LAB 2 REPORT – Aaron Bruner

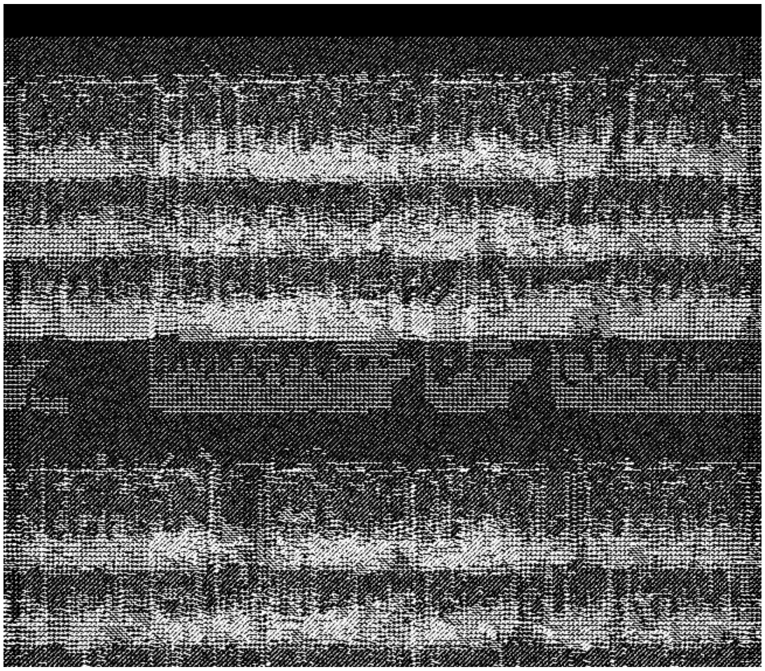
The purpose of this lab was to detect the location of characters in an image. The lab instructions laid out 4 steps for us to follow. The first step was to read the input image, template image, and ground truth files.

```
./lab2
Step 1:
Performing matched filter on images [parenthood.ppm] and [parenthood_e_template.ppm] using ground
truth [parenthood_gt.txt]
        * Reading in source image...    [SUCCESS]
        * Reading in template image...  [SUCCESS]
        * Opening ground truth file...  [SUCCESS]
        * Found 1261 number of rows in the ground truth file
        * Allocating space for ground truth file... [SUCCESS]
        * Scanning in values from ground truth file...  [Read in 1261 rows]
```

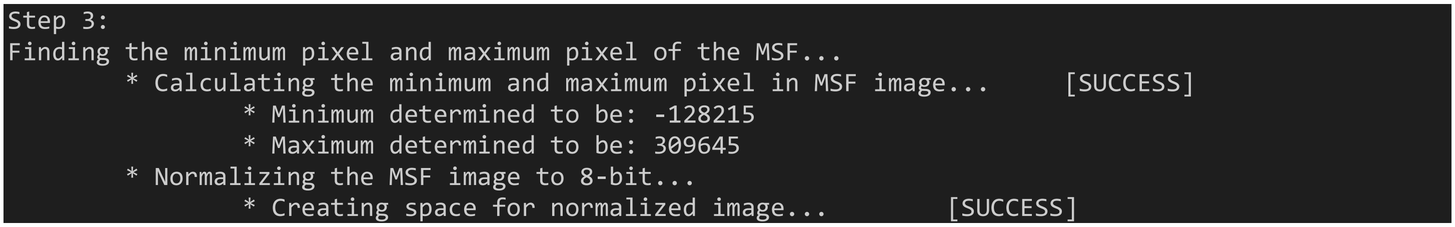
The above text is the first step output from the terminal when we execute out code. As we can see, the files parenthood.ppm, parenthood_e_template.ppm and parenthood_gt.txt are used since command line arguments were not provided. We have the option of specifying which files we want to use by using the following command: ./lab2 (sourceFile.ppm) (templateFile.ppm) (groundTruth.txt). We can see that 1261 rows were read in from the ground truth and all files were successfully opened and read in.

