

Project 2: Human Face Detection using Boosting

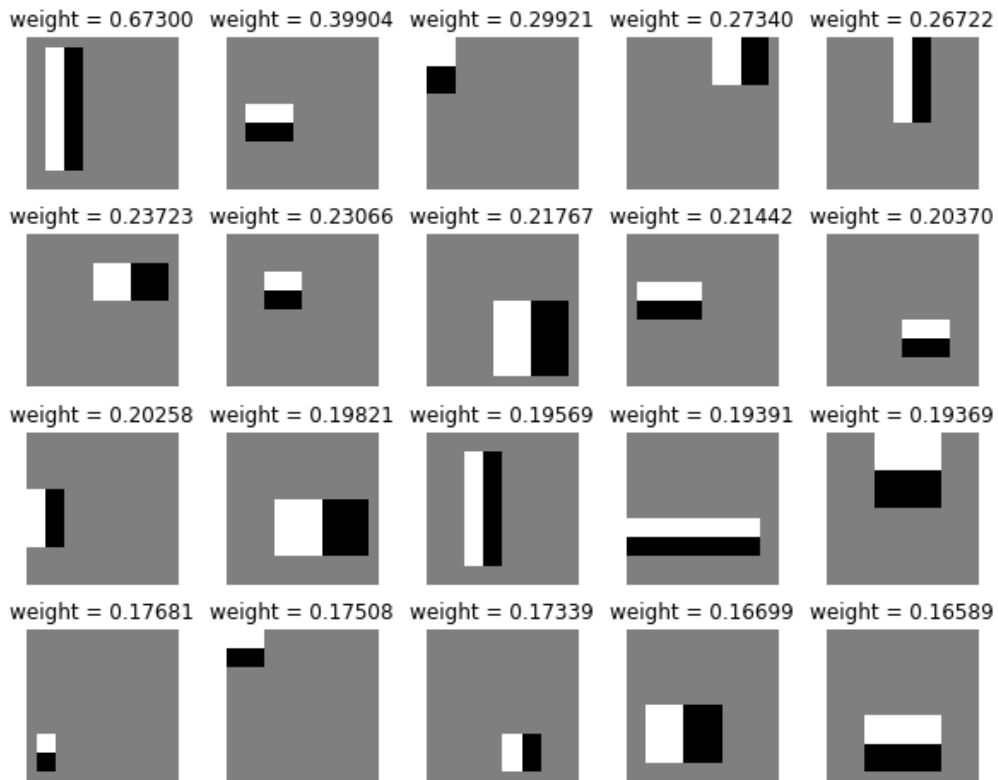
Biancheng Wang

1. Construct weak classifiers

2. Implement AdaBoost

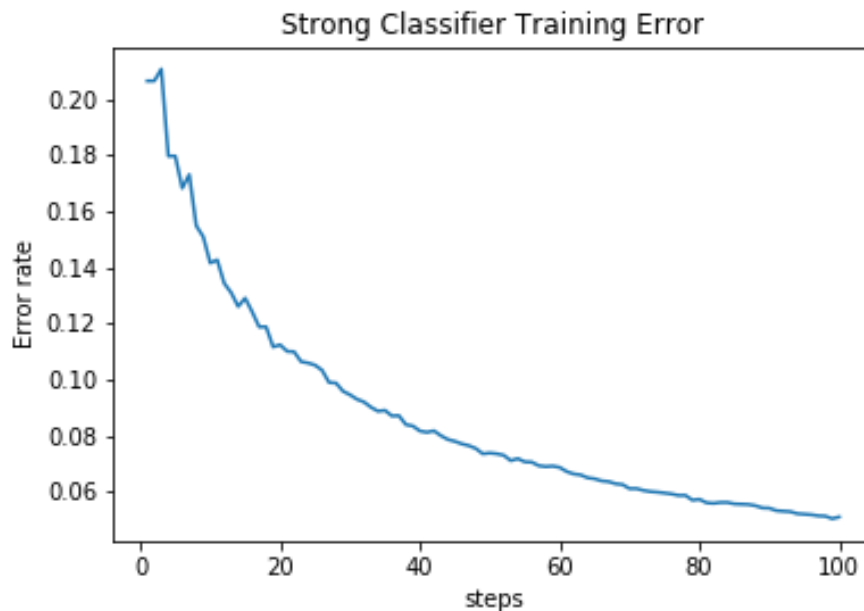
(a) Haar filters:

