Cairo University

Writer Identification

Pattern Recognition Course

Submitted to:

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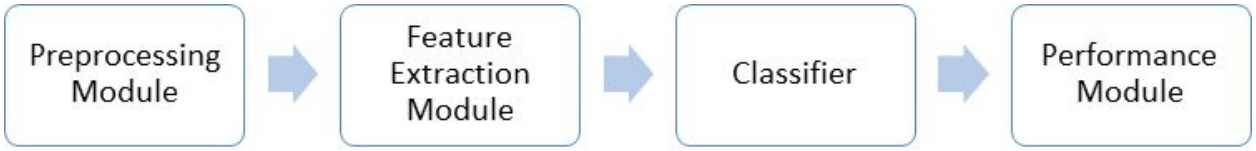
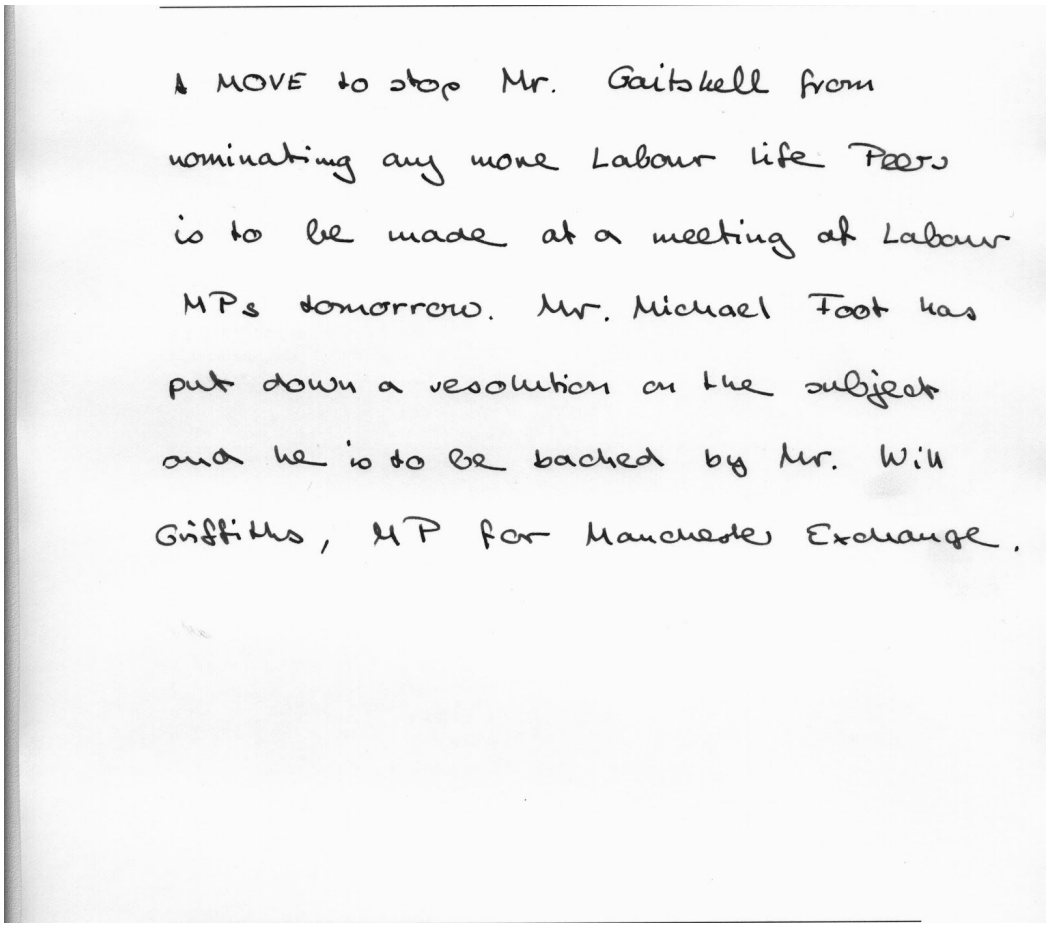
Project Pipeline:



Pre-processing Module:

Our Pre-processing Module focuses on extracting the handwritten text image through morphological operators, Otsu thresholding, and Hough Transform Line Detection.



