Face Detection and Processing: a Survey

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Abstract

In the recent era facial image processing is gaining more importance and the face detection from image or from video have number of applications which are video surveillance, entertainment, security, multimedia, communication, Ubiquitous computing etc. Various research work are carried out for face detection and processing which includes detection, tracking of the face, estimation of pose, clustering the detected faces etc. Although significant advances have been made, the performance of face detection systems provide satisfactory under controlled environment & may get degraded with some challenging scenario such as in real time video face detection and processing. There are many real-time applications where human face serves as identity and these application are time bound so time for detection of face from image or video and the further processing is very essential, thus here our goal is to discuss the face detection system overview and to review various human skin colors based approaches and Haar feature based approach for better detection performance. Detected faces tagging and clustering is essential in some cases, so for such further processing time factor plays important role. Some of the recent approaches to improve detection speed such as using Graphical Processing Unit are discussed and providing future directions in this area.

Keywords: face detection, clean environment, time- delay, Graphics Processing, face clustering, naming.

1. Introduction

Nowadays human face detection is very essential. It is gaining importance in various applications. This process is based on extracting facial features and pose etc. In face recognition identity of user can be found which is helpful for providing different computer reaction as per the specific application scope. In the domain Internet of thing, ubiquitous computing high security is very much required so, for this face-based digital signatures [1] and biometric hash [2] can be used. In video surveillance human faces are to be first detected this is the very important step in processing of faces, sometime face tracking also needed to locate the face from video.

 In object- class detection task is to find the sizes & locations of various objects in an image which belongs to given class. Face detection is particularly similar kind of problem where categories are as face or non face from image. In this process facial features plays vital role ,which are stored in database; if the features specified in criteria are matched then face   detection can be successful otherwise it invalidate the matching process. While detecting frontal faces the facial features like eyes, nose mouth are easily visible in the image.   So the frontal face detection is quite simple than detecting   profile faces in which due various pose these features are not completely visible. Angular variation is there thus profile faces with different pose variation not simple to detect. Most of the current face detection approaches focused on it, as in fig.1 frontal face detection is shown.

Fig 1: Face Detection

Face detection is more difficult problem in real world video if the pose invariant face detection is needed then various challenging factors are required to consider compare detecting faces from images. There are number of factors due which face detection process affect are discussed here [3], [4].

a. Pose: Multi view face detection is very essential, but pose variation due to angular movement of face towards left and right side cause the failure of detection of different features like nose, eyes, eye brows & ears. These features can be partially occluded and hence the process of face detection may fail.
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b. Structural components on face: There can be various structural components like beards, glasses because of which person facial look can be changed. As there can be variation in their size shape and wearing style so they may affect the face detection process a lot.
 c. Changing Facial Expression: Various facial expression are there like smiley, crying, sleepy in which facial feature like mouth, eyes change their original shape. Thus they dynamically vary with different expression and this creates the hurdle in normal facial

feature detection for finding the presence of face in image or in video.

d. Occlusion: Many times when we wear scarf, glasses, cap due to that face is occluded and not completely visible. Some of faces may be hided due to certain number of reason as shown in fig 2. Some time in video human faces might be not visible completely due to side angle or because of different obstacles.

e. Orientation of Image: Orientation of image which contain face is very important, as due to different image formation scenario face images changes with various angular movement and directly affect the detection performance.

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f. Image Formation Conditions: Various factors like indoor and outdoor lighting, use of different camera and resolution, color scheme affect the imaging and may change the face detection result. There are number of preprocessing approach which is useful before applying face detection algorithm these preprocessing techniques are utilized to adjust the contrast, removing the shadow on face in image [5].

Fig. 2 shows some examples of challenges such as variation in lighting, pose variations, facial images with complex background, and variations in facial expression, occlusion on face etc.

Fig.2: Examples of challenges such as variation in lighting, pose variations, facial images with complex background, variations in facial expression, occlusion on face etc.

In the face detection process the first and most important step is to detect facial features for finding & locating features on the face. Face identification is required in number of application so here the test image is compared with the face gallery and matching is resultant if its features are available [6]. Similarly authentication of faces is for verification of identity's claim of a person from given images\video. Generally, face spoof detection is very useful as presented in [7]. Now a day's face detection and recognition is used in

Financial transaction then very strict criteria must be used for face authentication for high security purpose, here face must be train in various pose but as numbers of samples of facial images grow time to compare and response increases it may cause delay in detection process.

