International Journal of Advance Research in Science and Engineering
Volume No.06, Special Issue No.(04), December 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354

Face Detection: A Review

Seek the Face, Peek the Beauty

Aayush Kamdar[1], Heet Savla[2], Dhruv Chamaria[3]

[1,2,3]*Computer Engineering, Shri Bhagubhai Mafatlal Polytechnic (India)*

ABSTRACT

Computer vision is an incorporation of multiple disciplines that deal with how computers can be made to gain high-level understanding from images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do. Object detection is the process to capture instances like human faces, cars or various objects. Face detection is the process of capturing a human face or multiple human faces. This paper talks about the detection of human face and tells about the characteristics and how the face detection AdaBoost algorithm works.

Keywords: Weak and Strong classifier, Haar-like features, Weighting, Face Beautification, ASIC chip.

I. INTRODUCTION

Humans use their eyes and their brains to see and visually sense the world around them. Computer vision is the science that aims to give a similar, if not better, capability to a machine or computer. Computer vision is concerned with the automatic extraction, analysis and understanding of useful information from a single image or a sequence of images. It involves the development of a theoretical and algorithmic basis to achieve automatic visual understanding. Computer Vision is nowadays used in wide variety of real-world application, which includes Face Detection.

Face detection is a computer technology being used in a variety of applications that identifies human faces in digital images. Face detection is a very attractive research theme and it is also important both in theoretical research and in practical application. Object-class detection is a specific case regarding to face detection. In object-class detection, the task is to find the locations and sizes of all objects in an image that belong to a given class. Examples include human faces, pedestrians, cars and many other objects [1].

Viola-Jones Face-detection algorithm focus on the detection of frontal human faces. Paul Viola and Michael Jones presented a fast and robust method for face detection. Viola-Jones Face-detection algorithm proposes four features i.e. Haar Features, Integral Image, Adaboost and Cascading.

A variety of excellent algorithms of face detection have been proposed, such as adaboost. The adaboost (Adaptive Boosting) is an improved algorithm based on the boosting technique proposed by Viola and Jones. There are three steps for face detection. Firstly, extracting haar features. Secondly, using these features to train classifier. Finally, detecting face in image using classifier. The final classifier is composed of many strong classifiers, and each strong classifier is composed of many weak classifiers. This paper mainly studies face detection by utilizing adaboost

algorithm.

II. THEORY

Haar-like Features

Haar features are similar to the convolution kernels which are used to detect the presence of that feature in the given image. The human faces share many similar properties, so these properties can be matched by extracting haar features. The template of haarfeature is composed of rectangular boxes, and that is why haar feature is also called as rectangular feature. Viola-Jones algorithm uses 24x24 window as the base window size to start evaluating these features in any given image.

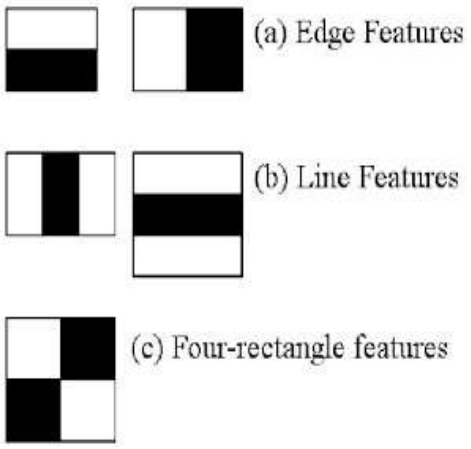

Fig.1 Types of haar features

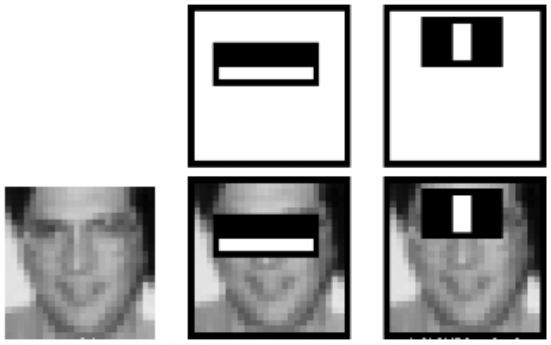

Fig.2 Haar feature applied on a face

Each feature results in a single value which is calculated by subtracting sum of pixels under white rectangle from the sum of pixels under black rectangle. If we consider all possible parameters of the haar features like position, scale and type we end up calculating about 160,000 + features in this window. This feature is used to find the eyes, cheeks and the bridge of the nose. These are the composition found in every human face.

Boosting

The concept of boosting was introduced to the computer vision community, which involves training a series of relatively weak classifiers and then creating a stronger classifier as compared to before.

In more detail, boosting involves constructing a classifier as a sum of simple weak learners, where each of the weak learners is an extremely simple function of the input, and hence is not expected to contribute much (in isolation) to the classification performance.

Adaboost

Adaboost (Adaptive Boosting) is a machine learning meta-algorithm used in conjunction with many other types of algorithms to increase its performance. Adaboost is adaptive in the sense that getting the output as some weak learners they are improved together in favour of those instances which is left by the previous classifiers.

IJARSE
ISSN (O) 2319 - 8354

The description of Adaboost algorithm to select a predefined number of good features given a training set of positive and negative example images [2].

AdaBoost refers to a particular method of training a boosted classifier. A boost classifier is a classifier in the form where each is a weak learner that takes an object as input and returns a value indicating the class of the object. Similarly, the classifier will be positive if the sample is believed to be in the positive class and negative otherwise. Each weak learner produces an output, hypothesis, for each sample in the training set. At each iteration, a weak learner is selected and assigned a coefficient such that the sum training error of the resulting t-stage boost classifier is minimized. The boosted classifier that has been built up to the previous stage of training, is some error function and is the weak learner that is being considered for addition to the final classifier.

