Image Processing Techniques To Recognize Facial Emotions

A. Mercy Rani, R. Durgadevi

Abstract: ***Recognize the human face emotions by computer is an interesting and challenging problem. Face recognition is used in security system effectively compared to other biometric such as fingerprint or iris recognition systems. Face emotion recognition is one of the crucial roles in face recognition system. It is used to recognize the muscle behaviors of the face. The goal of the proposed work is to build an emotion recognition system. It includes face detection, non-skin region extraction and morphological processing finally, emotion recognition. In this article, it begins with frame based detection. The image quality is analyzed. Face location is detected using viola-jones algorithm. Extract non-skin region, Morphological operations are applied to the extracted image to extract the facial feature for recognition of facial emotions. The experiment has shown that the proposed strategy is effective.***

Index Terms: Image Quality Metrics, Face Detection, Segmentation, Morphological Processing, Emotion Recognition, Mat lab.

I. INTRODUCTION

Image processing techniques are used in various types of applications. Biometric is currently a very active area of research spanning to several sub-disciplines such as image processing, pattern recognition, and computer vision. The main goal of biometric is to build systems that can identify people from some observable characteristics. The biometric modalities are in three types physical, behavioral and combination of physical and behavioral modality. The physical modalities are based on the measurement of the human body parts which includes iris recognition, fingerprint, shape, and position of fingers. These traits remain unaltered throughout a person's life. The behavioral modalities are related to change in human behavior over time including signatures and voice patterns. The combination of both modalities depending upon physical as well as behavioral changes.

The human face is a primary focus of attention in social life playing an important role in conveying identity and emotions. This is quite robust despite large variations in visual stimulus due to changing conditions such as environment, aging and other natural factors (beards, moustache, hairstyles and spectacles). Face detection becomes familiar feature in various technical fields such as video surveillance, military applications, identity verification, film processing, criminal identification, security system, tagging purposes and human-computer interaction. Face detection is a hot topic of research in both academics and commercial area throughout the world. It determines the locations and sizes of human faces in a given image and basically it detects only the facial features and ignores the rest like trees, building to the image. Nowadays most of the algorithms are used in facial detection research dealing with still facial images. These include Principal Component Analysis, Linear Discriminate Analysis and Elastic Graph Matching.

Face detection is the first step of face recognition system as it automatically detects a face from a complex background. Face recognition process appears to be promising in various fields such as law enforcement applications, secure information systems, multimedia systems, and cognitive sciences. Some challenges in face recognition are pose variation, occlusion, image orientation, illuminating condition, facial emotion and gender individuality. The facial emotion means to convey feelings, happiness, sadness and the confidence of human. The tremendous worldwide interest in intelligent biometric techniques in face detection and facial emotion recognition is fueled by the myriad of potential applications.

An approach to recognize the facial emotion using skin color segmentation and morphological operations is proposed in this paper.

The paper is organized as follows: In Section II different face emotion recognition techniques are reviewed. Image processing techniques to recognize the facial emotions are proposed in Section III. The results are analyzed in Section IV. Finally the conclusion and the future of work are made in Section V.

II. LITERATURE SURVEY

A literature survey on the developments in biometric image processing domain and techniques used for detecting face and recognizing facial emotions are reviewed and discussed below:

S. Amirhassan Monadjemi et al; proposed to enhance the performance of face detection and recognition systems. In face detection step, Skin color segmentation with YCbCr color space is used. Gaussian skin color model is used in color space image to segment the skin and non-skin pixels. Morphological operations are used to eliminate holes formed in eye, mouth, and nose in skin color segments. Gabor features extraction, dimension reduction using PCA, feature selection using LDA and SVM based classification are used to construct an efficient face recognition system with a high recognition rate [1].

Anala M R et al., presented Viola Jones classifier method, Background subtraction method and skin color detection on HSV color spaces.

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The Viola Jones classifier method gives good results for detecting faces but it takes more time for the detection and it does not give accurate results. The Background subtraction method and Skin color detection on HSV color space are more efficient when compared to the first method by giving accurate results for detecting faces in motion [2].

Jyoti Kumari et al; proposed a quick survey of facial expression recognition using various feature extraction techniques on JAFFE dataset. The noise is removed in preprocessing. Face detection is done by using viola jones algorithm. The facial component detection, detects the ROI (Region of Interest) for eyes, nose, cheeks, mouth, eye brow, ear, fore-head. The feature extraction techniques such as LBP(Local Binary Patterns), LDP(Local Directional Pattern), LGC(Local Gradient Code), HOG(Histogram of Oriented Gradients), LGC-HD (based on principle of horizontal diagonal) and LGC-VD (based on the principle of vertical diagonal) are used to extract the feature. K Nearest Neighbor classification methods are used to classify the features into the respective facial expression classes. Feature extraction techniques are compared based on recognition rate. LGC-VD features are best in emotion recognition. The LBP, LGC and HOG perform equally well, and the LDP is worst one[3].