Here, we display Top 20 Haar filters after boosting with the corresponding voting weights which indicates the importance of the weak classifiers in the final decision.



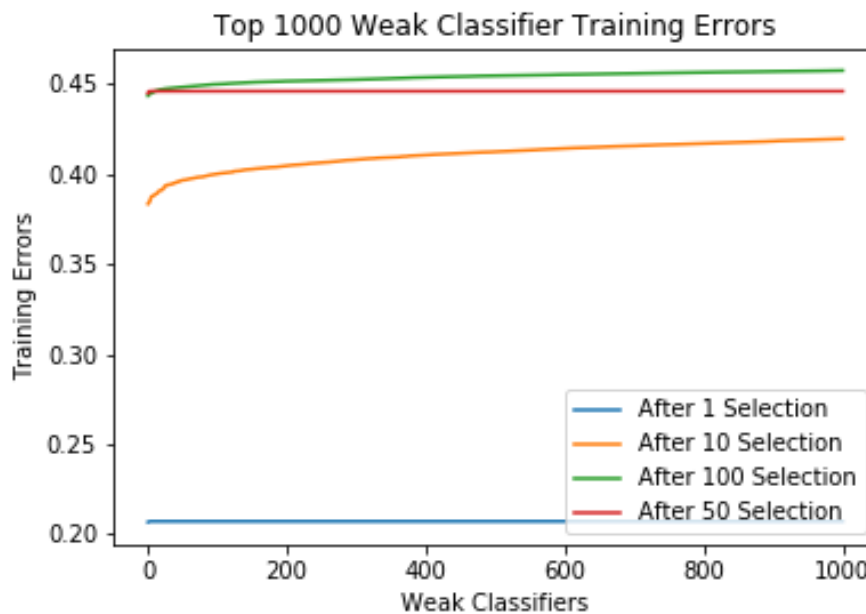
(b) Training error of strong classifier:

We plot the training error of the strong classifier over the number of steps T . It shows that the training error decreases as the number of steps increases as expected. After 100 steps, we reach a 0.949 accuracy rate.



