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A Novel Approach towards Facial Skin Detection using Back propagation Neural Network

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Abstract: Detecting faces in an image is a prime step in various computer vision applications, such as face recognition, facial expression analysis etc. Facial skin detection is the process of finding skin-colored pixels and regions in an image with respect to other skin present in the body. Several computer vision approaches like Knowledge-based, Feature invariant approaches, Template matching, Appearance-based methods have been developed for skin detection. A neural network based facial skin detector typically transforms a given pixel into an appropriate colour space and there, the work of the neural network based classifier is to label the pixel whether it is a skin or a non-skin (other than facial skin) pixel. A facial skin classifier defines a decision boundary of the skin color class in the colour space based on a training database of skin-colour pixels. In this paper we have used a neural network based classifier to identify a skin pixel from a non-skin pixel by using a back propagation neural network. Non-skin here refers to the skin other than the facial skin.

Keywords: Face detection, Back propagation algorithm, artificial neural network, Training set, testing set.

I. INTRODUCTION

Skin color and textures are important elements that people use consciously or unconsciously to infer variety of culture-related aspects about each other. These can be an indication of race, health, age, wealth, beauty, etc. [1]. However, such interpretations vary across cultures and across the history. In images and videos, skin color is an indication of the existence of humans in such media. Therefore, in the last two decades extensive research have focused on skin detection in images. Skin detection means detecting image pixels and regions that contain skin-tone color. Most the research in this area has focused on detecting skin pixels and regions based on their color. Very few approaches, also attempt to use texture information to classify skin pixels. Detecting skin pixels are computationally easy task and can be done very efficiently is a feature that encourages the use of skin detection in many video analysis applications. For example, in one of the early applications, detecting skin-colored regions was used to identify nude pictures on the internet for the sake of content filtering. [2] In another early application, skin detection was used to detect anchors in TV news videos for the sake of video automatic annotation, archival, and retrieval. [3] In such an application, it is typical that the face and the hands of the anchor person are the largest skin-tone colored region in a given frame. Since, typically, news programs are shot in indoor controlled environments with man-made background materials that hardly contain skin-colored objects. In many similar applications, where the background is controlled or unlikely to contain skin-colored regions, detecting skin-colored pixels can be a very efficient way to find human faces and hands in images. An example in the context of biometric is detecting faces for face recognition in a controlled environment.

Detecting skin-colored pixels, although seems a straightforward easy task, has proven quite challenging for many reasons. The appearance of skin in an image depends on the illumination conditions (illumination geometry and color) where the image was captured. We humans are very good at identifying object colors in a wide range of illuminations, this is called color constancy. Color constancy is a mystery of perception. Therefore, an important challenge in skin detection is to represent the color in a way that is invariant or at least insensitive to changes in illumination. As will be discussed shortly, the choice of the color space affects greatly the performance of any skin detector and its sensitivity to change in illumination conditions. Another challenge comes from the fact that many objects in the real world might have skin-tone colors. For example, wood, leather, skin-colored clothing, hair, sand, etc. This causes any skin detector to have much false detection in the background if the environment is not controlled.

In this paper, the focus is on improving the reliability of skin detection by a machine learning based method. Machine learning-based methods use a lot of training samples of faces and non-faces to give learning so that it can be able to identity faces. Machine learning-based methods have high detection rates, but their accuracy depends on the number of training samples. [4] These algorithms have been used in many applications. Choosing skin color as an element in detecting human existence is quite a simple and straight forward task, and in addition, skin color has processing time advantage, since color processing is faster compared to other features [8]. Still, it has several constraints since the skin color representation, which has skin-like color objects might be present in the image captured such as hair, soil, wooden materials, sand, drawings and animals. This is uncontrollable because the skin detection may contain errors and generate a false detection result and thus fails to identify the non-skin objects which have skin-like color pixels.

A.A Framework for Skin Detection

Skin detection process has two phases: a training phase and a detection phase. Training a skin detector involves three basic steps:

1) Collecting a database of skin patches from different images. Such a database typically contains skin-colored patches from a variety of people under different illumination conditions.

2) Choosing a suitable color space.

