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A Model for Creating Exact Colour Spectrum for Image Forensic

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Abstract

Colour identification plays a very important role in the everyday life of people because it occasionally assists people with the identification of objects from a scene. Unfortunately, individuals view colours differently based on their colour vision type, thus a match between exact colour sample and a visual appearance is almost impossible. In this work, an algorithm was designed and implemented to generate the complete colour samples in the Red-Green-Blue (RGB) colour model. A total of 16,777,216 colour samples, including their visual presentations and corresponding RGB codes, were created and stored in a colour database. An XML file that contains codes vis-à-vis the actual names of the colours was also created. Mapping between visual representation and exact colour was achieved with degree of variation. This will enable researchers have the complete view of colours based on the RGB colour code.

Keywords-Colour database, Colour identification, Colour models

I. INTRODUCTION

Colour is a powerful descriptor that often simplifies object identification and extraction from a scene [1]. Initial research in digital image identification were about classifying numbers of colours in digital images. This was rooted to simple image format containing only two colours of black and white [2]. Beyond the black and white image formats, earlier computers supported 16 fixed colours only. Currently, most devices can handle 256 colours simultaneously, a choice from a pool of 16 million colours. A digital image is a rectangular "array" of colours representing some form of data where each location is a sample from the array. Each location, usually called a pixel, stores the numerical value of the colour it renders. The colours represented by pixels in a digital image are acquired after the image acquisition process. This process involves the viewing of a scene through an optical system, which is equipped with a Colour Filter Array (CFA) like in [3] that is used to obtain the initial colour matrix of the image [4].

At this point, this 'image' does not really resemble the "captured" scene. The 'image' would then undergo another process called demosaicking [5][6][7] and some post-processing before the final image is produced and saved. It is the demosaicking process that produces the Red, Green and Blue colour values for each pixel in the image. The objective of demosaicking is to interpolate the missing red, green and blue pixels values from the available CFA samples and to reconstruct a full-colour image [4]. This can be observed from Figure 1 where the aim is to interpolate the Green value for pixel number 3 from the surrounding pixels.

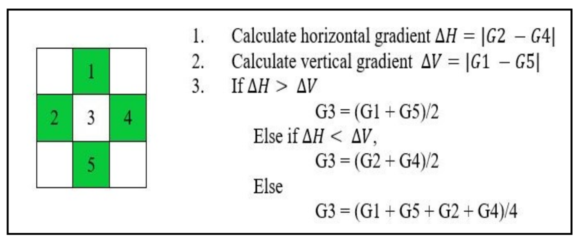

Figure 1. Demosaicking process.

Image analysis researchers examine the actual content (which are colours) of digital images with the aid of a computer system, in order to get useful information from images. Image analysis have in the past combined techniques that are computed statistically to measure properties of each pixel sometimes with respect to its neighbouring pixels or a reference point [8]. The analysis performed on the image was usually a function of the type of useful information that were desired. This useful information indicated whether the properties based on the grey-level intensities of the image pixels will be used or the actual colour of the pixels [9]. To use the actual colour of the pixels would mean, working with a wide range of colours, depending on the colour model.

A complete colour database created using the RGB colour framework and a matching technique for these colours can assist digital image forensic scientists to understand this wide range of colours better. Added to

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this, it will be possible to resolve divergent perception of "perceive colours" inherent, as a result of individual different colour vision types [10]. A report on divergent colour perception expressed in 'The Dress' [11] can be resolved with this work. The aim of this work is to create a colour database based on the RGB colour model to store the visual presentation of all the colours in this model as well as a matching technique. This is essential because the proportion of the red, green and blue components of a colour does not always determine its visual appearance.

