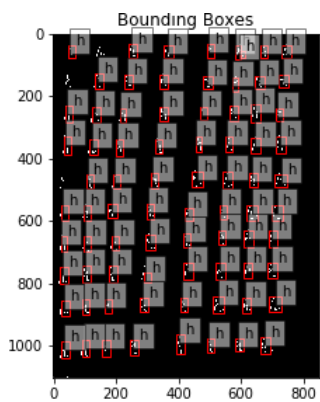
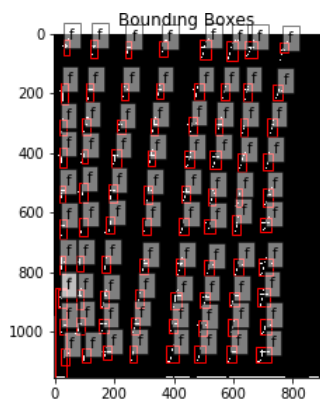
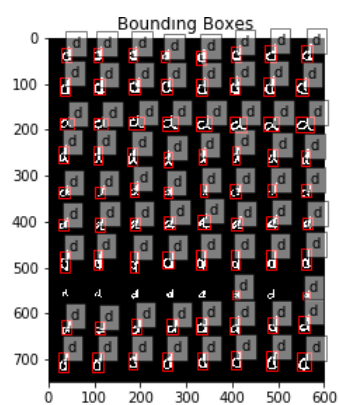
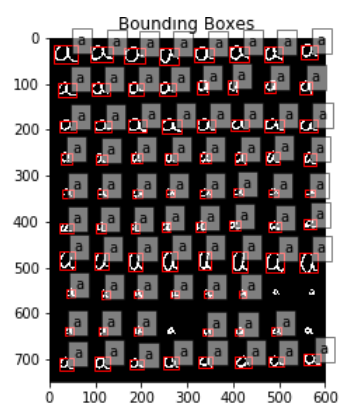


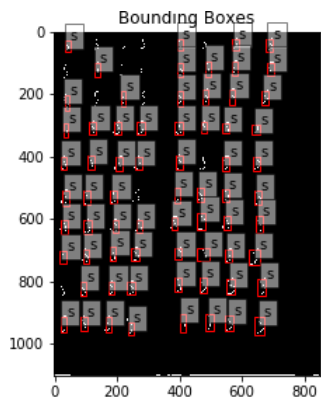
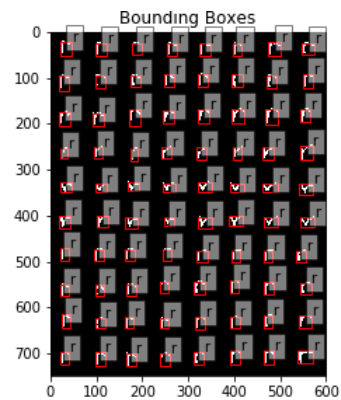
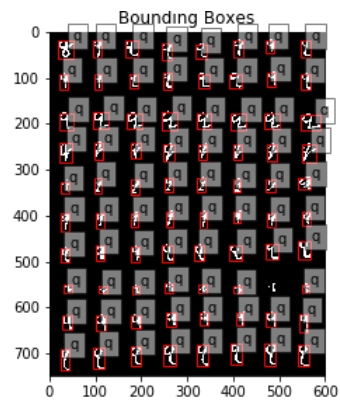
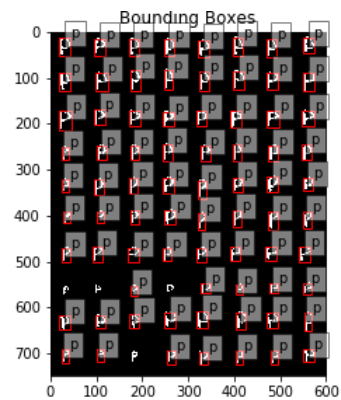
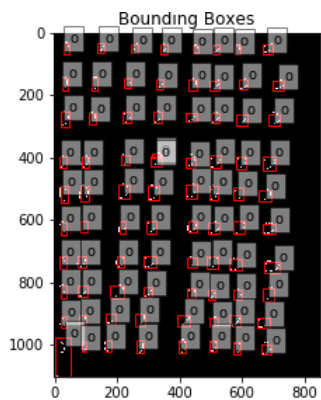
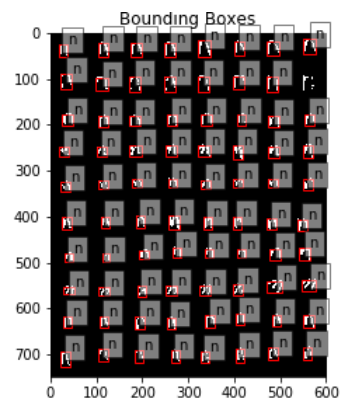
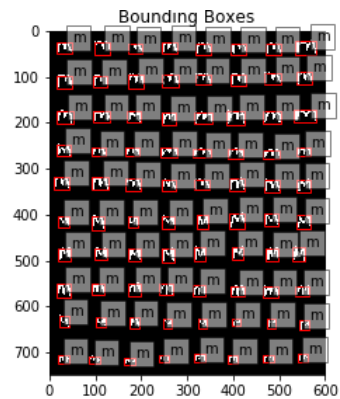
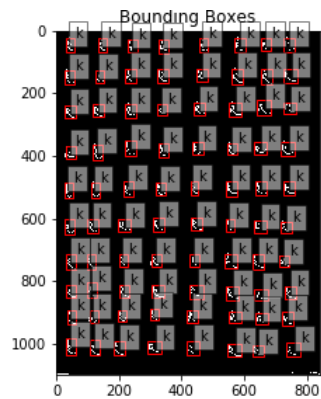
# 568Homework3