Feature Extraction Module:

Our feature extraction module is based on extraction of 3 type of features:

1. Codebook based features
2. Chain code based features
3. Polygon based features

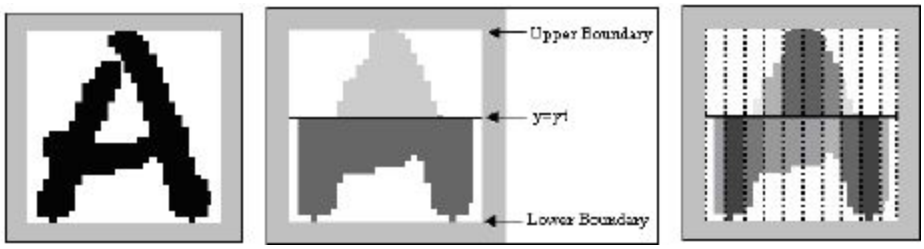
1. Codebook based Features:

They are features that are calculated for each clustered window ($n_x n$ dim.) and they are based on local features of that windows and they are:

1. **Horizontal Histogram:** sum of each row (n-dim)
2. **Vertical Histogram:** sum of each column (n-dim)
3. **Upper Profile:** the distance between the upper boundary and the average horizontal line of the shape (n-dim)
4. **Lower Profile:** the distance between the Lower boundary and the average horizontal line of the shape (n-dim)
5. **Orientation:** Angle at which the object is directed (1-dim)
6. **Eccentricity:** It shows how far the object of being between a circle and ellipse (1-dim)
7. **Rectangularity:** It is the ratio between the region area to the minimum bounding rectangle
8. **Elongation:** It measures elongation of the shape from it's boundaries (1-dim)
9. **Perimeter:** It measures the perimeter of the shape from its boundary (1-dim)
10. **Solidity:** It is the ratio between the contour area to the convex hull area (1-dim)

Notes:

1- Upper and Lower Profiles:



2- Orientation and Eccentricity are calculated by fitting an ellipse to the shape's contours then calculated the values as:

- Orientation: angle of the enclosing ellipse on X-Y coordinates.
- Eccentricity: sqrt(1 - (ratio between axes of the enclosing ellipse)^2)

3- Elongation is calculated from central moments of the shape as stated in this equation:

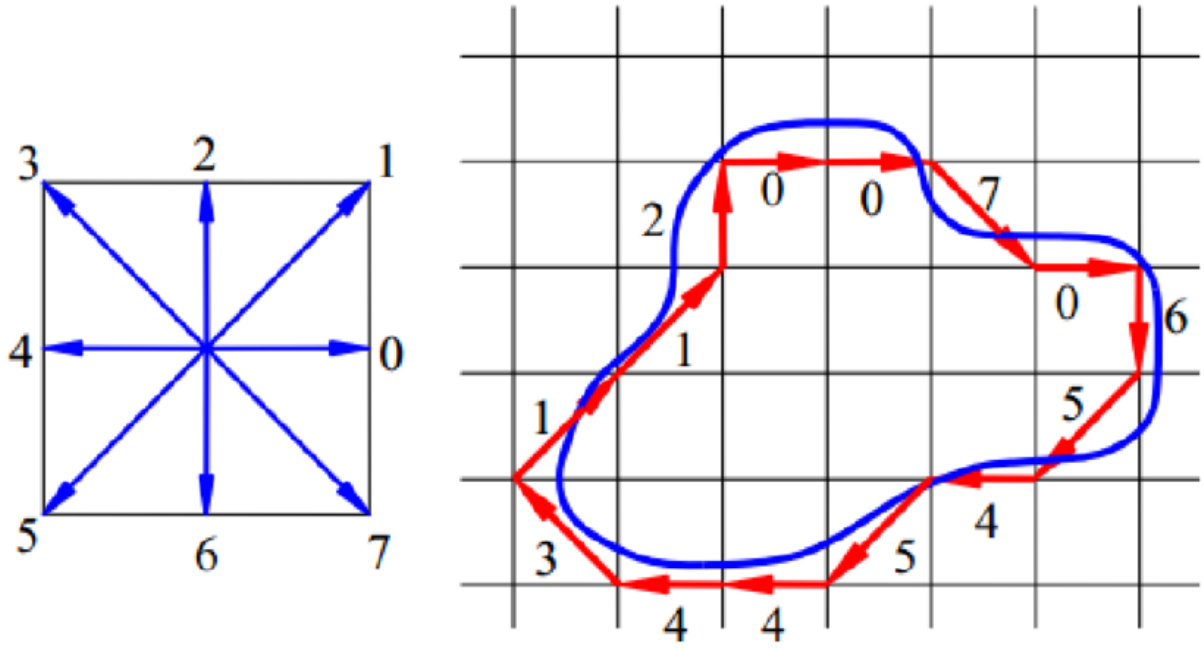
$$E(S) = \frac{\overline{m}_{2,0}(S) + \overline{m}_{0,2}(S) + \sqrt{4(\overline{m}_{1,1}(S))^2 + (\overline{m}_{2,0}(S) - \overline{m}_{0,2}(S))^2}}{\overline{m}_{2,0}(S) + \overline{m}_{0,2}(S) - \sqrt{4(\overline{m}_{1,1}(S))^2 + (\overline{m}_{2,0}(S) - \overline{m}_{0,2}(S))^2}}$$

4- Solidity visualized by this image:

Solidity = (Area of the hand) / (Area of the red polygon[convex hull])

Chain code Features:

Chain code features are features based on contours of the text in the image,so we first extract contours of the image then using the contours we extract chain code for the contours following the next image.



Then we extract Features from the chain codes,

- F1 : Distribution of chain codes.
- F2 : Distribution of 1st order differential chain codes.
- F3 : Distribution of 2nd order differential chain codes.
- F4 : Distribution of chain code pairs.
- F5 : Distribution of chain code triplets.
- F7,F8,F9 are the same as F1,F2,F3 but extracted from clustered windows of the image.

