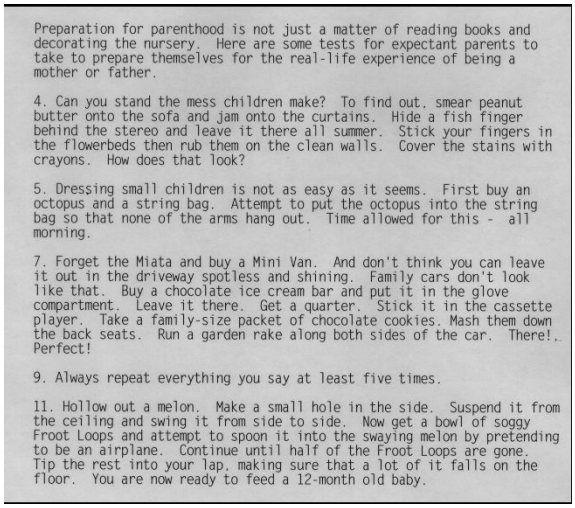
ECE 6310: Introduction to Computer Vision - Lab 3 Report
Letters

Objective: To implement thinning, branchpoint and endpoint detection to recognize letters in an image of text, create an ROC curve from the program output.

Implementation and steps:

1. Original input image, groundTruth, msf image were read and checked if read correctly. Normalized msf image had the pixel values obtained after template matching with a template of letter ‘e’. The template image size was 9*15.



Preparation for parenthood is not just a matter of reading books and decorating the nursery. Here are some tests for expectant parents to take to prepare themselves for the real-life experience of being a mother or father.

4. Can you stand the mess children make? To find out, smear peanut butter onto the sofa and jam onto the curtains. Hide a fish finger behind the stereo and leave it there all summer. Stick your fingers in the flowerbeds then rub them on the clean walls. Cover the stains with crayons. How does that look?

5. Dressing small children is not as easy as it seems. First buy an octopus and a string bag. Attempt to put the octopus into the string bag so that none of the arms hang out. Time allowed for this - all morning.

7. Forget the Miata and buy a Mini Van. And don't think you can leave it out in the driveway spotless and shining. Family cars don't look like that. Buy a chocolate ice cream bar and put it in the glove compartment. Leave it there. Get a quarter. Stick it in the cassette player. Take a family-size packet of chocolate cookies. Mash them down the back seats. Run a garden rake along both sides of the car. There!. Perfect!

9. Always repeat everything you say at least five times.

11. Hollow out a melon. Make a small hole in the side. Suspend it from the ceiling and swing it from side to side. Now get a bowl of soggy Froot Loops and attempt to spoon it into the swaying melon by pretending to be an airplane. Continue until half of the Froot Loops are gone. Tip the rest into your lap, making sure that a lot of it falls on the floor. You are now ready to feed a 12-month old baby.

*Fig. 1 parenthood.ppm (649*657)*

Fig. 2 parenthood_e_template.ppm

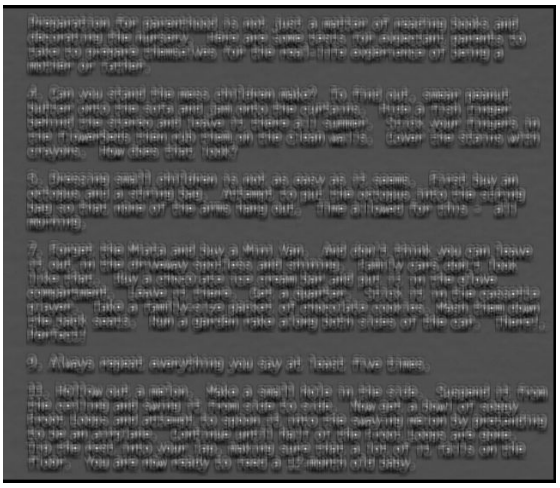


Fig. 3 Normalized MSF image

In this image, the highest pixel value was assigned to those points where template matched more accurately. (Most of these were the center locations of letter ‘e’ with the brightest pixels)

2. To check whether the letter is correctly detected or not, the following steps were performed, looping through 255 to 0 threshold values:

i) Binary MSF image was created by thresholding the normalized MSF image (values > threshold were assigned a value: 255, and 0 was assigned to all other values)

ii) By looping through ground truth center locations, checked a 9 x 15 pixel area centered at each location and took a sum of pixels in this region. If any pixel in the binary msf image was found greater than the threshold (sum >=255), considered the letter “detected”. If none of the pixels in the 9 x 15 area were greater than the threshold, considered the letter “not detected”.

iii) If the letter was not detected, calculated the TN and FN based on ground truth letter and continued to the next letter.

iv) Created a 9 x 15 pixel image that is a copy of the area centered at the ground truth location (center of letter) from the original image, thresholded this at 128 to create a binary image. Example image after thresholding is shown below on the left side.

