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# Face Detection using Neural Network Based Boosting Algorithm MLP and PCA

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**Abstract:**
An ideal Face Detection system should be able to identify and locate all faces regardless of their positions, scale, orientation, lightning conditions, and expressions and so on. Face Detection is the prior stage in any face processing system, as it provides challenging research area in computer vision and is of great interest. Challenges reside in the fact that the faces are non-rigid objects. The goal of face detection is to detect human faces in still images or in different situations. Some parameters plays a crucial role while detecting the faces amongst still images such as false positive, false negative, true positive, and detection rate. High detection rate with high speed and accuracy of detector is the prime goal of this system. In this paper, we applied Boosting Algorithm [5] which is capable of processing images rapidly. Here, we applied AdaBoost which is an aggressive learning algorithm for solving classification problems, which combines an ensemble of weak classifiers into a strong classifier. Specifically, to increase the Speed and Accuracy of the system which is the important feature in case of this face detection system is being done with these neural network based boosting algorithms. By taking AdaBoost classifiers in cascaded manner, a new boosting algorithm i.e. MLPBoost [1] which we used as a strong classifier for face detection. Basically, MLPBoost is hybridization between AdaBoost and multi-layer perceptron networks. PCA i.e. Principal Component Analysis is a very popular unsupervised statistical method to find useful image representation [2]. This method find out set of basic images and represents all the faces as a linear combination of those images.

**Keywords:** AdaBoost, Face Detection, MLPBoost, PCA (Principal Component Analysis).

## I. INTRODUCTION

Face detection becomes a more and more complete domain used in a large number of applications, among which we find out security, new communication interfaces, biometrics and many others. Face detection is one of the main components of face analysis and understanding with face localization and face recognition as an essential application of visual object detection [5]. The main challenge for detecting faces is to find a classifier which can discriminate faces from all other possible images. Variant pose, illumination condition, facial expression, occlusion, uncontrolled background display, these thing are the major factors to affect the performance of face detection system. But Boosting Algorithm performed very well under this all difficulties as this algorithm works with a strong classifier ensemble of number of weak classifier. A MLP is a feed forward artificial neural network model that maps sets of input data onto a set of appropriate outputs. The multilayer perceptron should be viewed as a nonlinear neural network whose nonlinearity can be tuned by changing the biases, parameters of the activation functions and weights. In the era of seventies, there was the beginning in the field of face processing system, as simple heuristic and anthropometric techniques were used for face detection. These techniques with various assumptions due to which it becomes highly rigid. To these face detection systems, any change of an image conditions would mean fine-tuning, if not a complete redesign. Back Propagation algorithm was independently rediscovered by Parker (1985) and by Rumelhart and McClelland (1986), simultaneously Back Propagation is a generalization of algorithm and allowed perceptrons to be trained in a multi-layer configuration, thus an n-1 node neural network could be constructed and trained. The weights are adjusted based on the error between the target output and actual output. Unlike the feature-based approach, these relatively new techniques incorporate face knowledge implicitly into the system through mapping and training schemes. In 1995, Parker and LeCun discovered a learning algorithm for Multilayer Network called Back Propagation for the Face Detection. In 1996, Viola and Jones demonstrated the AdaBoost based face detector by which faces can be fairly reliably detected in real-time under partial occlusion. The first real-time face detector was proposed by Viola and Jones [8]. The Viola and Jones frontal face detector consists of several classifiers trained by the AdaBoost algorithm that are organized into a decision cascade. Each cascade stage classifier is set to reach a very high detection rate and an acceptably low false positive rate. Since it is trained on the data classified as a face by the previous stages, the final false positive rate is very low and the final detection rate remains high. Besides similar detection rates as the previous approaches, the main advantage of Viola and Jones algorithm is the real-time detection. This cascading structure of AdaBoost with multilayer perceptron leads to the new boosting algorithm named as MLPBoost. As in 2010, some scientist provides the possibility of combining these AdaBoost and multilayer perceptron to develop the novel models for the face detection. And in 2012, some researchers [1] developed this combining effect of AdaBoost and multilayer perceptron.

## II. THE CHOOSEN APPROACH

Two important characteristics for a trained face detector are its detection and error rates. The detection rate is defined as the ratio between the number of faces correctly detected and the number of faces determined by a human. In general, two types of errors can occur False Negative, in which faces are missed, resulting in low detection rate and False Positive in which an image region is declared to be a face, but it is not. The goal of this project is to detect low resolution faces in single face images as well as in multiple face images very quickly and with minimum number of errors. As our prime goal is to increase the speed and accuracy of the system and here it is achieved with the help of Boosting Algorithm. AdaBoost is an efficient boosting algorithm which combines simple statistical learners. It reduces significantly not only the training error but also the more elusive generalization error.

