RESEARCH ARTICLE OPEN ACCESS

Face Detection – A Literature Survey

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Abstract:

The extensive research in the field of face detection can be gauged from the fact of great increase in face capturing devises. Millions of people are recorded everyday in cctv's, video recorder, media, social sites like YouTube, Vimeo, Facebook, Instagram and lot more. Face plays a core part in distinguishing and identifying a person and hence face detection is much sought after. Other factors, such as security have also provided impetus to research in face identification. Though, other detection techniques such as iris scanning, finger-prints scanning are also a way to identify a person but the problem it contains is the fact that it requires a dedicated hardware system and human resource for it. Such problems are not faced in face identification as face is detected through passive resources that do not require involvement from the user side. In this paper we would we would compare and look at the ongoing face detecting techniques and the underlying properties.

Keywords **— Face Detection, Haar Features, Adaboost, Viola-Jones, Feature Based Recognition, Elliptical Annotation**

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I. INTRODUCTION

Face Detection is regular and almost effortless task for human beings. But for computers/machine to identify the faces in a given scenario the task is not that simple. The main aim of any face capturing device is that of face recognition. The very first step of Face Recognition is Face Detection. In this paper we would be discussing about various methodologies employed in Face Detection.

The main aim of face detection can be broken down in two steps: [1]
A). To find out whether there is any face in an given image or not and
B). If, yes then where is it located.
There are several factors that makes face detection complicated in an image. They are profile pose, tilted pose, double chin, facial expression, hair-do, occlusion, low-resolution; out-of focus faces etc. which require different computation while detecting.

The rest of this survey paper is organized as follow. In Section II, we provide a broader overview of classification for Face Identification. In Section III, we discuss about the basic concepts/models used by majority of Face Detecting Algorithms/Approaches. In Section IV, we go in detail to understand two methods of Face Detection. In Section V, we provide our conclusion.

II. BROADER OVERVIEW OF FACE DETECTION CLASSIFICATION

Most of the Classification uses Feature Based Approach but they then differ in the way they use other different techniques and make related decisions on it. Taking this fact into account we classify different Approaches:

A. Feature Based Approach

This approach relies on extraction of facial features to detect face.

1) ***Low Level Analysis:*** It uses the concept of pixel analysis, edge detection in image (using Sobel or Canny) and gray scale. It also uses the concept of finding local maxima (to detect nose) and local minima (to detect eyebrows pupils and lips).[2]

2) ***Feature Analysis:*** It improves the result of Low Level Analysis. It incorporates the fact that all the parts of face (eyes, nose, mouth, chin, head-top) are at somewhat at relative positions with respect to each other. Prominent features

(mentioned above) are determined and they in result help in identifying potential face.[2]

B. Geometry Based Detection

It too uses the concept of Edge Detection using the concept of Canny filter and gradient analysis. All the predominant features/specific location of image is divided into block and each block has a corresponding pixel at centre. All the central pixels of blocks are connected to nearby central pixels with an aim to span the face. [3]

C. Appearance Based Approach

This approach relies on extraction of facial features to detect face. In this method entire image is processed in two dimensions. All the extracted characteristics are termed as features. In order to identify the face from the given image we would be required to match only those above features that correspond to the features of human face (nose, eyes, mouth etc.). To extract the feature vector, Principal Component analysis (PCA) and Independent Component Analysis (ICA) is used. We are using PCA because as the name suggest it would only compute or retain important/predominant vectors/variables and would reject the ones that don not contribute to any new information. This results in reducing computing and Time Complexity. [2]

III. BASIC CONCEPTS USED BY MOST FACE DETECTION METHOD

D. Haar Like Features

Initially to detect a face we were directly computing pixels. This features though exhaustive is also computationally not viable as in an HD image it would result in 1920*1080 = 2*10^6 pixels. Thus we moved on to feature extraction from pixel computation.

Entire human race possess face that has similar properties. The properties we refer to here are the positioning of eyes, nose, mouth etc., the relative size of them and the contrast/intensity of them. This uniformity of features can be replicated using features known as Haar-like Features.

A Haar-like feature consists of adjacent rectangular windows at specific location. It adds the pixel intensities in each region and then calculates the difference of both regions. The output value is categorizes this specific location. For example, Region of Eyes is darker then cheeks. Thus, the Haar feature for it would incorporate two adjacent rectangles. One on eyes and another below it, on cheeks. Then the summation of intensities is done for each rectangular and then value of summation of rectangle on cheeks is subtracted from the sum of values in rectangle on eyes. The same concept is used for identification of eyes, mouth and bridge of nose. [4]

E. Adaboost

Features computation using the concept of Haar-like features helps identify specific region. But, there are vast numbers of features for example there are about 1,80,000 features in 24*24 pixel window. [5] This would undoubtedly result in large scale computation and ultimately in high time complexity.

