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Facial features and Body parts Detection Methods: A Comprehensive Survey

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ABSTRACT

The aim of this research work is to give anoverview of recent research & development in the field of detection methods of human facial features and body parts. The need for a facial features and body part localization is being discussed here to find its possibility in actual practices.In this paper, the methods applied for face recognition and detection techniques, various algorithms for machine learning like adaboost algorithm and Cascade Classifiers are discussed here. Computer vision in object and body parts detection method is a very useful technique alongwith embedded system.

Keywords—Object detection, Face detection,Methods for body part detection, Algorithms,Integral image, Computer vision, Haar cascade algorithm.

I. INTRODUCTION

Over the past years important advances has been achieved in the automatic detection and tracking of human body parts and facial recognitionwhich is highly sensitive.Noticeable progress has been achieved in Computer Visionresearch, especially in gesture recognition. Those advances have created many newpossibilitiesof applications of Human-Computer Interaction, health-care and digital games. The assignment of human body part recognition and following is not paltry.This paper presents a survey and analysis of face & human body detection methods only as the inclusion of all the different categories of the methods.

Confront acknowledgment is a critical piece of the ability of human observation framework and is a standard errand for people, while building a comparative computational model of face acknowledgment. The computational model add to hypothetical experiences as well as to numerous reasonable applications like mechanized group reconnaissance, get to control, outline of human PC interface (HCI), content based picture database administration, criminal distinguishing proof et cetera.The programmed recognition and following of human body parts in shading pictures is profoundly delicate to appearance elements, for example, enlightenment, skin shading and garments. The first face detection system has been developed in early 1970. Though it is not able to satisfy the requirement of the users, it can identify faces from passport photographs real time[1]. Though this is a well-researched topic there are some challenges need to be addressed. These challenges include appearance variation, illumination changes, camera motion, jumbled scenes and impediment.

Body part detection and tracking in image sequences ischallenging because thistask requires information filtering to bring about the use of less information. Theresulting information must be structured because it will provide the detection ofthe body parts. The body parts are tracked with an algorithm, frame by frame,to store time sequence information. It is possible to use a feature extraction andmatching algorithm as part of a tracking method because it compares two inputimages. Once there are human poses to be identified, it is possible to use the position of each body part in each image in a sequence to define the human poses that can be applied to classification algorithms for prediction purposes.[2]

Now the detection has been achieved by various means like by using algorithmsand computer vision also.

II. LITERATURE SURVEY

There are various methods for the detection purpose of both, human face as well as body detection. But there are some problems regarding detection which are described here. The difficulties related to face detection can be given by the following components:

- **Pose.**The pictures of a face shift because of the relative camera-confront posture (frontal, 45 degree, profile, upside down), and some facial elements, for example, an eye or the nose may turn out to be halfway or entirely blocked.

- **Facial expression.** The appearances of faces are directly affected by a person's facial expression.
- **Presence or absence of structural components.**Facial elements, for example, whiskers, mustaches, and glasses might possibly be available and there is a lot of fluctuation among these segments including shape, shading, and size.
- **Image orientation.** Face images directly vary for different rotations about the camera's optical axis.
- **Occlusion.** Countenances might be incompletely impeded by different items. In a picture with a gathering of individuals, a few appearances may somewhat impede different countenances.
- **Imaging conditions.**At the point when the picture is framed, components, for example, lighting (spectra, source distribution and power) and camera qualities (sensor reaction, focal points) influence the presence of a face.

There are many closely related problems of face detection. *Face localization* means to decide the picture position of a solitary face; this is a streamlined identification issue with the supposition that an information picture contains just a single face [2], [3].Face recognition framework in applications can help from various perspectives: checking for criminal records, improvement of security by utilizing observation cameras, discovering lost kids by utilizing the pictures got from the cameras fit at some open spots, knowing ahead of time if some VIP is entering the lodging and discovery of unpalatable exercises at public place [4].

Early face-detection algorithms focused on the detection of frontal human faces [6], whereas present-day algorithms attempt to solve the problem of multi-view face detection in more general way, which is even more difficult problem [5]. This detection incorporates the identification of appearances that are either pivoted along the hub from the face to the onlooker (in-plane turn) or turned along the vertical or left-right hub (out-of-plane rotation) or both in shown in Figure1.

Figure1. Examples of face detection [7]

In general, the goal of face detection is to determine whether the face is present or not. The difficulties related with face identification can be credited to many factors.The major factors of face detection include pose illumination, image orientation, image condition, facial expression, presence and absence of structural components [8].

