

# Offline Handritting Word Recognition

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## Overview of the Project

# Off-line handwriting recognition

- It involves the automatic conversion of text in an image into letter codes which are usable within computer and text-processing applications
- Off-line handwriting recognition is comparatively difficult, as different people have different handwriting styles

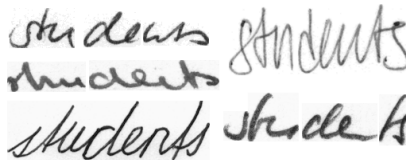


Figure: 'Students' written by different authors

# Our AI Project

A lot of research has been done over the past years.

We explored the topic and implemented a full pipeline for the task.  
The research touched different fields:

- Data Collection
- Image Processing
- Features extraction
- Machine Learning techniques
- Word Recognition using Hidden Markov Models

# Dataset

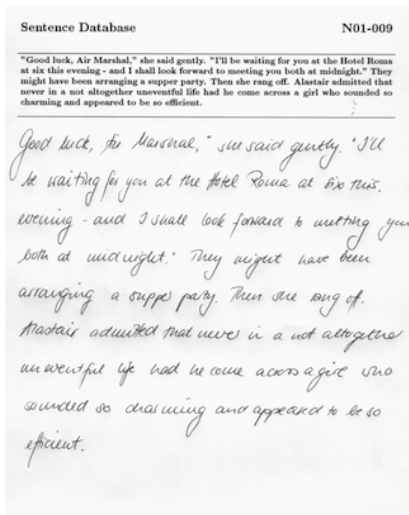
## The IAM Handwriting Database<sup>1</sup>

- Unconstrained handwritten text (scanned at a resolution of 300dpi and saved as PNG images with 256 gray levels)
- 1'539 pages of scanned text of 657 writers
- We extracted 35 instances of the 300 most frequent words (20 as training set and 15 as test set)

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<sup>1</sup><http://www.iam.unibe.ch/fki/databases/iam-handwriting-database>

## Example of a page of scanned text



## Implementation Details



# Pipeline

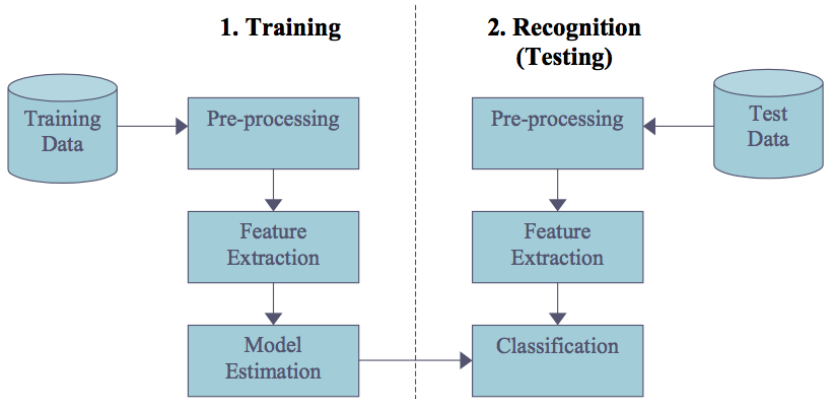


Figure: Pipeline of a word recognition system

## Implementation Details

### Pre-Processing

# Pipeline

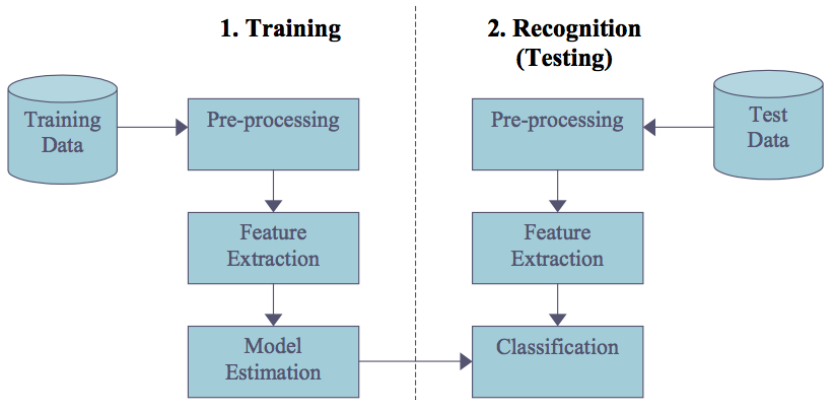
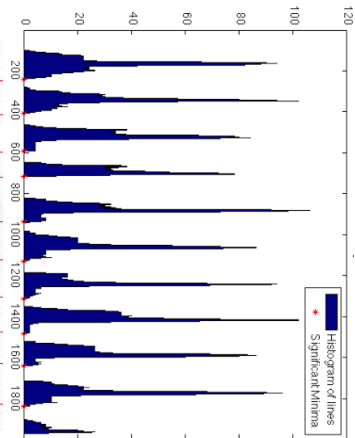


Figure: Pipeline of a word recognition system

# Line Segmentation

*Though they may gather some Left-wing support, a large majority of Labour M P's are likely to turn down the Foot-Griffiths resolution. The Foot's line will be that as Labour M P's opposed the Government Bill which brought life peers into existence, they should not now put forward nominees. He believes that the House of Lords should be abolished and that Labour should not take any steps which would appear to "prop up" an out-dated institution.*



