An efficient color detection in RGB space using hierarchical neural network structure

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Abstract

Color detection has a wide application area on computer based systems. In example, road sign detection, skin color detection, location detection etc. This paper describes a new method for color detection in RGB space. In order to improve any color detection system, neural networks, specialized for each color, are used. These expert neural networks are the keystone of the hierarchical structure. Conventional N.N. structure and hierarchical N.N. structure are tested with many different data sets to compare the results of these systems.

1. Introduction

The purpose of the color detection is to differentiate the objects based on their colors in an image. This detection gives you the chance of doing any kind of process related to that object. For example tracking, labeling in industry, skin color detection as a pre-process of face detection etc.

While image analysis in RGB space, an actual color is decomposed to its basic color percentages. In this color space, Red (R), Green (G) and Blue (B) colors are basics and all other colors can be obtained from their combinations. In color monitors for TV and computers, RGB color space is used as a standard. For our system, one of the advantages about RGB space is, it is convenient for the training part of N.N. This advantage contributes system at deciding level.

Many color detection methods have been developed until now. For example, color detection for road and traffic signs with taking images in a car and converting them into HSV color space [1]. Vehicle detection using normalized color and edge map, this detection is different from traditional methods which introduces a new color transform model to find vehicle color [2]. Tagging and tracking in video using neural network color detection and spatial filters, using a developed algorithm with neural network which is generated from the first frame of a video sequence to detect the object of a chosen color [3] . Detection of ice and mixed ice water pixels for MODIS ocean color data Processing [4] .

This paper describes a new developed method using neural network in a hierarchical structure by using RGB color space for color detection in any image.

2. RGB Color Space

A RGB color space is defined by the three different colors, red, green and blue. It can be produced any secondary color by those primary colors. One of the most widely used application of the RGB color model is the display of colors on CRT, LCD, or plasma display, such as a television or a computer's monitor. Each pixel on the display can be represented in the interface hardware as values of red, green and blue. Their rates can be changed in a range of 256 possible values. When written, RGB values are commonly specified using three integers between 0 and 255, representing red, green, and blue intensities, in that order. The basic scheme of RGB color space is shown as figure 1.

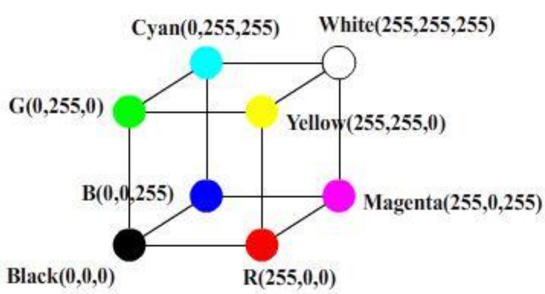

Figure 1: The basic scheme of RGB color space.

3. Multilayer Perceptron

A **multilayer perceptron** (MLP) is a feed forward artificial neural network model.

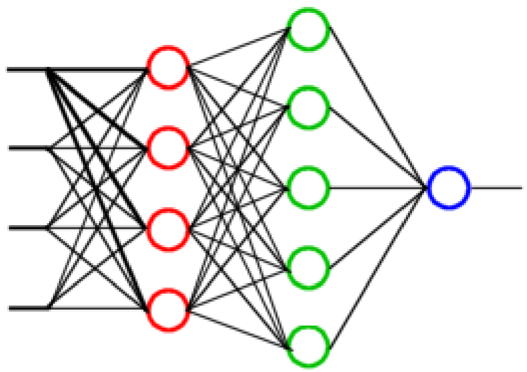

Figure 2: The basic structure of MLP

An MPL consist of one input layer, one or more hidden layers and one output layer. These layers have many nodes connected to each other. The input layer neurons collect the data, multiply them by the connection weights and send the processed data to the next layer and so on.
A neural network has to be trained before usage with a learning technique called back propagation. Learning happens in the MLP by changing the connection weights with respect to the expected outputs.
MLP is a model which can distinguish the non-linearly separable data. That's why MLP has a non-linear activation function. Output of the activation function is the output of the network.
MLP can be used for any kind of classification problem, especially for complex ones. Speech processing, image processing and applications that need artificial intelligence are some of them.

