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A Neural Network Color Classifier in HSV Color Space

Gargi V. Sangamnerkar, Dr. Kishor K. Bhoyar
Department of Information Technology,YCCE. Nagpur University, Nagpur

ABSTRACT :
In this paper, a neural network approach for color classification in HSV color space based on color JND (just noticeable difference) is presented. The HSV color samples are generated using an interactive tool based on JND concept and these samples are used for supervised training. A four layer feed forward neural network is trained for classifying a given color pair as similar or dissimilar pair. An interactive tool for color pixel comparison is developed for testing the color classifier on real life images. Research shows that neural network classifier in HSV color space works better than RGB classifier in terms of efficiency for segmentation purposes. Thus the experimentation results can be used for segmenting real life images.

***Keywords* -** Elliptic Curve Cryptography, Encryption Algorithms, Types of services in Cloud Computing, Cloud Security, Encryption

I. INTRODUCTION

In color image processing, there are various color models in use today. Folklore has it that the RGB (Red Green Blue) color space arising naturally from color display hardware is user-hostile and that other color models such as the HSV(Hue Saturation Value) scheme are preferable. In the RGB model, images are represented by three components, one for each primary color – red, green and blue. Although human eye is strongly perceptive to red, green, and blue, the RGB representation is not well suited for describing color image from human perception point of view. Moreover, a color is not simply formed by these three primary colors.

When viewing a color object, human visual system characterizes it by its brightness and chromaticity. The latter is defined by hue and saturation. Brightness is a subjective measure of luminous intensity. It embodies the achromatic notion of intensity. Hue is a color attribute and represents a dominant color. Saturation is an expression of the relative purity or the degree to which a pure color is diluted by white light. The HSV model is motivated by the human visual system. In the HSV model, the luminous component (brightness) is decoupled from color-carrying information (hue and saturation). It is more natural for human visual system to describe a color image by the HSV model than by the RGB model [8].

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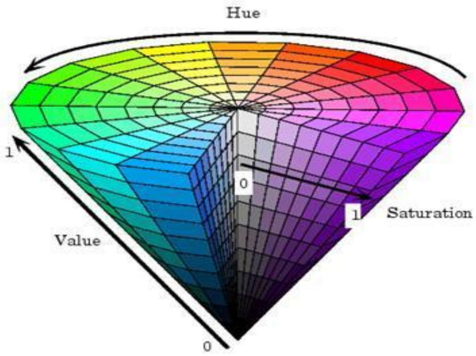


Fig. 1 HSV color model single hex cone [2]

MLF (Multilayer feed-forward) neural networks, trained with a back-propagation learning algorithm, are the most popular neural networks. A MLF neural network consists of neurons that are ordered into layers (Fig. 2). The first layer is called the input layer, the last layer is called the output layer, and the layers between are hidden layers. The MLF neural network operates in two modes: training and prediction mode. For the training of the MLF neural network and for the prediction using the MLF neural network we need two data sets, the training set and the set that we want to predict (test set). The training mode begins with arbitrary values of the weights they might be random numbers - and proceeds iteratively. Each iteration of the complete training set is called an epoch. In each epoch the network adjusts the weights in the direction that reduces the error. As the iterative process of incremental adjustment continues, the weights gradually converge to the locally optimal set of values. Many epochs are usually required before training is completed [3].

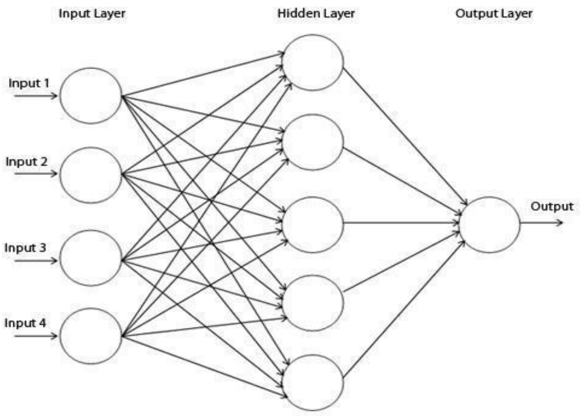


Fig. 2 Typical feed-forward neural network [4]

The application of MLF neural networks offers the following useful properties and capabilities such as-

Leaning: ANNs (Artificial Neural Networks) are able to adapt without assistance of the user. Nonlinearity: A neuron is a non-linear device. Consequently, a neural network is itself non-linear.

