Handwriting Recognition

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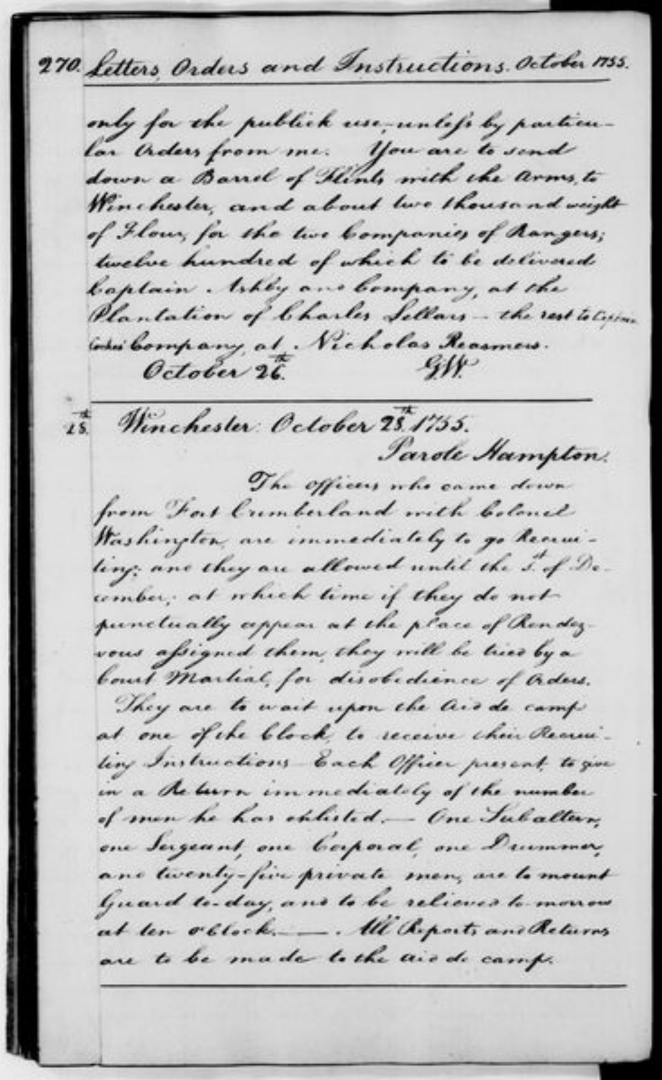
Problem Statement

The George Washington dataset contains 20 pages of letters written by George Washington and his associates in 1755 and thereby categorized into historical collection. The images are annotated at word level and contain approximately 5,000 words.



270. Letters, Orders and Instructions. October 1755.

only for the publick use, unless by particu-
lar Orders from me. You are to send
down a Barrel of Flints with the Arms, to
Winchester, and about two thousand weight
of Flour, for the two Companies of Rangers;
twelve hundred of which to be delivered
Captain Ashby and Company, at the
Plantation of Charles Sellars — the rest to Captn
Cocke's Company, at Nicholas Reasmers.
October 26th. G.W.

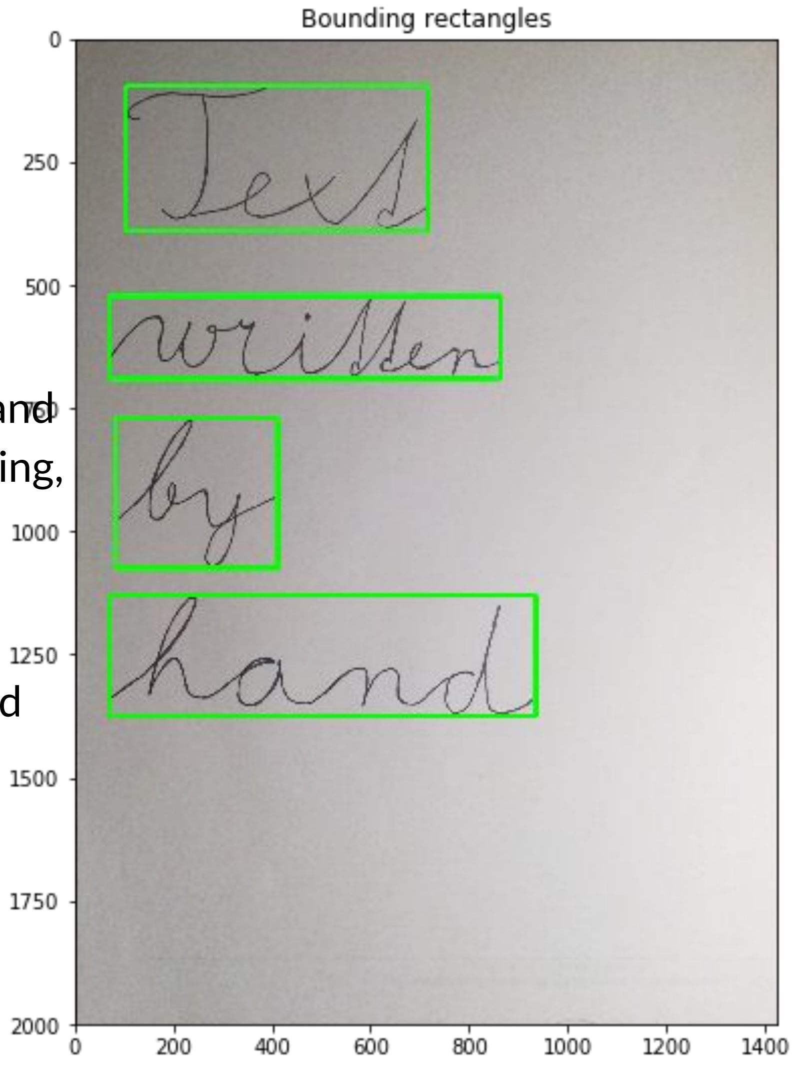
28th. Winchester: October 28th 1755.
Parole Hampton.