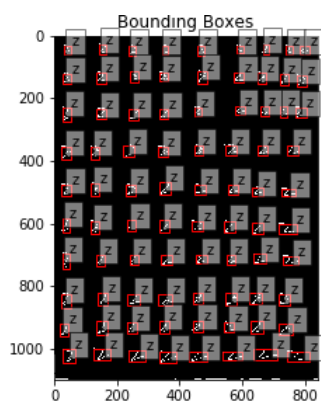
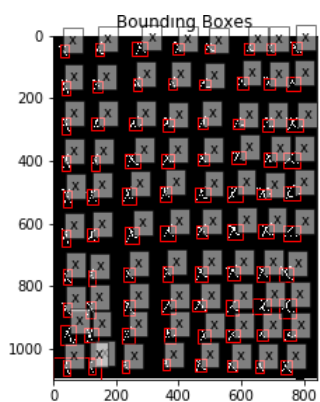
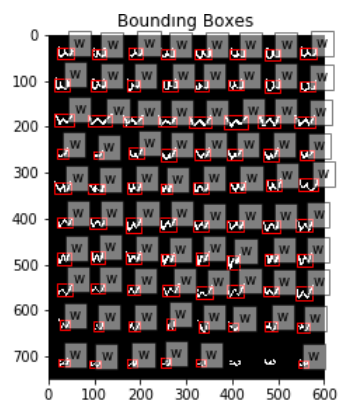
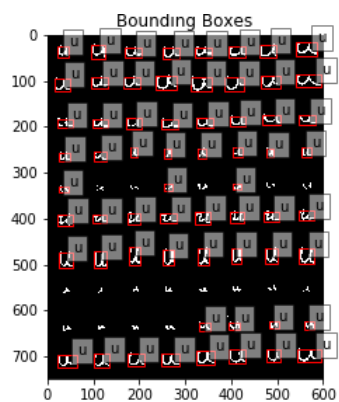
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March 3, 2019

1. Connected component image with bounding boxes and recognition results







## 2. Distance matrix (D)

```
[[ 0.          0.19239384  0.11554729 ... 36.95903684  2.78715464
 41.22757456]
 [ 0.19239384  0.          0.07805201 ... 36.94721035  2.72555292
 41.21158959]
 [ 0.11554729  0.07805201  0.          ... 36.95051384  2.74546496
 41.21591481]
 ...
 [36.95903684 36.94721035 36.95051384 ... 0.          34.78710619
 36.17929195]
 [ 2.78715464  2.72555292  2.74546496 ... 34.78710619  0.
 40.47853367]
 [41.22757456 41.21158959 41.21591481 ... 36.17929195 40.47853367
 0.          ]]
```

As the picture showed above, the Distance matrix is a  $N \times N$  matrix and the diagonal is always 0 since it is the distance between each character and itself.