But, of these lakhs of features there are only selected features that would help predict face with better accuracy. In general terms, there are only selected features that are necessary to build a model/algorithm that detects the face with required accuracy.

Adaboost is used for this very purpose. It selects the few necessary features which when combined together/amalgamated provides a classifier that is effective for the classification of face/required object in an image. What makes Adaboost applicable in different scenarios is the fact that it is adaptive in nature. Subsequent classifiers are built so as to modify and improve on those cases that were misclassified by previous classifier. [4]

IV. METHODS OF FACE DETECTION

We would be going through the two basic methods of face detection.

F. Annotation of face using ellipse

Aim: Annotating face in shape of ellipse. Technique used: Three features are required to be extracted for face detection. They are, head-top, chin and pair-of-eyes. The distance between chin and head-top is taken as the length of major axis. The length of two eyes from ones end point to another and then some other value added to it is

taken as the length of minor axis. From the length of major and minor axis we create ellipse which is approximated to encompass human face (it does not include ears as part of face). This technique requires modification when dealing with irregular face poses. That is, the faces that contain double chin, hairdo, facial expression and occlusion. Though the basic concept of minor and major axis remains the same, the way of calculating it differs. [6]

Faces that are not to be considered: Faces looking away from the camera are considered as non-face region. Face with non-visible two eyes is not to be considered. Also, the faces are rejected where position, size and orientation are not clearly visible.

TABLE I
ANALYSIS OF ANNOTATION OF FACE USING ELLIPSE

Advantages	Disadvantages
Uses simple way to compute face outline(that is ellipse)	Does not include ears as part of face
Require fewer features to be computed (locating eyes, chin and head-top)	Face outline not always accurate as it computes few features
Effective on different poses of face	Doesn't work on variety of faces (as mentioned above)

G. Viola-Jones

Viola-Jones uses the concept of Haar-Like Features, Cascade Filtering and Adaboost. For face detection this algorithm goes through three stages:

1) ***Computation of Integral Images:*** It uses the concept of Haar-Like features. Rather, it computes the Haar-Like features through the concept of Integral Image. Integral image is a name given to the concept of Summed Area Table (both a data-structure and an Algorithm) which is used to effectively and efficiently compute the sum of values in a rectangular subset of grid. [7] Thus the concept of Integral Image computes rectangular features (Haar Features) in constant time. The integral image at location (x,y) is the sum of the pixels above and to the left of (x,y), inclusive.[8]

2) ***Usage of Adaboost Algorithm:*** From vast number of features computed in part (i) we are interested in only selected few features that would enable us to detect face with great accuracy. For this, we use Adaboost Algorithm to select principal features and to train classifiers that would be using them. Aim of this algorithm is to create strong classifier from linear combination of weak classifier.

3) ***Creating Cascade Structure:*** This cascade structure consists of classifiers. It works in a manner that initial classifiers are simpler and they are used to reject majority of sub-windows and at end complex classifiers are used to achieve low false positive rates. [9] The classifiers are trained using the above concept of Adaboost Algorithms. The deeper we go in the cascade the more difficult the task of the classifier is. [5]

TABLE III
Analysis of Viola-Jones Algorithm

Advantages	Disadvantages
Extremely fast and efficient feature selection	Less effective on non-frontal images
Capability of scaling the features	Varied results for a given image under different lightning Conditions
Can be used to detect other types of objects too	Multiple computation of part of same face occurs

V. CONCLUSIONS

On referring various papers we come to understand the challenges faced in Face Detection and the various methodologies used to detect face. From this Literature Survey we have following take-aways:

It is very important to remove background information. Removing irrelevant information, such as noise and non-face part would make face detection less complicated.

Feature based analysis is one of the predominant methodology that most of the Detection Algorithms use in one way or another. Hence, efficient feature selection is very crucial.

We must chose at-least two features for face identification. Because, depending only on one feature might result in erroneous detection.

Varied Facial Expression and poses makes face detection more complicated.

Lightning conditions greatly affects face detection.

Computations need to be fast and should require less main memory as majority of application are of real time in nature.

When going through the cascade like methodology, re-computation of an already computed face must be avoided.

It is very essential for a methodology to define its definition of face and successful face detection.

As we saw that the elliptical face method did not consider ears as part of face whereas other methods did. Thus, definition of terms is important.

ACKNOWLEDGEMENT

Guidance of Prof. Ratnik Gandhi and Prof. Mehul Raval helped in gaining insights in this field of study.

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