3) Learning the parameters of a skin classifier using neural network.
Given on a trained skin detector, identifying skin pixels in a given image or video frame involves:

(i) Converting the image into the same color space that was used in the training phase.
(ii) Classifying each pixel using the skin classifier (Neural network) to either a skin or non-skin.

II. RELATED WORK

Face Detection is the technique where, on a given arbitrary image, the work is to determine whether or not there are any faces in the image and, if present, return the image location and extent of each face. The challenges associated with face detections are

1) Pose: The images of a face vary due to the relative camera-face positions and some facial features such as an eye or the nose may become partially or wholly occluded.

2) Presence or absence of structural components: Facial features such as beards, mustaches, and glasses may or may not be present and there is a great deal of variability among these components including shape, color, and size.[5]

3) Facial expression: The appearance of faces is directly affected by a person's facial expression.

4) Occlusion. Faces may be partially occluded by other objects. In an image with a group of people, some faces may partially occlude other faces.

5) Image orientation: Face images directly vary for different rotations about the Camera's optical axis and imaging conditions, when the image is formed.

For face detection, different methods like artificial neural network, support vector machine, Bayesian classifier, Hidden Markov model have been used and implemented successfully.[5] Though many techniques are available for skin detection, the area of facial skin detection still have a lot of scope for research.
Neural networks have been applied in many pattern recognition problems including face recognition. There are many image based face detection using neural networks have been used mainly by taking

skin color segmentation to test an image and classify each DCT based feature vector for the presence of either a face or non face [6].The neural networks used in this paper is the back propagation neural networks. This is chosen because of simplicity and its capability in supervised pattern matching. The structure of the neural network with three layers , the input layer is a coefficient vectors of neuron from each image either face or non face image , the hidden layers has ‘n’ neurons, and the output layer is a single neuron. The neural networks is trained using coefficient feature vectors taken from the training set and is tested over the shown images.

III. Proposed Work

The proposed work can be divided into several sub tasks. Such as:

- Input and Target Data Preprocessing
- Creation and training of the Neural Network
- Simulation Using the Test Set
- Output Image generation

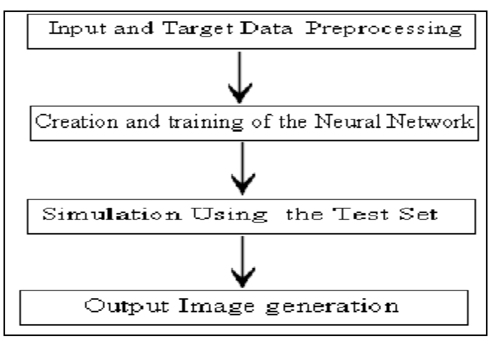


Fig. 1: Steps for the face detection model using neural network

A. Input Data Processing

The input for this work is taken first with a smaller sample of skin and non skin pixels which are taken from the image database. These samples are of size 20X20 each. Then all the samples are read and converted into a large matrix. For example if 10 samples are there then a matrix with size 20X200 is created. Then another matrix is created that contains the red, green and blue values for all the pixels present in the previous matrix. For example for the previous matrix with size 20X200, the new matrix contains the red green and blue values for all 2000 pixels. Hence the size of the new matrix becomes 2000X3. Now the resultant matrix is transposed and normalized in order to create the input data set for the neural network. (size becomes 3X2000)

B. Output data Processing

The output data is created by placing 0 for each non-facial skin pixel sample and 1 for each facial skin pixel sample. Hence, for a matrix with size 1X2000 is containing only 0s or 1s corresponding to each sample in the input dataset.

C. Creation and training of the Neural Network

In BP algorithm, initially the weights are initialized to very small random numbers. Each unit has a bias associated with it.

The biases are similarly initialized to small random numbers.

Propagate the inputs forward: First, the training tuple is fed into the input layer of the network. The inputs pass through the input units, unchanged. Next, the net input and output of each unit in the hidden and output layers are computed using activation functions. The net input to a unit in the hidden or output layers is computed as a linear combination of its inputs. To compute the net input to the unit, each input connected to the unit is multiplied by its corresponding weight, and is summed and is passed through some non linear filter function. The weight sets connecting the hidden to output layer and connecting the input to hidden layers are adjusted basing on the error generated by the actual output and the target output till the network will not reach to a convergence condition.