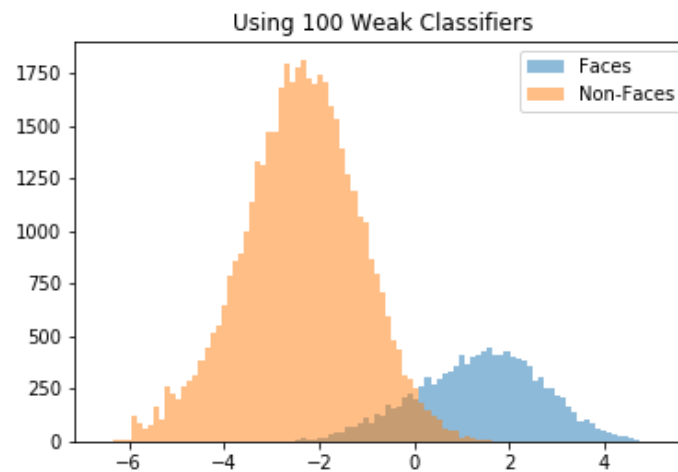
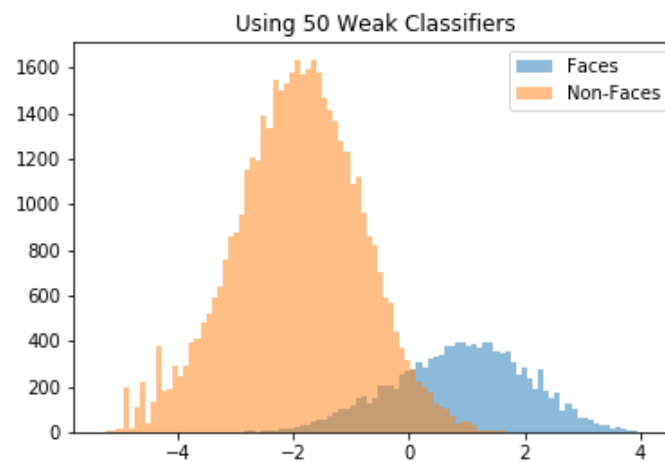
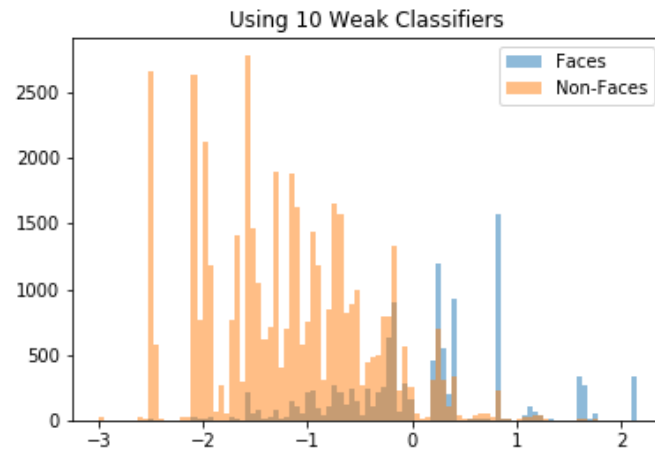
(c) Training errors of weak classifiers:

At steps $T = 1, 10, 50, 100$, we plot the curve for the training errors of the top 1000 weak classifiers among the pool of weak classifiers in increasing order. From the plot, it seems that, as the number of step increases, the training errors of weak classifiers increase dramatically at the first several steps and increase slightly after 50 steps.



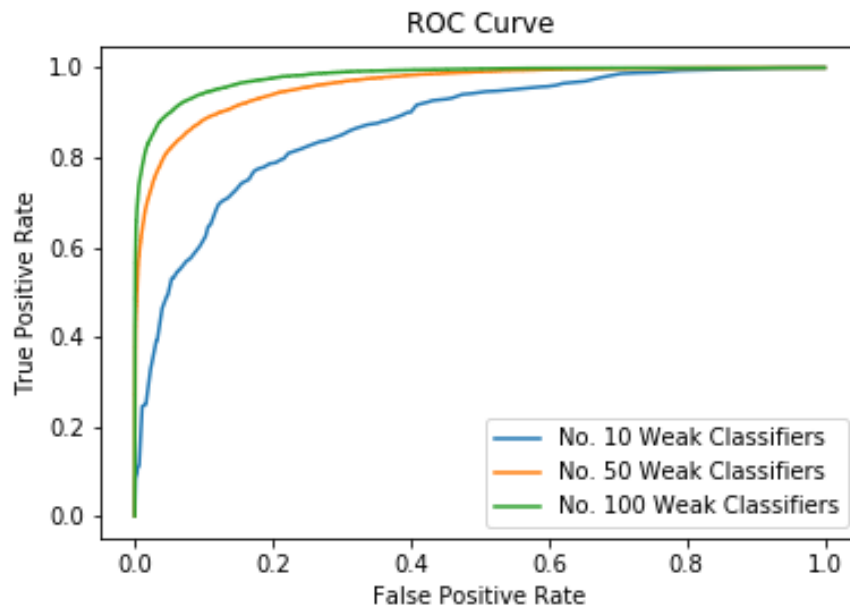
(d) Histograms:

We plot the histograms of positive and negative populations for $T=10, 50, 100$, respectively. Not surprisingly, two populations are better separated with more steps.