Fig 4. After thresholding

Fig. 5 After thinning

Fig. 6 Endpoint, branchpoint

v) Thinned the thresholded image down to single pixel wide components.
Example image after thinning is shown next to thresholded image, in the middle.

vi) Checked all remaining pixels to determine if they were branchpoints or endpoints.

Example detection of branch-points and endpoints is shown in fig 6, the rightmost image above.

vii) If there were not exactly 1 branchpoint and 1 endpoint, did not further considered this letter (it became “not detected”).

viii) To check if detections were actually true positive or false positive, the ground truth value was checked with each of the detected value, if the letter was ‘e’, it was a case of true positive, else, it was a false positive

ix) Similarly, if the letter was not detected and it was ‘e’ from ground truth, it was a false negative, if program output and ground truth both had a value other than ‘e’, it was a true negative.

x) The detections and values of TP(True Positive), TN(True Negative), FP(False Positive), FN(False Negative), TPR (True positive rate), FPR(false positive rate) were calculated for each threshold.

3. ROC Curve with TPR and FPR was plotted to get the optimal threshold value.

Results and evaluation:

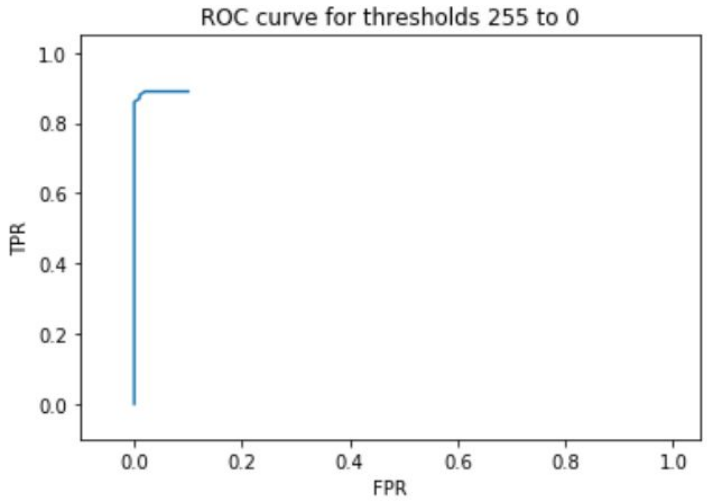


Fig 7. ROC Curve for threshold values from 255 to 0

Using the TP, FP, TN, FN values, TPR and FPR are calculated as follows,

TPR = TP / (TP+FN)
FPR = FP / (FP+TN)

Sensitivity= TPR
Specificity= 1 - FPR

Based on ROC curve above, optimal value of threshold would be somewhere at the top left, where TP is close to maximum (all possible detections) and FP is also a reasonable value, not the maximum one. Usually, optimal value of threshold is chosen at the knee of the curve, that establishes a balance between TP and FP values, and still closer to 1 compared to other points on the ROC curve. Ideal case is FP 0 and TP 1.

In this case, since the end points and branch points were checked for each detected letter, the number of false positives was reduced significantly. The last value obtained for TPR was 0.89 and last FPR was 0.10.

Optimal Threshold Selection:

For this template matching example using branch points and end points, the optimal value for threshold I have chosen is **T= 205**.

At this threshold, **TP count: 132, FP count : 9, TN count: 1102, FN count: 19.**
TPR: 0.874, FPR: 0.008

Actual count of e in the image was 151, and count for letter not e was 1111.

```
modjoul1@LAPTOP-7FILMC9D:/mnt/c/Users/Netra Inamdar/Documents/fall_19_courses/Intro_to_cv/assignments$ vi letters_lab3.c
modjoul1@LAPTOP-7FILMC9D:/mnt/c/Users/Netra Inamdar/Documents/fall_19_courses/Intro_to_cv/assignments$ gcc -o lab3_op letters_lab3.c
modjoul1@LAPTOP-7FILMC9D:/mnt/c/Users/Netra Inamdar/Documents/fall_19_courses/Intro_to_cv/assignments$ ./lab3_op
Threshold:205   detected:141    not detected:1121       tp count:132    fp count:9      fn count:19     tn count:1102
TPR:0.8741722   FPR:0.0081008
modjoul1@LAPTOP-7FILMC9D:/mnt/c/Users/Netra Inamdar/Documents/fall_19_courses/Intro_to_cv/assignments$
```

Fig 8. Results for T = 205