In this work a back propagation neural network is created with 3 input neurons, 5 hidden neurons and 1 output neuron. (3-5-1 BPNN). Here log sigmoidal function is used as the transfer function. Transfer functions calculates a layer's output from its net input.[7] LOGSIG (N) takes one input, N - SxQ matrix of net input (column) vectors and returns each element of N squashed between 0 and 1.The network uses TRAINSCG (Train Scale Conjugate Gradient) as the training function. TRAINSCG updates weight and bias values according to the scaled conjugate gradient method. As the TRAINSCG function is found to work better for large datasets. The LEARNGDM function is used as the adaption learning function. LEARNGDM is the gradient descent with momentum weight/bias learning function.

MSE (Mean Squared Error) is a network performance function which measures the network's performance according to the mean of squared errors. The proposed work has been implemented using MATLAB7 .The neural network tool present in the MATLAB is used to create the required network. The network architecture is shown in fig-2.

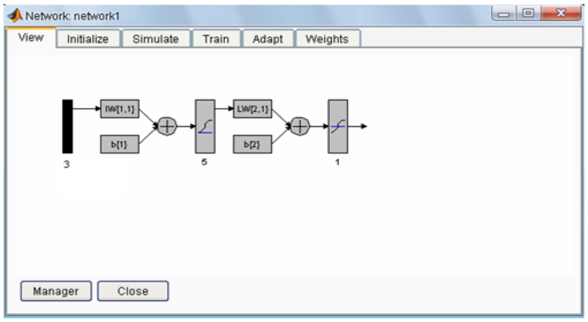


Fig- 2 Back-propagation neural network architecture with 3 input neurons, 5 hidden neurons and 1 output neurons.

IV: Results and Observations

Here several facial images are taken along with non-facial pixels as the input to the proposed neural network. Output for each input image is processed and multiplied back to the original image in order to detect the facial skin pixels

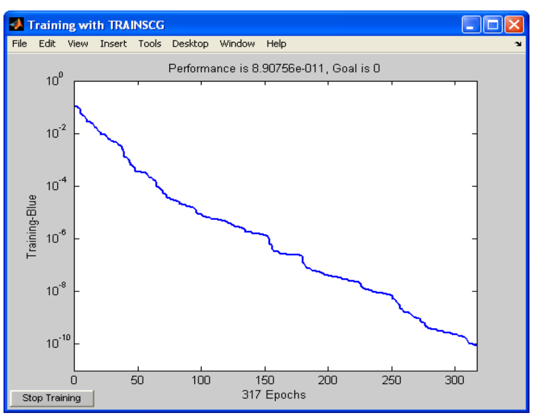


Fig. 3: Showing the Training plot for the Neural Network after the network is being converged

The following table shows the input and the corresponding output images

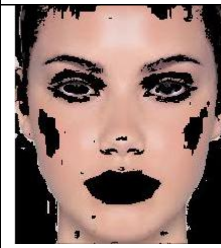
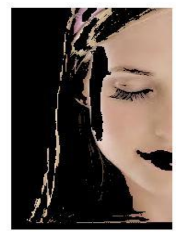
Input Images	Output Images
	
	
	
	

Fig. 4: Showing the input images with their corresponding output images

The results shown here shows the classification and distinction between facial and non-facial skin pixels (The black colored patches represent the non-skin). In this approach the efficiency of the classification depends on the amount of training provided to the neural network. But the advantage of this approach is that once the neural network is trained then it works accurately for similar type of images. In image3 some portion of the face is misclassified because of the lighting effect and skin color mismatch. In image

4 some portion below the neck is also misclassified as the skin color matches with the face .How ever this technique can be used to detect the facial skin pixels for images with similar skin color and lighting effect.

V. Conclusion

Though many techniques are available for skin detection, the area of facial skin detection is still having a lot of scope for research. This work again specifies the area by introducing the concept of neural network for facial skin detection. By observing the results it can be seen that the neural network is successfully classifying the facial skin and non-facial skin pixel up to a great extent. Another observed aspect is that the efficiency of the facial skin detection depends on how well the neural network has been trained. It could be observed that if the training sample is containing comparatively large number of related samples, the classification accuracy rate is significantly increased. In this work only one color space has been taken and found to perform well, it could be tested with another color space other than RGB and the result can be tested.

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