III. METHODS OF FACE DETECTION

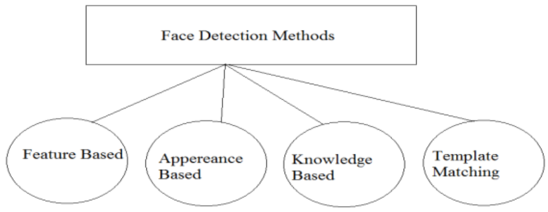

Fig 3Commonly used face Detection methods

A. Knowledge-based Face Detection Methods

Knowledge based techniques, use the basic facial knowledge (such as the elliptical shape and the triangle feature) to obtain the final region of the face. It can be classified into hierarchical and vertical/ horizontal classifications. They use simple rules to describe the features of a face and their relationships. These knowledge based methods can reduce computational cost, but they are rotation-dependent.The general steps are:

a) The center part of face has uniform intensity values.

b) The difference between the average intensity values of the center part and the upper part is significant.

c) A face frequently shows up with two eyes that are symmetric to each other, a nose and a mouth.

Fig 4. A typical face used in knowledge-based top-down methods.

There are three levels in this methods:

Level 1 (lowest resolution): Apply the rule — the middle some portion of the face has 4 cells with a fundamentally uniform intensity to scan for competitors.

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Level 2: local histogram equalization followed by edge equalization followed by edge detection.
Level 3: Scan for eye and mouth highlights for approval.

B. Model-based Face Detection Methods

Model based method can be classified into the category of template matching. They use both predefined template, deformable template [9] and multi-correlation template. These template matching methods find the similarity between the original and training images. It can be applied to the pose, scale and shape of the images [10]. These predefined template image methods are easy to implement, but they are scale-dependent,rotation-dependent, and computationally complex. The major curb of this approach is that it is not effective [11]. The deformable templates are specified by a set of parameters which enables a priori knowledge about the expected shape of the features to guide the detection process. Multi-correlation template methods are represented by Yuille [12].

C. Feature-based Face Detection Methods

Feature-based procedures are isolated into three orders, viz., Low-level investigation, Feature examination, and Active shape investigation techniques. Facilitate, the low-level investigation depends on the spatial distribution. Rather than the information based top-down approach, scientists have been attempting to discover invariant components of countenances for discovery.The fundamental suspicion depends on the perception that people can easily recognize faces and questions in various postures and lighting conditions and, in this way, there must exist properties or components which are invariant over these fluctuations. Numerous methods have been proposed to first detect facial features and then to inferthe presence of a face. Facial features such as eyebrows, eyes, nose, mouth, and hair-line are commonly extracted using edge detectors. In view of the extracted features, a measurable model is worked to portray their connections and to check the presence of a face. One issue with these element based algorithms is that the picture components can be seriously debased because of light, clamor, and impediment. Include limits can be debilitated for appearances, while shadows can bring about various solid edges which together render perceptual gathering algorithms futile.

Advantage:

- Features are invariant to posture and orientation change.

Disadvantage:

- Difficult to locate facial features because of several interruption (illumination, noise, occlusion).
- Difficult to detect features because irregular background.

D. Appearance-based Face Detection Methods

The appearances of facial features may be captured by different cameras of two-dimensional views of the object-of-interest. The appearance based algorithms mostly rely on extensive training and powerful classification techniques as specified by Yang et al., [22]. Samuel Kadoury and Martin D. Levine proposed an appearance-based technique that identifies confronts, subject to an assortment of huge conditions from a static 2D scale picture.These conditions incorporate outrageous varieties in head turn, brightening, facial expression,occlusion and maturing. [23].

Advantages:

- Use powerful machine learning algorithms.
- Has demonstrated good empirical results.
- Fast and fairly robust.
- Extended to detect faces in different pose and orientation.

Disadvantages:

- Need lots of positive and negative examples.
- Limited view-based approach.

E. Template matching

It is commonly used in the systems where there is highpossibility of getting a human face. A template is predefined structure of a uniform size and shape that makes detection of desired object easy just by comparing the template with the objects. In case of face detection, the template matching finds the relation between the input image or video and the face patterns or the features. Fig 5.shows a template for face detection.

Fig 5. A template of human face shape oriented in vertical and rotated form.

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Template matching method is deformable and based on the facial contours. Unlike the appearance based method which uses neural network, templates are hand coded (not learned) and uses correlation to locate the faces.

Advantages:

- Simple method
- Include less amount of data points for face detection

Disadvantages

- For frontal views, face must be having no occlusion
- Face(s) must of same size as that of the template
- This method is dependent to size, scale and rotation
- Computational efficiency is less
- To cover more views of the face, more number of templates are needed and hence needs more time to detect a face.