II. LITERATURE REVIEW

Colour models explain how colours are represented and also specify the components of the colour space accurately for a better understanding of how each colour looks [12]. Colour models are the digital representation of contained colours [13] or a system for measuring colours that can be perceived by humans. In various literatures in the domain of physics, engineering, computer science, psychology and philosophy four basic colour model families can be distinguished [14]. They include:

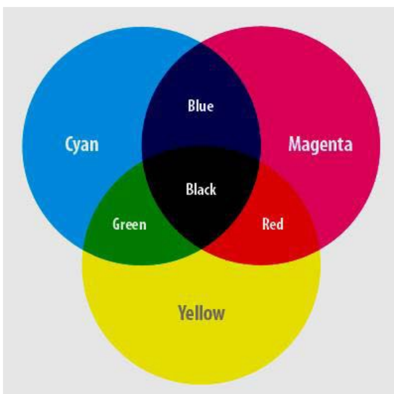

Figure 2a. The CMYK colour model

1. Colorimetric colour models that are based on physical measurements of spectral reflectance.
2. Psychophysical colour models that are based on the human perception of colour.
3. Physiologically inspired colour models, which are based on the three types of cones in the human retina.
4. Opponent colour models, which are based on perception experiments, utilizing mainly pairwise opponent primary colours, such as the Yellow-Blue and Red-Green colour pairs.

In image processing and analysis however, the classification of colour models is different and dependent on its applications. For image processing applications, the colour models can be divided into three categories [13]. These are (1) ***Device-oriented colour models***, used widely in many applications which demand that the colour be consistent with the hardware tools used such as TV [14]; (2) ***User-oriented colour models*** which are utilized as a bridge between the human operators and the hardware used to manipulate the colour information [15]; (3) ***Device-independent colour models*** which are not affected by the given device properties [14]. Most researchers use the colour model best suited for their application, some of which are described next.

A. Hue, Saturation, and Intensity (HSI) Model

Hue, Saturation, and Intensity (HSI) are three independent dimensions of colour [16]. Hue is what is generally referred to as colour. Saturation is often called Chroma. Intensity also called brightness or luminance, refers to the amount of light received by the eye regardless of colour [17]. The HSI Colour Model are three important descriptors used by human beings in describing colours [18]. Hue represents the purity of the colour (that is pure red, yellow, and green); while Saturation represents the measure of the degree to which a pure colour is diluted by white light; and Intensity is the grey level value of the colour [19]. Although Hue, Saturation, and Intensity describe more naturally the different aspects of colour sensation as experienced by humans, HSI is not very useful in some other applications. For some research and other purposes, Cyan-Magenta-Yellow-Black (CMYK), Cyan- Magenta-Yellow (CMY) and Red-Green-Blue (RGB) colour models are often used.

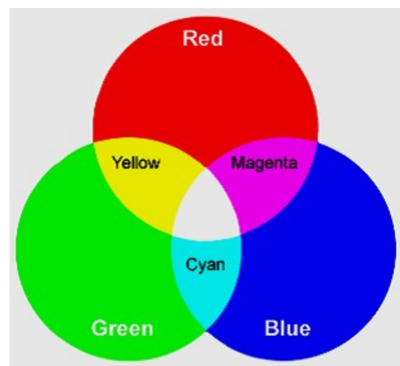

Figure 2b. RGB colour model

B. Cyan, Magenta, Yellow and (Black) CMY(K) Model

The CMY(K) model is a subtractive colour model based on Cyan, Magenta, Yellow, and (Black) [20]. CMY(K) is generally used for computer printers as well as printing press. The representation of this model is shown in Figure 2a. This kind of mixing is called "subtractive mixing", because it starts with a white canvas and subtracts colours from it to get other colours, while the RGB model works by 'adding' two or three colours to produce a colour.