There are number of method for human face detection such as knowledge based, feature invariant method, templates matching, and appearance based method etc, but these methods may take more time when we need fast detection of faces like in video telephony. Detecting faces from video also have its own importance as in video surveillance camera low resolution images are captured and need to detect. Face detection using skin color and facial features is very useful [8]. Presence or absence of faces mainly determined by facial features and motion prediction

Face tagging and clustering are very useful in many real world scenario, after face detection annotation is required in certain application, as well as number of similar faces need to cluster depending upon requirement [31][32]. Graphical Processing Units

are having number of applications in image processing for better speed up the task [9]. Basically it is for the purpose of accessing multiple pixels simultaneously in graphics application and designed for improving performance graphics applications. As multiple pixels can be accessed simultaneously and can be processed very fast compared to CPU [34].

Mostly Central Processing Unit (CPU) is general-purpose processors and it runs many different applications. There are fundamental differences between architectures of CPUs and Graphics Processing Unit (GPU). For maximizing performance CPU is always optimized for providing high instruction level parallelism. Recently developed CPUs also have multiple cores processing in parallel manner whereas, GPU uses a parallel architecture which has many cores i.e. smaller processing elements. They can perform a very high degree of data based parallelism. Single Instruction, Multiple Data (SIMD) can provide high performance and GPUs are very much designed to be SIMD machines.

Generally used in image processing application like face detection. Recently many approaches are focused on GPU based face detection from videos for better performance of a system.

This paper includes various sections; in section 2 face detection techniques are explored. In section 3, we provide a review of techniques in face detection. Specifically focusing on feature invariant based approaches. In section 4 we have given an overview of face detection process. Review analysis and discussion is provided in section 5. Section 6 provides conclusion and future scope.

2.   Face Detection Techniques

This section provides, face detection existing techniques from images. We can categories these techniques into four types; some of them may be included in more than one method. There might be overlapping in category boundaries [4].

1.   Knowledge based methods

The rule based methods are generally used for encoding knowledge of human that constituting a typical face. Mostly for capturing relationships between facial features different rules are used. These systems are mainly designed for locating
the faces. It is simple and easy to design for example two eyes are symmetric to each other. The main difficulty in this method is human knowledge translation to well defined rules.

2.   Feature invariant approaches

In this method the main objective is finding structural information of features which remain although the, viewpoint, poses or illumination changes, afterwards they are used for locating faces. Here global features such as shape, size and skin as well as other detailed features like eyes, nose, and lips are used. Recently it has become popular and the global features are used to identify the candidate area and then tested using the detailed features. Texture is also a important feature, the human face have difference in texture from other objects. For texture Space Gray Level dependency (SGLD) matrix, can be used for examining the similarity of sub image to belong to human face texture.

3.   Template matching methods

In this method predefined face pattern are stored and they are based on measurement of degree of similarity between these stored pattern and candidate sub images. These patterns can be for complete face

or for individual facial feature such as nose, eyes, lips, eyebrows, and mouth etc. For modeling the elastic facial feature Deformable Templates are used for a reference model. These methods are utilized for both detection of face and localization.

4. Appearance based methods

Here the models are learned from a group of images used for training which must capture the representative variation of face appearance then such models are utilized for detection. Some of the techniques under this category are Eigen face, Support Vector Machine, Neural Network [28], Naïve Bayes Classifier.

3. Literature Survey

Face detection is important domain, various techniques have been proposed and studied by various researcher. Which are focused have on different aspect of it. here we have discussed some of the work in face detection process. Specifically in feature invariant based techniques are focused. We have also discussed various skin color based approaches, where skin color is used in face detection process for segmenting the human face.

Rajib Sarkara and et al have presented an approach in which they have detected skin region from an image and finds presence of mouth & eye region in the detected skin region. Skin region can be mark as a face if these features are present and then fit an oriented rectangle to the face. Canny operator is utilized [6]. Here use of Skin color model & combination Eye+ mouth region for pinkish, yellowish, brownish skin are

done which limit to gray scale face image detection. FERET face database images are used for testing performance of system. These are different images which contain multiple faces captured in uncontrolled real world scenario, and on frames extracted from IP surveillance. In other approach with

the help skin color model, month detector is used for checking face is present or absent in every region. YCrCb Color

Space, Histogram Projection, Motion Prediction camera are used for implementation [8]. As in [9] various object can be detected based on the color in high definition video with enhanced speed on Graphics Processing Unit.