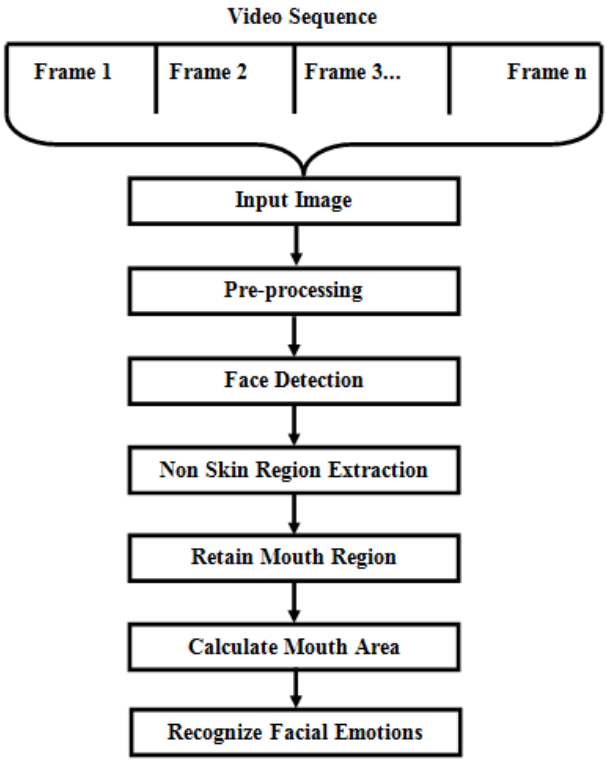
Reza Hassanpour et al; presented an adaptive skin color model based on the gaussian mixture model. Ethnic group images and changing illumination video frames are used for segmentation. YCbCr color space is used to reduce the effects of illumination. Gaussian mixture model is used to represent the features. Model parameter estimation is performed using iterative Expectation Maximization (EM) algorithm. This algorithm is compared to non-adaptive parametric models[4]. Ajit Danti et al; proposed to recognize the facial expressions based on mouth feature. JAFFE database images are used to recognize the expressions. Median, average and wiener filters are applied to the image for enhancing the image quality. Sobel, canny, prewitt edge detectors are applied on the image to detect edges and SUSAN operator is applied to detect corner for different features. Area, height and width of the mouth features are extracted for expression recognition. 25 images of three persons with four facial expressions are selected for processing. Different facial expressions (1 is happiness, 2 is neutral, 3 is sadness, 4 is surprise) are classified based on the range of statistical values [5].

III. METHODOLOGY AND PROPOSED WORK

In this research work, a novel face emotion recognition system from video frames is proposed. Detection and recognition of emotion depends on the input video frames taken. The quality of the image is found using image quality metrics. Initially Face region is detected from the human face by Viola Jones algorithm and skin color segmentation with RGB color space is used to extract the face skin and non skin regions. After the segmentation, morphological operations are applied to extract the boundary of the non skin regions namely eyes and mouth. Then the emotions are recognized by calculating the area of the mouth region. The proposed methodology involves; image acquisition, pre-processing, face detection, segmentation, morphological processing and area calculation. The frame work of the proposed research work is shown in Fig 1.

Algorithm

- Convert video into frames.
- Read the input video frame image
- Convert the image into grayscale image.
- Enhance the input image with median, wiener and gaussian filters.
- Find the best filter based on PSNR, RMSE values.
- Apply viola-jones algorithm to detect the face region.
- Use bounding box method and crop the face region.
- Use threshold value to extract non skin regions.
- Apply morphological operations to extract continuous boundaries of non-skin region.
- Mask the boundary from the original image.
- Extract the mouth region.
- Area is calculated from extracted mouth region.
- Recognize facial emotions based on the value of area.



A. Image Acquisition

An input video of a child with different emotions is recorded in .mp4 file format by a digital video camera and converted into video frames of .jpg format using MATLAB *VideoReader()* function. [1] The recorded video is shown in Fig 2.

Fig 2. Sample Video for Frame Conversion

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The input video frame is taken for processing as shown in Fig 3.