Step 2 asked us to calculate the matched-spatial filter (MSF) image. Below is the output from the terminal and the MSF image.

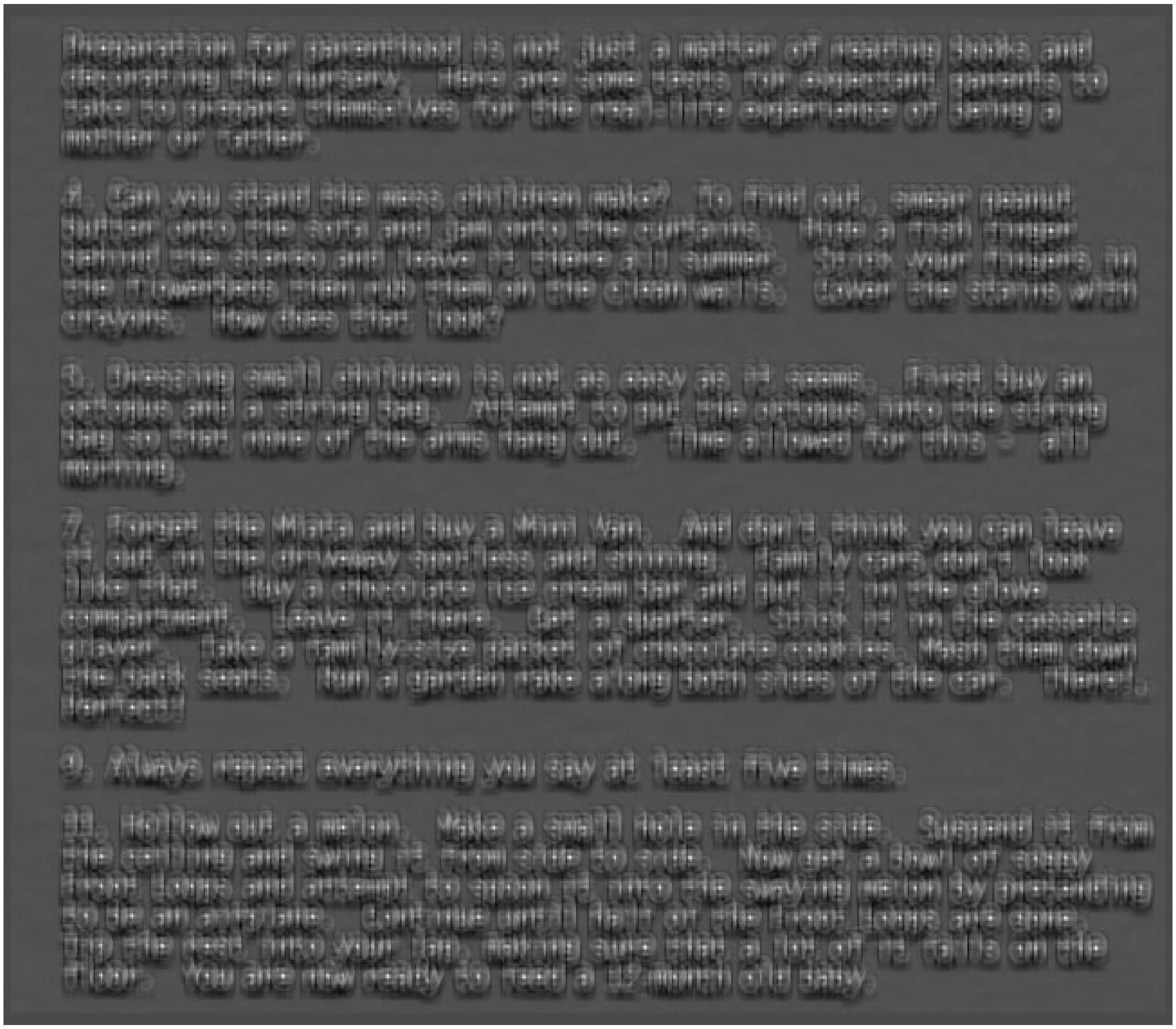
```
Step 2:
Calculate the mean of the template image...