## 3. Test image connected components with bounding boxes and recognition results

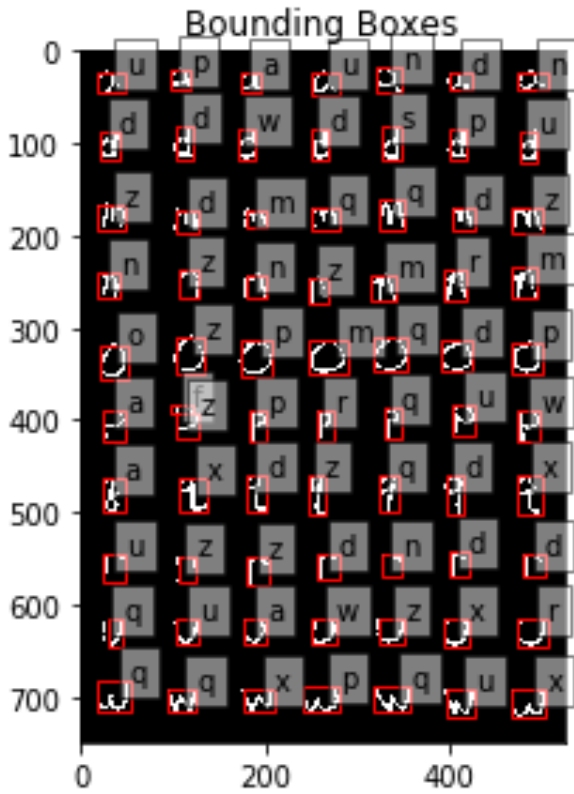


Figure 1: regular1

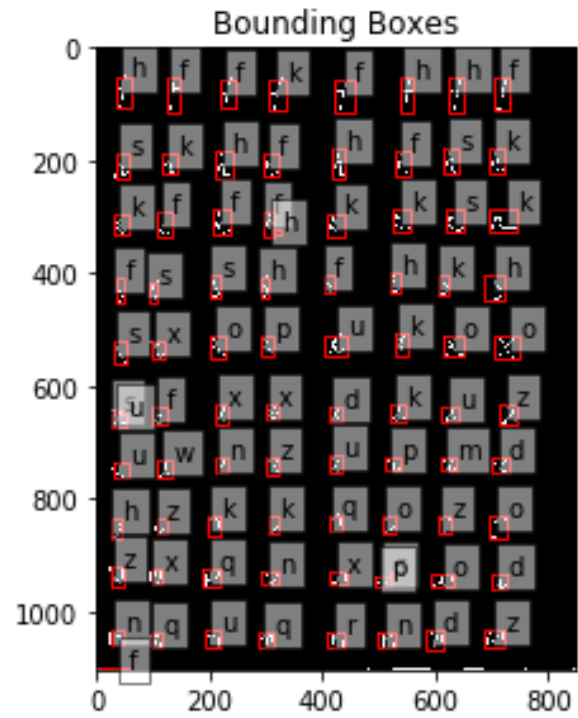


Figure 2: regular2

As the pictures Figure 1 and 2 showed above, this is the recognition by normal way without any enhancement. There are 149 bounding boxes and 26 predictions are right, the rate is 16.77%.

The normal way means that the binary threshold is 200, the threshold of bounding box is 5, no

binary morphology used and the nearest neighbor algorithm.