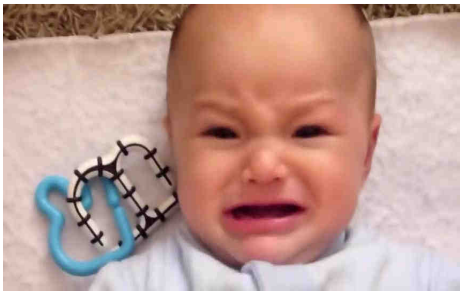

Fig 3. Input Image

B. Image Pre-Processing

The aim of pre-processing is to improve the quality of the image. During acquisition, some unwanted blur and noises are occurred in the video due to out of focus. These noises are cleaned up with the help of filters. In preprocessing stage, Median filter, Wiener Filter and Gaussian filters are applied to reduce the noises from the image and the filtered outputs are analyzed using the image quality metrics Peak Signal to Noise Ratio (PSNR) and Root Mean Square Error (RMSE). The input image is preprocessed by these filters are shown in Fig 4 and the comparison of metric values are given in the Table 1.

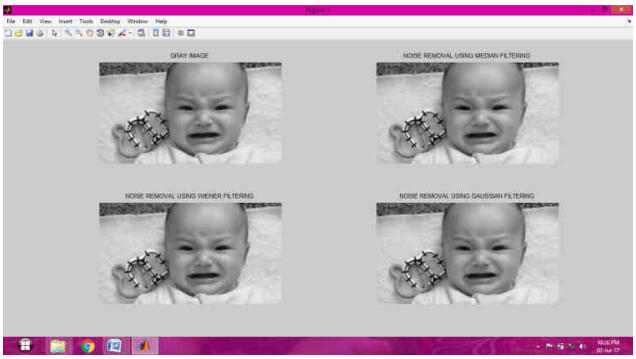

Fig 4. Image Pre-processing

Table1-Comparison of PSNR and RMSE Values

Filters	PSNR Value	RMSE Value
Median Filter	46.7528	1.1719
Wiener Filter	48.4654	0.9622
Gaussian Filter	43.9122	1.6253

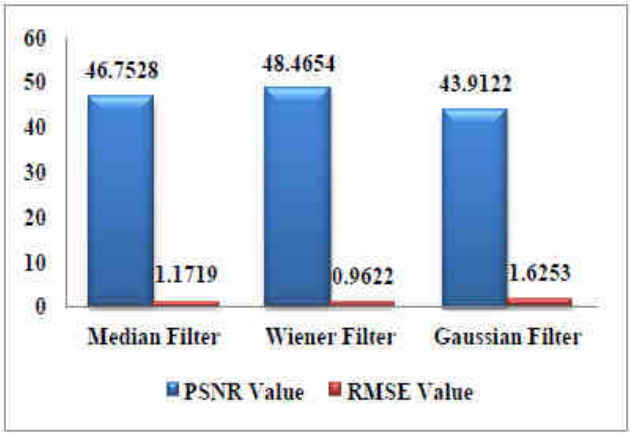

Fig 5. Comparison Chart

The chart is plotted for PSNR and RMSE values for different filter outputs. The analysis shows that the performance of Wiener Filter is better when compared with other two filters having high PSNR value and low RMSE noise value.

C. Face Detection

The input image may have number of objects in its background like human, building, tree etc. Paul Viola and Michael Jones presented a fast and robust method to detect faces with 95% accuracy and less computing time. This face detection framework is capable of processing images extremely rapidly while achieving high detection rates.

In MATLAB, *vision.CascadeObjectDetector()* function is used to detect the face. It creates a system object called detector to detect items. The cascade object detector is used to distinguish people's faces, noses, eyes, mouth and upper body. By default, the detector is configured to detect faces. The function, *bbox = step (detector, i)* displays a bounding box to detect the face region. After preprocessing the face is detected as shown in Fig 6.

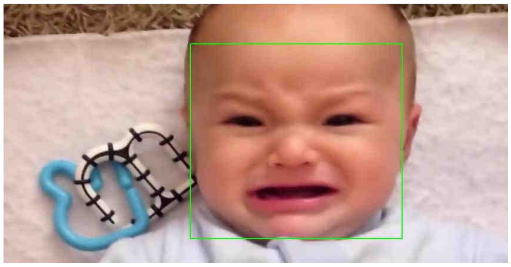

Fig 6. Face Detection

D. Face Cropping

After the face region is identified by the bounding box, the cropping function *imcrop()* is used to crop the face region from the input human image. The coordinates of a rectangle will define the crop area. *% rect* is a four-element position vector [xmin ymin width height] specifies the size and position of the crop area and the cropped face is shown in Fig 7.