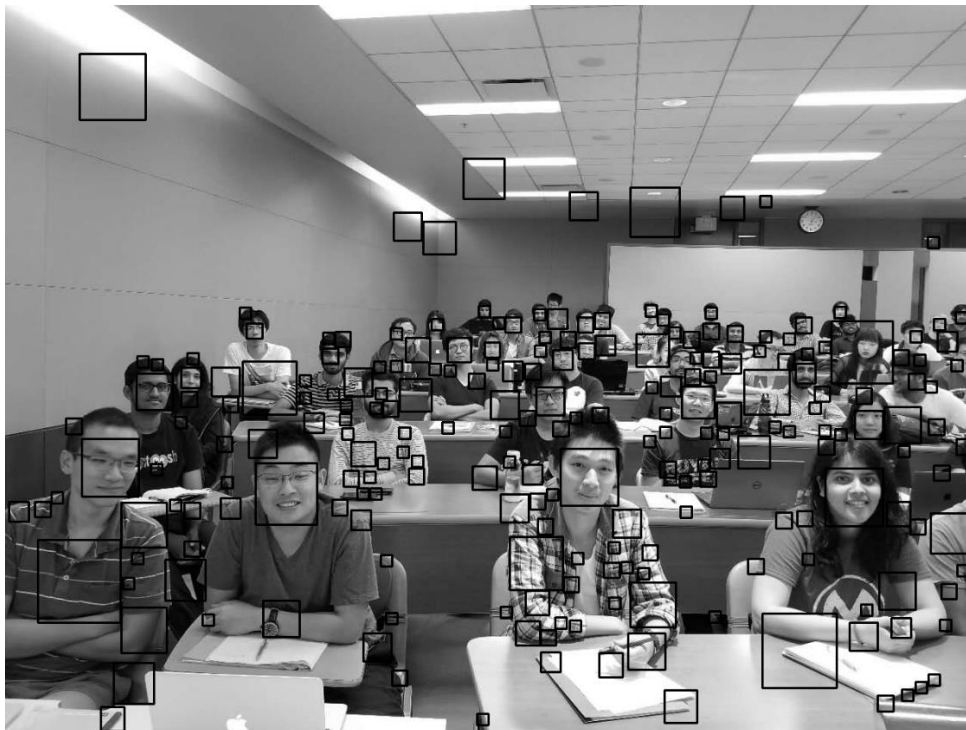
(e) **ROC:**

Based on the histograms, we plot the corresponding ROC curves below. We can find that the AUC becomes larger when the number of steps increases.



(f) **Detections:**

Face 1 without hard negative mining



Face 2 without hard negative mining



Face 3 without hard negative mining



Without hard negative mining, there are many false positive cases in all three test images.