## III. ADABOOST TECHNIQUE

Basically AdaBoost consist of training set and family of weak classifier as their inputs and it provides strong classifier as an output. Now to develop a Strong Classifier there is a combination of simple weak classifiers. The most basic theoretical property of AdaBoost concerns is its ability to reduce the training error, i.e. the fraction of mistakes on the training set. AdaBoost has two main goals, Selecting a few set of features which represents all the possible faces. Train a strong signal classifier with a linear combination of these best features.

$$f(x) = \sum_{t=1}^{T} \alpha_t h_t(x) \quad (1)$$

Both $_t$ and $h_t(x)$ have to be learned during the boosting process [1]. Here, $h_t(x)$ are the number of weak classifiers and $_t$ are the weights associated with it. It provides a method of choosing the weak classifiers $h_t(x)$ and setting the weights $_t$ . AdaBoost is an algorithm for constructing a Strong Classifier out of a linear combination of simple weak classifiers. So that,

$$H(x) = sign\ f(x) \quad (2)$$

Where, $H(x)$ is the strong classifier requires detecting faces. It is made up of sign function and number of weak classifiers. So the combination of linear classifier can be shown as,

$$H(x) = sign[\alpha_1 h_1(x) + \alpha_2 h_2(x) + \alpha_3 h_3(x)] \quad (3)$$

As $h_1(x)$ , $h_2(x)$ , $h_3(x)$ are the number of weak classifiers and $_1$ , $_2$ , $_3$ are the weights assign to these classifiers respectively. The very first advantage of AdaBoost is, No Prior knowledge i.e. the most representative features will automatically be selected during the learning. Second advantage is, Adaptive Algorithm i.e. at each stage of the learning, the positive and negative examples are tested by the current classifier. And lastly the training error theoretically converges exponentially towards 0. Now, to use the more complex classifier with the objective to improve the Speed and Accuracy. The technique is based in the substitution of every strong classifier in the AdaBoost model to Multilayer Perceptron (MLP). The combined approach of AdaBoost and multilayer perceptron network, MLPBoost approach is developed.

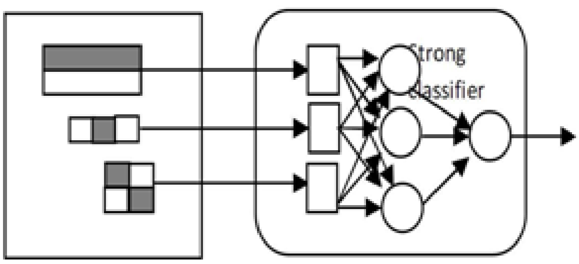

**Figure. 1. Strong Classifier [1].**

The strong classifier [1] is composed by a MLP network that receives as input the value of characteristic and generates as output an indication if the input characteristics correspond to a face or not. This procedure was adopted because of power of the MLP networks as a pattern classification method in comparison to the Perceptron. The weak classifiers $h_t(x)$is composed of a rectangular characteristic $f$ , a threshold , and a polarity $p$ , over an image $x$ provides [1], [2]

$$h(x, f, p, \theta) = \{1\} \quad \text{If } pf(x) \le p\theta \quad (4)$$

The use of weak classifiers based threshold function as input for MLP networks undermining the potential of modeling as strong MLP classifier.

## IV. MLPBOOST TECHNIQUE

Main characteristic for the MLPBoost is weak classifiers using directly the value of rectangular features, without the need for a threshold. Also it is a new model of strong classifiers, each one consisting of MLP network. And the final classifier is formed by a cascade of MLP networks, trained using the Back-Propagation for the optimization of weights. The goal of the cascade detection is to achieve both false positive and detection rate. The principle is to reject quickly the majority of negative windows while keeping almost all positive examples and then focus on more sensitive sub windows with more complete classifiers. In the cascaded structure of AdaBoost which consists input vectors along with the individual weights assign. Then the next is threshold function which requires in making decisions of the desired values. And at the last control function which controls all the functions. From fig. 2, there is a single layer perceptron structure which is applied one after another in the cascaded manner then we will get the entire cascaded structure of the AdaBoost. If the value is true then it get accepted and if it is not then get rejected. To transform the cascade of AdaBoost classifiers in a cascade of MLP networks, each of the classifiers is replaced by a strong network MLP. A neuron equation [1],

$$Y = \sum_{i=1}^{n} w_i x_i \ge \theta \quad (5)$$

If C(X) = 1, then we get equation (5) otherwise 0 [1].

$$C(X) = \sum_{t=1}^{T} \alpha_t h_t(x) \ge (1/2) \sum_{t=1}^{T} \alpha_t \quad (6)$$

By comparing equation (4) and equation (5), it is clear the strong relationship between neuron and strong classifier. It means any AdaBoost classifier can also be seen as a neural network. As $w_i = \alpha_t$ , $x_i = h_t(x)$ , $\theta = (1/2)\sum_{t=1}^{T} \alpha_t$ and n=t.

### 4.1 MLP Learning Algorithm

MLP Learning Algorithm is,

**Step1:** Initialize the network, with all weights set to random numbers between -1and +1.

**Step2:** Present the first training pattern, and obtain the output.

**Step3:** Compare the network output with the target output.

**Step4:** Propagate the error backwards.

Correct the output layer of weights using the following formula.

$$W_{ho} = W_{ho} + \eta \delta_o o_h \quad (7)$$

Correct the input weights using the following formula.

$$W_{ho} = W_{ho} + \eta \delta_o o_h \quad (8)$$

**Step5:** Calculate the Error, by taking the average difference between the target and the output vector.

## V. PRINCIPAL COMPONENT ANALYSIS

The PCA Algorithm is [2],

**Step 1**: Obtain the original image A from the data, concatenating each row (r) or column (c) of an original Image

**Step 2:** Compute the covariance matrix, this matrix gives information about the linear independence between the features.