4. Test image connected components with bounding boxes and recognition results - For every (successful) enhancement

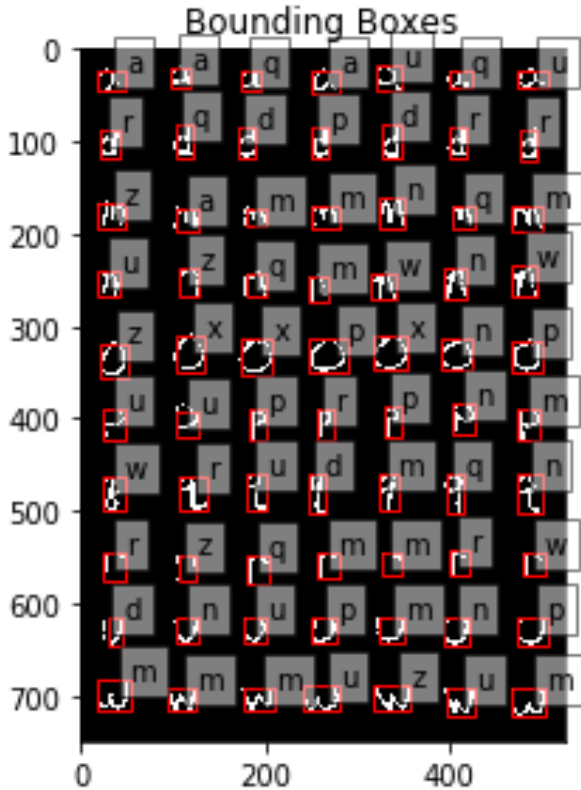


Figure 3: otsu1

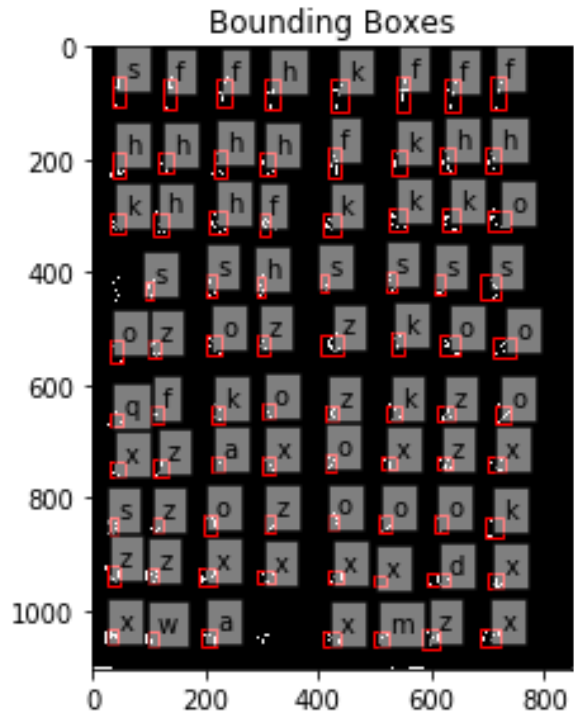


Figure 4: otsu2

As the Figure 3 and 4 showed above, I use OTSU algorithm to get the dynamic threshold for each character which is used for binary the picture. There are 148 bounding boxes and 43 predictions are right, the rate is 29.05%.

As the Figure 5 and 6 showed above, I changed the threshold of bounding boxes from 5 to 15, which will ignore more small boxes. There are 148 bounding boxes and 28 predictions are right, the rate is 18.79%.

As the Figure 7 and 8 showed above, I use the k-nearest neighbors algorithm for recognition. There are 155 bounding boxes and 53 predictions are right, the rate is 34.19%.

I still try to use binary morphology to improve the recognition rate, but the erosion way and the dilation way neither performed well, since I think the bounding boxes is small, and the character is