C. Red, Green and Blue (RGB) Model

The colours: Red (R), Green (G) and Blue (B) are referred to as the primary colours and when mixed at various intensity proportions, can produce all visible colours. The RGB model can be used to represent any colour visible to the human eye. It decomposes a colour into the three primary colours (Red, Green, and Blue) [21] and quantifies them with a number between 0 and 255. This colour model is 'additive' in nature, as shown in Figure 2b, in which the three colours of light

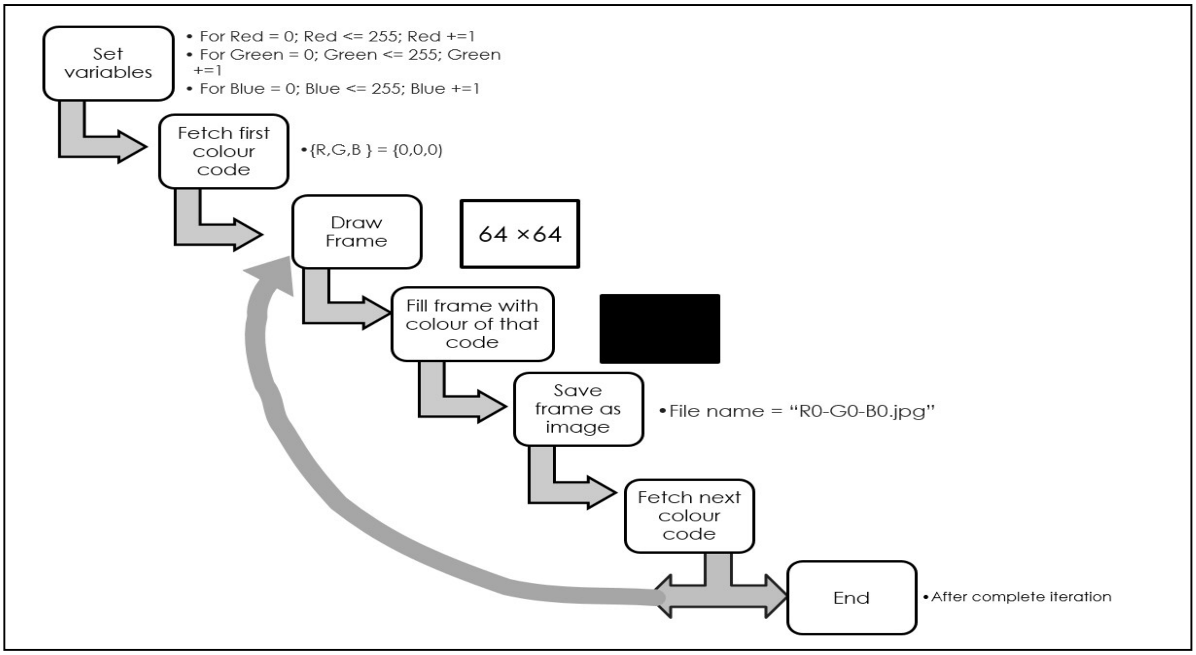

Figure 3. Model for generating the colour database

are added together to produce various colours [12]. In this model for example, ***Black*** is the absence of all the colours and is represented as (R, G, B) = (0, 0, 0) while ***White*** represents the presence of all the colours and coded as (255, 255, 255). Other colours have varying combinations of the RGB component.

The range of 0-255 is used for two good reasons: The first is that the human eye is not sensible enough to make the difference between more than 256 levels of intensity for a colour. The second reason for the value of 255 is that it is convenient for computer storage because the maximum value 8 binary digits can store is 255 [22]. RGB currently provides the greatest flexibility for capturing of colour information in a digital image and it can be converted to CMYK for printing purposes or HSI for other research purposes.

III. Methodology

The RGB colour model has the combination of 256 'Red', 256 'Green', 256 'Blue' values at varying combinations. The varying combinations determine the visual appearance of the colours. The steps used in building the complete colour database that depicts the colour spectrum, are presented in Figure 3. At first, the variables representing the RGB codes were initialized to 0-0-0. Then the frame that will hold a colour was drawn and then filled with the appropriate colour depending on the RGB values. This frame was then saved with its name depicting the corresponding RGB combination that make up the colour. To generate the complete colour database, the *BufferedImage image* class of Java programming language was used imported and used to implement the steps depicted in Figure 3.

