LOWERING FALSE POSITIVE DETECTION RATES USING MULTIPLE HAAR CLASSIFIERS

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Abstract

The Haar classifier is a tree based classification technique that can rapidly detect rigid objects within an image. Orginally introduced by Paul Viola and Michael Jones[Viola and Jones, 2001], it was later improved apon by Rainer Lienhart and Jochen Maydt[Lienhart and Maydt, 2002]. This technique has high detection rate at the cost of low rejection[Bradski and Kaehler]. With a low rejection rate the number of false positive or wrongly detected objects can be high. By applying image processing and multiple "feature" classifiers to the area of the image detected as containing an object, we can lower the false positive rate. With only a marginal increase in compution time.

1 Introduction

Object detection is one of the most challenging aspects in the field of computer vision and also one of the most important. There is a wide range of practical applications for object recognition from converting human handwriting into digital text, to error detection in industrial production lines. All applications involve analyzing digital images or video sequences and then being able to extract usable data from what a computer sees as essentially nothing more than a grid of numbers.

Many detection algorithms have been created over the years, with various computational times and detection methods. Paul Viola and Michael Jones introduced the Haar Classifier that uses a boosted rejection cascade architecture. This architecture was used to design the first real time face detector with high classification accuracy [Saberian and Vasconcelos]. Paul Viola and Michael Jones were able to produce rapid facial detection by developing a method to quickly calculate digital image features.

2 Haar-like features

Haar-like features are digital image features that are established by summing pixel intensity in adjacent rectangular regions of the detection area. These sums are used to find the difference between regions. The differences can then be used to classify the sub region of an image. These differences are compared against learned threshold values to determine whether or not the object appears in the region. For example with facial recognition, one Haar-like feature could be the darker regions of eyes being a relative distance apart determined by the learned threshold value. However a large number of Haar features are needed to accurately identify a given object. Therefore, the Haar classifier is organized into what is call a boosted rejection cascade. The rejection cascade incorporates multiple Haar features and checks them in order of mostly likely to occur allowing unlikely regions of an image to be rejected early in computation.

3 Haar Classifier Theory

The Haar detector uses a form of Adaptive boosting or Adaboost. Adaboost is a machine learning algorithm that utilizes a chain of classifiers where the next classifiers in the chain are modified in favor of the instances where misclassification in the previous classifier occurred. The Haar detector is organized as a rejection cascade of nodes, where each node is a multitree Adaboosted classifier designed to have a high detection rate at the cost of a low rejection rate. Any stage of the cascade can terminate the computation if the object in question is not found. Thus positive detection is only declared if the computation makes it through the entire cascade. Rejection cascades reduced computation time due to the fact that most of the regions searched terminate quickly. [Bradski and Kaehler]

4 Training a Classifier

Classifiers are trained using hundreds of sample images of a particular object; these positive images need to be scaled to the same size. In addition to the positive images, a set of negative examples are needed as well; negative examples consist of arbitrary images of the same size. In order for the Classifier to perform well we would need to gather large numbers from 1000-10000 images of high-quality data [Gary Bradski and Adrian Kaehler], making the process of training a classifier a long, tedious operation. Thankfully OpenCV[Intel] offers a streamlined solution to building and training the classifiers providing a Haar training application. OpenCV also provides a set of public domain classifiers that we will be using to improve the false positive detection rate of a single classifier.

5 EXPERIMENT

5.1 Experimental Setup

Using a testing set of images containing various numbers of faces and lighting conditions, a baseline is produced by running a single frontal face Haar classifier over the images. Given we know the number of faces throughout the images we are able to determine the number of false positives, that is areas not containing faces classified as faces. Once the baseline is established, we then apply a multi-classifier system to the same set of testing data. We are then able to lower the false positive rate.

