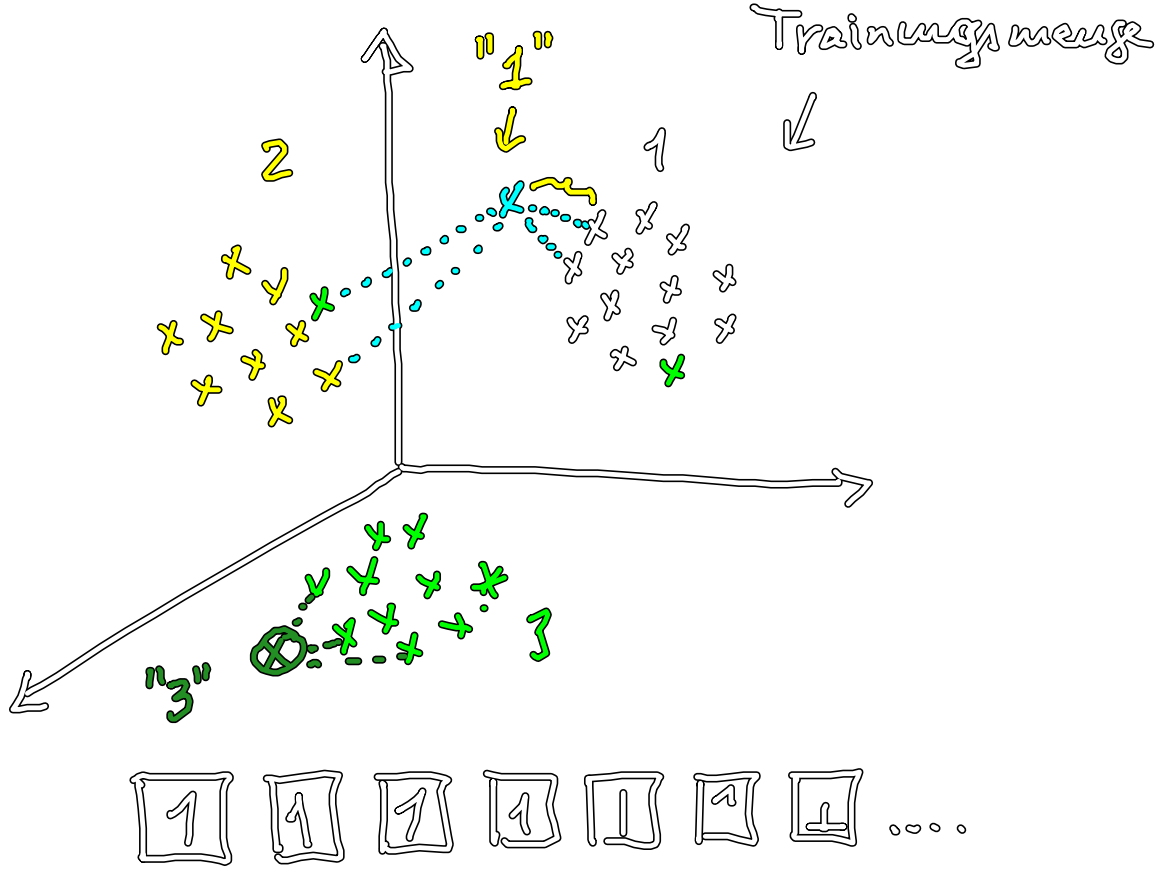


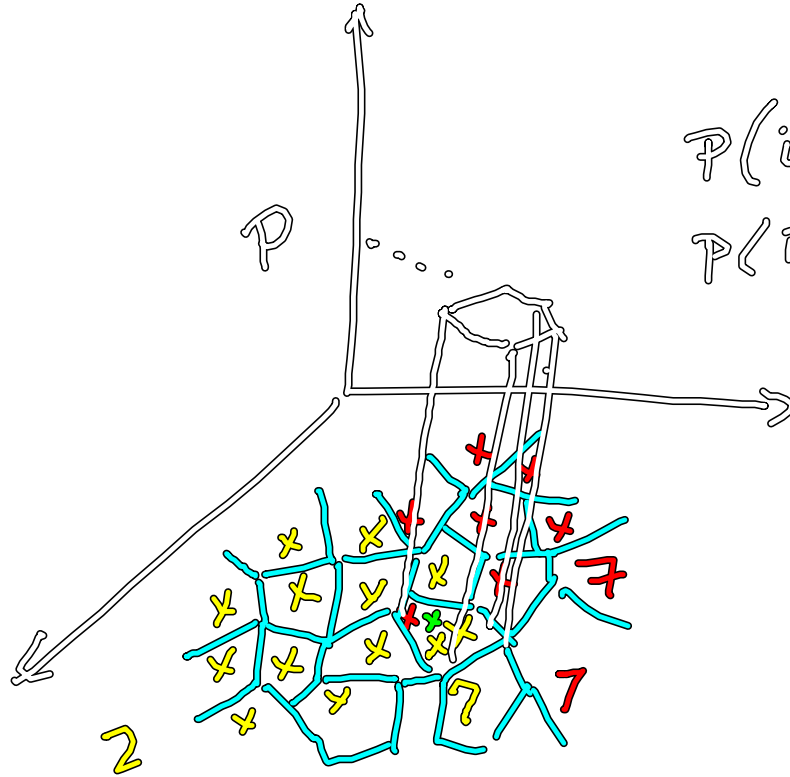
Nearest Neighbor



Parameterraum







$$P(\text{input} | 2) = \frac{0,4}{0,2}$$

$$P(\text{input} | 7) = 0,2$$

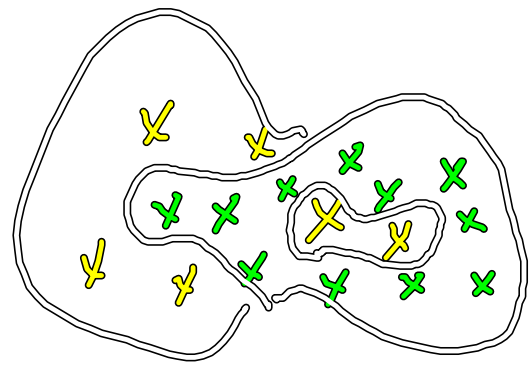
Nearest-Neighbor-Klassifizierung

→ Die Klasse einer neuen Eingabe
 ist die Klasse des nächsten
 Nachbarns.