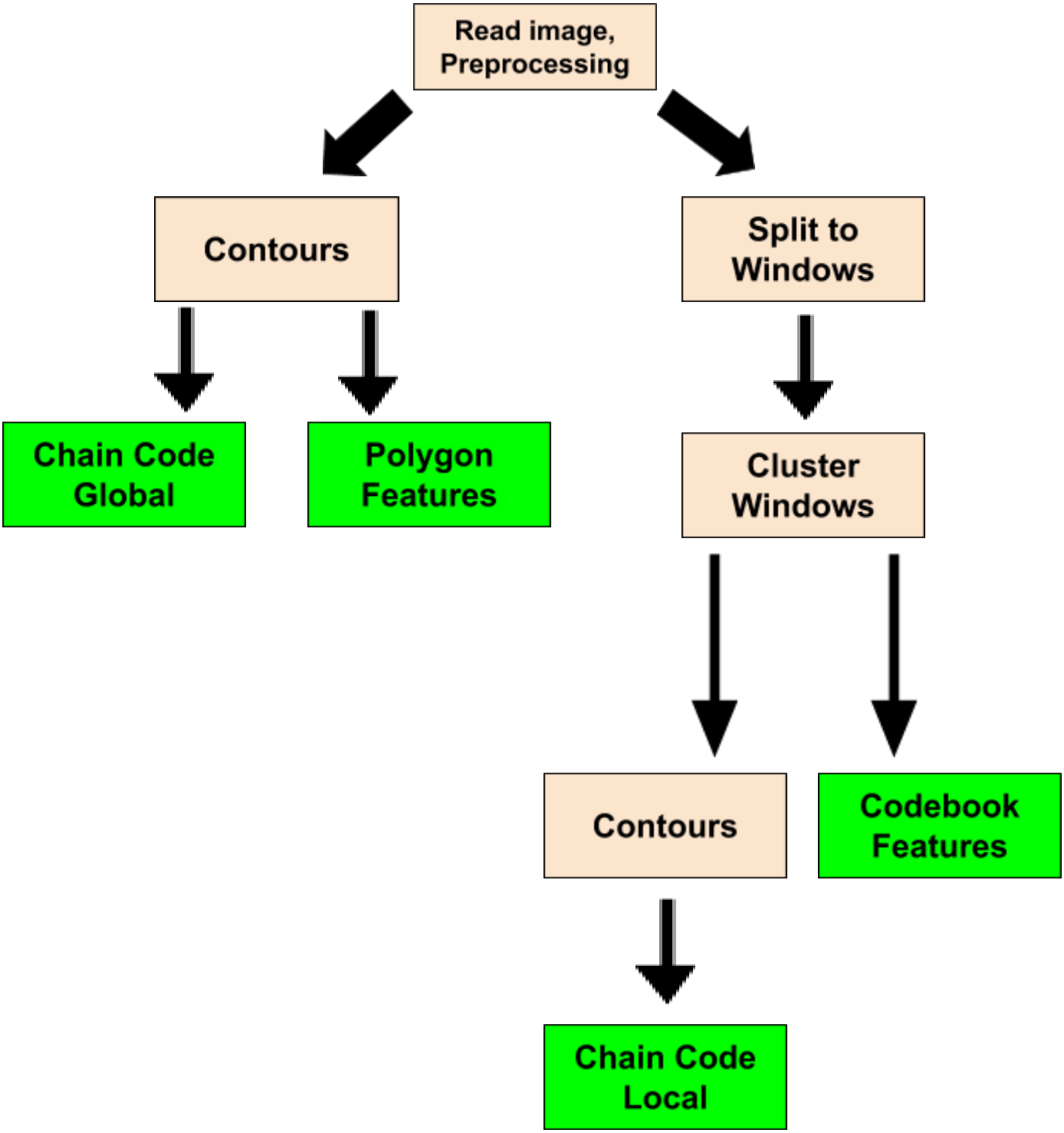
Polygon-based Features:

These features aim to construct an estimate on how a writer writes by capturing the slopes of lines of the contours' segments, and the angles between consecutive segments, in a form of histograms and probability distributions.

We begin with contours extraction:

Then we use the contours to extract features:

- F10: Distribution of segment slopes.
- F11: Length-weighted distribution of segment slopes.
- F12: Distribution of curvature.
- F13: Length-weighted distribution of curvature.
- F14: Distribution of segment lengths.


Read image, Preprocessing
Contours
Split to Windows
Chain Code Global
Polygon Features
Cluster Windows
Contours
Codebook Features
Chain Code Local

Feature Selection:

We have many features which can be represented by the following :

- F1 : Distribution of chain codes.
- F2 : Distribution of 1st order differential chain codes.
- F3 : Distribution of 2nd order differential chain codes.
- F4 : Distribution of chain code pairs.
- F5 : Distribution of chain code triplets.
- F6 : Distribution of curvature indices
- F7 : Local stroke direction distribution
- F8 : f 2 computed locally
- F9 : f 3 computed locally
- F10: Distribution of segment slopes
- F11: Length-weighted distribution of segment slopes
- F12: Distribution of curvatures
- F13: Length-weighted distribution of curvatures
- F14: Distribution of segment lengths
- Codebook based features