(g) **Hard negative mining:**

Face 1 with hard negative mining



Face 2 with hard negative mining



Face 3 with hard negative mining

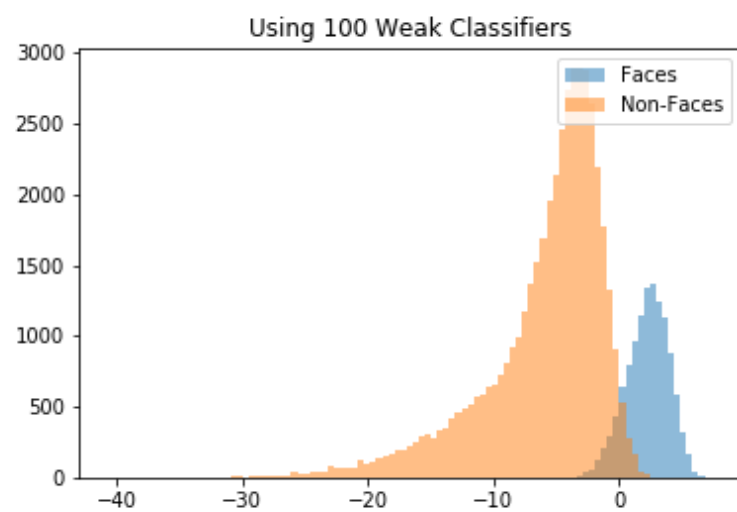
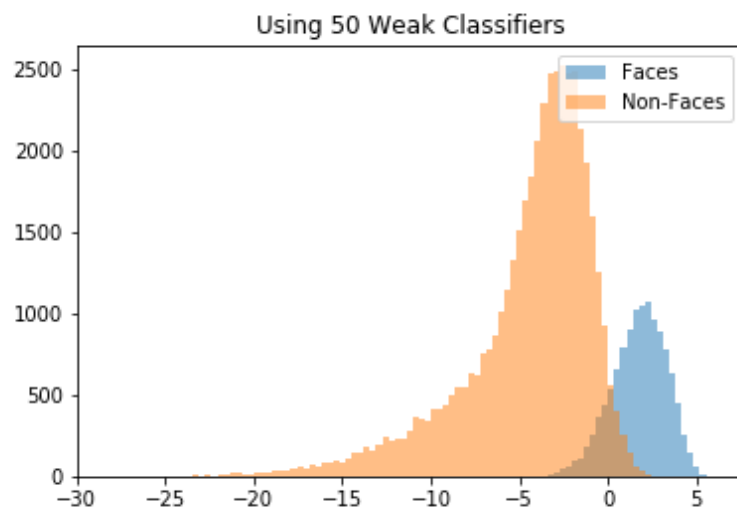
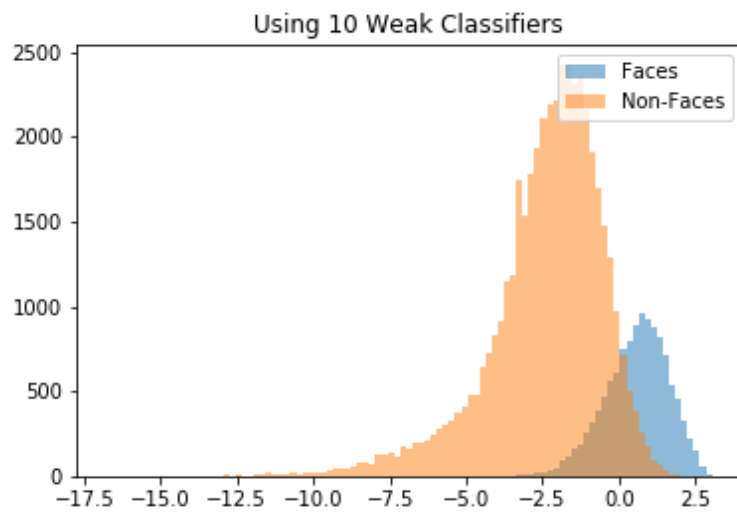


By adding 5603 hard negative examples, we get a 0.953 training error which is slightly larger than the previous one. It seems that we get a better face detection result after hard negative mining by comparing them with the corresponding results in (f).