Vorsicht! Ich brauche eine
 gute Metrik

1
2
3
→


1 0 0 1 0 0 1 1 1 1
1 0 1 1 0 0 1 1 1 1

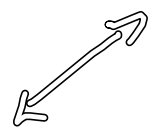


Nachteil: 50,000 Ziffern

↓
Vorverarbeitung

↓
1000,000 Parameter

Empfehle




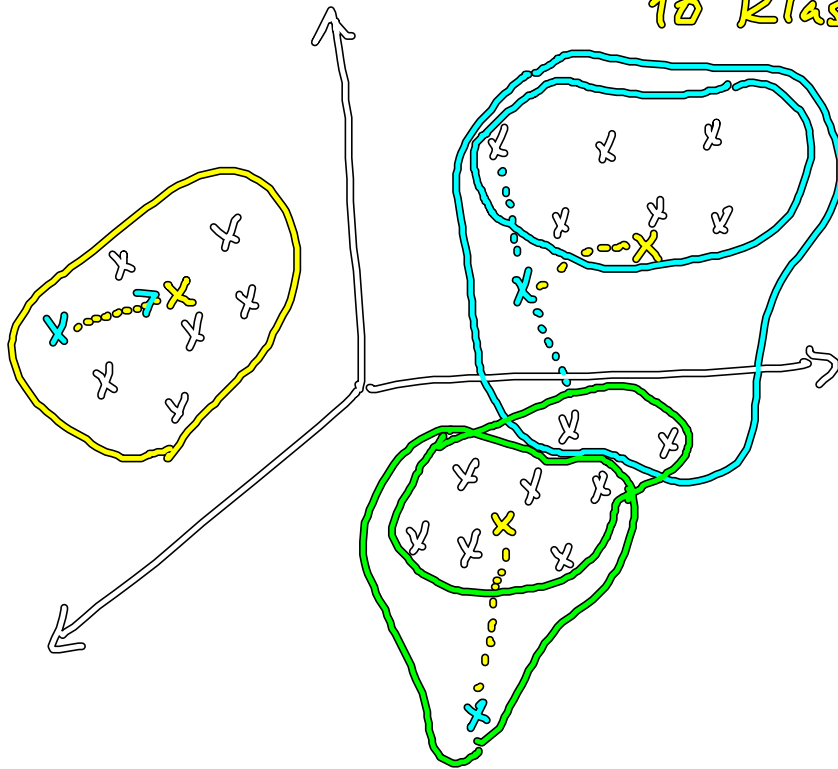
50,000 Euklidische Abstände in \mathbb{R}^{20}

1/10 Sek

Verbesserung : Clustering

LBG - Algorithmus (Expectation Maximization)
 K-means

Ungelabelte Daten 10 Klassen



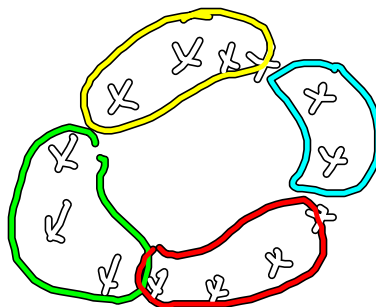
1) - Prototypen werden zufällig verteilt.

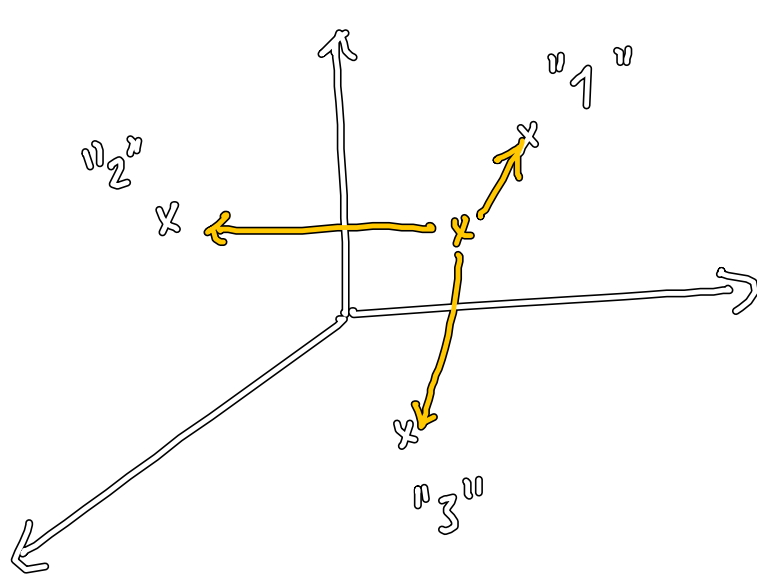
→ Expectation 2) - Die Eingabedaten werden klassifiziert

↳ Maximization 3) - Die Prototypen werden auf den Schwerpunkt der Klassen gesetzt.

→ bis keine Änderung mehr eintritt

→ bis ich müde bin (es gibt keine Garantie, dass es terminiert).



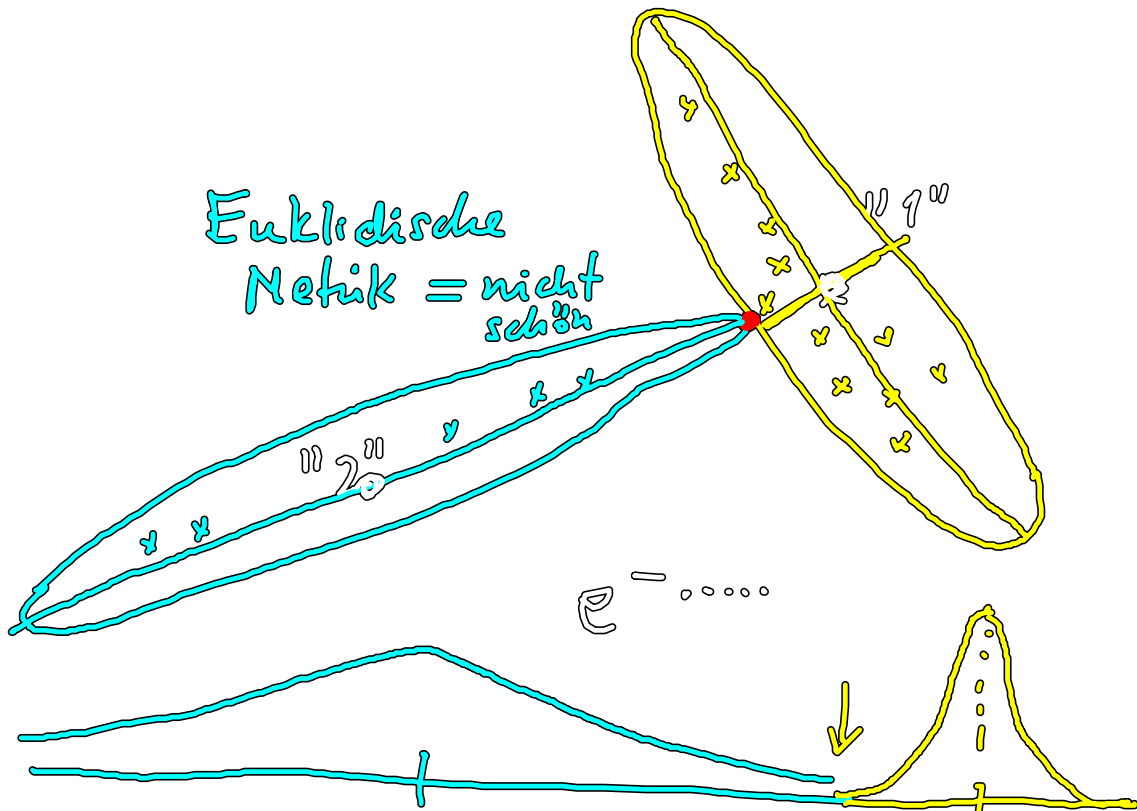


Vorteil

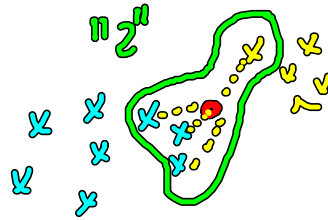
10 Euklidische
Abstände

Nachteil:

Ich verlore die Struktur



"1"



K - nearest neighbor

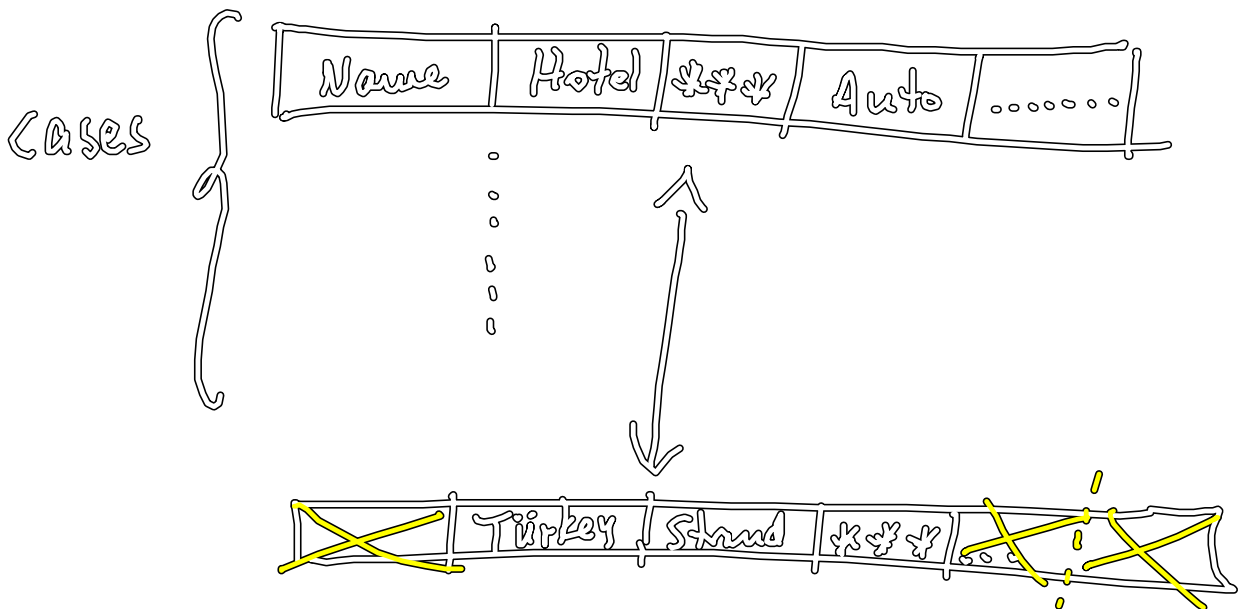
4 - " "

nearest neighbor

"

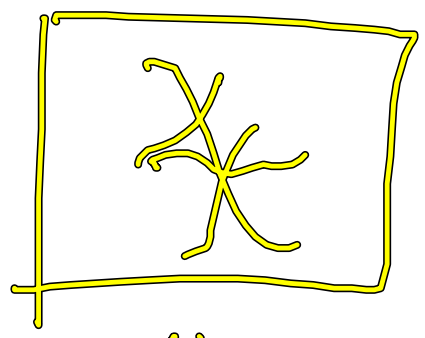
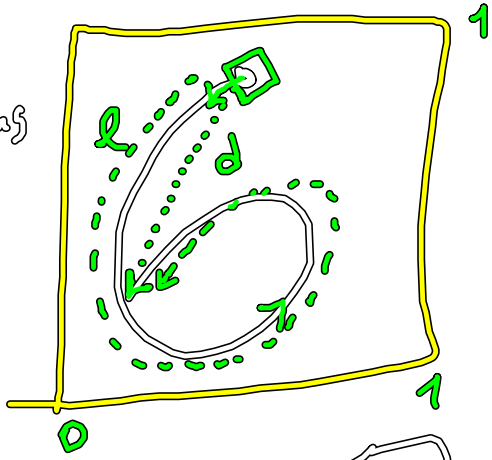
case based reasoning

Reisebüro

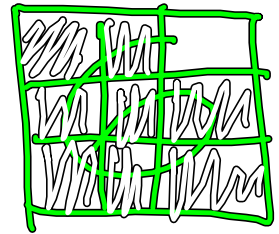
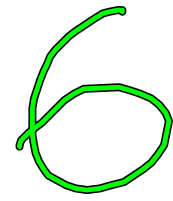
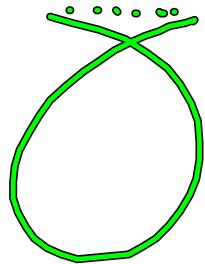
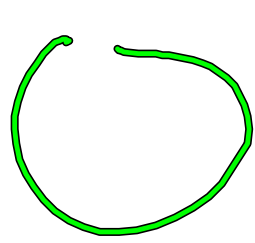
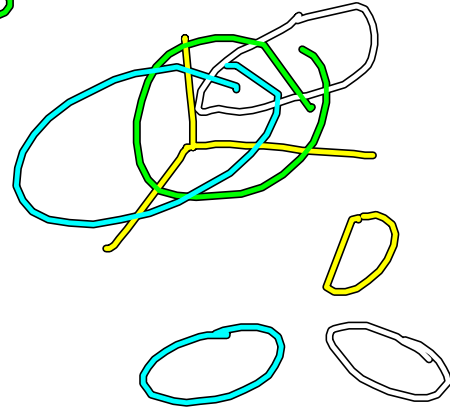


Mehik : Parameter

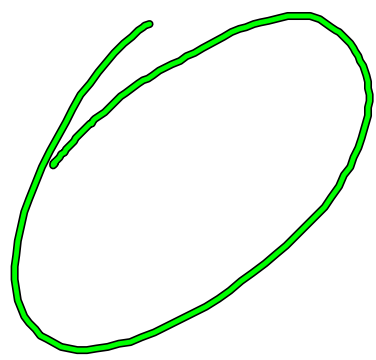
$\left\{ \begin{array}{l} 1 \text{ Linienart} \\ 360^\circ \\ l \\ d/l \end{array} \right.$