        * Mean pixel value in the template image = 165
        * Generating the zero mean template image
                * Allocating space for template MSF image...    [SUCCESS]
                * Allocating space for MSF image...     [SUCCESS]
                * Convolving source and zero-mean centered image...     [SUCCESS]
```



Step 3 asked us to normalize the MSF image to 8-bits. Below is the output from the terminal and the normalized image.

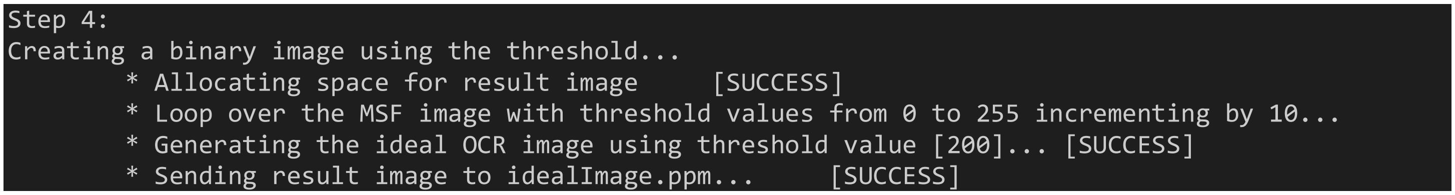


```
Step 3:
Finding the minimum pixel and maximum pixel of the MSF...
        * Calculating the minimum and maximum pixel in MSF image...     [SUCCESS]
                * Minimum determined to be: -128215
                * Maximum determined to be: 309645
        * Normalizing the MSF image to 8-bit...
                * Creating space for normalized image...        [SUCCESS]
```



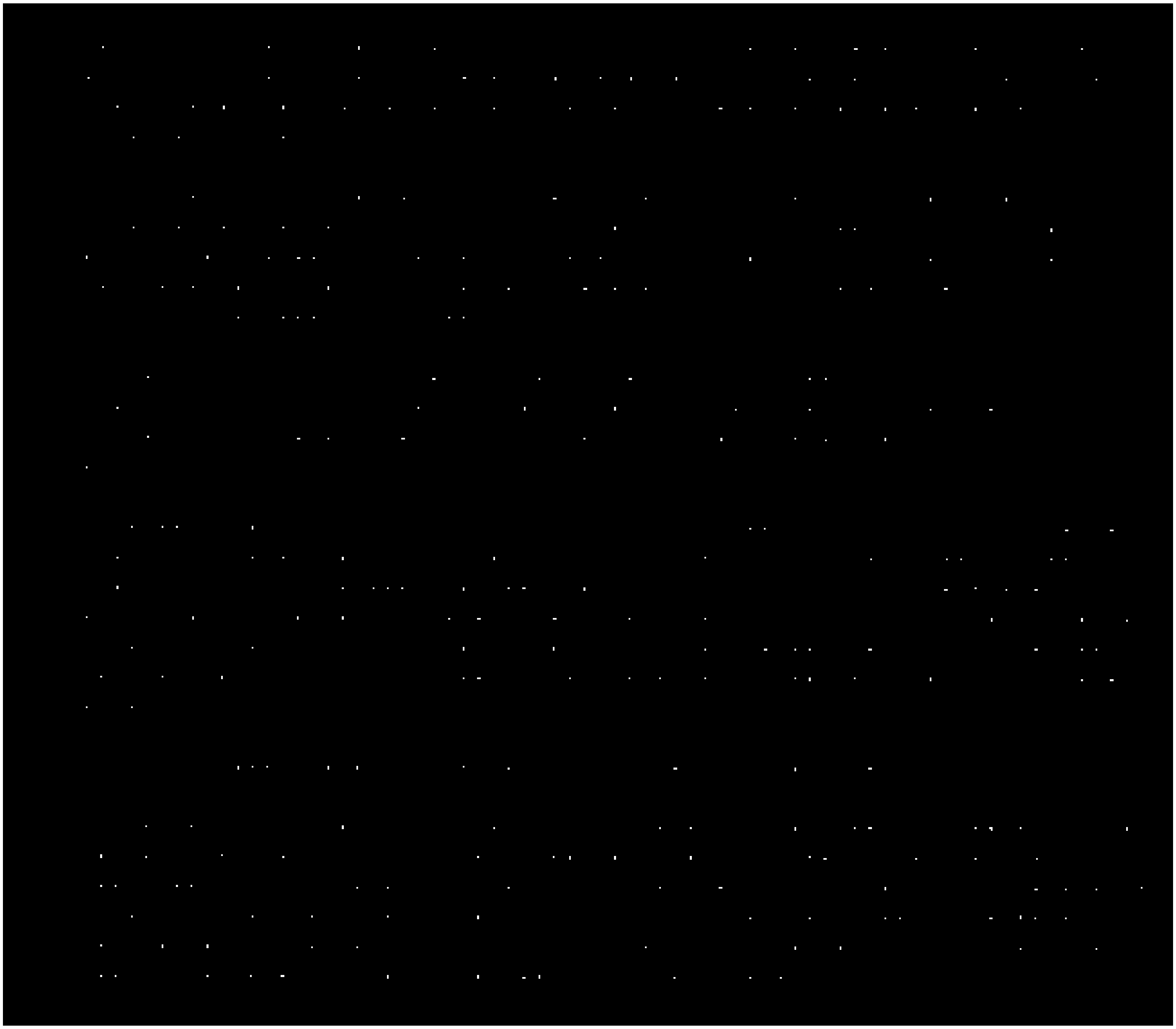
The pixel values with values closer to 255 are more likely to be e.

Step 4 has us thresholding the above image for ranging values of T. The ideal value of T was determined to be 200 which yields the highest number of e's with the lowest number of FP.

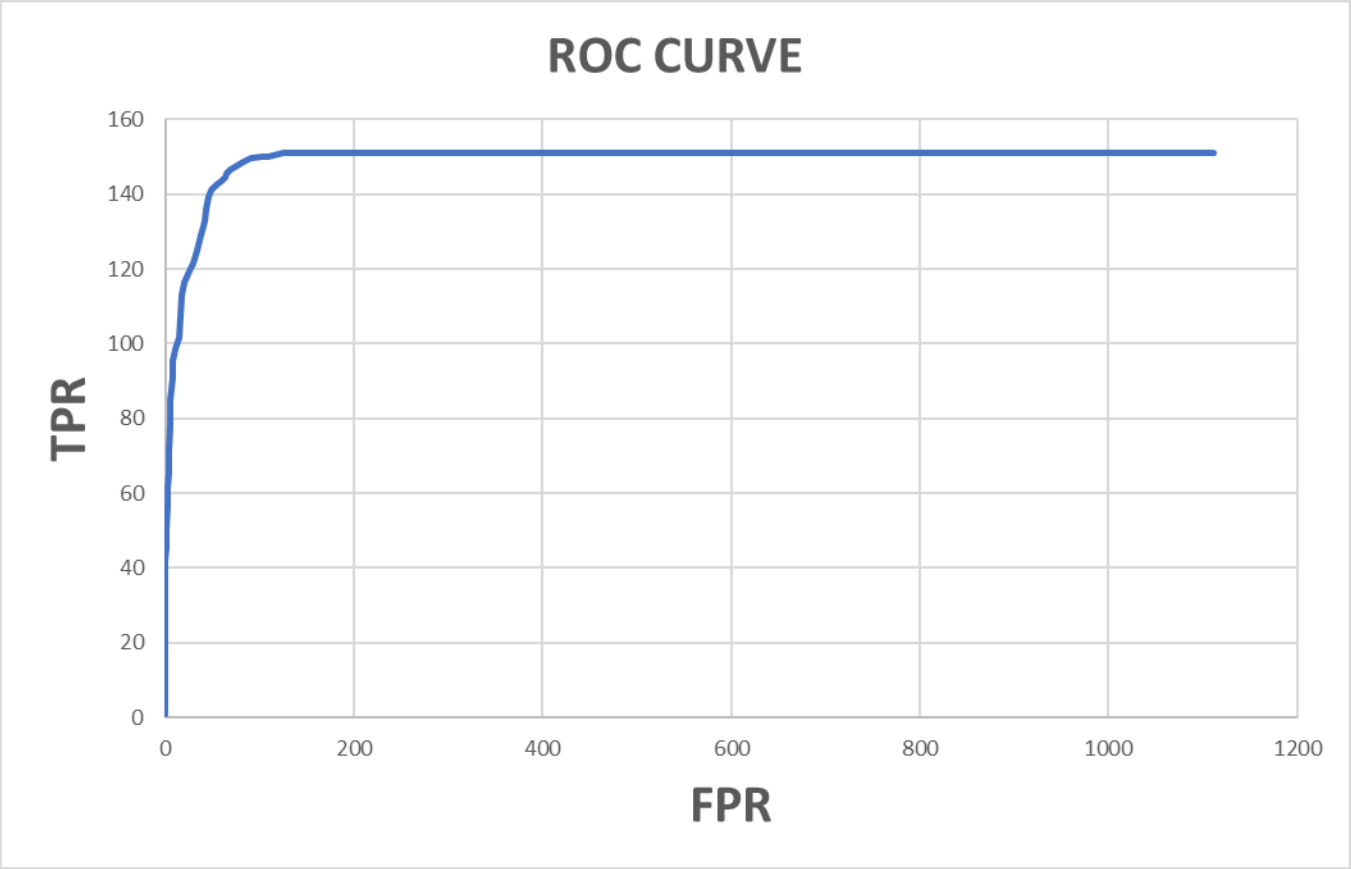


```
Step 4:
Creating a binary image using the threshold...
        * Allocating space for result image     [SUCCESS]
        * Loop over the MSF image with threshold values from 0 to 255 incrementing by 10...
        * Generating the ideal OCR image using threshold value [200]... [SUCCESS]
        * Sending result image to idealImage.ppm...     [SUCCESS]
```

The full output of TP and FP values for T values ranging from 0 to 255 are on the next page along with the ideal output image at 200.



```
Threshold [  0] : TP =  151   | FP = 1111
Threshold [  1] : TP =  151   | FP = 1111
Threshold [  2] : TP =  151   | FP = 1111
Threshold [  3] : TP =  151   | FP = 1111
Threshold [  4] : TP =  151   | FP = 1111
Threshold [  5] : TP =  151   | FP = 1111
Threshold [  6] : TP =  151   | FP = 1111