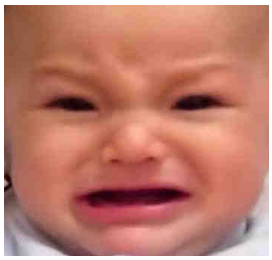

Fig 7. Cropped Face Image

This cropped face is detected iteratively with viola jones algorithm to eliminate the background effects like shirts etc. An iterative face detected image is shown in Fig 8.

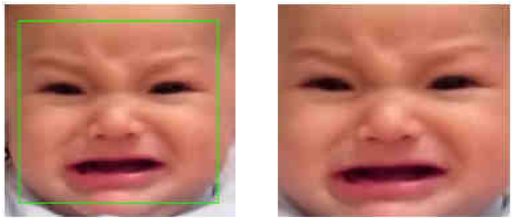

Fig 8. Iterative Face Detection Image

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E. Image Segmentation

Skin color is the most vital feature in human face. Since the emotions are to identified from the non-skin regions, The main goal of this work is to extract the non-skin regions like mouth and eyes from the image. It requires an appropriate color space for segmentation. RGB color space is one of the most used color spaces for processing. By applying thresholding technique to the RGB image the skin and non-skin pixels are easily discriminated. The threshold values applied are given below and the non skin parts are correctly identified and shown in Fig 9

$$R > 95 \&\& G > 40 \&\& B > 20$$
$$max(R,G,B) - min(R,G,B) > 15$$
$$|R-G| > 15 \&\& R > G \&\& R > B$$

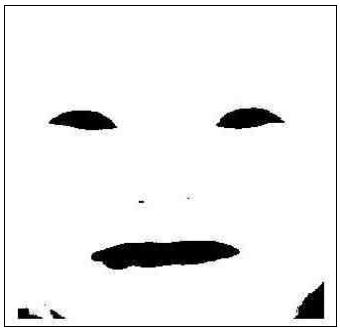

Fig 9. Skin Color Segmentation

F. Morphological Processing

The next step of the face emotion recognition system involves morphological processing to refine the non skin regions extracted from the segmentation step. To perceive and recognize human faces, the prominent characteristics or features with their geometric distribution will be extracted. Morphological operations reduce the unwanted skin parts and background noises from the segmented image.

Morphological Opening *imopen()* with valued structuring element is applied to the segmented face image to eliminate small isolated overlapping objects.

```
SS = strel('disk',12);
TT = imopen(fin,SS);
```

Erosion function *imerode()* is applied to the opened image to shrink the foreground in the object.

```
UU=strel('disk',3,0);
VV=imerode(TT,UU);
```

The boundary of the face is obtained when the opened image is subtracted from the eroded image.

```
WW=VV-TT;
```

An area opening function *bwareaopen ()* is applied to the boundary extracted image for removing unwanted object and to get the boundary of the regions like eyes and mouth accurately.

```
lee=bwareaopen(WW,300);
```

These morphological processed images are shown in Fig 10.

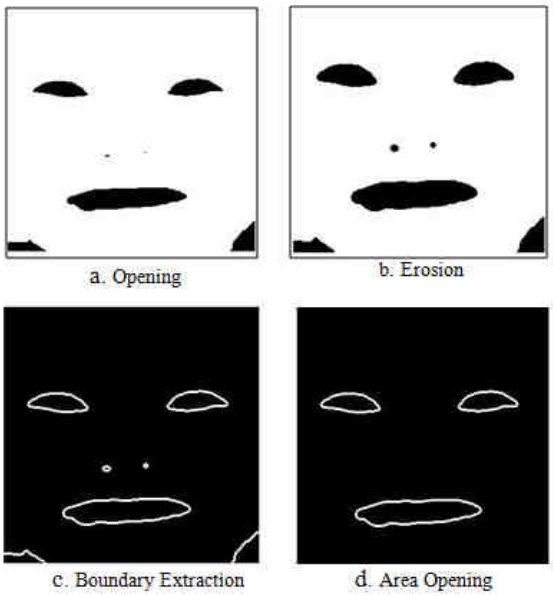

Fig 10. Morphological Processing

G. Masking

Masking is also known as spatial filtering. The edge boundary is a mask. In this stage, boundary extracted image is applied on the cropped face image in order to check whether the mask fits the cropped image exactly. The mask applied image is shown in Figure 11;

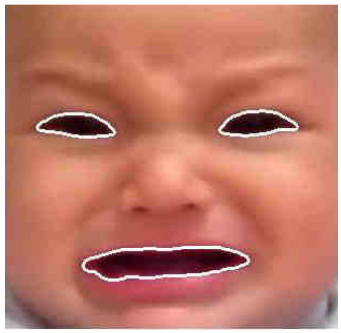

Fig 11. Mask Applied Image

H. Emotion Recognition

Recognition of the emotion is based on the mouth region. The area opening function is used to extract only the mouth region.

```
mee=bwareaopen(lee,500);
```