4
 Vertikal
 horizontal
 :

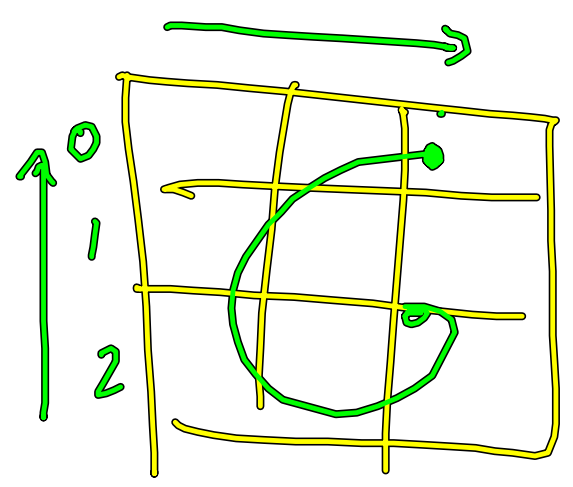
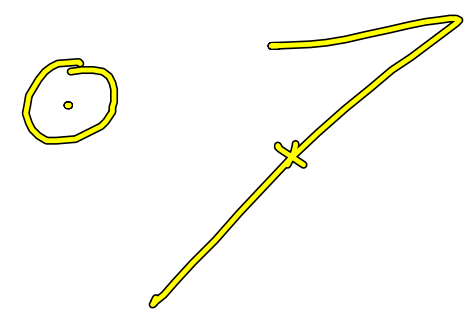
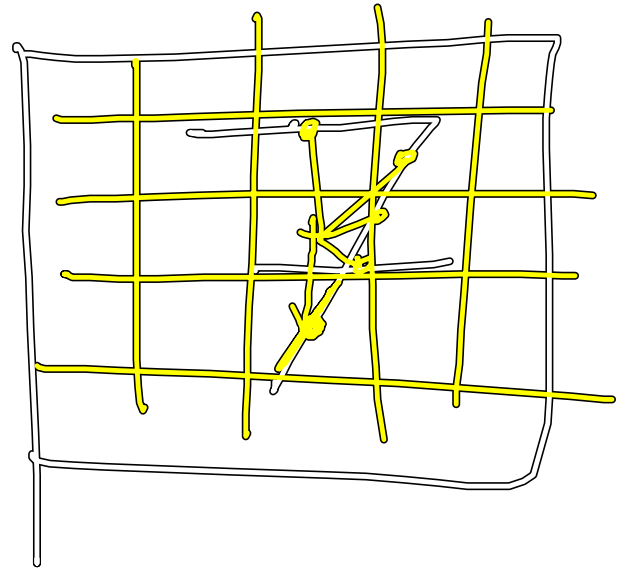


Momente



Kurvenlänge
 Kon. Winkel
 L
 d/L

$p = 2, 3, 4, \dots$
↓
 $(x_i - x_0)^p$



0, 2

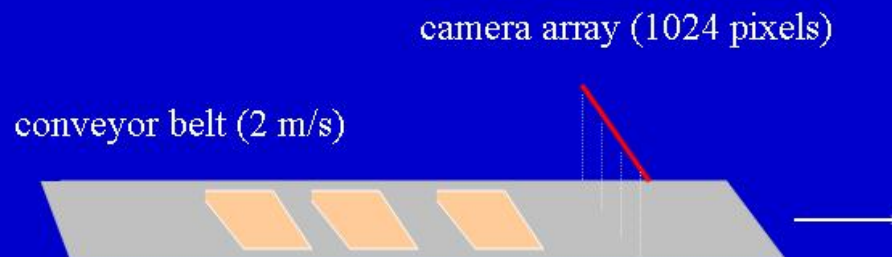


But first: Mail sorting machines

- Millions of letters are delivered every day in Germany
- A GFS machine sorts 20,000 flats (large format envelopes) per hour (5-6 pieces per second)
- At least 85% of the pieces should be classified automatically
- The rest semi-automatically
- Miss-classification penalty: 1 day



Capturing the data

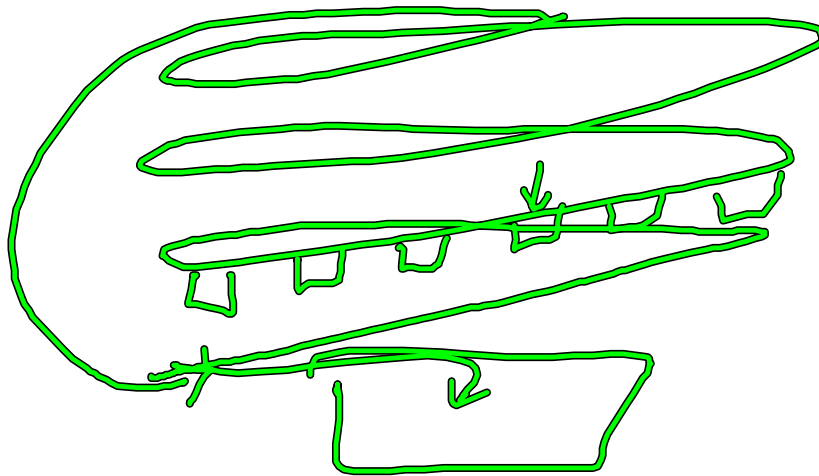
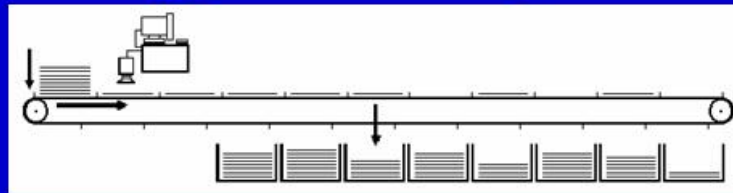
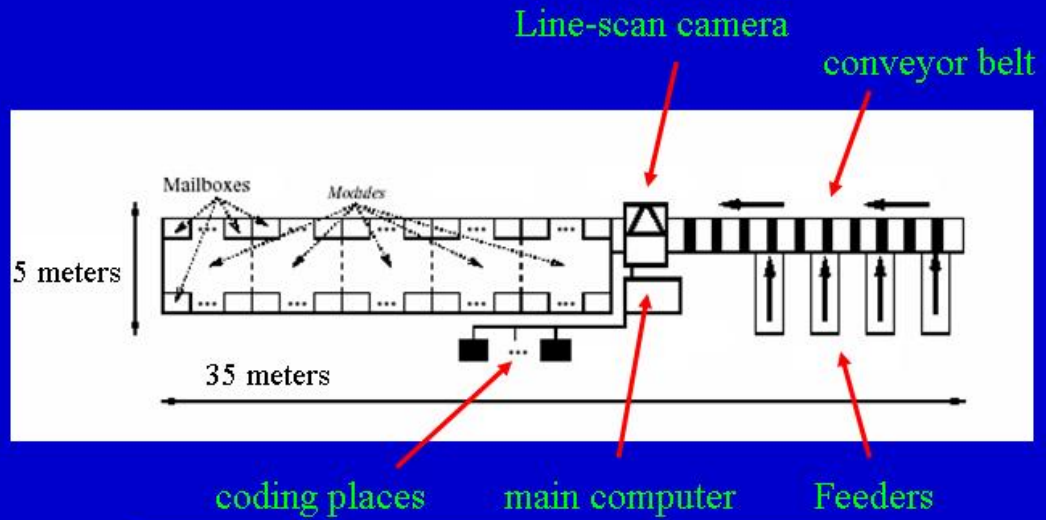


