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Design of Face Detection in Colour Images with Complex Background

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ABSTRACT:- Locating and tracking human faces is a prerequisite for face recognition and/or facial expressions analysis, although it is often assumed that a normalized face image is available. In this paper, we try and propose faster yet efficient system which can detect potential face regions with accuracy of over 90%. We use skin colour based model for the experiment. The paper includes the experiment details along with the detail functionality. The entire experiment was hand coded and executed using a live actual camera.

Keywords:- Colour images, Face Detection, Face Recognition, Biometric

I. INTRODUCTION

Human face localization and detection is often the first step in applications such as video surveillance, human computer interface, and face recognition and image database management. In order to locate a human face, the system needs to capture an image using a camera and a frame-grabber to process the image, search the image for important features and then use these features to determine the location of the face. For detecting face there are various algorithms including skin colour based algorithms. Colour is an important feature of human faces. Using skin-colour as a feature for tracking a face has several advantages. Colour processing is much faster than processing other facial features. Under certain lighting conditions, colour is orientation invariant. This property makes motion estimation much easier because only a translation model is needed for motion estimation. However, colour is not a physical phenomenon; it is a perceptual phenomenon that is related to the spectral characteristics of electromagnetic radiation in the visible wavelengths striking the retina.

The accurate detection of human faces in arbitrary scenes is the most important process involved prior to face recognition. When faces could be located exactly in any scene, the recognition step afterwards would not be so complicated. As pointed in recent technical report by Jain and Learned-Miller, face detection in completely unconstrained settings remains a very challenging task, particularly due to the significant pose and lightning variations. The modern face detectors are mostly appearance-based methods, which mean that they need training data to learn classifiers. Collecting a large amount of ground truth data remains a very expensive task, which certainly demands more research. In environments which have low variations, adaptation could bring very significant improvements to face detection. In this context, we planned to develop a system that is useful in analysing the proposed algorithms already developed for face detection. We would like to create our own database and test the system against the ground truth data.

II. CONCEPT UNDERSTANDING

Our algorithm is designed to overcome the deficiencies present in the existing algorithms. The present algorithms strictly use template matching as their primary segmentation algorithm. This process is very time consuming. We also state the argument that if a template is to be eventually matched to get a face region then why is the need to perform any localization technique? We would however be able to detect the faces without doing the segmentation. Moreover, the complete algorithm takes lot a time (nearly 100seconds) to complete so the time can be balanced by removing the initial segmentation step.

Hence, our aim has been to provide results without using template matching as our primary analysis. Our aim has also been in producing an algorithm which can be used by starters in order to understand the underlying concepts and thus improve their understanding of the problem at hand and thus be in a better position to find out solutions for it.The model that we propose is a combination of feature-based and view based approaches. Initially the image is divided in terms of the skin colour. This is the most vital stage as the success of the entire algorithm depends on the efficiency of the segmentation thresholds. Thus an extensive time has been given to this stage in the entire process of algorithm building. Once the segmentation of the probable skin regions are made, then regions to be searched for potential faces has been reduced thus improving the efficiency of the algorithm in terms of time. The very next step is to clear the image of all possible noise pixels. Here the noise is considered to be a part of the background or any non-face region for that matter. Thus an effective solution has been proposed in terms of morphological operations which effectively eliminate noise and also highlight the face region effectively.

Next, the possible edges are found in the image to aid the decision of finding out whether if any related regions remain disconnected in the image. Thus if any face region has got segmented due to algorithm the faces can then be combined resulting in a complete face. Thus faces have been detected. This algorithm works well not only for single face images but also for images with multiple faces. Its robustness can be measured from the fact that it also works very well for complex backgrounds as it does for simple backgrounds. The various advantages and disadvantages have been mentioned in the next section.

Our algorithm takes the following path:
Stage1: Segmentation based on Skin colour
Stage2: Morphology to eliminate noise
Step3: Removal of unwanted regions
Step 4: Determining the edges in the image
Step 5: Merging of related regions
Step 6: Removal of non-face regions

III. EXPERIMENTAL ANALYSIS

The model was made after many experiments and over many versions. The current version of the proposed model is 4.5. For this algorithm we consider the above figure as our test image. The multiple faces images have been downloaded from Stanford University website [4].