In [10] authors have suggested skin segmentation technique which uses color pixel for classification analysis and comparison. As it is useful in different skin texture based face detection. In [11] approach classification of pixels from given image into non- skin color and skin color by using a skin-color reference map in YCrCb color space is done. They used density regularization of density and Luminance for segmenting out a human face from a test image. The images used here consist of person's head-and-shoulders view with complex background and used of 60 faces images of 3 skin types which are black, white and yellow. It is observed that there is a similar chrominance values pixel for pixel in facial region of image.

In [12] authors have work on a method which detect skin regions over the complete image & then generate the candidate based on the spatial arrangement of these skin patches, for verification of faces eye, mouth & boundary map is constructed. 206 images with resolution the 640X480 are considered pixel 89% detection rate achieved for frontal face but is decreased to 74 for half profile face.

Maruf Monwar et al.[13] have introduced a system for recognition of faces. It is based on skin color for detecting faces and Eigen face method for recognition. It detects almost all skin regions but not all detected regions are faces some of detected regions are body parts of human or other objects which are of same skin color. In [14] authors have worked on a approach that associates faces & names in

news videos. They have utilized skin color model and Eigen faces in which the skin color model is used for extraction and tracking.

It is very much important to check how much variation is there in the range of skin color under varying illumination. It may differ for various color models. Skin color could be visualized in variation under different illumination further In [15] authors have worked for analyzing and detecting variations in skin color under rapidly changing illumination.

As utilization of skin color and features based approach may not provide satisfactory performance in uncontrolled environment so number of other techniques are studied and useful for better detection in various challenging scenario like light variation ,changing pose such as use of Haar Cascade . With the skin color and Haar detector also used. Many

approaches use Haar detector as in [16] for frontal face detection authors introduced a Integral image representation with cascade of adaBoost classifiers. Haar feature based approach works much faster than pixel based system but detect faces which are in tilt position up to about +/-45 degree out of plane & +/-15 degree in plane.

In [17] Binu Muraleedharan Naira et al. have worked on face detection approach in which they used both frontal face and profile faces. Haar features are utilized for detection. This approach developed for three poses which are right and left and frontal. In this approach lighting variations, may affect the performance. However, these methods may fail to represent the faces when there are large variations in, facial occlusion, expression on face, illumination conditions and are present.**.**

Local Binary Pattern [18] is also useful in face detection. Detection process time is essential in real-time applications, for example, if it is used in person authentication instead of biometrics then delay in detection can't be tolerable. As we know GPU based on parallel architecture has a better computational performance thus for getting speed up in the face detection and recognition approaches GPU based various work has been proposed.

There are many applications where response time of system plays very important role. This system cannot tolerate the delay so accelerate the detection process the CPU and GPU are used together. There are number of GPU manufacturer such as NVIDIA, AMD etc. For utilizing the parallel architecture of these graphics processors different programming technology are used. Significant architectural change in NVIDIA processor, GPU is with greater register memory and rich instruction set for communicating between registers through available threads. There is different application and techniques for improving performance on GPU based system one of them is register based Discrete Wavelet Transform implementation is an approach [30].

NVIDIA is one of the leading manufacturers of GPU, they developed Compute Unified Device Architecture (CUDA) is programming platform. It is similar to the C programming language. Language bindings for CUDA have also been developed for various other popular programming languages due that writing code for utilizing the computational power of GPUs become much easier[34],[35].

In Graphics Processing Unit has numbers of cores. These cores are utilized for executing task in parallel manner. Generally CUDA from NVIDIA is used for programming. OpenCL as well as various other programming technologies are also available. In [19] Viola and Jones with OpenCL implementation have been focused for achieving high performance. For improving performance of face detection researchers have work with real world video, in [20] authors have worked on real-time HDTV video, in which they have provided a highly optimized Haar based face detection.

Which can works robust for input from real-world HD videos. In this, with 35 fps under 1080p resolutions and when block size yields

then the best results observed for 1280_720 up to 2048_2048 resolution, but still need to overcome challenging lighting conditions
 In [21] Authors have presented parallel approch using Local Binary Pattern (LBP) for face recognition on GPU. They have used OpenCL for implementation. LBP is used to describe shape and textures of a digital image. Image dataset used to test performance of face detection, its performance may change over real time video. They used ORL database with 40 subjects are tested on AMD 6500 GPU. In [22] Authors have focused on an approach for improvement in the speed of detecting faces with different ways like processing image pixels concurrently optimised memory transfer between Central Processing Unit and Graphics Processing Unit.
In [27] Support Vector Machine (SVM) is trained based on Local Binary Pattern feature. The recognition result of SVM and the result of skin-color ratio feature are merged by weighted voting strategy, and then occluded faces are classified as concealed, partially concealed, and visible. From study of different approaches that increase in performance depend upon the ability to take advantage of the data parallel nature of GPUs. Graphics Processing Unit and Central Processing Unit cooperative acceleration for detection of faces on modern processors is presented in [29]
Various approaches towards skin color based techniques with the combination of facial features, Haar features are essential and useful to simplify and speed up the detection processes considering different challenging conditions in real time video.