Nonlinearity: is very important property, particularly, if the relationship between input and output is inherently non-linear.

Input-output mapping: In supervised training, each example consists of a unique input signal and the corresponding desired response. An example picked from the training set is presented to the network, and the weight coefficients are modified so as to minimise the difference between the desired output and the actual response of the network. The training of the network is repeated for many examples in thetraining set until the network reaches the stable state. Thus the network learns from the examples by constructing an input-output mapping for the problem.

Robustness: MLF neural networks are very robust, i.e. their performance degrades gracefully in the presence of increasing amounts of noise.

Quite a few systems have been implemented for classifying colors, using neural networks and Neuro-Fuzzy techniques. The use neural network in color classification has been proposed in [5]. They have used neural network to improve flexibility of color classification result in a changed environment using the EM algorithm which is a general method for the maximum likelihood problem. Their experiment proved that it is applicable and significant. The ANNs can be applied for fruit sorting has been proposed in [6]. They have provided an investigation on the applicability of color classification using an artificial neural network in the fruit-sorting domain. Using the well-known network generalization property they have investigated the applicability of this approach to the segmentation of coloured images represented by the RGB color system. In [7] the authors have proposed an identification and classification system of different types of bulk fruit images using artificial neural networks. They have used a Back Propagation Neural Network (BPNN) to classify and recognize the fruit image samples, using three different types of feature sets, viz. color, texture, combination of both color and texture features. Their study reveals that the combination of color and texture features are out performed the individual color and texture features in identification and classification of different bulk fruit image samples. In [8] a novel approach to distinguishing computer graphics from photographic images has been proposed. They have investigated the influence of different image color representations on the feature effectiveness. Specifically, the efficiency of using RGB and HSV color models is investigated. Their experiments show that the features extracted from HSV color space, which decouples brightness from chromatic components, have demonstrated better performance than that from RGB color model. By the means of color's primary components (Red, Green, and Blue) the computer can visualizes what the human does in hue and lightness. In [2]; a review of most popular color models are given with the explanation of the components, color system, and transformation formula for each other, application areas and usages are also included in this work with the classification of color models according to its dependence and independence on the hardware device used in specific application. In their work, the HSV color model has following features: the chrominance components (H and S) are associated with the way humans perceive, it became perfect for image processing applications, the (Hue) component can be used for performing segmentation process rather than the three components which fasts the algorithm.

In [9], two different approaches to color binning and subsequent JNS (Just Not the Same) color histogram computation have been proposed. The First approach is based on a neural network color classifier trained using error back prorogation training algorithm. The second approach is based on heuristically designed fuzzy classifier using fuzzy if-then rules for classifying color pixels into one of the eleven JNS colors. In [10] an approach for finding histogram of a color image with these JNS (Just Not the Same) colors using a neural network has been proposed. They have trained a three layer feed-forward neural network for classifying a given RGB color into one of the eleven color classes by supervised training using Error Back Propagation Training Algorithm. They have generated histogram with just eleven bins for the eleven colors to facilitate efficient matching of color signatures. This technique can be used to find the global color signature of an image in color image retrieval systems. In [1] the authors have presented the results of studying color segmentation using machine learning algorithm and color space analysis. They projected RGB (red, green, blue) color space data points from an image into HSV (hue, saturation, value) color space to provide data points that are insensitive to the variations of illumination in outdoor environment. They have used multi layer neural network trained using backpropagation algorithm to segment the color image. Their results show that the algorithm is able to segment the images reliably with less appearance of small blobs. This may help to improve the accuracy and minimize the processing time of the subsequent processes in the robot vision system where real-time issue is of important.

The rest of the paper is organized as follows. The tool used for generating training samples has been described in section II. In section III, the proposed neural network color classifier is presented. The testing results are presented in section IV. Section V presents concluding remarks.