5.2 Baseline Detection

In the baseline trial the detector finds a total of 63 faces throughout the set of images.
A number of regions have been misclassified as faces throughout the data set. see figure 1

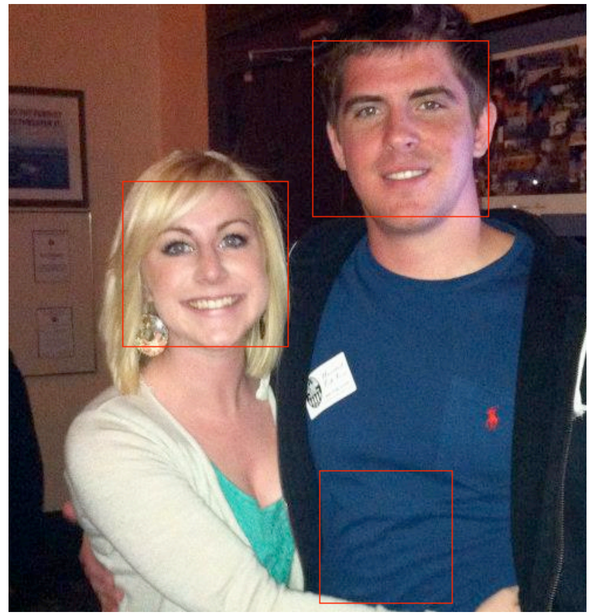

Figure 1: false positive detection

5.3 Multi-classifer system

Using the baseline classifier we determine areas of the image that have a high probability of containing a face. These areas are used to create regions of interest for the multi-classifer system. The regions of interest produced are significantly smaller than entire image allowing classification time to be relatively fast. Smaller images allow us to perform image processing in an acceptable time frame. Regions of interest are generally a square sub image from the original. Due to variations in original image size the sub images need to standardize to maintain computation performance. Each region of interest is resized to a width x height of 300 by 300 pixels and then is smoothed to remove any ridged aspects produced during the resizing process. Once the region of interest is resized and smoothed the multi-classifer system reapplies the original facial Haar classifier and two Haar classifiers that detect eye pairs. The first eye pair classifier is trained to detect small eyes and the other large eye pairs[Castrillon-Santana *et al*.,]. The two eye pair system is use to eliminate variation in original image size and distance from the camera. If the multi-classifier system determines that region of interest contains a face and at least one eye pair, then the region is confirmed as containing a face. Figure 2, Figure 3

Figure 2 Positive detection: Fail recheck (blue), Small eye Pair(white), Large eye pair(green).

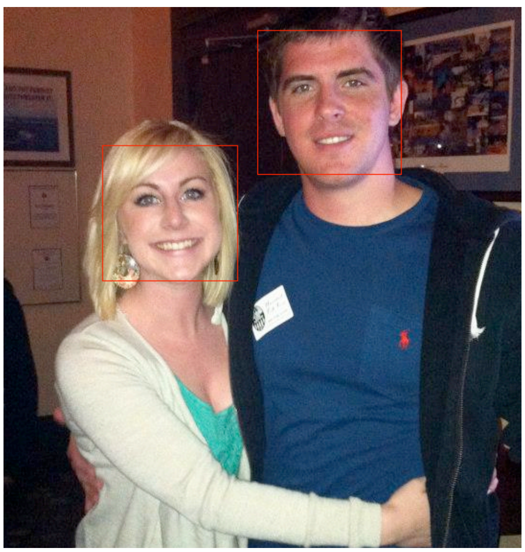

Figure 3: Elimination of false postitive.

6 Results

Out of a total of 44 faces throughout the testing image set, the single facial Haar classifier detected a total of 63 faces, with 19 regions falsely detected. Meanwhile, the multi-classifier system was able to correctly confirm 43 faces with no false positive regions. The loss of one face was due to the limitations of confirming eye pairs on faces that are slanted. Further analysis shows that out of the 19 regions that did not contain face; 3 had positive facial rechecks and were only eliminated when they failed to contain an eye pair.

7 Conclusion

Overall we see an improvement in false positive detection, however we are limited by the performances of the initial classifier, that is the multi-classifier system does not increase overall detection rates, however it does allow use to confirm faces in the detected area.

References

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[Intel] Intel Open Source Computer Vision Library