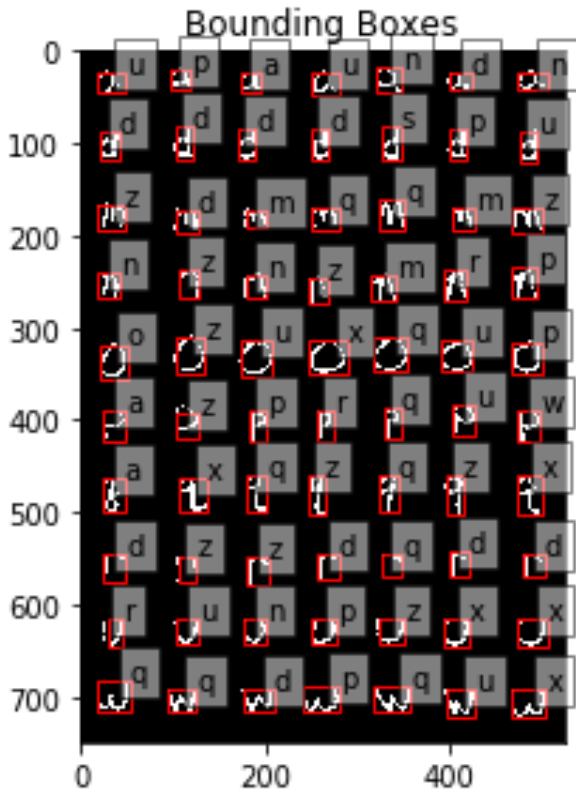


Figure 5: RC1

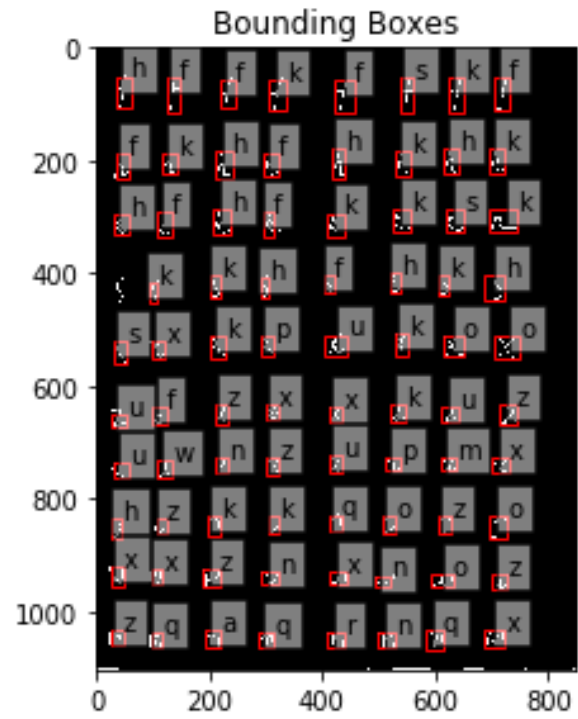


Figure 6: RC2

very small, which makes the binary morphology make no sense to the recognition rate.

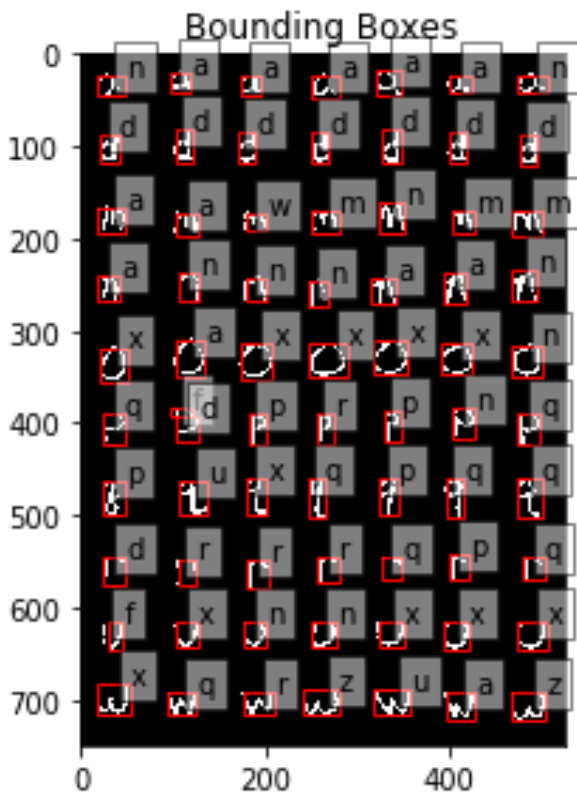


Figure 7: knn1

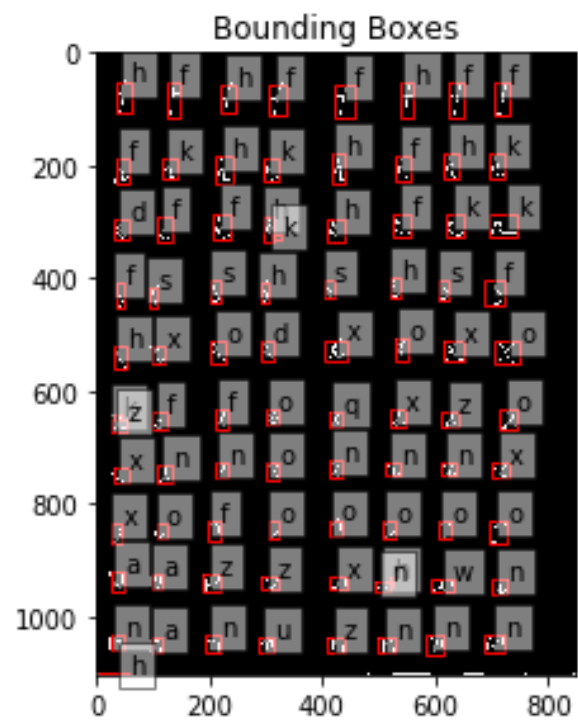


Figure 8: knn2

- Test image connected components with bounding boxes and recognition results - For all enhancements combined.