Original image segmented in lines

Vertical histograms and significant minima

# Skew and Slope Correction

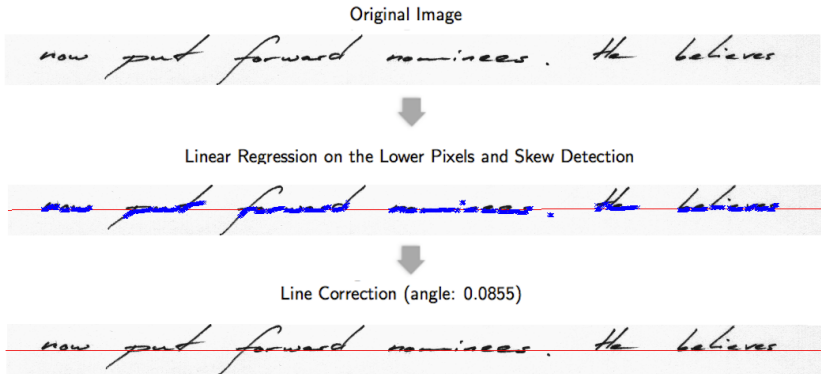
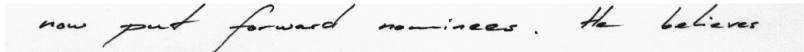


Figure: Skew detection and correction pipeline

# Slant detection and Correction

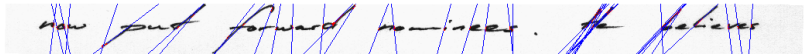
Image after skew correction



now put forward nominees. He believes



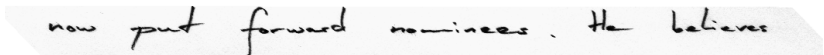
Slant Detection



now put forward nominees. He believes



Slant Correction



now put forward nominees. He believes

Figure: Slant detection and correction pipeline

# Word segmentation

# Vertical Scaling



## Implementation Details

### Feature Extraction

# Features

We want to find features that minimise the within-class variability and maximise the between class variability. On top of this, the features should be robust against distortions caused by different handwriting styles. Moreover, we want to find low dimensional feature vectors and would therefore like features to be highly descriptive. The selection of features depends both on the pre-processing and the classifier to use. If all characters are assumed to have the same orientation, we need rotation variant features to distinguish between for instance a 6 and a 9 and a b and an p, etc.

# HMM

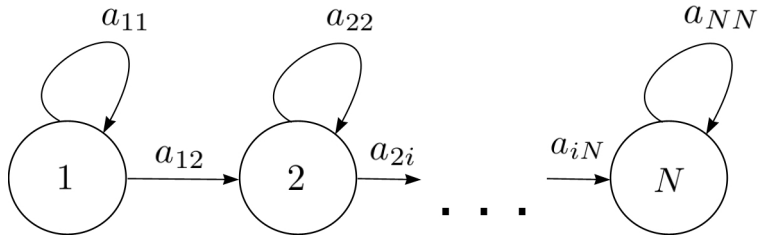


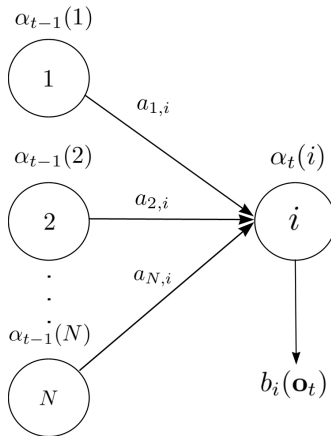
Figure: Left-to-right HMM with  $N$  states

# Main problems in an HMM

- 1 The probability of an observation sequence, given the model,  $P(\mathbf{O}|\lambda)$ .
- 2 The most likely state sequence, underlying a given observation sequence and the model,  $Q^* = \max P(Q|\mathbf{O}, \lambda)$ .
- 3 The most likely parameters of the model  $\lambda^* = \max P(X|\lambda)$ , given a training set of  $M$  observation sequences  $X = (\mathbf{O}_1, \mathbf{O}_2, \dots, \mathbf{O}_M)$ .

## Forward probability

Solution to the first problem, use *forward-backward* algorithm, a special instance of the sum-product algorithm

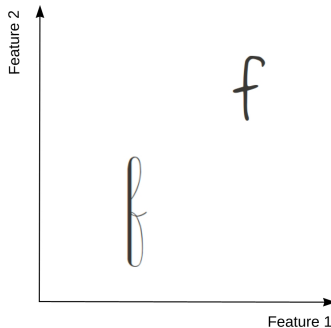


# Updating the parameters

Use EM-algorithm

# Updating parameters

## Within class variations



Using features such as loops, this will give quite different feature vector.



## Within class variations

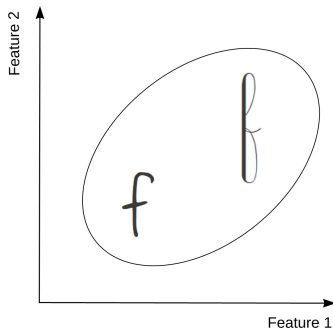
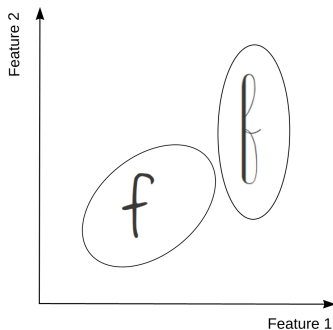


Figure: Fitting a single Gaussian

## Within class variations



Fitting a mixture of 2 Gaussians

## Problems we ran into

$$X = \begin{pmatrix} -1 & 0 \\ 2 & 0 \\ 1 & 0 \\ -2 & 0 \end{pmatrix}$$

## Problems we ran into

$$X = \begin{pmatrix} -1 & 0 \\ 2 & 0 \\ 1 & 0 \\ -2 & 0 \end{pmatrix}$$
$$\Sigma = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}$$

# Results

blabla

# Conclusions

blabla

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