4. Overview of Face Detection Approach

Here we have particularly discussed face detection process based on facial feature invariant techniques like skin color, Haar like feature for facial feature representation. In the process of face detection, input to the system can be given as an image which may contain single or multiple faces. The goal is that to detect all the faces in the image. Video can be given as input then from this video various frames are extracted and faces are detected in it. In the real world video various lighting effect may occur so preprocessing of acquired frames plays vital role [23]. Some pre-processing is required so that input image can be adapted to particular algorithm prerequisites. In pre-processing different techniques can be used such as contrast stretching, histogram equalization etc. As there can be multiple faces of same person per frame so they can be cluster together for some specific application [25]. Basic flow of face detection process is as shown in fig. 3. In face detection process if the input given is video then this process can include the main step as image preprocessing, detection, localization, and tracking.

Image Color Features: Color feature is most prominent feature and it is very popularly used in various image processing applications. This feature is treated as one of the low-level descriptor in the image. Color feature is easy to use but in changing illumination colors in the image may looks different so in certain application this feature is used for skin color segmentation but result is tested using different skin color like yellow black, pink and considering multiple color model and color spaces. Various color models like RGB for providing primary color Red, blue and green. Other color model is YCbCr where Y is luminance component and Cr and Cb are chrominance components. In HSV color model
Hue and saturation are vey essential component, for indicating the intensity of color Value component is used many other color models are avail to use.[24].
In many face detection approaches to avoid the non face region skin color face mask threshold is used, but the skin color values may change as per the color model so conversion & specification can help to adapt the changes in skin color. Most of the time use of

multiple color model and proper selection of these models play vital role.
In the YCbCr color space, representation of chrominance is given by Cb and Cr. Cb & Cr values are very essential because these values are used to derive skin color model. Thresholds are used and pixels of skin color are verified by the presence of a particular range of Cb & Cr values. There is respective range of Cb & Cr values which need to consider. These values correspond to particular ranges of rCb & rCr values of skin color. If the values are in this range then categorize as skin otherwise non skin color.
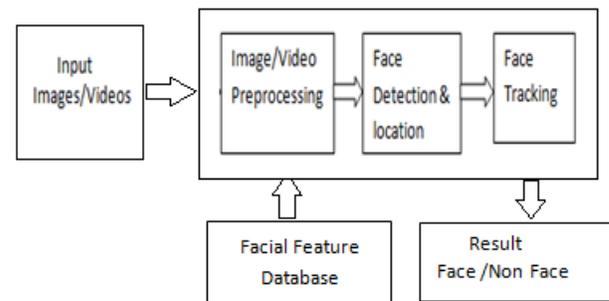

Fig. 3: Basic flow of Face Detection

Locating face is a simplified approach of detection of face here goal is to locate a face in given image. Generally detection of faces and locating faces difference can be found out and methods such as locating head boundaries are more useful in face location.
 Feature vectors are used as the representation basis for the face images, dimension reduction of it is very essential and need to consider for processing. Face candidate using features such as lip, eye, eye brows, nose and ear is to be utilized, and global feature such as shape, size and skin color are for verification of face.
The next step is to extract features of the faces which will be compared to decide presence of face and its location. Some of the algorithms have a learning process to generate new data. Considering face detection two class problem in it we can decide a face or non face in a picture.
 Face recognition has to classify a given face, and there are as many classes as candidates as in [33] authors have discussed challenges in face recognition process from real world scenario. Consequently, many face detection methods are very similar to face recognition. Techniques used in face detection are often used in face recognition.
 Very popular face detection technique is using Haar like feature [16] In Viola Jones algorithm Haar like feature consider rectangular regions at a particular location in
window used for detection as shown in fig. 4. Pixel intensities are summed of every region & difference between
these sums are calculated. Intermediate representation for the input image called as, rectangle features computation is very fast with the use of it which can be further consider for facial feature detection. On an image scanning windows of size 24X24 or 36X36 pixels are used, hence on GPU many number of scanning windows can be generated, processed for better speed up of face detection operation.
Face tracking sometimes is a consequence of face detection. Some time face tracking is very essential, while using video input, there are different methods used to track the face from video. Many systems's goal is to detect a face and also locate this face in real time.
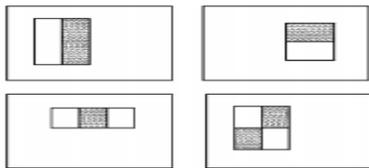
Fig. 4: Haar like features