The image is captured by
A computer

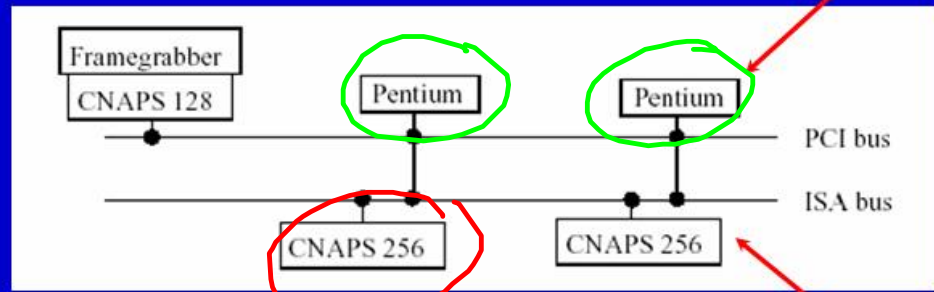
A person can type in the
ZIP code at video coding places



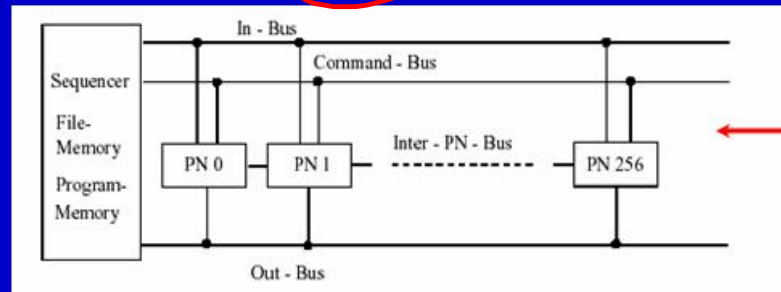
Floor plan of a machine



Special hardware



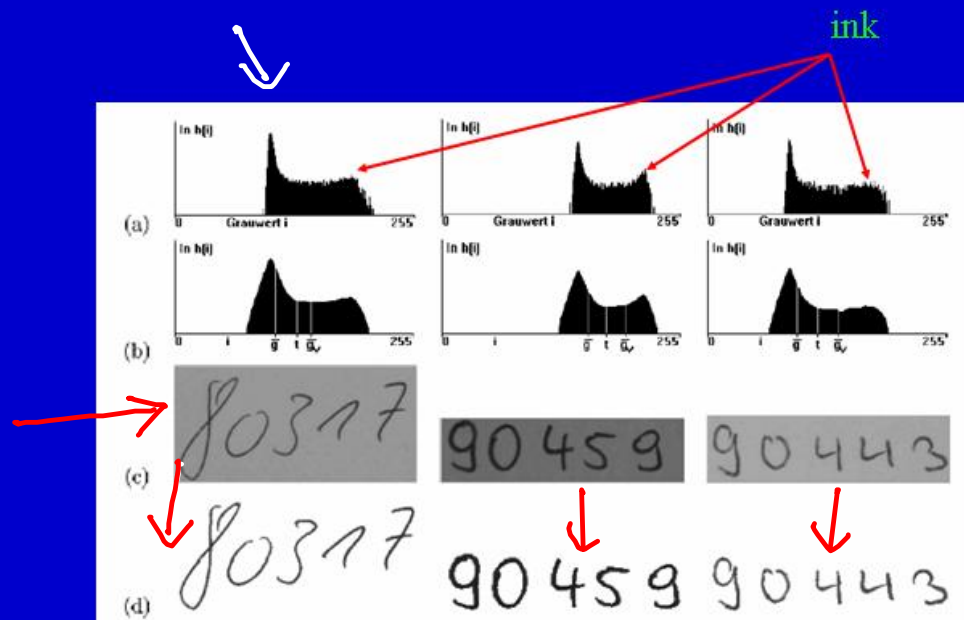
Classifier 1

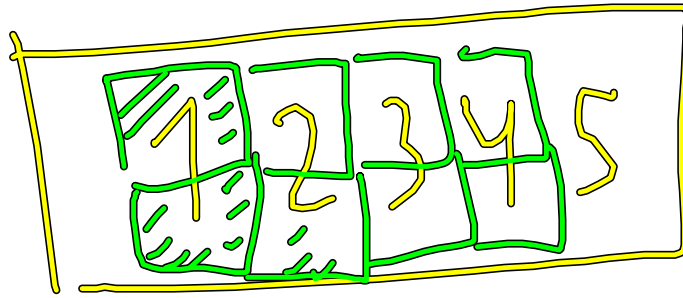


Classifier 2

Parallel
SIMD
machine

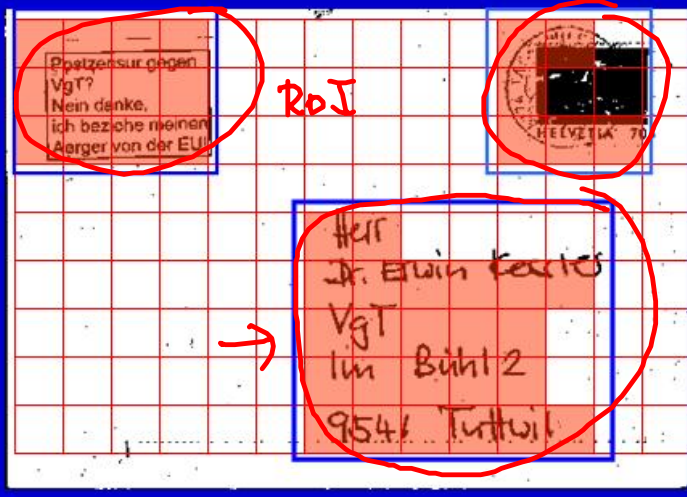
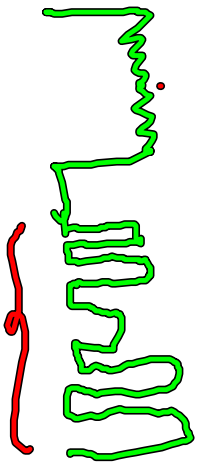
Binarization