3. Implement RealBoost

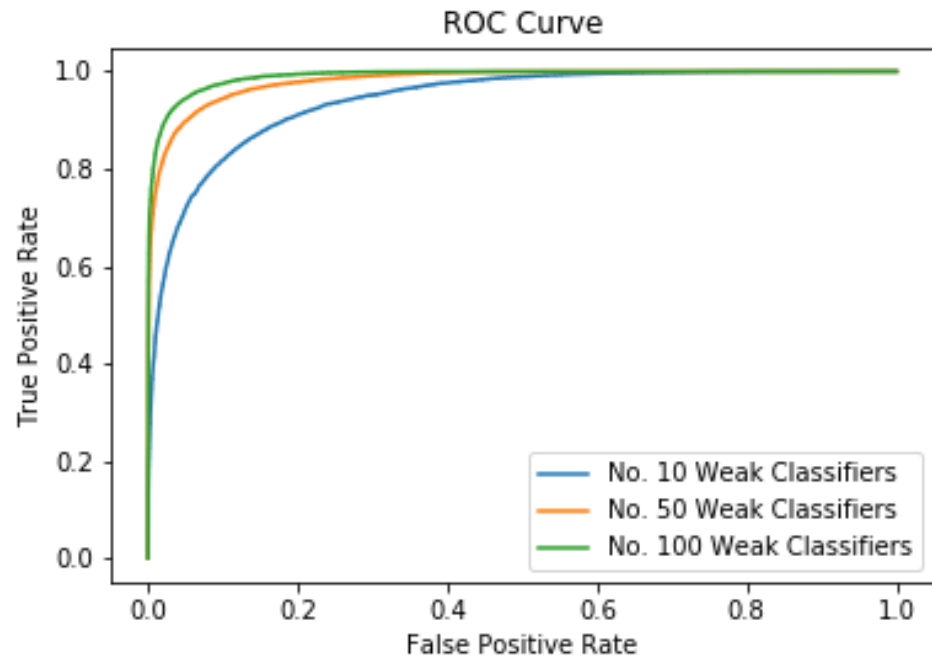
(h) Histograms:

After implementing RealBoost, we plot the histograms of positive and negative populations for $T=10, 50, 100$, respectively.

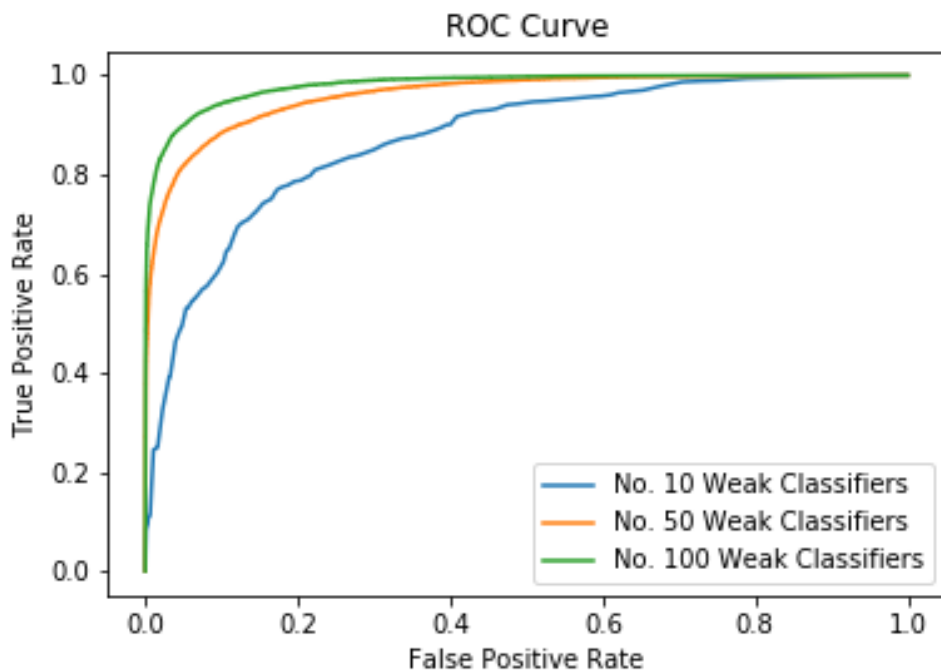


(i) **ROC:**

After implementing RealBoost, based on the histograms, we plot the corresponding ROC curves below. As a kind of extension of AdaBoost, RealBoost has a larger AUC than the corresponding one in using AdaBoost.



RealBoost



AdaBoost