**Step 3:** Images are mean centered by subtracting the mean image from the original image.

z = Original Image (A) – meanVec (9)

**Step 4:** Our goal is to find the set of eigenvectors (V) and eigenvalues (D).

**Step 5:** Once the Eigen values are extracted, several types of decision can be made depending on the application.

### 5.1 Basics of PCA

The Principal Component Analysis (PCA) is one of the most successful techniques that have been used in an image detection and compression. This technique is also known as the Karhunen Loeve (KL) transforms or the Hotelling transform. It is based on factorization techniques developed in linear algebra. Factorization is commonly used to diagonalize a matrix. The purpose of PCA is to reduce the large dimensionality of the data space (observed variables) to the smaller intrinsic dimensionality of feature space (independent variables), which are needed to describe the data economically. This is the case when there is a strong correlation between observed variables. The jobs which PCA can do are prediction, redundancy removal, feature extraction, data compression, etc. Because PCA is a classical technique which can do something in the linear domain, applications having linear models are suitable, such as signal processing, image processing and control theory, communications, etc. The main idea of using PCA for face recognition is to express the large 1-D vector of pixels constructed from 2-D facial image into the compact principal components of the feature space.

**Table.1.Showing results for multiple faces using MLP Boost.**

| Image No_X | Number of Faces | TRUE POSITIVE | FALSE POSITIVE |
|---|---|---|---|
| Image_17 | 07 | 07 | none |
| Image_85 | 17 | 17 | 01 |
| Image_65 | 09 | 09 | none |
| Image_69 | 04 | 04 | none |
| Image_139 | 02 | 02 | 01 |
| Image_184 | 6 | 6 | none |
| Image_90 | 09 | 09 | 01 |

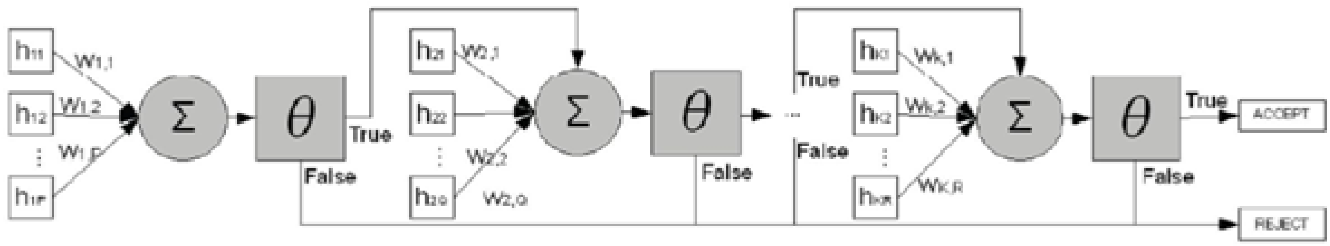


**Figure.2. Cascade of Ada Boost Classifier [1]**

## VI. RESULT

An Output window [6] which consist Train Faces, Classify, Input Image, Recognize section as a push button as shown in fig. 3. First we have to take an input image and then we have to press recognize button which will detect the face from that image and then the system will try to match the class of available database. If that image is from our database then it shows the matched class, as shown in fig. 3. This is the AdaBoost Algorithm for single faces.


**Figure.3. Window Shows FACE DETECTION using Ada Boost for Single Face Images.**

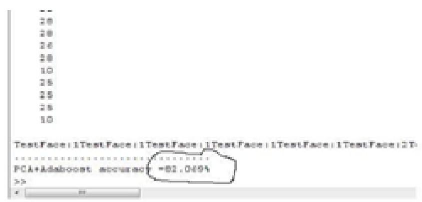

**Figure.4. shows the accuracy result of AdaBoost and PCA. As AdaBoost algorithm provides the accuracy up to 82.069%.**

Fig. 4 Accuracy of AdaBoost + PCA. But our main target is multiple faces to get detected from still images. So with the help of MLPBoost we can achieve our target output as shown in fig. 5.

**Figure.5. Multiple Faces Detected using MLPBoost Algorithm.**

MLPBoost is efficient for single as well as for multiple face images, and its face detection rate is very high. An image with number of face images is accurately get detected with the help of MLPBoost as shown in fig. 5.

## VII. CONCLUSION

Face detection using Boosting algorithm is an interesting compromise between image based and feature based methods. We use a learning procedure to extract feature which are linked to the geometrical characteristics of faces. Though various difficulties reside in face detection but this boosting algorithm performs very well under all these difficulties. For single faces AdaBoost gives 82.069% accuracy whereas for single faces and multiple faces MLPBoost is very efficient as it gives nearly 90% of result. Some parameters we can trace such as True Positive and False Positive and also the detection rate. So far for PCA concern it provides an efficient feature extraction method in case of image analysis.

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