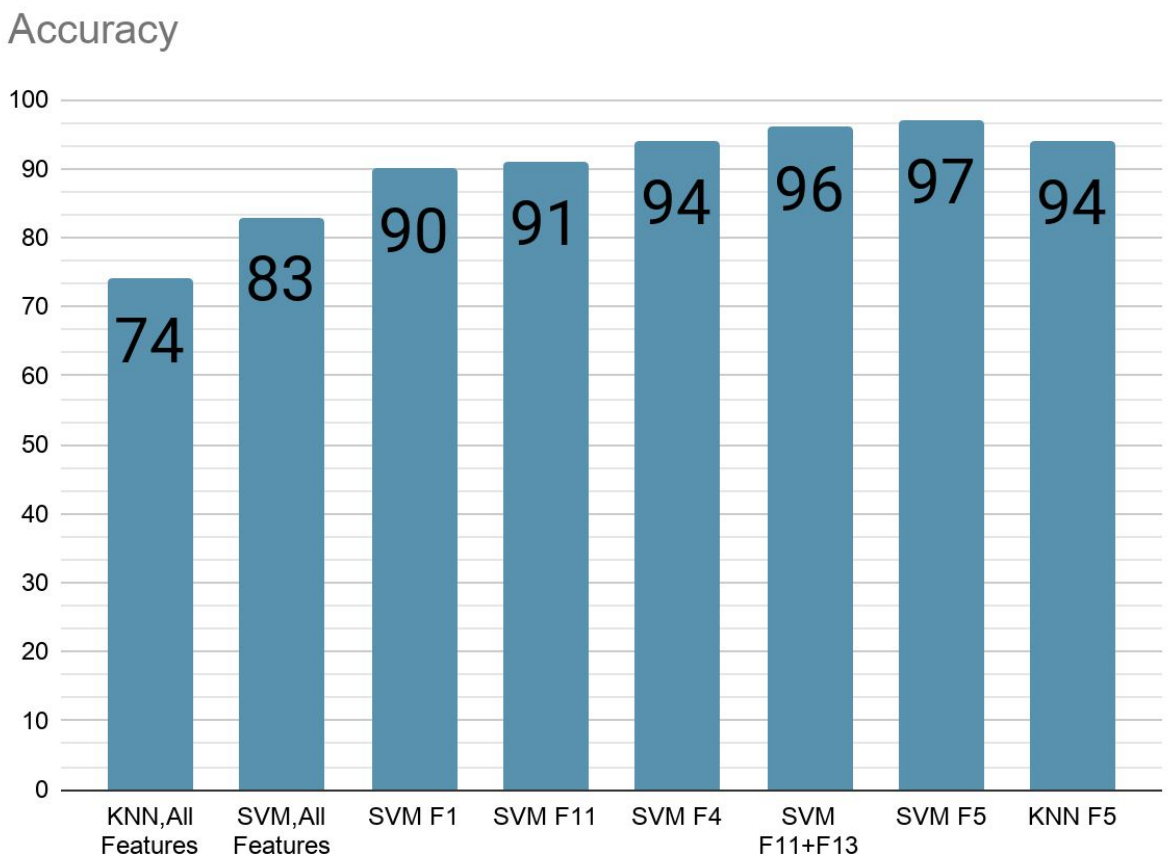
After trying all features together and some combination of the features,we have found that using **F5 (Distribution of chain code triplets)** is the best option and will discuss why later in the "Performance Analysis section".

Model Selection:

After extracting the features, we tried many classifiers and we have chosen to go with **SVM Classifier** and we will explain why we choose it in the "performance analysis section".

Performance Analysis:

- We have tried many combinations of our features and different classifiers on the "IAM dataset", we split the dataset to test cases, each test case consists of 3 writer, 2 images for each writer and one test image for each test case, So each test case consists of 7 images.
- We have found that the best accuracy is 97.2% tested on 500 test cases and is found using **F5 Feature only** and **SVM Classifier.**



- By Measuring The Time we have found that one test case that consists of 7 images takes only 0.8 sec.
- We Are Resizing the image from (3500,2500) to (875,625), as we found by resizing we don't affect the accuracy but makes the algorithm very fast.

Enhancement and future work:

- In the future we can use deep learning techniques to extract features and do the classification , we think it will get better accuracy.

Work distribution:

- **Aly Ramzy**

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  Work: Chain Code Features.

- **Ali Khaled**

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  Work : Codebook based features.

- **Mohamed Ahmed Ibrahim**

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  Work : Polygon based Features.

- **Ahmed Mohamed Elkarashily**

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  Work : Pre-processing, Window division, window clustering.