Texture Analysis

Spalten

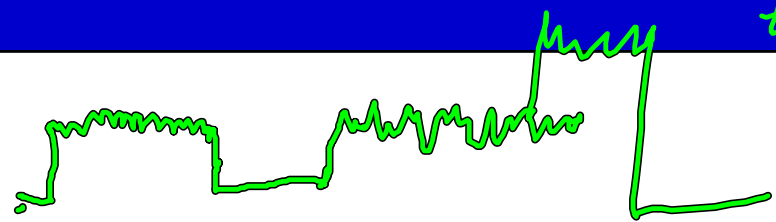


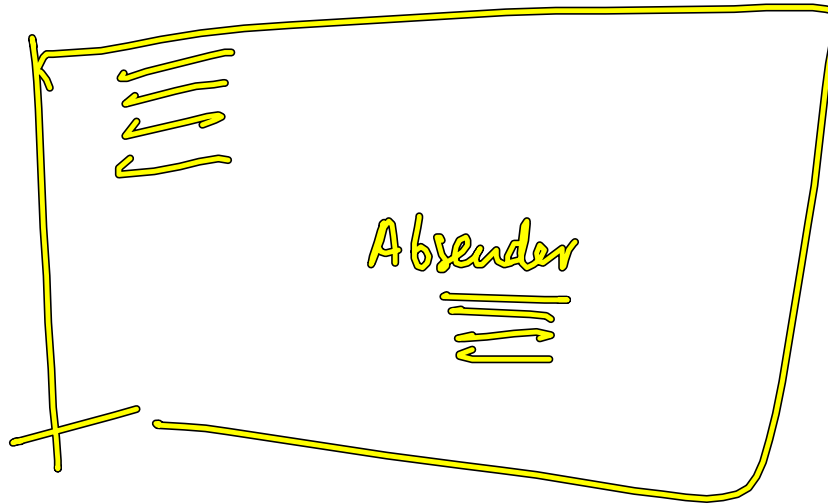
1) Identify regions containing writing

2) Select regions of interest

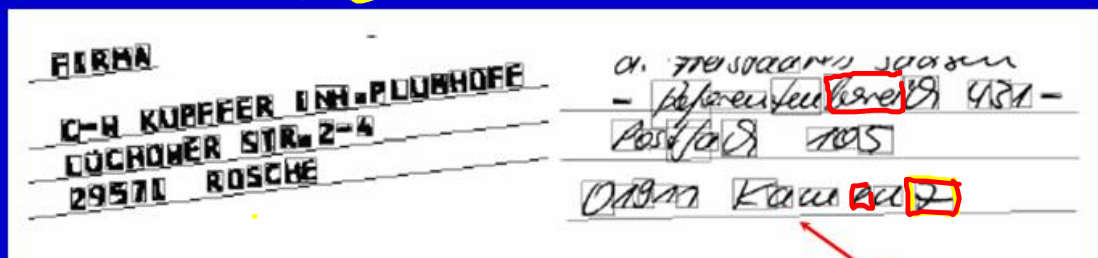
3) Process according to heuristics

Zeilen





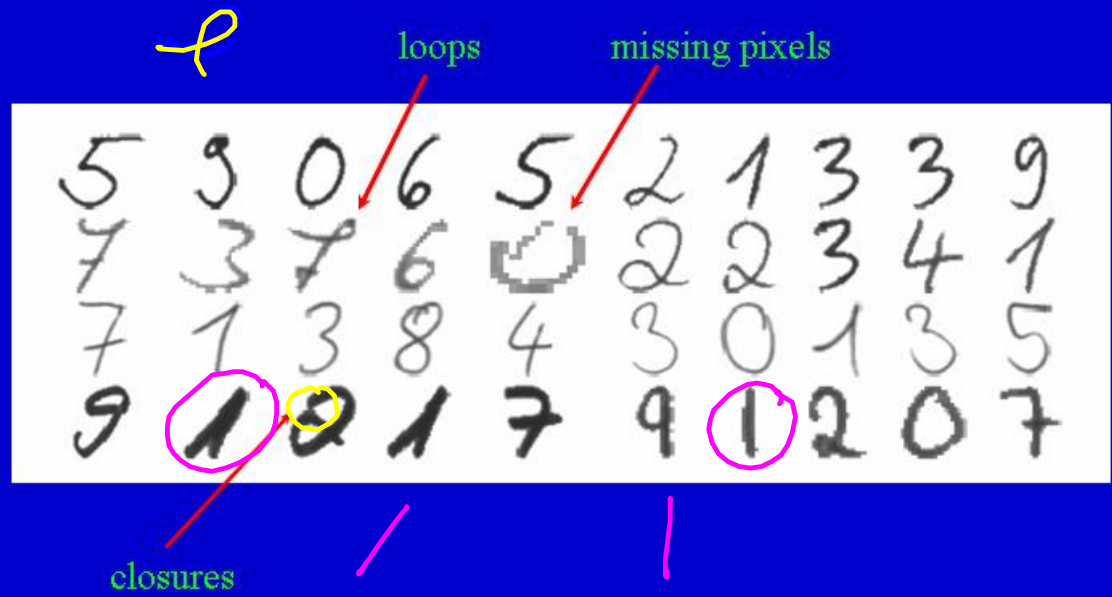
Find lines



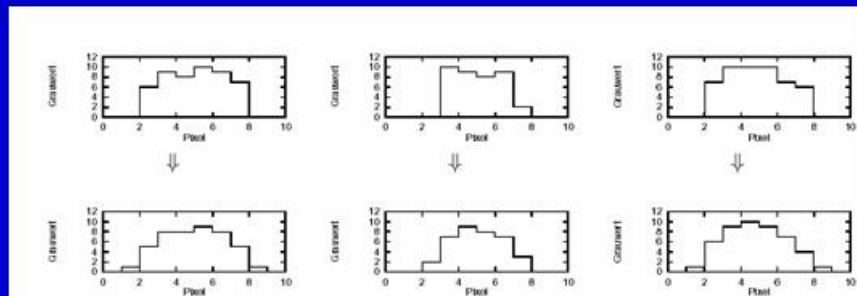
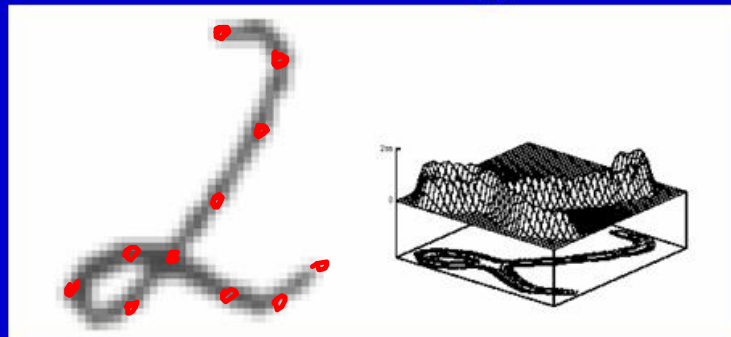
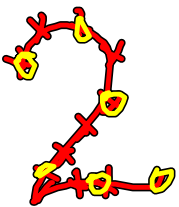
- 1) Find connected components
- 2) Bound with boxes
- 3) Detect orientation of chains of boxes (lines)
- 4) Distinguish between handwritten and typed text
(from the variability and geometry of the boxes)