In auto face annotation human faces from a facial image/video are detected & assignment of proper human names. It is beneficial to various real-world applications. In this direction work given in [14] authors have worked on a approach that associates faces & names in news videos. Further to this other similar approaches for movies and web video of celebrity provided in [25],[26]. As face detection is very initial step so in the work Haar based detection is used.

5. Review Analysis and Discussion

As initial discussion in review various approach focused for improving detection rate. A very important factor is the training & detection time which depend on number of factors. Number of scanning windows that can vary & cover smaller or larger face from image or video.

Fig. 5 (a) Sample test image. (b)Various criteria lead to different detection results.

In the evaluation step for face detection, from various study we can say that the criteria which is used for reporting the detection rates are usually not clear or it may be dependent on specific need. In two class classifier the result can be face or non face, now as per the particular requirement if detection criteria are very strict then more false resultant will be found otherwise for loose criteria most of the time result will be successful. Illustration is shown in fig. 5a sample image for testing and fig. 5b shows some sub-images which require classifying as a face or non face.

Skin color changes with variation in lighting condition as well as different color models are different color spaces so the related decision for the selection of the color model and color conversion have important role.

In detection of faces from color images skin color is a very useful. The main benefit of this technique is that it's simplicity in skin detection rules. Human skin color has a special distribution of color which differs significantly. There are different color models but still skin color pixel region exhibit similarity in chrominance component within and across different human faces. It means that though skin color differ like yellow ,black, white still skin color pixel region exhibit mostly similar chrominance components.

While designing a face detector various factors to be consider so that different type of input image or video can be taken. Here from this input the face may be frontal or profile face still the face detector should provide accurate detection considering various other challenges like changing facial expression, different light variation. Design of such detector become more complex and may need more

face and non face samples in training phase. This may be time consuming so multiple techniques can be blend together as well as instead of only using CPU both CPU and GPU can be used for fast and better performance of system. fig 6 shows CPU Memory and GPU memory while utilizing GPU in the coordination of CPU broadly it needs to reduce the number of memory transfer from memory to GPU memory and vice versa.

GPU is having different types of memory as per nature of data appropriate of them can be used. From study of various approaches for maximizing performance, possibly few transfer back and forth from the GPU. Code must be written in such a way which will utilize the multitude of cores on the GPUs in parallel way so that overall processing time per image must decrease and comparable throughput is achieved.
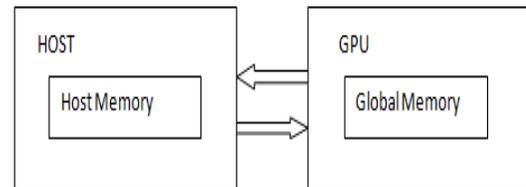

Fig. 6: Host Memory and GPU Memory

Face detection and recognition plays an important role, related to this segmenting faces by using o skin-color map is an important application for the advancement in technology. Today there are requirement of such system which detect a person in uncontrolled environment with high speed and accuracy these system could be used with secure banking system, access control , in many security system as well in many more application in industry, education etc.

6. Conclusion

In this paper survey on recent advances in face detection process for improving the face detection time is done. Many of the approaches based on in skin color for tracking face from video or segmenting the facial part are discussed. Challenges in face detection process from the real time video such as different pose, orientation, features occlusion, changing illumination and facial expression are studied. There are number of application where detection of face within certain time is required so delay in this processing may not be tolerable and thus various approaches exist some of the approaches are for tackling detection accuracy whereas some are for reducing processing time.

In combination of facial features and usages of skin colors in face segmentation process can be less complicated for only particular type of skin as compare to different techniques. For such approaches selection of multiple color model and study of color variation in changing illumination plays important role. As well as processing time and implementation complexity can be reduced with the help of effective utilization of Graphics Processor in coordination with Central Processing Unit.

Face detection rate can be improved by using more computationally intensive operations from image without sacrificing current levels of performance. Information extraction from video in real world environment play important role so after detection of faces tagging and clustering them for a particular applications like security, access control without delay have become need of time.

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