Threshold [  7] : TP =  151   | FP = 1111
Threshold [  8] : TP =  151   | FP = 1111
Threshold [  9] : TP =  151   | FP = 1111
Threshold [ 10] : TP =  151 | FP = 1111
Threshold [ 11] : TP =  151 | FP = 1111
Threshold [ 12] : TP =  151 | FP = 1111
Threshold [ 13] : TP =  151 | FP = 1111
Threshold [ 14] : TP =  151 | FP = 1111
Threshold [ 15] : TP =  151 | FP = 1111
Threshold [ 16] : TP =  151 | FP = 1111
Threshold [ 17] : TP =  151 | FP = 1111
Threshold [ 18] : TP =  151 | FP = 1111
Threshold [ 19] : TP =  151 | FP = 1111
Threshold [ 20] : TP =  151 | FP = 1111
Threshold [ 21] : TP =  151 | FP = 1111
Threshold [ 22] : TP =  151 | FP = 1111
Threshold [ 23] : TP =  151 | FP = 1111
Threshold [ 24] : TP =  151 | FP = 1111
Threshold [ 25] : TP =  151 | FP = 1111
Threshold [ 26] : TP =  151 | FP = 1111
Threshold [ 27] : TP =  151 | FP = 1111
Threshold [ 28] : TP =  151 | FP = 1111
Threshold [ 29] : TP =  151 | FP = 1111
Threshold [ 30] : TP =  151 | FP = 1111
Threshold [ 31] : TP =  151 | FP = 1111
Threshold [ 32] : TP =  151 | FP = 1111
Threshold [ 33] : TP =  151 | FP = 1111
Threshold [ 34] : TP =  151 | FP = 1111
Threshold [ 35] : TP =  151 | FP = 1111
Threshold [ 36] : TP =  151 | FP = 1111
Threshold [ 37] : TP =  151 | FP = 1111
Threshold [ 38] : TP =  151 | FP = 1111
Threshold [ 39] : TP =  151 | FP = 1111
Threshold [ 40] : TP =  151 | FP = 1111
Threshold [ 41] : TP =  151 | FP = 1111
Threshold [ 42] : TP =  151 | FP = 1111
Threshold [ 43] : TP =  151 | FP = 1111
Threshold [ 44] : TP =  151 | FP = 1111
Threshold [ 45] : TP =  151 | FP = 1111
Threshold [ 46] : TP =  151 | FP = 1111
Threshold [ 47] : TP =  151 | FP = 1111
Threshold [ 48] : TP =  151 | FP = 1111
Threshold [ 49] : TP =  151 | FP = 1111
Threshold [ 50] : TP =  151 | FP = 1111
Threshold [ 51] : TP =  151 | FP = 1111
Threshold [ 52] : TP =  151 | FP = 1111
Threshold [ 53] : TP =  151 | FP = 1111
Threshold [ 54] : TP =  151 | FP = 1111
Threshold [ 55] : TP =  151 | FP = 1111