The officers who came down
from Fort Cumberland with Colonel
Washington, are immediately to go Recrui-
ting; and they are allowed until the 1st of De-
cember; at which time if they do not
punctually appear at the place of Rendez-
vous assigned them, they will be tried by a
Court Martial, for disobedience of Orders.
They are to wait upon the Aid de camp
at one of the clock, to receive their Recrui-
ting Instructions. Each Officer present to give
in a Return immediately of the number
of men he has enlisted. — One Subaltern,
one Sergeant, one Corporal, one Drummer,
and twenty-five private men, are to mount
Guard to-day, and to be relieved to-morrow
at ten o'clock. — All Reports and Returns
are to be made to the aid de camp.

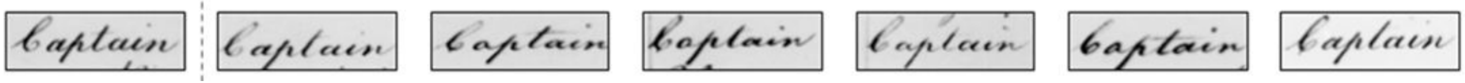
Motivation

Handwriting recognition is essential for digitizing handwritten content, enabling efficient data entry, improving accessibility for people with disabilities, and enhancing applications in education, language learning, and search engines.

It has broad practical applications in document management, signature verification, AI, robotics, and more, making it a valuable technology with widespread implications for various industries and everyday life.



GW


Captain
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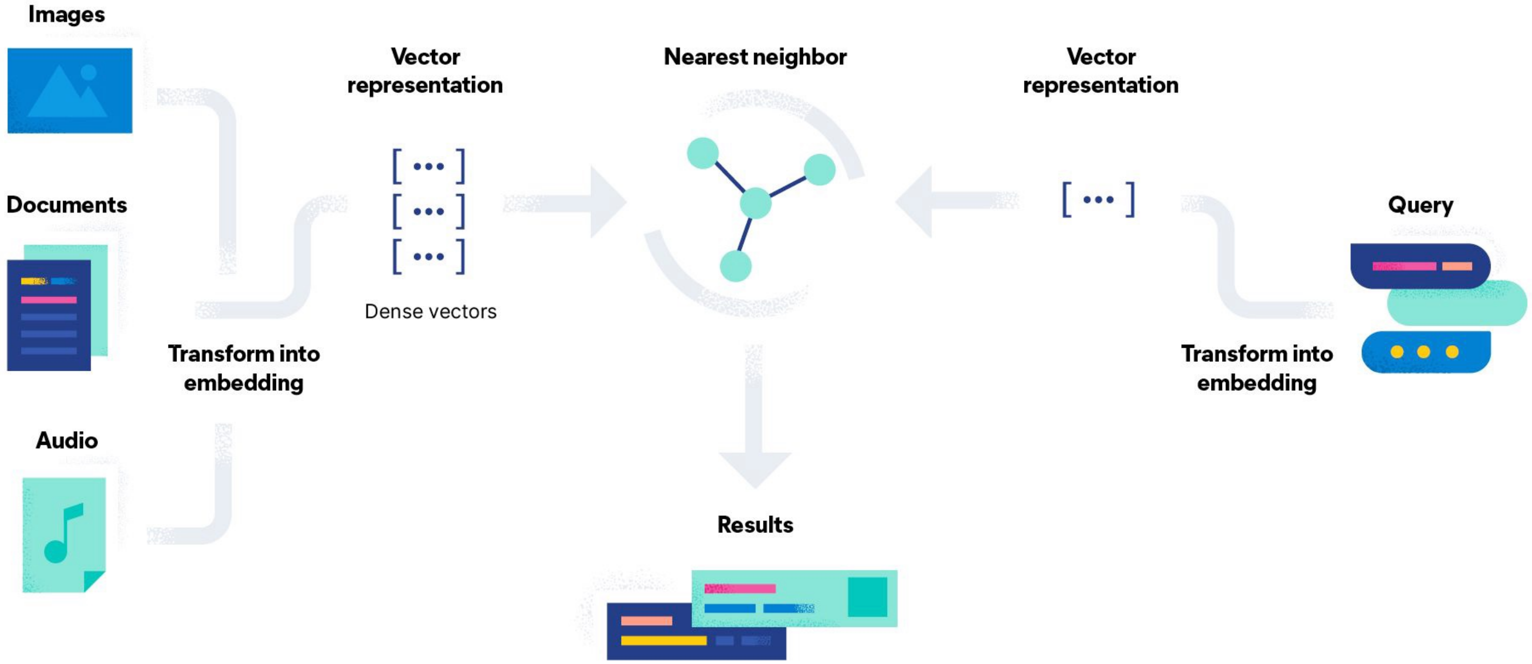
Images
Documents
Audio
Transform into embedding
Vector representation
Dense vectors
Nearest neighbor
Vector representation
Query
Transform into embedding
Results