II. GENERATING TRAINING SAMPLES

HSV values of different color samples used for training are obtained with the help of tool developed by us specifically for this classifier. The aim of this process is to collect the color samples from each color class such that, for each color class the samples collected, spans entire HSV color space of a given color. As many as 33026 different samples are selected for the training purpose. This data set is verified by persons with normal color vision and with different gender and background. This step is necessary

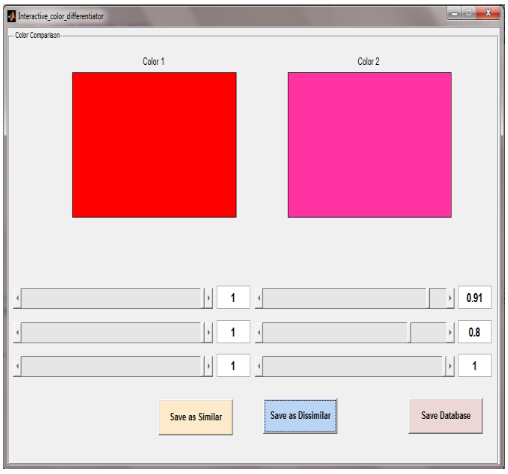


Fig. 3 Interactive tool for generating HSV color database

The tool displays two colors based on HSV values. The three sliders on left are used to adjust the HSV (Hue Saturation Value) values of color 1and are displayed in corresponding textboxes. Similarly the slides and textboxes on the right represent values of color 2. Two buttons are provided for saving the color pair as similar and dissimilar respectively. The save database button is used to make the changes permanent.

A human eye can discriminate between two colors if they are at least one just noticeable difference away from each other [12]. (Color JND) Color just noticeable difference is the first difference that an observer notices when we go in increasing the value of one of the two similar colors by small quantities.

The data collection is done in following manner. For each hue selected both colors are same initially, which becomes first similar pair. Then, keeping color 1 the hue of color 2 is gradually incremented till the first JND (just noticeable difference) appears, which is considered as the dissimilar color. All the colors visited before this color are considered similar to color 1 and all the colors visited after this color are considered dissimilar to color 1. Similarly, the saturation and value are also incremented to find first just noticeable difference. Different combinations of hue, saturation and value are used to explore the HSV color space. Out of 100 hues color pairs of 90 hues are used for training purpose and that of 10 are used for testing purpose.

III. NEURAL NETWORK

A. Neural Network configuration

A four layer feed forward neural network is trained for classifying a given color pair as similar pair or dissimilar pair. The architecture of the four-layer feed forward neural network used for color classification is shown in figure 1. It is having six neurons in input layer, fifteen neurons in hidden layer

1, five neurons in hidden layer 2 and one neuron in output layer.

The input neurons represent the hue, saturation and value of color 1 and color 2 respectively [H1 S1 V1 H2 S2 V2]. If the value of output neuron is 1 the given pair is considered as similar pair and if the value is 0 then given pair is considered as dissimilar pair.

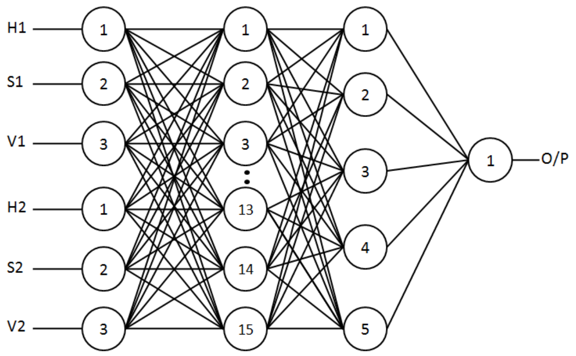


Fig. 4 Neural network configuration

A lot of experimentation has been done to find the number of neurons in the hidden layers so as to achieve proper classification of the samples. The hidden layer is required, as the patterns belonging to various colors are linearly non-separable. Log sigmoidal activation function is used for all the neurons in the network. The traingd, a gradient descent backpropagation function is used for training the neural network. Traingd is a network training function that updates weight and bias values according to gradient descent.