Threshold [ 56] : TP =  151 | FP = 1111
Threshold [ 57] : TP =  151 | FP = 1111
Threshold [ 58] : TP =  151 | FP = 1111
Threshold [ 59] : TP =  151 | FP = 1111
Threshold [ 60] : TP =  151 | FP = 1111
Threshold [ 61] : TP =  151 | FP = 1111
Threshold [ 62] : TP =  151 | FP = 1111
Threshold [ 63] : TP =  151 | FP = 1111
Threshold [ 64] : TP =  151 | FP = 1111
Threshold [ 65] : TP =  151 | FP = 1111
Threshold [ 66] : TP =  151 | FP = 1111
Threshold [ 67] : TP =  151 | FP = 1111
Threshold [ 68] : TP =  151 | FP = 1111
Threshold [ 69] : TP =  151 | FP = 1111
Threshold [ 70] : TP =  151 | FP = 1111
Threshold [ 71] : TP =  151 | FP = 1111
Threshold [ 72] : TP =  151 | FP = 1111
Threshold [ 73] : TP =  151 | FP = 1111
Threshold [ 74] : TP =  151 | FP = 1111
Threshold [ 75] : TP =  151  | FP = 1111
Threshold [ 76] : TP =  151  | FP = 1111
Threshold [ 77] : TP =  151  | FP = 1111
Threshold [ 78] : TP =  151  | FP = 1111
Threshold [ 79] : TP =  151  | FP = 1111
Threshold [ 80] : TP =  151  | FP = 1111
Threshold [ 81] : TP =  151  | FP = 1111
Threshold [ 82] : TP =  151  | FP = 1111
Threshold [ 83] : TP =  151  | FP = 1111
Threshold [ 84] : TP =  151  | FP = 1111
Threshold [ 85] : TP =  151  | FP = 1111
Threshold [ 86] : TP =  151  | FP = 1111
Threshold [ 87] : TP =  151  | FP = 1111
Threshold [ 88] : TP =  151  | FP = 1111
Threshold [ 89] : TP =  151  | FP = 1111
Threshold [ 90] : TP =  151  | FP = 1111
Threshold [ 91] : TP =  151  | FP = 1111
Threshold [ 92] : TP =  151  | FP = 1111
Threshold [ 93] : TP =  151  | FP = 1111
Threshold [ 94] : TP =  151  | FP = 1111
Threshold [ 95] : TP =  151  | FP = 1111
Threshold [ 96] : TP =  151  | FP = 1111
Threshold [ 97] : TP =  151  | FP = 1111
Threshold [ 98] : TP =  151  | FP = 1111
Threshold [ 99] : TP =  151  | FP = 1111
Threshold [100] : TP =  151| FP = 1111
Threshold [101] : TP =  151| FP = 1111
Threshold [102] : TP =  151| FP = 1111
Threshold [103] : TP =  151| FP = 1111
Threshold [104] : TP =  151| FP = 1111
Threshold [105] : TP =  151| FP = 1111
