A Novel Face Detection and Facial Feature Detection Algorithm using Skin Colour and Back Propagation Neural Network

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ABSTRACT
Face detection is an important topic in the world of computer science and information technology. Face detection is a computer technology that determines the locations and sizes of human faces in arbitrary (digital) images [1]. It detects facial features and ignores anything else. In this paper a unique method to identify faces is given using back-propagation neural network.

Keywords
Face Detection, Neural Networks, Face Blobs

1. INTRODUCTION:
Recognition of human faces from images is an important topic in computer science and information technology. This paper shows how back-propagation neural network can be used to detect faces using the database initially prepared. The face detection method described in this paper follows a set of steps as shown in Fig 1.

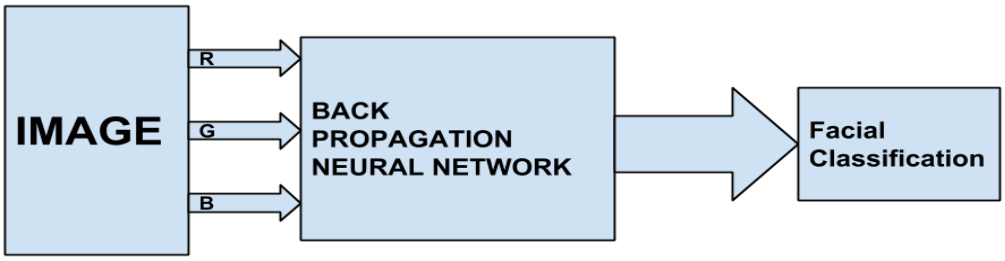

Fig 1: Methodology for Face Detection

The steps used in the Face Detection Algorithm uses a set of algorithms which are described in the following parts of this paper. The first step is skin colour detection which uses a Back Propagation Neural Network [2] to separate the regions in the image that may be considered as part of human skin. The Neural Network used for the detected is given below.

2. SKIN COLOUR CLASSIFICATION
The initial step of the face detection algorithm is recognizing the skin colour. Initially a database of skin tones is prepared manually using a set of images [3]. This step uses a back propagation neural network to train the neural net with a large database of skin tones. The neural network is used to find if the colour of a pixel matches any of the skin tone.

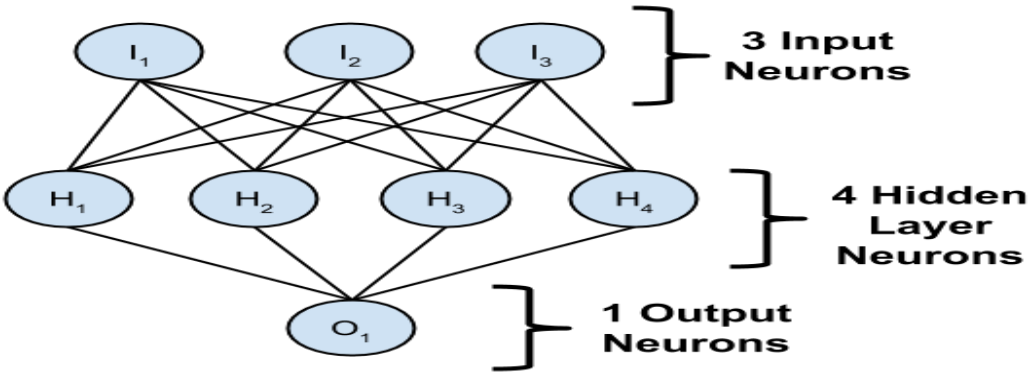

Fig. 2: Back Propagation Neural Network

Matches the colour set in the database. The algorithm then proceeds to segment out the different parts of the face. If all the segments match to a standard features then the face is detected.

The neural network is composed of three layers, namely input layer, hidden layer and the output layer as shown in Fig. 2. The input layer has 3 neurons for the red, green and blue channels. The hidden layer has 4 neurons and the output layer has one neuron. The output neuron results '1' if the RGB values of the pixel is of a skin colour else the output is '0'. After training the neural network, different RGB values of various skin tones are applied as inputs.

After this step, the image is converted to binary using a special algorithm, given below

2.1. Conversion to Binary

The original image is represented as a 2D Vector Image[X,Y] where X,Y are the index numbers to denote the particular pixel [4]. The converted binary image is represented by another 2D Vecotr Binary_Image[X,Y]. The Neural_Network (R,G,B) takes the red, green and blue channel values of a particular pixel of the image and checks if the pixel is a skin pixel. The neural Network is initially trained using a database of skin tone RGB values.