Region filling function, *imfill()* is used to fill any holes in the individual blobs inside the mouth region.

```
Ke=strel('disk',3,0);
fy=imfill(mee,holes);.
```

The area of the mouth region is calculated based on the number of pixels multiplied with the pixel width (0.26458333) and the minimum and maximum value of the mouth region area based on the emotions is tabulated in Table 3:

```
Aarea=sum(fy(:));
Area=Aarea*0.26458333;
```


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Table 3. Classification of Emotions based on Mouth Area

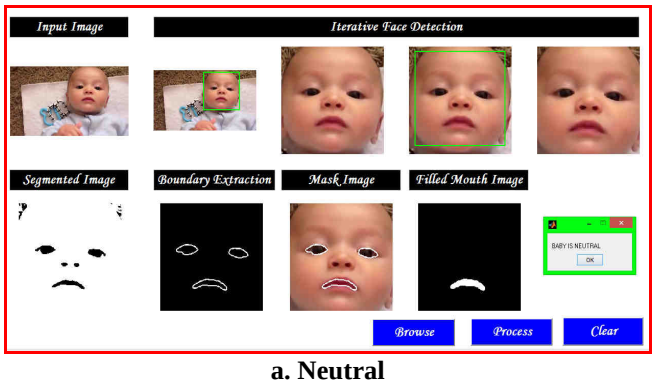
Facial Emotions	Mouth Area in mm	
	Min Value	Max Value
Neutral	3	4
Smile	11	17
Cry	5	10

The holes filled image is shown in Fig 12. The area of the given image is 9, thus the facial emotion is recognized as crying for the given image.

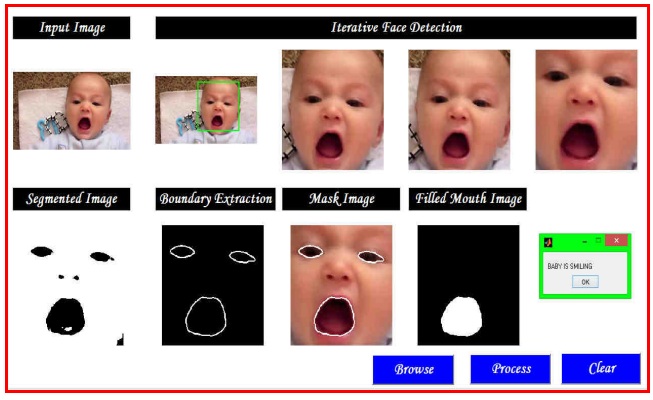
Fig 12. Region Filled Mouth

IV. EXPERIMENTAL ANALYSIS & RESULTS

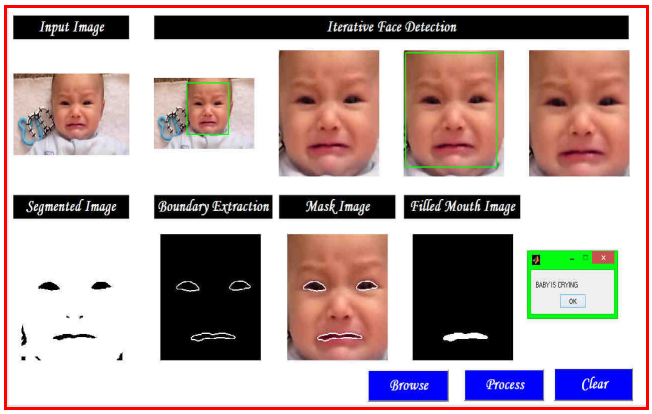
For experimentation, a video of child with 810 frames and three different emotions is recorded. Video frame is taken as an input image and then filtering techniques are applied on it for noise removal and to calculate the image quality metrics. The face is detected from an input image and the segmentation technique is applied to the detected face and then the morphological operations are applied to extract only the mouth region for geometric feature calculation. Finally, the facial emotion is identified based on the filled mouth region area. Various facial emotions recognized are shown in Fig 13.



a. Neutral



b. Smile



c.Cry

Fig 13. Various Facial Emotions

V. CONCLUSION

Emotion recognition of human face is the most common process in biometric applications. This research work is focused on recognizing the facial emotions from the mouth regions. The main intention is to develop an automatic emotion detection system with the robust real time face detection algorithm and segmentation process. Proposed system is tested on video frames from the single video for facial emotions and satisfactory results are obtained.

In future, this research work may be extended to extract the features from other non skin regions (eyes) for recognizing facial emotions.

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