Cosine Distance

1. Data Preprocessing:
   Input: Handwritten text images
   Output: Preprocessed images

2. Binary Vector Conversion:
   Input: Preprocessed images
   Output: Binary representation of images

3. Cosine Distance Calculation:
   Input: Binary vectors
   Output: Cosine distances bw all pairs of vectors

5. Evaluation Metrics:
   Input: Cosine distances, Ground truth labels
   Output: Precision-Recall metrics, AP values

6. Mean Average Precision (MAP) Calculation:
   Input: Individual AP values
   Output: Overall recognition performance

Results: Stage 1

```
Mean Average Precision (MAP) for the dataset: 0.3114319259338441
```

```
Query Data Point:
Label: d-o
Cosine Distances: [0.38228272 0.27470845 0.32385437 ... 0.15140344 0.4391105  0.40655764]

Top 10 Closest Data Points:
Label: d-o
Cosine Distance: 1.1657341758564144e-13
Label: o-r-s_mi
Cosine Distance: 0.045102731461981294
Label: a-n-y
Cosine Distance: 0.05328777315483302
Label: H-o-g-g-s
Cosine Distance: 0.05509417581635956
Label: l-e-a-v-e
Cosine Distance: 0.05590934198609143
Label: m-a-r-c-h
Cosine Distance: 0.05628044174575364
Label: C-l-o-t-h-e-s
Cosine Distance: 0.056608082863565445
Label: g-l-a-d
Cosine Distance: 0.0567882471914698
Label: u-n-d-e-r
Cosine Distance: 0.05694799905125025
Label: D-r-u-m-s_cm
Cosine Distance: 0.05702428174819274
```

Euclidian Distance

Improved Handling of Dissimilarity: L2 (Euclidean) distances are more effective in measuring dissimilarity. They perform well when recognizing characters with significant variations, artistic elements, or diverse writing styles, making the method more robust.

More Comprehensive Feature Representation: L2 distances allow for a more comprehensive representation of handwriting, as they capture various features like stroke thickness, pen pressure, and subtle differences in character structure, which Method 1 might miss.

Results: Stage 2

```
Mean Average Precision (MAP) for the subset of the dataset: 0.5246844500066226
Mean Recall (MRecall) for the subset of the dataset: 0.7506343826342283
```

```
Query Data Point:
Label: o-r
L2 Distances: 0.0

Top 10 Closest Data Points:
Label: o-r
L2 Distance: 0.0
Label: o-f
L2 Distance: 0.37578922561439365
Label: t-o
L2 Distance: 0.3813298767930956
Label: t-h-a-t
L2 Distance: 0.39100947664003005
Label: y-o-u
L2 Distance: 0.3913327432348945
Label: n-e-l-s
L2 Distance: 0.39652320027810467
Label: a-r-r-i-v-e
L2 Distance: 0.4031411928542059
Label: s-u-p-p-l-i-e-d
L2 Distance: 0.40869229405449203
Label: n-o-n-e
L2 Distance: 0.4099049895081434
Label: r-e-c-e-i-v-e
L2 Distance: 0.41087349376335086
```

```
Query Data Point:
Label: t-o
L2 Distances: 0.0

Top 10 Closest Data Points:
Label: t-o
L2 Distance: 0.0
Label: T-o
L2 Distance: 0.4018648490959157
Label: t-h-o-s-e
L2 Distance: 0.41272989802840987
Label: n-e-c-e-s_s-s-a-r-i-e-s
L2 Distance: 0.42213313061367674
Label: a-t
L2 Distance: 0.4238384694908548
Label: b-e
L2 Distance: 0.4283414292480474
Label: c-a-n
L2 Distance: 0.4323604430595629
Label: A-r-m-s
L2 Distance: 0.4456172648703772
Label: p-a-r-t-i-c-u-l-a-r
L2 Distance: 0.4500375366987378
Label: I
L2 Distance: 0.4516357262168649
```

Future Directions

- Improving these models
- Improving the features
    - Variable Length Features: Projection Profile
    - Variable Length Features: Upper and lower-word profile
    - Dynamic Time Wrapping
    - HOG, SIFT, SURF and Others
- Using better models
    - Voting classifiers
    - Bag of Visual Words

Conclusion

- The most significant personal learning from this project was the importance of iterative experimentation and the value of understanding the intricacies of data preprocessing, feature extraction, and distance calculation in the context of handwriting recognition.
- Top 3 Technical Learnings
    - Feature Extraction Techniques
    - Distance calculation methods
    - Evaluation metrics and performance analysis