The algorithm used for converting the original image to binary using the trained network is given bellow

Algorithm 1: Converting Image to Binary

```
For Y=1 to Image_Height
    For X=1 to Image_Width
        K=Neural_Network(Image[X,Y].R, Image[X,Y].R,
          Image[X,Y].R)
        If K=1
            Binary_Image[X,Y]=0
        Else Binary_Image[X,Y]=1
    End Loop
End Loop
```

The algorithm simply converts the skin pixels to 0 and rest of the pixels to 1. The binary conversion using the algorithm is shown in Fig 3.

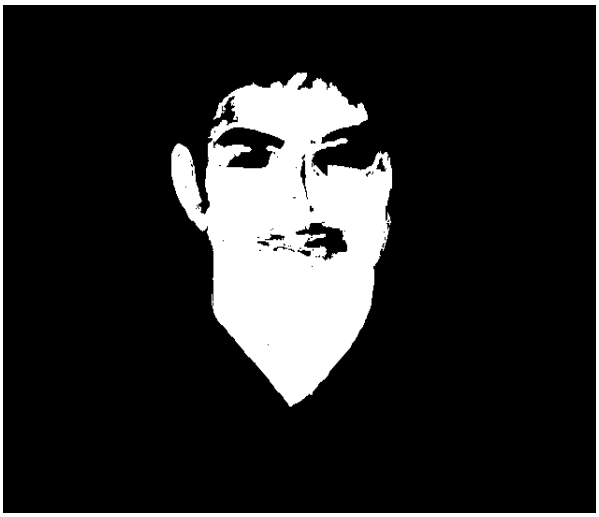

Fig. 3: Converted Image

2.2 Dilation of Pixels

Dilation of the black pixels inside the white blobs is important so that the facial features such as eyes and nose are separated from each other and from the blob borders [5] . The separation is necessary in order to detect the nose and eyes. The dilation algorithm used is given below and a constant k which is set to 5. The algorithm basically deletes all the edge pixels inside the blob that lie on the inner side of the contour as. The function Edge_Pixel(pixel) takes a pixel as a parameter and checks if it is an edge pixel by comparing its 8 background pixels. Another function, Boundary_Pixel takes a pixel as parameter and returns the number of black boundary pixels it has.

The algorithm used is given below

```
Algoritm 2:
For Y=1 to Image_Height
    For X=1 to Image_Width
        If Edge_Pixel(Image(Y,X)) And
          Boundary_Pixel(Image(Y,X))=4
            Image(Y,X)=1
        End If
    End For
End For
```

2.3. Eyes and Nose Detection

The binary image consists of white pixels denoting the facial part and other regions that could be any of the other human parts such as hands. The eye detection algorithm separates the face from the other regions. All the white blobs are scanned with a horizontal run. The scanning starts from the middle of the blob and moves towards the top of the blob. If in any of the horizontal run, two closely separated black blobs are found and those happen to be separated by equal distances from the blob borders the scan is done towards the middle of the blob again. If in this scan towards the middle we find a black blob such that the three blobs form a triangle with the length of above two blobs and the middle blob are almost equal, then the facial parts are detected. The algorithm is described below

For every white Blob in the binary image the following algorithm is used to determine the facial parts (eyes and nose).

Algorithm 3:

Step 1: For $Y=1$ to WhiteBlob_Height
  For $X=1$ to WhiteBlob_Width
    Find connected components inside the White Blob

Step 2: Sort the blobs according to number of pixels, $P(b)$

Step 3: For $Z_1=1$ to B_n
  For $Z_2=Z_1+1$ to B_n
    If $|Centre(B_{Z1}).Y - Centre(B_{Z2}).Y| <= 2$
      And $|P(B_{Z1})-P(B_{Z2})| < P(B_{Z1})/2$
        Eye Found [Green]
        Break Step 3

Step 4: For $X=Mid(Blob[A],Blob[B])$ to White_Blob.Height And $Y=Centre(B_{Z1}).Y$
  BX=Blob found
  If $P(BX)>Max$
    $PX=BX$
    $Max=P(BX)$
  (BX denotes the Nose [Violet])

The mouth is the largest blob bellow the nose. [Mouth]

Fig. 4 shows the facial parts detected.

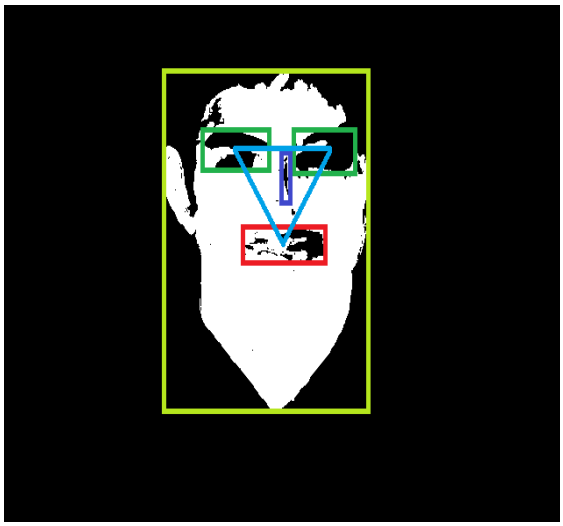

Fig. 4: Facial Parts

After the facial detection part is completed, the face is assumed to be detected and Fig. 5 depicts the same.