line with the
appropriate ZIP features

Some typical digit images

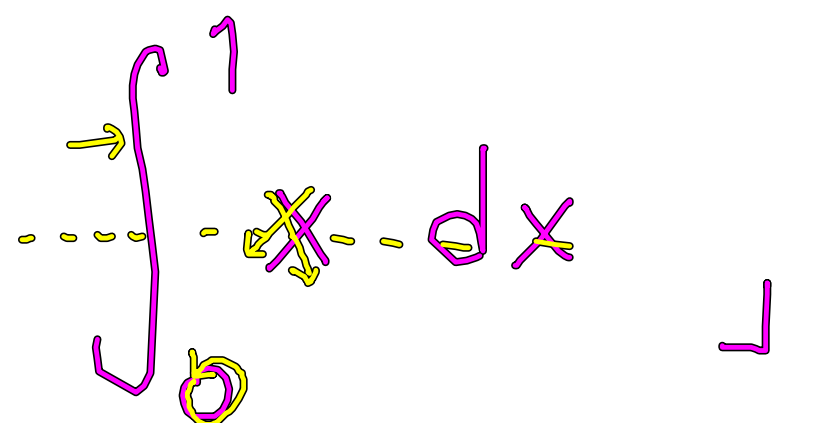


First classifier: smooth the gray value image

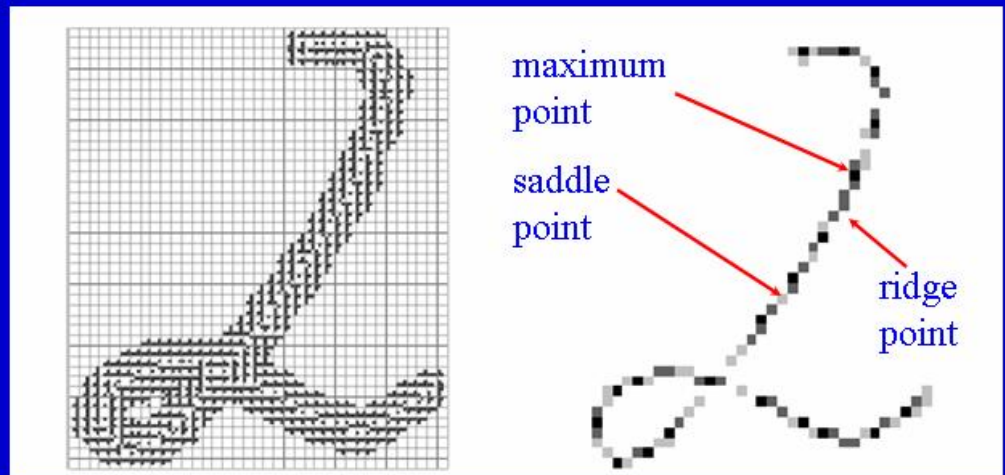


2
0 2^/ 0 = \$Failed

2
2 = 2

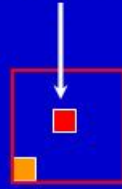

[Integral] 0 dx [Differential] x =
1
-
2

Compute skeleton in one pass

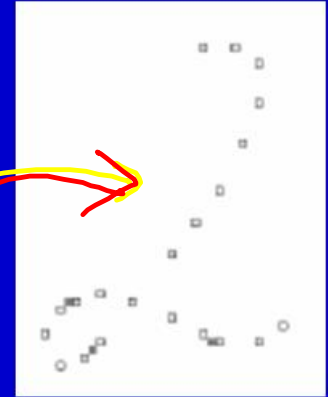


Simplify digit

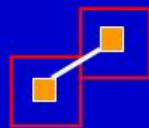
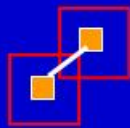
Keep most dominant points



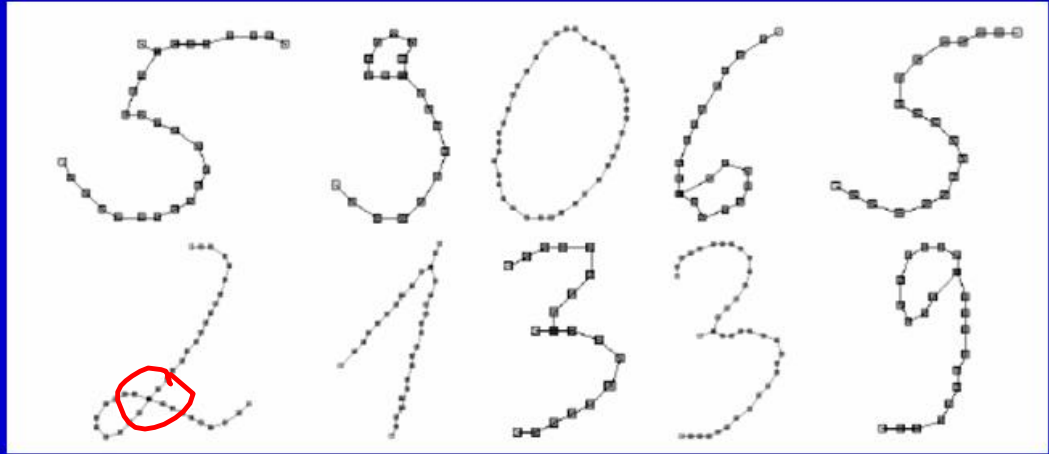
Delete points in the neighborhood



Connecting $m \times m$ overlapping neighborhoods

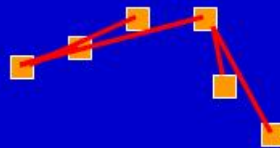


Reconstruct connections (best continuity)

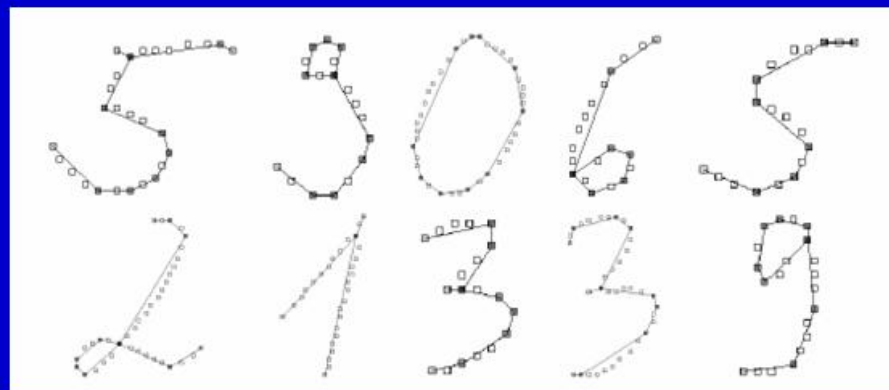


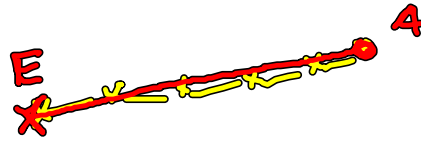
Only a few pixels represent now each digit

Simplify stroke representation



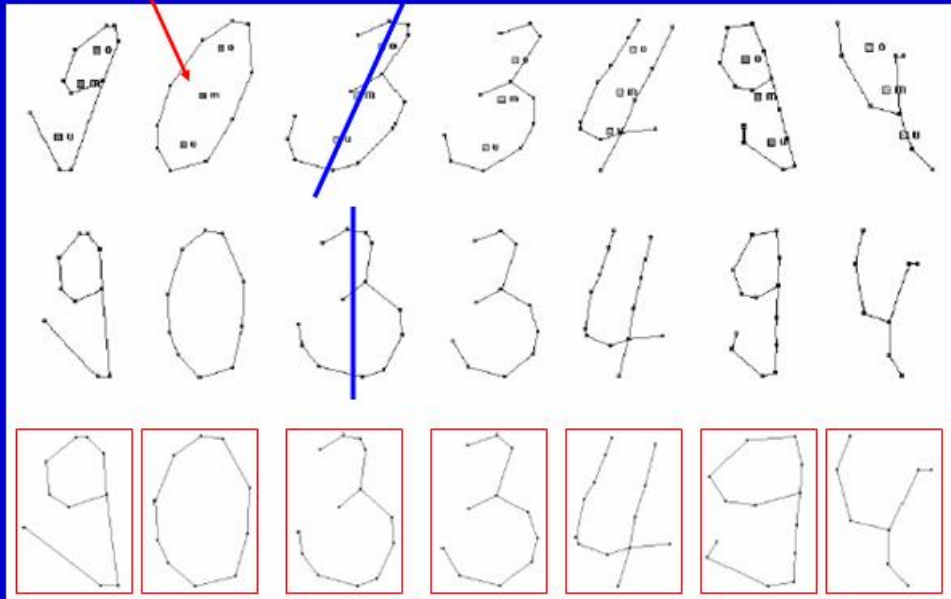
Start new stroke
if covered points are
too far away, or if
angle is too steep