IV. Body Detection methods

There are various methods available for human body parts detection localization which are implemented worldwide for the human body detection purpose according to need and circumstances application. But there is no generalized method or technique available for the confrontation of human body parts detection. So every technique has its own importance whenever it is found. Here some of the techniques are elaborated for the study purpose.

A. Detecting Pedestrians

As accidents with pedestrians in traffic increases, there is a growing need for pedestrian detection systems which make sure that pedestrian crossings are empty before the traffic-lights for other traffic turns green. To solve this issue several techniques are proposed. Tani, H. et al [28] proposes to use space-time images made with a CCD camera to control the time green for the handicapped and the aged. First, measurement areas are defined along the white line of the crosswalk. Next, space-time pictures are made with the end goal that a slip of picture on the estimation territory is arranged. At last, walkers are distinguished by processing the picture. [28]

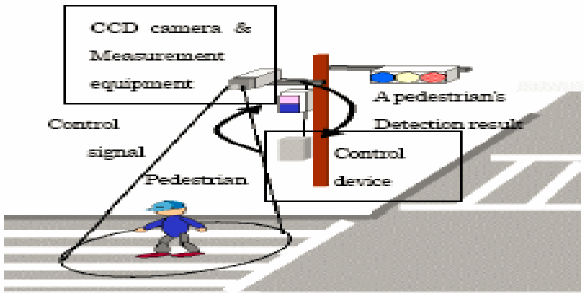

Fig.6. overview of the system [28]

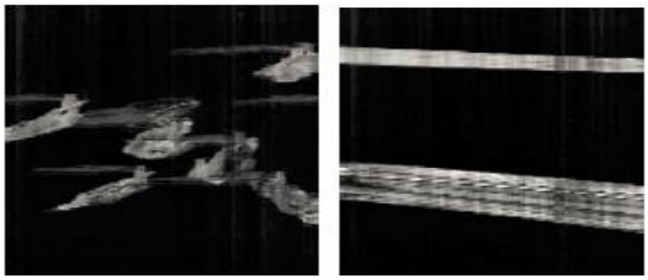
Pedestrian vehicle

Fig.7. difference in space-time image [28]

The Overview of the system is shown in Fig 6. A CCD camera should be installed near a traffic light in order to overlook the whole crosswalk, and images can be taken per 100ms. Two measurement areas should be set on crosswalk in order to make our system robust. One should be set on dark lines, the other should be set on white lines. By using them, one can make space-time images. In addition, it can make use of difference between background images and input images, and can detect only passing objects. Space-time pictures of people on foot and vehicles are appeared in figure 7. Presently the framework can remove a few elements, for example, size, shape and surface example, from space-time pictures and identify people on foot.
When something disregards a crosswalk, the shade of a few squares will change. The framework can distinguish it by the measure of squares. It is also necessary to recognize passing objects as pedestrians or vehicles. In order to identify them, the systemdesigner use shape of blocks and the difference of edge. Usually, the shape of pedestrians on a space-time image is complex. In addition, pedestrians walk perpendicularly against white lines of crosswalk. On the other, vehicles move along white lines of crosswalk. Therefore, system can decide whether passing ones is pedestrians or not by the concavo-convex degree and texture pattern. Feature parameters are calculated every 1 second,

pedestrians are detected. In our experiment, system took a picture of crosswalk for 1 hour.. As a result, the precision of detecting pedestrians was more than 99%. Demonstrated that the system is effective [28]

PERSON DETECTION IN BACKGROUNDS

One of the strategies to identify human bodies is background subtraction. This frequently causes issues like with shadows and no isolated people so as to distinguish people in complex scenes, background, Maojun, Z et al [29] proposes a strategy which makes an all encompassing picture from the foundation before a man enters. Once someone comes in front of the background a detection process is started. They propose an algorithm for deciding the camera movement parameters, which is utilized to get the background picture concealed by the people from the all-encompassing image. The currently caught picture and the background picture are contrasted with recognizing the people utilizing the background subtraction calculation in view of logarithmic intensities. Experiments show that the proposed method can be real-time run on a high-performance personal computer.