4. Color Detection Using MLP

Color detection is a common problem which can be solved by using neural networks.
First thing has to be done is to create a database which consist of RGB percentages of colors that is going to be detected in an image. And also the target for each data has to be determined to train the network.

Color	R	G	B	Target
Blue	10	14	230	10000
Green	14	220	12	01000
Green	20	210	25	01000
White	255	250	253	00010
Yellow	220	215	45	00001
Red	215	25	18	00100
Blue	24	42	226	10000
White	245	250	249	00010
Yellow	230	190	17	00001

Table 1: Data set sample

- **Normalized RGB**

$$R = \frac{R}{R+G+B} \quad G = \frac{G}{R+G+B} \quad B = \frac{B}{R+G+B}$$

Normalized RGB values are the inputs and the targets are the expected outputs for a neural network.
A network trained with a larger data set gives better results.
After the training, the network is ready to use. While testing the input are the RGB values of a pixel in an image. The network will produce a result which is based on the results of the training. For instance, the network may produce a result like 0.998 0.0001 0 .001 0.002 -0.001 for an input like 13 15 213. By looking at the results it is easy to say that pixel is blue. After this process is done for the all pixels in an image, colors in the image are detected by the N.N.
As an example, colorful images were used as inputs for the conventional N.N. structure [figure3-4-5-6]. In order to show a result, the images were re-generated by the outputs of N.N. [figure 7-8-9-10].

Figure: 3 – Parrots [5]

Figure: 4 – Peppers [6]

Figure: 5 – Milk Drop [7]

Figure: 6 – Lena [8]

Image Name	Parrots	Peppers	Milk-Drop	Lena
Number of sample colors	9	5	8	10
Sample Colors (RGB)	98-124-25 220-220-220 220-3-12 235-47-61 3-33-3 99-144-186 6-47-79 12-12-12 72-41-13	193-45-43 108-176-85 182-203-80 209-219-208 38-0-0	210-223-216 187-190-183 188-138-49 183-151-92 41-0-0 86-24-3 56-65-62 78-82-81	221-159-100 186-102-66 216-184-169 220-232-232 116-126-195 14-21-76 247-255-255 240-212-201 24-14-15 70-53-69
Image Size	600x400	512x512	450x305	512x512

Some colors were generated with respect to the picked sample colors. Neural network was trained with a learning technique called back propagation and data sets consist of these colors were used for the training. The neural network has 4 inputs, 1 hidden layer including 10 neurons and the output is equal to the number of sample colors.

Input 1: $\frac{R}{R+G+B}$ Input 2: $\frac{G}{R+G+B}$ Input 3: $\frac{B}{R+G+B}$

Input 4: $\frac{R+G+B}{255}$

Figure: 7 – Result of conventional N.N. structure

Figure: 8 - Result of conventional N.N. structure

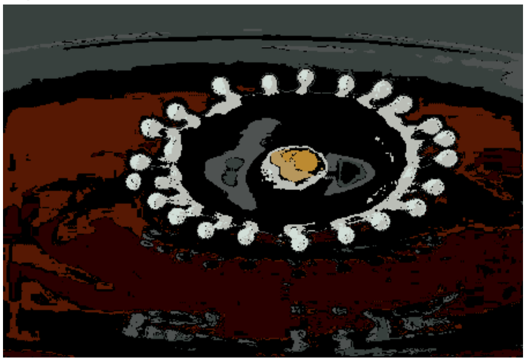

Figure: 9 - Result of conventional N.N. structure

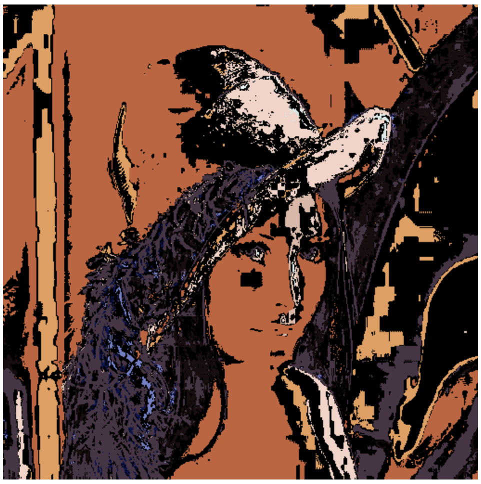

Figure: 10 - Result of conventional N.N. structure

5. Proposed Structure for MLP

In our method more than one neural network were used. We have neural networks at the first layer of the hierarchy as the number of color classes. These neural networks are specialized for each color and they are very important at deciding level. If one N.N. is expert about red, it produces only two outputs related to its input. It says the input is red or not. These all outputs, we get from all these neural networks, are the input of the other N.N. at the second layer of the hierarchy. The whole structure is depicted in figure 7.