Threshold [106] : TP =  151| FP = 1111
Threshold [107] : TP =  151| FP = 1111
Threshold [108] : TP =  151| FP = 1110
Threshold [109] : TP =  151| FP = 1110
Threshold [110] : TP =  151| FP = 1110
Threshold [111] : TP =  151| FP = 1110
Threshold [112] : TP =  151| FP = 1109
Threshold [113] : TP =  151| FP = 1109
Threshold [114] : TP =  151| FP = 1108
Threshold [115] : TP =  151| FP = 1107
Threshold [116] : TP =  151| FP = 1106
Threshold [117] : TP =  151| FP = 1105
Threshold [118] : TP =  151| FP = 1105
Threshold [119] : TP =  151| FP = 1102
Threshold [120] : TP =  151| FP = 1101
Threshold [121] : TP =  151| FP = 1097
Threshold [122] : TP =  151| FP = 1097
Threshold [123] : TP =  151| FP = 1096
Threshold [124] : TP =  151| FP = 1096
Threshold [125] : TP =  151| FP = 1094
Threshold [126] : TP =  151| FP = 1091
Threshold [127] : TP =  151| FP = 1088
Threshold [128] : TP =  151| FP = 1084
Threshold [129] : TP =  151| FP = 1079
Threshold [130] : TP =  151| FP = 1073
Threshold [131] : TP =  151| FP = 1068
Threshold [132] : TP =  151| FP = 1066
Threshold [133] : TP =  151| FP = 1058
Threshold [134] : TP =  151| FP = 1053
Threshold [135] : TP =  151| FP = 1047
Threshold [136] : TP =  151| FP = 1041
Threshold [137] : TP =  151| FP = 1035
Threshold [138] : TP =  151| FP = 1026
Threshold [139] : TP =  151| FP = 1016
Threshold [140] : TP =  151| FP = 1010
Threshold [141] : TP =  151| FP = 1003
Threshold [142] : TP =  151| FP =  994
Threshold [143] : TP =  151| FP =  984
Threshold [144] : TP =  151| FP =  971
Threshold [145] : TP =  151| FP =  957
Threshold [146] : TP =  151| FP =  947
Threshold [147] : TP =  151| FP =  929
Threshold [148] : TP =  151| FP =  921
Threshold [149] : TP =  151| FP =  908
Threshold [150] : TP =  151| FP =  889
Threshold [151] : TP =  151| FP =  873
Threshold [152] : TP =  151| FP =  849
Threshold [153] : TP =  151| FP =  830
Threshold [154] : TP =  151| FP =  809
Threshold [155] : TP =  151| FP =  791
Threshold [156] : TP =  151| FP =  767