Baisheng, C. et al. [30] proposes a background model initiation and maintenance algorithm for video surveillanceWith a specific end goal to distinguish frontal area objects, firstly, the underlying background scene is statically learned to utilize the recurrence of the pixel power values amid preparing period. The frequency proportions of the intensities values for every pixel at a similar position in the casings are figured; the force values with the greatest proportions are fused to show the background scene. Furthermore, a background upkeep model is likewise proposed to adjust to the scene changes, for example, brightening changes (the sun being hindered by mists or enlightenment time-differing), unessential occasions (a man quits strolling and remain unmoving, individuals escaping a stopped auto, and so on.). At last, a three-arrange strategy is performed to identify the frontal area objects: thresholding, noise clearing, and shadow evacuation. The exploratory outcomes show vigor and constant execution of our calculation. [30]

B. HUMAN POSTURE TECTION/RECOGNITION

An method to solve the human silhouette tracking problem using 18 major human points is proposed by Panagiotakis, C. et al. [31] They used: a simple 2D model for the human silhouette, a linear prediction technique for initializing major points search, geometry anthropometric constraints for determining the search area and colour measures for matching human body parts. The researcher proposed a strategy to take solve of the issue of human individuals recognition and 18 noteworthy human focuses identification utilizing the outline. This outcome can be utilized to introduce a human following algorithm for continuous applications. Our fundamental reason is to build up a low calculation cost algorithm, which can be utilized freely of camera movement. The yield of the following algorithm is the position of 18 noteworthy human focuses and a 2D human body extraction. In cases of low quality imaging conditions or low background contrast, the result may be worst. For these cases they defined an appropriate criterion concerning tracking ability. [31]

V. VIOLA JONES APPROACH

A very fast and accurate approach to detect an object was devised by viola and Jones[18] in the year 2001. Nowadays, this method is used in cell phone cameras, security perimeters and list goes on. Due to the use of Haar features and adaboost machine learning computational speed increased. And within a millisecond a face can be detected in a frame. Further improvements were done by Lienhart and Maydt [19] in the year 2002.In this method, firstly, the estimation of all pixels in grayscale pictures which are in dark aggregated. At that point, they subtracted from the aggregate of white boxes. At long last, the outcome will be contrasted with the characterized limit and if the criteria are met, the component considers a hit.

This approach to detecting objects combines four key concepts:

1. Simple rectangular features, called Haar-like features.
2. Integral image for rapid features detection
3. AdaBoost machine-learning method
4. Cascade classifier to combine many features efficiently

A. Haar like features

Haar like features are used to detect variation in the black and light portion of the image. This computation forms a single rectangle around the detected face. Based on the color shade near nose or forehead a contour is formed. Some commonly used Haar features are:

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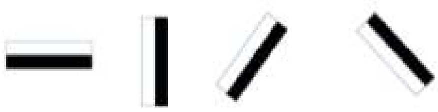
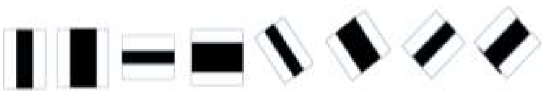
1. Two rectangle feature.
2. Three rectangle feature.
3. Four rectangle feature.



(a)



(b)

(c)

Fig.8. (a) Two Rectangle Feature, (b) Three Rectangle Feature, (c) Four Rectangle Feature

The value of two rectangle feature is the difference between the sums of the pixels within two rectangle regions as sown in Fig 8. In three rectangles, the value is center rectangle subtracted by the addition of the two surrounding rectangles. Whereas four rectangle features computes the difference between the diagonal pairs of the rectangles [23].
Haar-like feature can be calculated with the following Equation [25]:
Feature = *Σ ie{1..N}wi.RecSum (x, y,w,h)* (1)
Where *RecSum (x,y,w,h)* is the summation of intensity in any given upright or rotated rectangle enclosed in a detection window and x,y,w,h are for coordinates , dimensions , and rotation of that rectangle, respectively. Haar Wavelets represented as box classifier which is used to extract face features by using integral image which is described in the next
section.

B. Integral Images

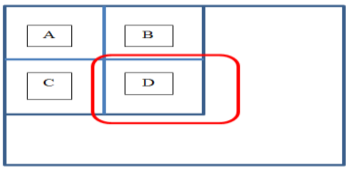
They are also known as summed area tables. Integral image is used to felicitate quick feature detection. The meaning of integral image is the outline of the pixel values in the original images. The integral image at location (*x*,*y*) contains the sumof the pixels above and to the left of (*x*,*y*) inclusive

$$II(x,y)=\sum_{x'\le x,\, y'\le y} i(x,y) \quad (2)$$

Original Image Integral Image

Fig 9 Demonstrating the concept of integral image

As can be seen from Fig 9, each location of x and y in the integral image is the sum of pixel values in above and left location of x and y [26].