At each iteration of the training process, a weight is assigned to each sample in the training set equal to the current error on that sample. These weights can be used to inform the training of the weak learner, for instance, decision trees can be grown that favour splitting sets of samples with high weights.

Pros and Cons of Adaboost Algorithm:

Pros:

1. Very simple to implement
2. Improves classification accuracy
3. Not prone to over fitting

Cons:

1. Suboptimal solution
2. Sensitive to noisy data and outliers

III. PSEUDO - CODE

Given: $(x_1, y_1), \ldots, (x_m, y_m)$ where $x_i \in X, y_i \in Y = \{-1, +1\}$
Initialize $D_1(i) = 1/m$.
For $t = 1, \ldots, T$:

- Train weak learner using distribution D_t.
- Get weak hypothesis $h_t : X \to \{-1, +1\}$ with error

$$\epsilon_t = \Pr_{i \sim D_t}[h_t(x_i) \neq y_i].$$

- Choose $\alpha_t = \frac{1}{2} \ln\left(\frac{1-\epsilon_t}{\epsilon_t}\right)$.
- Update:

$$D_{t+1}(i) = \frac{D_t(i)}{Z_t} \times \begin{cases} e^{-\alpha_t} & \text{if } h_t(x_i) = y_i \\ e^{\alpha_t} & \text{if } h_t(x_i) \neq y_i \end{cases}$$
$$= \frac{D_t(i)\exp(-\alpha_t y_i h_t(x_i))}{Z_t}$$

where Z_t is a normalization factor (chosen so that D_{t+1} will be a distribution).

Output the final hypothesis:

$$H(x) = \operatorname{sign}\left(\sum_{t=1}^{T} \alpha_t h_t(x)\right).$$

Fig.3 Adaboost algorithm [3]

IV. PROPOSED FRAMEWORK

By learning this adaboost algorithm we propose a work of fiction hardware architecture of face-detection engine for mobile applications. We are using MCT (Modified Census Transform) and Adaboost learning technique as basic algorithms of face-detection authentication and also applying face beautification as a factor to get an insightful output in mobile applications. To work as fiction hardware we use ASIC (Application-Specification Integrated Chip). A chip that is custom designed for a specific application rather than a general-purpose chip such as a microprocessor. This chip we will be using to burn MCT, Adaboost and face beautification algorithms. Working of this chip will be divided into several steps:

- MCT (Modified Census Transform)

  MCT presents the structural information of the window with the binary pattern {0, 1} moving the 3×3 window in an image. It compares the average value in a pixel (X) and brightness value of a pixel (Y). If X < Y, then the pixel is coloured else it remains as it is. With this transformation we are able to determine 511 structures defined on a 3 x 3 window [5].

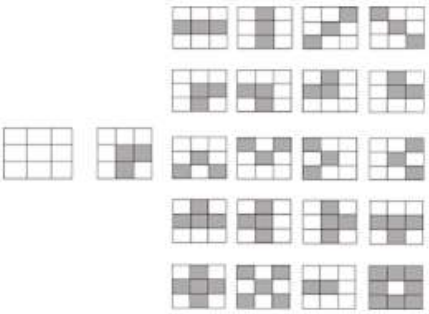

Fig.5 Our approachFig.6 511 Structures defined in 3x3 window

- Adaboost face detection algorithm

  Adaboost algorithm is then performed, it generally takes 38 phases of local structures but after introducing MCT the number of local structures is decreased to 4 phases. Then, it performs its local learning algorithm.

- Face Beautification

  Given a portrait, we identify a variety of predetermined facial locations and compute a set of distances between them .These distances define a point in a high dimensional "face space". We then search the face space for a nearby point that corresponds to a more attractive face. The key component in our search is an automatic facial beauty rating machine: a Support Vector Regressor,

  There are two techniques used to achieve this objective:

  1. KNN (K – Nearest Neighbours) search
     - An effective way of beautifying a face, while maintaining a close resemblance to the original is to modify the distance vector of the face in the direction of the "beauty weighted" average of the K nearest neighbors of that face.
  2. SVR based beautification
     - This is used directly to seek feature distance vectors with a higher beauty score.

  To beautify the image, beauty estimating machine (includes KNN and SVR techniques) is used to identify new feature distance vector. These corresponding modified facial distances are embedded in the plane and serve as a target to define a 2D warp field which maps the original facial features to their new, "beautified" locations. The beautified output is obtained after the mapping operation [6].

This fiction hardware or ASIC chip can be used in various mobile applications like mobile cameras, cameras, CCTV, and other mobile applications. Using an ASIC chip and burning thesealgorithms, itself has an advantage of getting a clean beautified and focused image. The normal cameras or mobile cameras use these features, but to beautify and get a focused image it uses an external application software. But this chip itself has focused face detection transformed technique and beautification technique burnt on it. This is more efficient than using an external software to get the output.

V. CONCLUSION

Here, we conclude this paper by reviewing that computer technology, which identifies human faces called face detection. We explained the background of face detection technique which includes Haar features, Boosting and Adaboost. We also focused on the explanation of Adaboost algorithm. We then proposed a fiction hardware called the ASIC chip on which we thought of implementing the Face detection technique. It includes several steps, firstly the transformation of local structures of an image by MCT (Modified Census Transform), Secondly implementing the Adaboost algorithm for face detection and lastly beautifying the face with its two main techniques KNN and SVR.

Our future scope would be implementing the Adaboost algorithm for face detection. Our next aim would be at the implementation of the high-performance face detection burnt on the ASIC chip and built that chip for a better use.

VI. ACKNOWLEDGEMENTS

We would like to thank our college professor Mr. Pankaj Rathod for detailed reviews and constructive comments, which have helped to improve the quality of our work.

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