Threshold [157] : TP =  151| FP =  746
Threshold [158] : TP =  151| FP =  726
Threshold [159] : TP =  151| FP =  699
Threshold [160] : TP =  151| FP =  675
Threshold [161] : TP =  151| FP =  656
Threshold [162] : TP =  151| FP =  643
Threshold [163] : TP =  151| FP =  624
Threshold [164] : TP =  151| FP =  612
Threshold [165] : TP =  151| FP =  597
Threshold [166] : TP =  151| FP =  580
Threshold [167] : TP =  151| FP =  565
Threshold [168] : TP =  151| FP =  554
Threshold [169] : TP =  151| FP =  544
Threshold [170] : TP =  151| FP =  535
Threshold [171] : TP =  151| FP =  519
Threshold [172] : TP =  151| FP =  509
Threshold [173] : TP =  151| FP =  492
Threshold [174] : TP =  151| FP =  477
Threshold [175] : TP =  151| FP =  468
Threshold [176] : TP =  151| FP =  450
Threshold [177] : TP =  151| FP =  440
Threshold [178] : TP =  151| FP =  421
Threshold [179] : TP =  151| FP =  400
Threshold [180] : TP =  151| FP =  386
Threshold [181] : TP =  151| FP =  372
Threshold [182] : TP =  151| FP =  349
Threshold [183] : TP =  151| FP =  339
Threshold [184] : TP =  151| FP =  319
Threshold [185] : TP =  151| FP =  308
Threshold [186] : TP =  151| FP =  292
Threshold [187] : TP =  151| FP =  283
Threshold [188] : TP =  151| FP =  272
Threshold [189] : TP =  151| FP =  253
Threshold [190] : TP =  151| FP =  231
Threshold [191] : TP =  151| FP =  215
Threshold [192] : TP =  151| FP =  200
Threshold [193] : TP =  151| FP =  187
Threshold [194] : TP =  151| FP =  180
Threshold [195] : TP =  151| FP =  169
Threshold [196] : TP =  151| FP =  162
Threshold [197] : TP =  151| FP =  148
Threshold [198] : TP =  151| FP =  141
Threshold [199] : TP =  151| FP =  133
Threshold [200] : TP =  151| FP =  124
Threshold [201] : TP =  150| FP =  113
Threshold [202] : TP =  150| FP =  108
Threshold [203] : TP =  150| FP =  101
Threshold [204] : TP =  149| FP =   90
Threshold [205] : TP =  148| FP =   82
Threshold [206] : TP =  147| FP =   75
Threshold [207] : TP =  146| FP =   69
Threshold [208] : TP =  145| FP =   65