Integral Image

Fig 10Finding the sum of the shaded rectangular area

For instance in Fig 10, let 1,2,3,4 be the values of the integral image at the corner of a rectangle, next the sum of original image values within the rectangle can be computed as the below equation and only 3 additions are required for any size of the rectangle.
SUM = 4-2-3+1
Value = Σ (Pixels in White area) – Σ (Pixels in Black area) (3)

C. Adaboost machine learning method

It uses an important concept of Bagging that is procedure for combining different classifiers constructed using the same data set.It is an acronym for bootstrap aggregating, a motivation of combining classifiers is to improve an unstable classifier and an unstable classifier is one where a small change in the learning set/classification parameters produces a large change in the classifierAdaBoost algorithm chooses little elements from the face that encourages quick and simple calculation [27]. The AdaBoost algorithm gives fancied area of the object disposing of the superfluous foundation. The working model can in deciphered by utilizing neural systems [27].

- Given image is in the form **(x_1, y_1)…… (x_n,y_n)**
- **y_i**=0,1 for negative and positive examples.
- Initialize the weights **$w_{i,1}$**=$\frac{1}{2m}, \frac{1}{2l}$ **for y_i=0,1** respectively, where m and l are

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number of positives and negatives respectively.

- For t=1,..,T:
  1. . Normalize the weights,

$$\mathbf{W}_{t,i} = \frac{w_{t,i}}{\sum_{j=1}^{n} w_{t,i}} \quad (4)$$

$\mathbf{W}_t$ is the probability distribution

  2. For each feature j, train a classifier which is restricted to use a single feature. The error is evaluated with respect to $\mathbf{w_t}$, $\mathbf{E_t}$

$$= \sum_i w_i \left| h_j(x_i), y_i \right| \quad (5)$$

  3. Choose the classifier $\mathbf{h_t}$ with lowest Error $\mathbf{E_t}$.
  4. Update the weights

$$\mathbf{w_{t+1,I} = w_{t,i} B_t^{1-e}{}_i} \quad (6)$$

Where $\mathbf{e_i}$=0 if examples is classified correctly.

$\mathbf{e_i}$=1 otherwise

And $B_t = \dfrac{e_t}{1-e_t}$

The final strong classifier is:

$$h(x) = 1 \quad \sum_{t-}^{T} = a_t h_t(x) \geq \frac{1}{2} \sum_{t=1}^{T} a_t \quad (7)$$

Where $a_t = \log \dfrac{1}{Bt}$

AdaBoost learning process is fast and gives more number of desired data. This data can be classified into classifier. A classifier contains small features the face. It is commonly employed for pattern detection. This method has high accuracy and detection speed with about 1% false detection but requires more time to train.

D. Cascade classifier

The Viola and Jones face detection algorithm eliminates face candidates quickly using a cascade of stages. The cascade eliminates candidates by making stricter requirements in each stage with later stages being much more difficult for a candidate to pass. Candidates exit the cascade if they pass all stages or fail any stage. A face is detected if a candidate passes
all stages. This process is shown in Fig. 11.

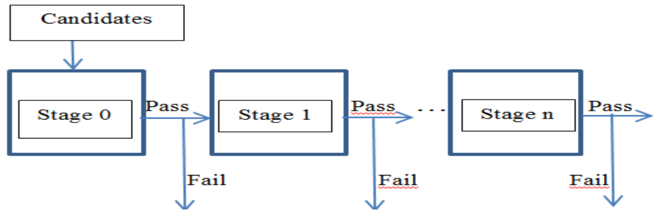

Fig 11.Cascade of stages. Candidate must pass all stages in the cascade to be concluded as a face.

VI. CONCLUSION

In this paper, we have discussed about the commonly used face detection methods. Each of these methods signify the importance and utility for different applications. Since these methods are progressive, more and more advancements are made every day to achieve accurate and true face detection. For applications such as employee details, member details and criminal record uses the frontal views of the face. Hence feature based and knowledge based methods are used. For identifying faces in videos or images those are occluded and oriented other than frontal view, template matching network and appearance method are used. A rapid approach using machine learning and haarlike features are used recently for fast detection and reduce the likelihood of computing huge amount of data. This approach was designed by viola and jones to increase computational efficiency despite of having false face detection.

VII. FUTURE ASPECTS

From the study of various methods, one can build a system that can detects which uses the Haar like cascade classifier for feature extraction and object detection, using computer vision (Open-CV and cameras) and adaboost algorithm these all are can be implemented on an embedded platform for many application like urban search and rescue, disaster handling robots, border patrolling robots and many more.

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