Normalization

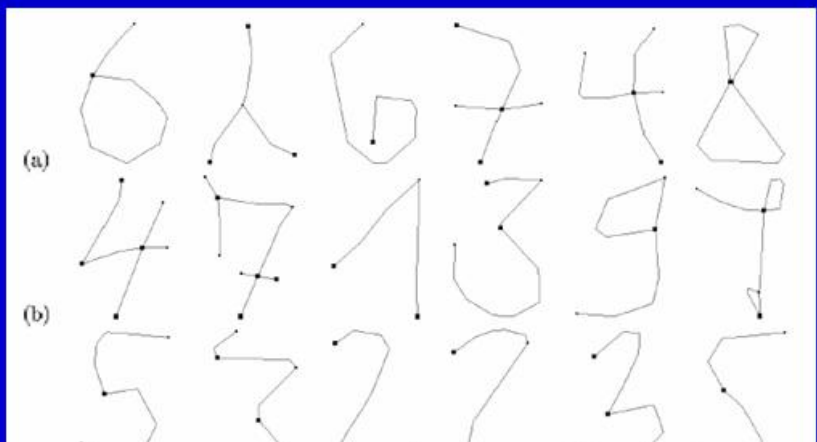
center of mass



Find strokes

Collect lines
if they provide
a smooth
continuation

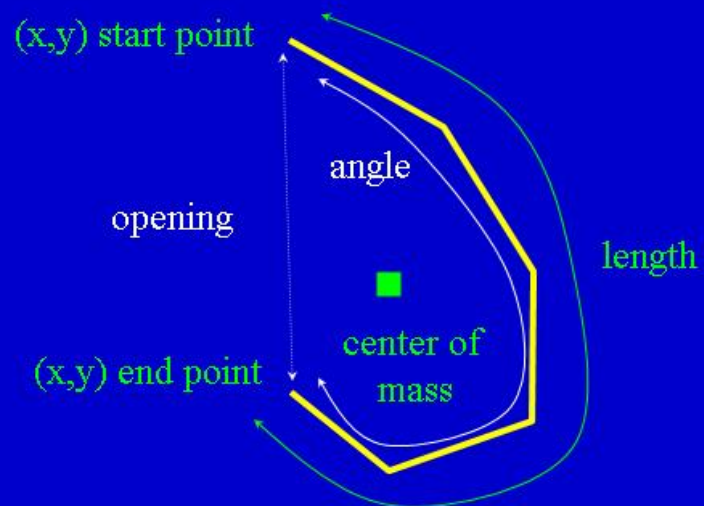
Gestalt rules



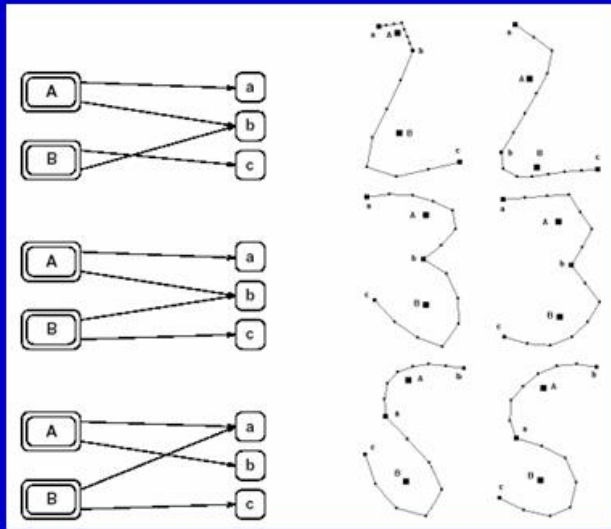


off-line \rightarrow on-line

Encode stroke features



Find model and classify



There is a neural network for each kind of model

Features



NN



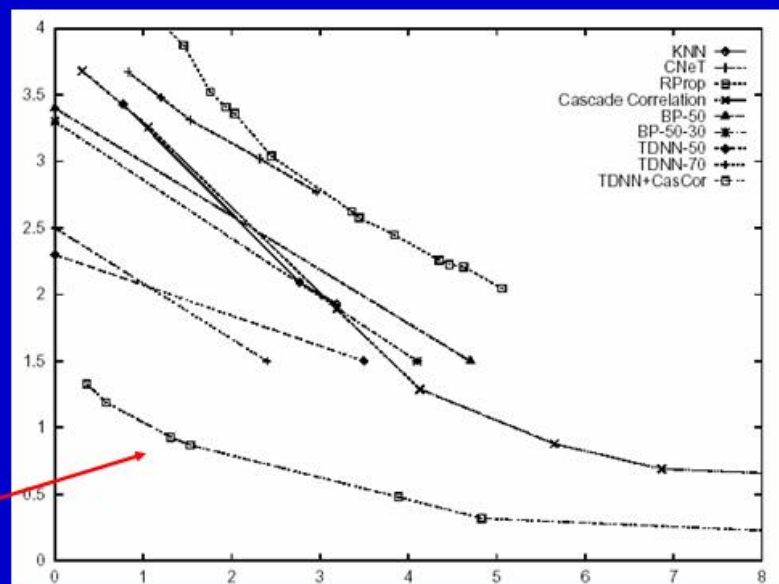
class

Klassifikation

Results

substitution rate

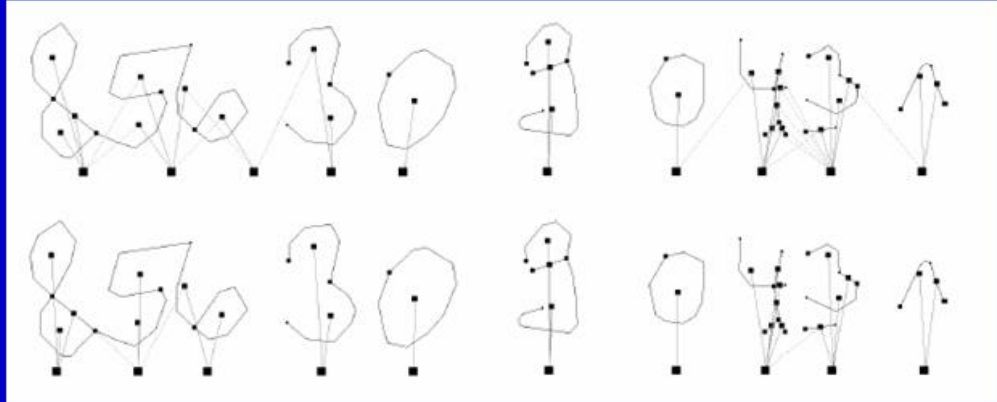
combined classifier



rejection rate

Clustering ZIP strokes

initialization



last iteration