Threshold [209] : TP =  144| FP =   64
Threshold [210] : TP =  143| FP =   59
Threshold [211] : TP =  142| FP =   54
Threshold [212] : TP =  142| FP =   52
Threshold [213] : TP =  140| FP =   48
Threshold [214] : TP =  139| FP =   45
Threshold [215] : TP =  133| FP =   43
Threshold [216] : TP =  133| FP =   42
Threshold [217] : TP =  130| FP =   40
Threshold [218] : TP =  128| FP =   37
Threshold [219] : TP =  122| FP =   34
Threshold [220] : TP =  121| FP =   30
Threshold [221] : TP =  118| FP =   25
Threshold [222] : TP =  115| FP =   20
Threshold [223] : TP =  111| FP =   17
Threshold [224] : TP =  104| FP =   16
Threshold [225] : TP =   99  | FP =   14
Threshold [226] : TP =   98  | FP =   10
Threshold [227] : TP =   93  | FP =    7
Threshold [228] : TP =   89  | FP =    7
Threshold [229] : TP =   81  | FP =    5
Threshold [230] : TP =   75  | FP =    5
Threshold [231] : TP =   68  | FP =    4
Threshold [232] : TP =   63  | FP =    4
Threshold [233] : TP =   60  | FP =    2
Threshold [234] : TP =   53  | FP =    2
Threshold [235] : TP =   48  | FP =    1
Threshold [236] : TP =   43  | FP =    1
Threshold [237] : TP =   41  | FP =    0
Threshold [238] : TP =   39  | FP =    0
Threshold [239] : TP =   35  | FP =    0
Threshold [240] : TP =   31  | FP =    0
Threshold [241] : TP =   28  | FP =    0
Threshold [242] : TP =   24  | FP =    0
Threshold [243] : TP =   23  | FP =    0
Threshold [244] : TP =   20  | FP =    0
Threshold [245] : TP =   16  | FP =    0
Threshold [246] : TP =   13  | FP =    0
Threshold [247] : TP =   11  | FP =    0
Threshold [248] : TP =    8   | FP =    0
Threshold [249] : TP =    6   | FP =    0
Threshold [250] : TP =    5   | FP =    0
Threshold [251] : TP =    1   | FP =    0
Threshold [252] : TP =    1   | FP =    0
Threshold [253] : TP =    1   | FP =    0
Threshold [254] : TP =    1   | FP =    0
Threshold [255] : TP =    1   | FP =    0
```


ROC CURVE
TPR
FPR
0
20
40
60
80
100
120
140
160
0
200
400
600
800
1000
1200