Stage1: Segmentation based on Skin colour.

This stage is equivalent to previous stages where the segmented to contain only the skin regions.

Fig.1. Skin Regions of a given image

Stage2: Morphology to eliminate noise:

Fig.1 shows that skin colour segmentation did a good job of rejecting non-skin colours from the input image. However, the resulting image has quite a bit of noise and clutter. A series of morphological operations are performed to clean up the image. The goal is to end up with a mask image that can be applied to the input image to yield skin colour regions without noise and clutter.

A description of each step is as follows:

- Since morphological operations work on intensity images, the colour segmented image is converted into a grey scale image.
- Intensity thresholding is performed to break up dark regions into many smaller regions so that they can be cleaned up by morphological opening. The threshold is set low enough so that it doesn't chip away parts of a face but only create holes in it.
- Morphological opening is performed to remove very small objects from the image while
- preserving the shape and size of larger objects in the image. The definition of a morphological opening of an image is erosion followed by dilation, using the same structuring element for both operations. A disk shaped structuring element of radius 1 is used.
- Hole filling is done to keep the faces as single connected regions in anticipation of a second much larger morphological opening. Otherwise, the mask image will contain many cavities and holes in the faces.

- Morphological opening is performed to remove small to medium objects that are safely below the size of a face. A disk shaped structuring element of radius 6 is used.
- The result of applying the mask to the grey scale version of the input image is shown in Fig. 3.

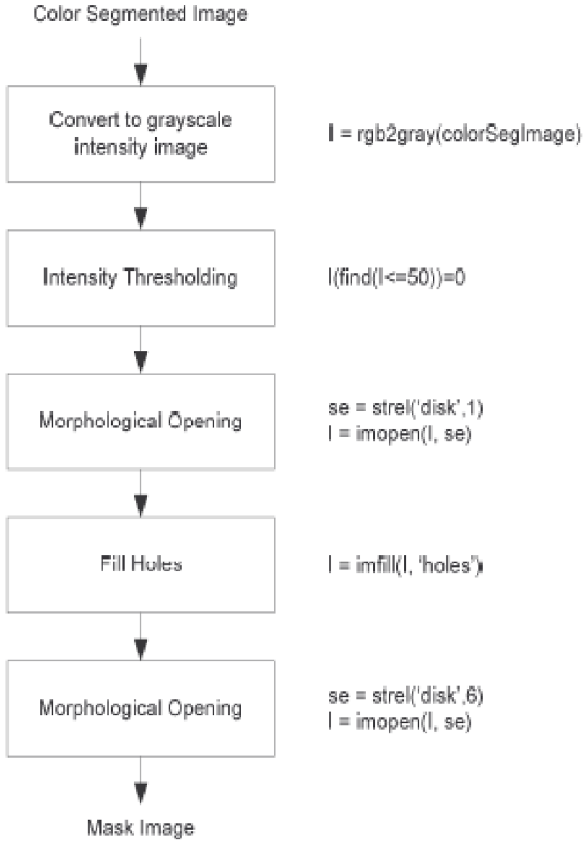

Fig.2. Phases in Morphological image process for noise elimination

Fig.3 Mask image generated as the output of morphological operations

Step3: Removal of unwanted regions

The output from the previous stage contains non-face regions, thus the need for eliminating them. The above input is converted into binary image. The area of regions in the binary image is then calculated.

Fig.4. Binary image due to elimination of non-face regions.

As can be observed from the above result there are numerous non-face regions. Few of the non-face regions can be observed to occupy small areas thus these regions can be removed by determining a threshold.

Fig.5. Further refined face detected scene.

Step 4: Determining the edges in the image

To detect the edges we use Sobel operator. Horizontally we use 'Sh'-operator and vertically we use 'Sv'-operator

$$Sv = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} \qquad Sh = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

The output for the above edge detection is given in Fig.6 which contains a lot of unnecessary edges which needs to be removed. The removal of unwanted edges is done by setting up a threshold, any edge strength value that appears between the thresholds is accepted as the required edge as shown in Fig. 7.

