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Reliable Skin Detection Using Hybrid Neural Network Model

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Abstract: Skin detection is an important process used on color images and videos. It can be applied for face tracking, pornographic image filtering, hand detection and video surveillance. Many techniques that have been used to detect skin faced several drawbacks since it is difficult to detect skin when the color is between skin and non skin range. In addition, the skin appearance of humans when exposed under different lighting conditions adds complexity to the process. Finally, many detection approaches gave low detection rate when the image contains a group of people.
To overcome this problem and produce a fast processing technique, this paper proposes a hybrid back probgation neural network model based on various skin detection models which gave the highest hit rate. This model of combining the output of various skin classifiers has improved the correct detection by 5.2% compared with the best single skin detection technique and scored a 98.3% classification rate.

Keywords: Image Processing, Skin Neural Network, Skin Detection, Block Matching, Human Skin Detection

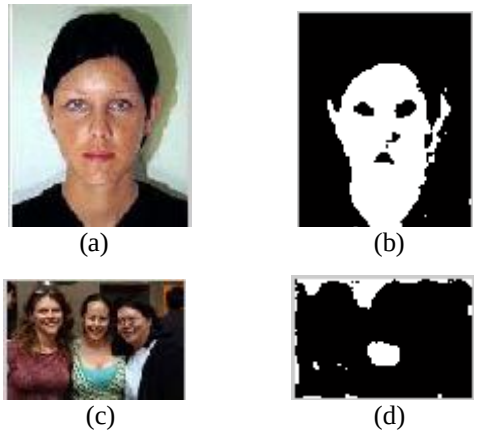
I. INTRODUCTION

Human skin detection is one of the important applications and urgent research area in digital world. Skin detection is a technique which searches for locations of human skin in an image segment which simulates the natural process of skin detection by human vision system (eyes) using computerized systems[1].
Human skin detection is not a simple task since human skin is highly dynamic when it comes to various imaging conditions during acquisitions such as lighting and shadow, and in addition to the fact that human skin colors occupy a wide range of pixel values. The detection technique must consider some variables such as camera distance, background color and illumination [2, 5, 6, 7].
Skin detection models have been used in various applications. Choosing skin color as a factor in detecting human existence is a simple and straight forward task. Nevertheless, skin color can be easily misinterpreted with other objects in images such as wood, leather, skin-colored clothing, hair, and etc [10, 11]. This causes the skin detection techniques to have false results if the environment and background is not controlled. Another challenge comes from the fact that the appearance of skin in an image depends heavily on the illumination conditions that involves illumination geometry and color where the image is captured. So skin detection models presented different results when using different images. To bypass these issues, there is a need for a new method which presents a fast and better precision.
The aim of this research is to capitalize on the weaknesses of other skin detection techniques by decreasing the false detection rate without changing the environment. We have accomplished:
(i) Studying different skin detection methods and determine the strength, reliability and weaknesses of each method.
(ii) Design and implement a comprehensive a skin detector technique based on back probgation neural network that overcomes the drawbacks of the current skin detection techniques.
(iii) Compare the new skin technique to the existing and previously experimented models.

II. RELATED WORK

We have experimented with several researches that were presented and applied to detect human skin in image, but all of these models give a different result using different images, and many of these models give a ghastly result when working with images containing a group of people due to various conditions they used. Some of these models were presented in our earlier work [9].

- Kapur system [3] converts RGB images into IRg By values then using the median filter to detect skin. This research gives a good result when it is applied to an image of single person, but gives a low performance when image contains group of people as seen in Figure 1.



(a) (b) (c) (d)

Fig. 1 (a & c) Original Image, (b & d) Skin Detection Result

- Gomez and Morales [2] build a skin probability map, this method gives a better performance when it is applied to single images, but gives a different performance when the image contains a group of people as seen in Figure 2.

