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CS 4379C: Computer Vision
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# Face Detection using Adaboost,Bootstrapping, Cascading, and Skin Detection

Face detection is a computer technology being used in a variety of applications that identifies human faces in digital images. In our model, we applied bootstrapping,cascading, skin detection, and Adaboost.

We started our face detection algorithm by first implementing a Adaboost model. Our data set consisted of 3047 cropped face images and 130 non-face images. We decided to crop face photos down to 60 x 60 because for our image set this gave us valuable information of the eyes,nose, and mouth. We wanted to excluded any neck, ears and forehead information. The 130 non-face images were then randomly cropped 20 times, this gave us 20 random patches of each non-face image which generated 2600 images of non-face data, which is a total of 5647 training images. The images needed to be stored so we decided to put them into two seperate cell arrays(non-face and face cell arrays). All elements of a matrix are laid out contiguously in memory, while a cell array contains pointers to each element of the array. After storing all images into non-face and face cell arrays, we compute the integral images for every image in its respected cell array. Now it is time to generate random weak classifiers, we decided on 5000 weak classifiers because of the amount of training images was 5647. We started with 1000 weak classifiers and incremented by 1000 to find a stopping point with great accuracies. Running the adaboost function, we decided to run it on 50 rounds, we began with 20,30,40 rounds then tried 60,65 rounds. Rounds 20,30,40 gave us 92%-88% ,55-60%, 55%-60% for cropped faces, faces, and non-faces images respectively. Using 50 rounds gave us accuracies 96.9%,70%,80.5% for cropped faces, faces, non-face images, respectively. The adaboost model took 10 minutes and 20 seconds.

### Confusion Matrix

| | True Positive | True Negative |
|---|---|---|
| **Predicted Positive** | 770 | 7 |
| **Predicted Negative** | 20 | 29 |

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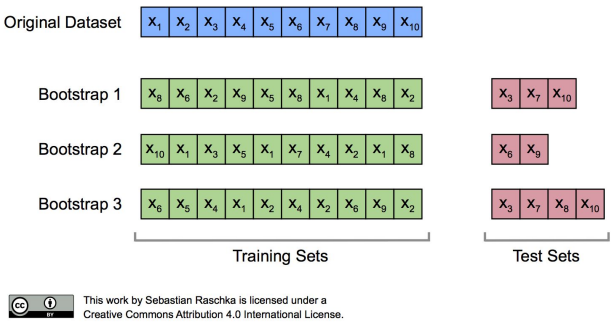


Bootstrapping is used to improve the stability and accuracy of our Adaboost model. For bootstrapping we ran our boosted classifier on all training images, identified the misclassified and correctly classified images.We store all misclassified images into an array and added 1000 images that were correctly classified into the array with misclassified. This array of 1000 images plus misclassified  We then generate a new set of weak classifiers of 1000, then apply the adaboost function to images with 50 rounds.With the new adaboost model, we are able to apply it to our test face images to increase accuracy by 1.2% and a decrease in non-face images by 0.3%.

After training our adaboost model, we applied skin detection to improve accuracy. We used a set of test images (color images). In color images, faces have skin color and therefore skin detection is faster than face detection. We loaded and read in a histogram of positive and negative examples of skin to use for the test and began iterating through our testing samples. In our iteration, we ran our skin detection function on those test images that contained rgb values and ignored the rest. After identifying the correct images and obtaining the result from our skin detection method, we took those results and combined them with our boosted classifier and drew corresponding boxes around faces identified.  We then compared results on accuracies running

our model with and without skin detection; performance improved on those images with significant amount of skin color.

A classifier cascade is a sequence of classifiers, where the first classifier is very fast but relatively inaccurate, and each subsequent classifier is slower but more accurate. The goal of cascading is to improve detection efficiency without sacrificing accuracy. Our AdaBoost-based detector was applied to every single window of the our training images. For every classifier in the cascade (except for the final classifier), we chose a threshold that determines whether a window should be classified as non-face, or if it should be passed on to the next classifier in the cascade. That threshold that was chosen was meant to cause as few mistakes as possible. Unfortunately, we were unable to test the accuracy of the classifier cascades. Below is depiction of how cascading works in more detail. Note that the following uses a Computer Vision Toolbox but the underlying idea applies nonetheless:

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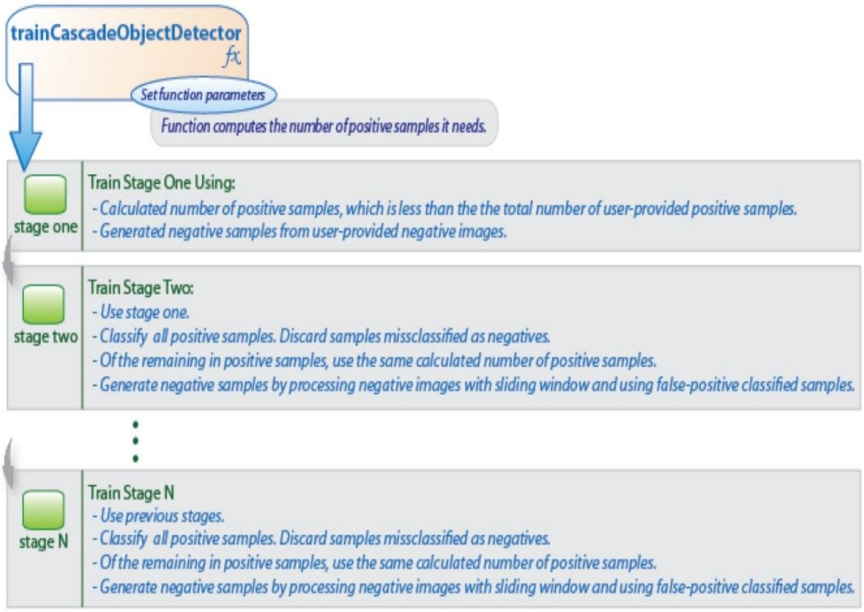


In conclusion, during this course we have learned a variety of different computer vision methods, these methods allowed us to design our model in a more efficient manner. This gave us an opportunity to use what we have learned which may come in practical in later endeavors.