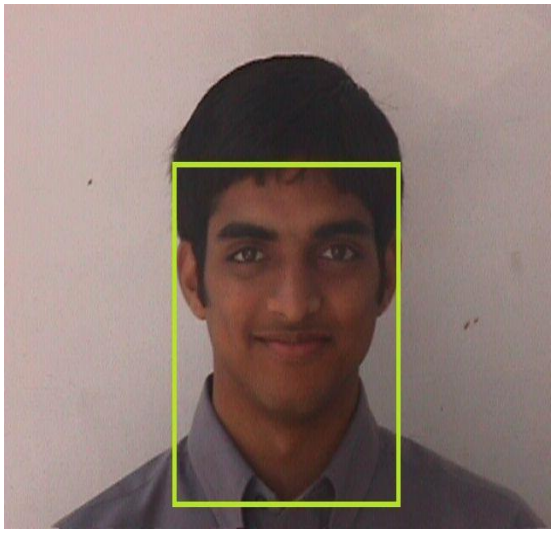

Fig. 5: Face Detected

The algorithms are put to test and implemented as an application.

3. IMPLEMENTATION

The algorithms are implemented in an application. Fig. 6 shows the face detected using the application. The application uses the algorithms described in this paper to detect faces. The neural scan initializes the Neural Network and using the Back Propagation Network the face is detected.

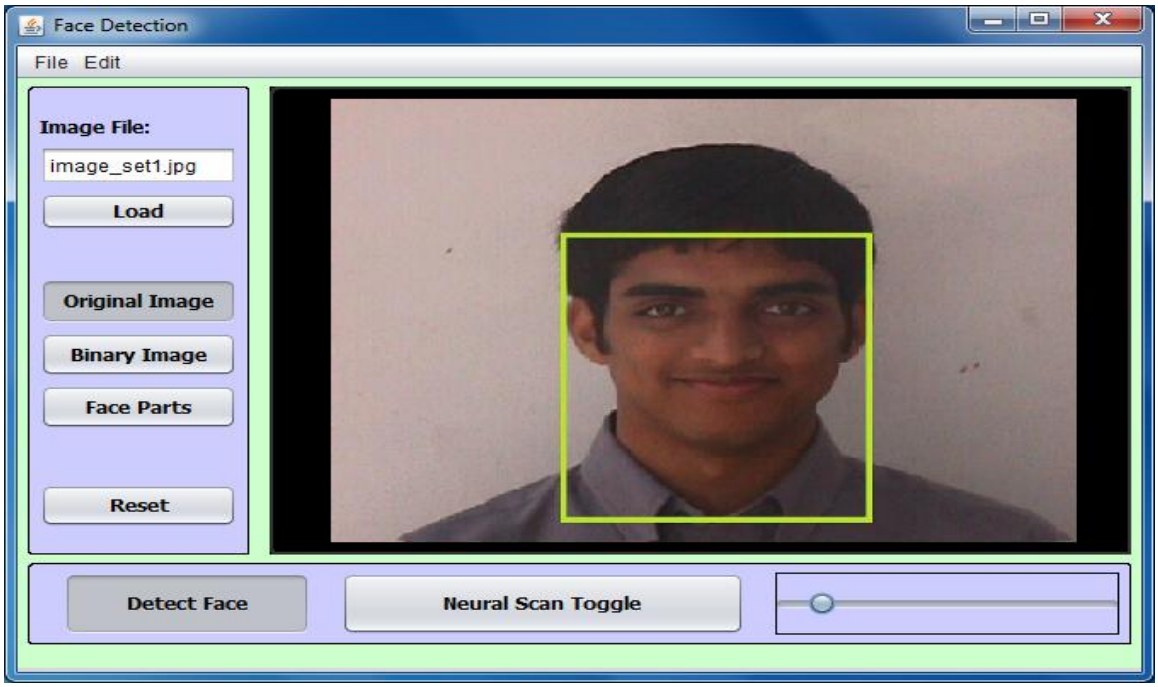

Fig. 6: Face Detection Application

4. CONCLUSION

The paper shows that using Back-Propagation Network, human faces can be recognized. The algorithms used can be used for classifying various images having a face. The results of the shown back-propagation approach are acceptable for different images. The time taken for training is a factor and for large number of characters, the neural network may take some time to train itself. This approach can also be extended for detecting multiple faces too. The same concept can be used for detecting other object as well. The RGB values can then be considered as coordinates. This algorithm is thus useful in various ways.

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