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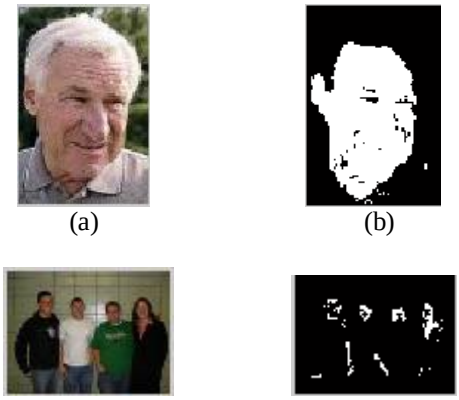
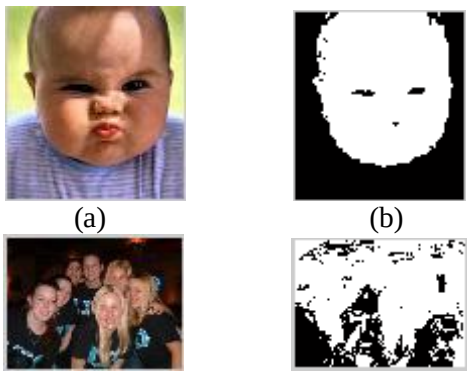


(a) (b) (c) (d)

Fig. 2 (a & c) Original image, (b & d) Skin Detection Result

(a) (b) (c)

Fig. 3 Different output applied on the same image using YCrCb.



(a) (b) (c) (d)

Fig. 4 HSV Model Applied on Images, (b&d) Skin Detection Results

- Kim, Prieto and Pugalia model was based on detecting skin using YCrCb values. This model gave a better results on both single and group images, but the main problem using this model is the randomness when computing the mean and covariance which gives a different result using same image as seen in Figure 3 [4].
- Mohsin and Mar converts images into HSV values and using a training set to detect skin regions. This model fails to detect skin in images with many subjects as seen in Figure 4 [8].

III. OUR APPROACH

This proposed skin detection system using backprobgation neural network is shown in Figure 5. Firstly, we have to prepare the image database containing over 2000 human skin images with various skin tones, backgrounds and lighting conditions. Those images were downloaded from the internet and some were taking using digital camera. The hybrid approach is based on integrating the five skin detection models. The process is to make the neural skin detection is based on the hit score of the various models. A skin neural network selector used to compute error percentage of each model.

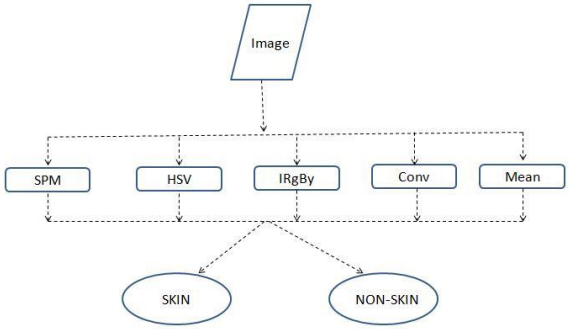


Fig. 5 Overall Structure.

A. *Training Phase*

In this phase, we will train the neural system to be able to differentiate the skin dataset and non skin dataset collected from different models we have experimented with. The most important things in this phase are how accurate the data set is so that the neural trained data covers a wide range of skin color in both part of skin and non-skin. The two data sets for training phase can be classified as non-skin images and skin images.

The hybrid model is designed to capitalize on the redundancy of pixels in skin mask. The pixels which frequently appear in more than one mask take the highest probability. To do that, as a first step each mask values which obtained from the five models is divided into blocks, then searching for frequent appearance of blocks, the block with most appearance takes the highest probability to be a part of the hybrid mask model. The probability factor is calculated by:

$$P(skin \mid x) = \frac{P(x \mid skin)P(skin)}{P(x \mid skin)P(skin) + P(x \mid \neg skin)P(\neg skin)}$$

Where P(x|skin) and P(x|¬skin) is directly computed from the models. The probability of P(skin) and P(¬skin) can be estimated from the overall number of skin and non-skin samples in the skin filter. Figure 6 shows an example of how errors decrease as the neural network is trained. While it is difficult to see on the large chart, the blowup of the last few points shows that the error does, in fact, go up on the last data point, indicating that the neural network has been trained enough.

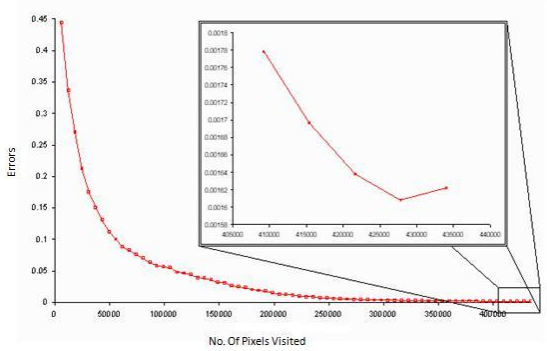


Fig. 6 Output errors of a neural network as a function of learning cycles.