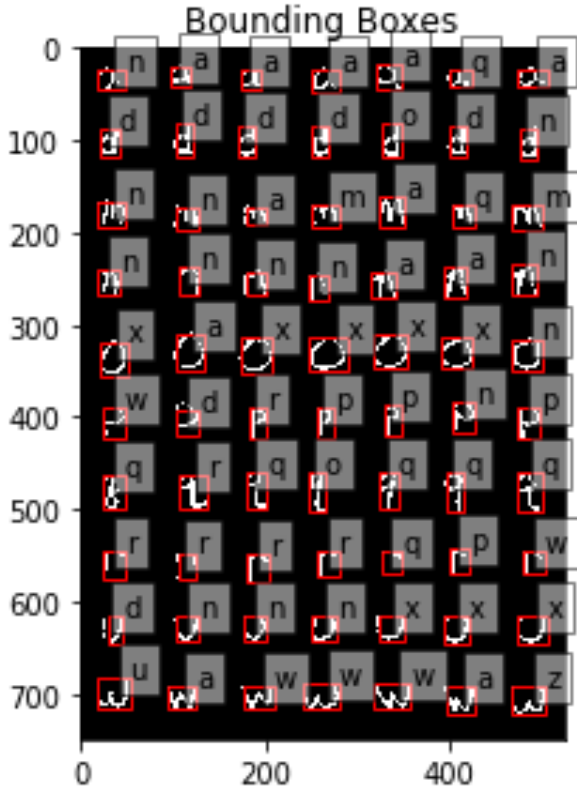


Figure 9: combined1

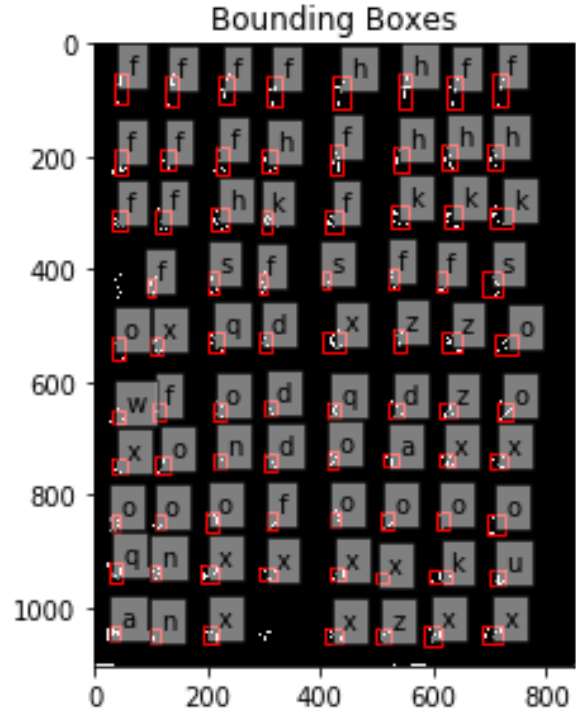


Figure 10: combined2

For all enhancements combined, There are 148 bounding boxes and 60 predictions are right, the rate is 40.54%.

- Threshold value you have picked, or any algorithm you used to find a threshold

| bmp file | a   | d   | f   | h   | k   | m   | n   | o   | p   | q   | r   | s   | u   | w   | x   | z   |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| OTSU     | 192 | 185 | 155 | 152 | 162 | 181 | 196 | 156 | 183 | 186 | 181 | 156 | 188 | 186 | 166 | 165 |
| TRIANGLE | 249 | 249 | 237 | 237 | 229 | 249 | 249 | 233 | 249 | 249 | 249 | 237 | 249 | 249 | 229 | 229 |

I use two different algorithm to find the threshold to binary the gray picture, the OTSU algorithm has better performance.

- Number of components you obtained for test image
- Recognition rate for the test image and after each enhancement and after all enhancement combined



|                             | number of components |
|-----------------------------|----------------------|
| Normal                      | 149                  |
| OTSU                        | 148                  |
| threshold of bounding boxes | 148                  |
| knn                         | 155                  |

|                             | Recognition Rate |
|-----------------------------|------------------|
| Normal                      | 16.77%           |
| OTSU                        | 29.05%           |
| threshold of bounding boxes | 18.79%           |
| knn                         | 34.19%           |
| combined                    | 40.54%           |