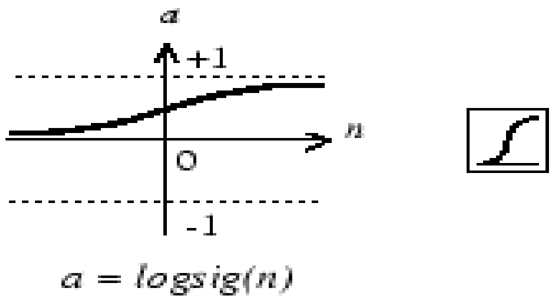
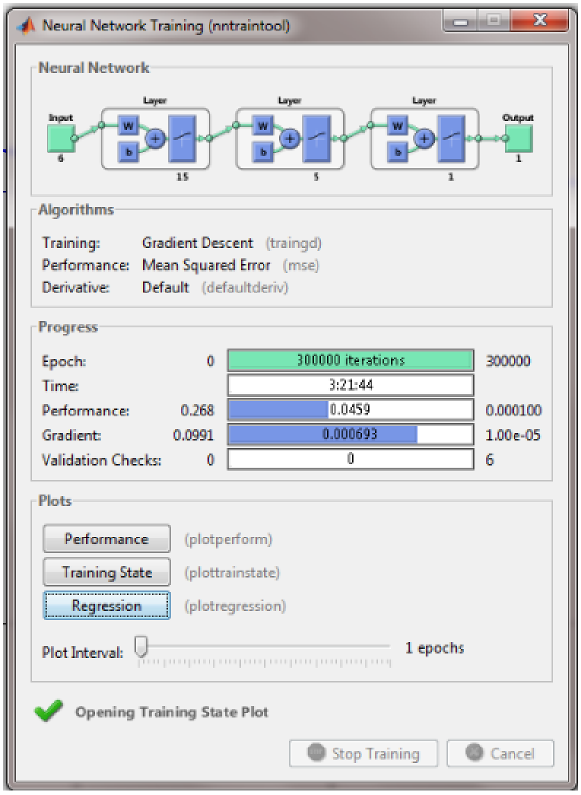


Fig. 5 Log-sigmoid transfer function

3 lacks iterations are required to achieve an error of 0.045.

B. Performance

The performance of neural network is measured in terms of mean squared error (mse). The color classifier has a mean squared error of 0.045 and the time required for training of 16513 samples is 3 hours 21 minutes and 44 seconds



IV. EXPERIMENTAL RESULTS

Experimentation has been done in MATLAB on Intel i5 64 bit processor with 4GB RAM.

A. Testing on training and testing data

The testing is done separately on training samples as well as testing samples. The testing results are as follows:

TABLE I

TESTING RESULTS

Data Set	Classification			
	Similar	Dissimilar	Misclassified	Percentage efficiency
Testing Data (4000 samples)	1874	1782	344	91.4

B. Testing on training and testing data

An interactive pixel comparison routine has been designed for testing the color classifier:

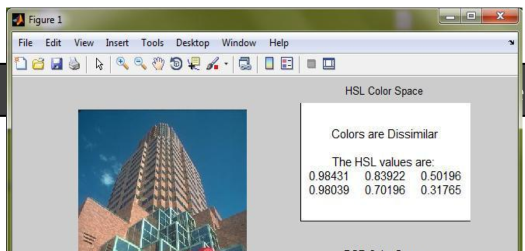
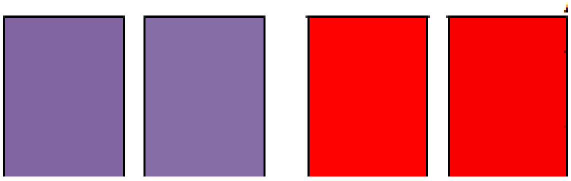


Fig. 7 Interactive pixel comparison routine

The user needs to select two pixels from the given image and its classification is shown on adjacent subplots. The first subplot gives classification of selected pixels as similar or dissimilar according to the proposed color classifier. The second subplot gives classification according to a RGB threshold of 2700 [13]. If squared Euclidian distance of RGB values of the colors is greater than 2700 then they are different otherwise they are similar. Since both the outputs match, our classifier works fine with real life images too.

C. Analysis of misclassified samples

Shown below are some samples that are misclassified by the neural network color classifier. It can be seen that the colors shown below are similar when looking casually but when we look closely they seem different.



One possible solution is to put these samples in one of the classes. For region growing approach, like color segmentation, such samples should be included in similar pair samples while generating the training data.

V. CONCLUSIONS

Thus we have been able to train the neural network using a large training data set of HSV color pairs with 91.4% accuracy. The classifier works fine with real life images too. From the analysis of misclassified samples, it is observed that these samples are also equally difficult to classify for the human observer. In future our work will focus on resolving ambiguities for such samples and using this technique for color based image segmentation.

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