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B. *Skin Neural Network*

In the proposed method, we have optimized (number of layers, number of nodes, threshold, training algorithm etc.) to get the best performance. Our neural network model consists of three layers inputs, hidden layer and an output layer as shown in figure 7.

Figure 7 shows the neural network architecture of back propagation neural network with six neurons in the hidden layer and one neuron in the output layer for segmentation task.

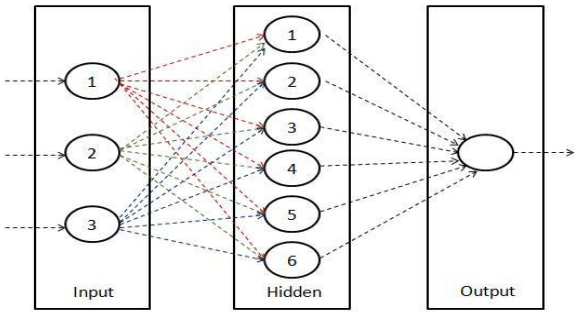

Fig. 7 Neural Network Layers

To get the exact result, number of nodes which used in each layer is the same and equal to total number of pixels in the whole image.

The skin Neural network starts by calculating the weights of output layer and hidden layer, using these values, the skin neural gets the error percentage of each pixel in the original mask [7].

IV. EXPERMENTAL RESULTS

The test-bed was based on images with different sizes, camera distance, illumination and different number of skin regions, in order to cover maximum number of different factors, which make detection skin hard to do. The data set contained both single and a group of people since most models had difficulties in identifying skin regions in a group of people images. Finally, in order to get the highest possible accuracy, there weren't any morphological operations used in this approach.

Table 1 shows the rate of positive return for different models using different configurations. Although different models use different setting as reported by the authors, we have tried to use the same setting on all of them to test for accurate rate of return.

TABLE 1
PERFORMANCE OF DIFFERENT MODELS USING THE SAME DATASET.

Skin Algorithm	Criteria	% Detection	
		Single	Group
SPM	Accuracy	94.5%	78.8%
	Processing Time(s)	926.3	872.3
	% detection	90.1%	100%
HSV	Accuracy	95.2%	94.7%
	Processing Time(s)	725.7	433.8
	% detection	99%	99.1%
IRgBy	Accuracy	74.35%	29.1%
	Processing Time(s)	911.9	623.78
	% detection	91.1%	88.2%
Conv.	Accuracy	83.33%	55.88%
	Processing Time(s)	912.65	523.1
	% detection	77.3%	89.3%
Mean	Accuracy	83.3%	94.11%
	Processing Time(s)	845.3	456.93
	% detection	93.5%	96.0%
Hybrid ANN	Accuracy	98.3%	99.2%
	Processing Time(s)	723.1	324.22
	% detection	100%	100%

The output results of the ANN model shows various results of skin detection. We notice that it gave higher scoring results than other models since it was based on the accuracy of the models. The result is shown in figure 8.

Fig. 8 Results from neural system with high detection rate (98.3%).

V. CONCLUSION

Skin color detection is generally a prepossessing step in many applications such as face detection, pornographic image filtering, hand detection, and video surveillance. Nevertheless, skin detection is still a challenging task as the proposed techniques could not overcome the problem of illumination and background which produces a high false percentage rates. In order to enhance the detection accuracy, an artificial neural network has been adopted for skin detection. This paper has presented some skin detection models which have mostly improved the detection performance and used their skin detection results as a test-bed for better neural network dataset. The results from the neural network selector gave a higher hit rate since it was trained to search for better skin values. The results of this model applied on both single and group images scored 98.3% since a key modification on the models were done. However, time complexity and computation is still a major factor when applying a real-time application.

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BIOGRAPHY

Dr. Khalid Kaabneh received his Bachelor's degree in Electrical Engineering and Computer Engineering in 1989. In 1991, he earned an MS Degree in Management Information Systems. A Ph.D. was bestowed upon him in 2001 for his research in the area of Multimedia audio watermarking. All degrees were awarded from The George Washington University in Washington DC, USA. An Associate Professor and vice dean at the Department of Computer Science at Amman Arab University for Graduate Studies. Currently working as a faculty member at the department of multimedia, Isra University His research interests include areas like Digital Communications, Wireless Networks, Digital Multimedia, Copyright Protection, and Data and Systems Security. Dr. Kaabneh was employed as Computer System Security administrator at Intranet Consultants, USA from 1998 to 2000. He is an approved Computer Security Consultant and published various security research papers in a multitude of local and international journals.