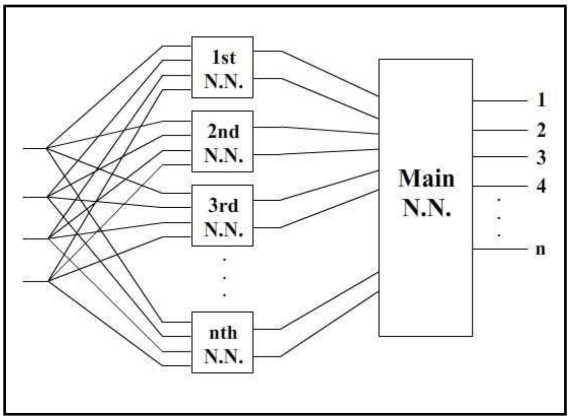

Figure: 7

The simulation results of the expert neural networks are used for the training of the main N.N.
If we have n color we will also have n output and these outputs are the final results of the whole system.
The images shown in figure 3-4-5-6 are also applied as input for this structure and the images were re-generated to show the results. Figure [11-12-13-14]

Same data sets were used for this structure. All of the neural networks were trained with a learning technique called back propagation. Expert neural networks were trained first and simulated. Main network was trained with the simulation results.

Figure: 11 - Result of hierarchical N.N. structure

Figure: 12 - Result of hierarchical N.N. structure

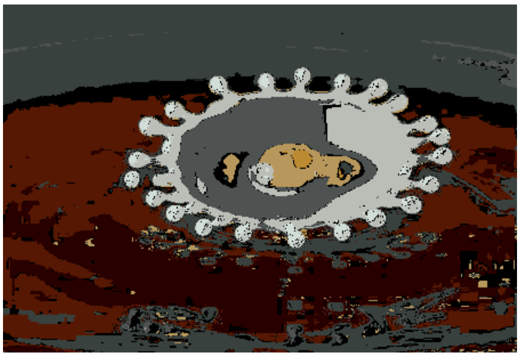

Figure: 13 - Result of hierarchical N.N. structure

Figure: 14 - Result of hierarchical N.N. structure

6. Results

In order to figure out the generated images are how close to the original images we used the method below.

$$X = \frac{|Ir - I'r| + |Ig - I'g| + |Ib - I'b|}{total\ pixel}$$

Ir: Red values of the original image
I'r: Red values of the generated image
Ig: Green values of the original image
I'g: Green values of the generated image
Ib: Blue values of the original image
I'b: Blue values of the generated image

For the conventional N.N. structure:

X1 = Figure 3 – Figure 7 = 31.6561
X2 = Figure 4 – Figure 8 = 31.4984
X3 = Figure 5 – Figure 9 = 33.3089
X4 = Figure 6 – Figure 10 = 63.4298

For the hierarchical N.N. structure:

X5 = Figure 3 – Figure 11 = 26.6377
X6 = Figure 4 – Figure 12 = 25.0414
X7 = Figure 5 – Figure 13 = 20.5376
X8 = Figure 6 – Figure 14 = 36.6699

Since X5 is less than X1, X6 is less than X2, X7 is less than X3 and X8 is less than X4 the result of our method is closer to the original picture.

7. Conclusion

Color detection is a really important process and widely needed in many applications such as, face recognition, image filtering, road sign detection, real time tracking etc. Automatic Color Detection for Car Repainting [9]
Neural networks are the basis of the artificial systems and they have been used in many approaches of color detection. Since color detection is a classification problem our method can be implemented for any kind of classification problem. Because the results show that the hierarchical structure for the neural networks is good at classifying the colors than the classical structure.
In the future we will be using this method on more complex problems. The classical structure consist of one neural network is also good at classifying but as the complexity increases our method will produce better results.

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