Fig.6. Image due to edge detection

Fig.7. Threshold based edge detected image

Step 5: Merging of related regions

This step is same as performed stage 4. It does not show any significance with respect to our test image and the output remains the same. The major difference of this stage than the previous versions is that, the two regions are merged based on the criteria's given below.

- Edge thickness between the two regions:
  - A threshold has been set that defines the object boundaries. The edge thickness between the two regions to be combined is calculated. If they exceed the threshold, then the regions are not related and are not combined.
- Distance between the two regions:
  - From the extremities calculated, we find the distance to the next region. A threshold has been determined which gives the average distance between two regions. The calculated distances if exceeds the threshold then the regions are not combined.

Fig.8. Merged image regions due to edge thickness

Step 6: Final output 1(Creating of bounding box)

Fig.9. Bounding box placed scene image

The above result contains a many non-face regions like hands, stairs, arms, shirts, etc.

Step 7: Final output (Removal of non-face regions):

The above output contains many unwanted regions like the fist, shoulders, jacket, exposed hands and arms etc. These are removed based on the fact that they occupy lesser area than the other regions or that the aspect ratio doesn't depict a face region. Thus we have the following criteria based on which the eliminations of unwanted regions are made:

- Based on area:
  - The area of each region is found out and the threshold is set, all the areas which are above the threshold value are accepted and others are rejected.
- Based on aspect ratio:
  - Some regions have lesser width and greater height or vice versa, which are other than the face.

Fig.10. Face detected regions

IV. EXPERIMENTAL RESULTS

The following are the different images on which this algorithm was applied.

1. All the regions containing potential faces are detected effectively, as shown in Fig 10.
2. The algorithm is robust because it will work on variety of different images with varying face sizes.
3. The algorithm is invariant to scaling and rotation.

These features can be proved by the images below. Fig.11 and Fig.12 shows situations where there are multiple faces the detections are perfect. Fig.13 depicts image where the faces are present at various distances from each other thus having a differing size ratio of faces. Thus proving invariance to scaling effect. Fig.14 depicts image where the faces are tilted to an angle. This proves invariance to rotation.

Fig.11. Localized face images with multiple faces

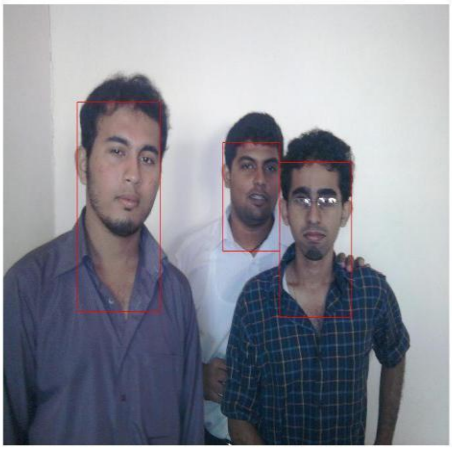

Fig.12. Localized face images with multiple faces occluded

Fig.13. Localized face Images having multiple faces with pose variation

Fig.14. Localized face regions with other scene objects

V.CONCLUSION

Segmentation based on skin color is a non-trivial task as it takes extensive amount of time and resources. The skin colour differs from people to people across the globe and accounting for these changes is a very important issue when it comes to thresholding, which indicates the large number of training data that is required in order to establish and diagnose an efficient threshold. The absence of standard diagnostics database set of different skin colours is another problem, which means that we need to search for different images based on our requirement. Though massive study may be launched with this respect, it however still is not very efficient, as a slight variation in the input data may cause the system to become unreliable.

The description provided above states many advantages and disadvantages. The issue here is to eliminate the use of template matching. The computation time is in terms of 10s of seconds, but has not exceeded more than 20 seconds for the most complex of all images. The 2nd disadvantage which states this fact clearly is a sign that we cannot use this method for video processing. The solution of using multithreading has been applied and yet it has been found that the reduction in computation time isn't that significant.

The algorithm was implemented using MATLAB R2010a. Thus most of the functions used were built in function thus reducing the chance of exploiting the in-depth procedure logic effectively. The algorithm must be implemented in more efficient environment like OpenCV where the entire process is under the programmers control and has can produce more efficient programs.

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