The initial design was to draw a frame of size 128 by128 pixels as the standard, using a 64-bit dual core computer system with 8GB RAM, running Windows 7. However, after more than 24 hours, the program had only generated less than half of the colours in the spectrum. This necessitated the modification of the algorithm such that the frame size was reduced to 64 pixels by 64 pixels. This modified program was then ran on a 64-bit,Intel Core i7, 2.00GHz computer system with 16GB RAM and running Windows 8.1.While running the modified program, it was observed that if all the colour frames were put in the same folder, it would be challenging to open. It was achievable to save the colours in the same folder, however viewing the contents of this single folder containing the 16 million colours was problematic as the computer system malfunctioned each time an attempt was made. Consequently, the algorithm was further modified with an additional step to create a new folder each time a previous folder had a total of 250,000 colour frames. Consequently, 67 folders were created by the program to house the complete sets of colours.

IV. Results and Discussions

The complete colour database based on the RGB colour model was created to enable the visual verification of any recognised colour code combination in the RGB model. Using the steps illustrated in Figure 3,a total of 16,777,216 colour samples, including their visual presentations and RGB codes, were created and stored in a colour database. An XML file that contains the RGB codes vis-à-vis the actual names of the some of the colours was also created. Each colour sample was saved as a picture of jpeg format with a file name that indicates what combination and quantity of the Red, Green, Blue values make up that colour presentation. Figure 4 shows a snapshot of the first set of colours, that is starting from R=G=B=0 to some certain number.

Figure 4a shows a snapshot of the last set of colours, towards R=G=B=255. The complete 16 million colours available in the RGB colour model was generated and saved in several folders.

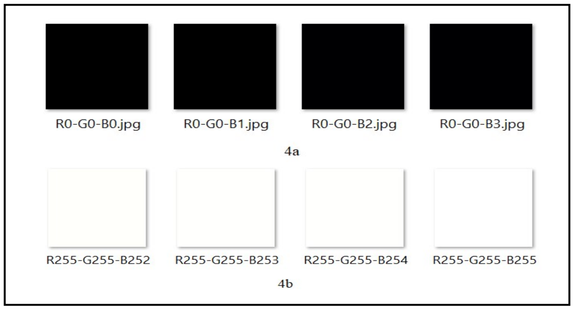

Figure 4. A cross section of the colour database showing the first and last set of colours from the RGB code 0-0-0 to 255-255-255

From this work, it was noted that some visual appearances of colours are so close that it is challenging for humans to notice a small change in the appearance, vis-à-vis the change in the value of one of the RGB values. This can be seen in Figure 5 where the Red and the Green values were maintained as 49 and 151 respectively while the Blue value is gradually increased from 80 to 94. Physically looking at the snapshot, one may not be able to tell the difference in the visual appearance of the different colour code combinations. The appearance is only noticeable when the difference in the blue value exceeds ten (10).

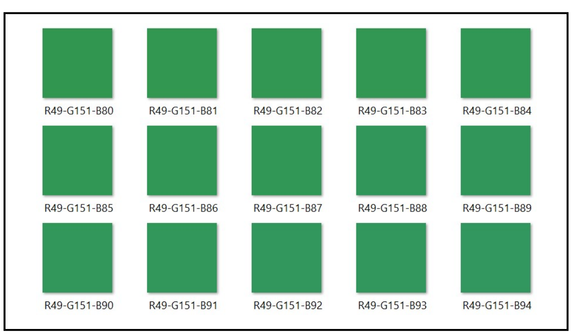

Figure 5. A cross-section of the colour database showing colours in close range

Furthermore, in the R-G-B colour model, 0-0-0 represents the colour “black” while 255-255-255 represents the colour “white”. In most available incomplete colour databases online, the “grey” colour is usually denoted as having equal values of red, green and blue. Figure 6 depicts several scenarios when the R-G-B values are equal say, 1-1-1, 141-141-141, 201-201-201 or 252-252-252. They represent the various shades of the grey colour. The higher the values, the lighter the shade of grey conversely, the lower the values the darker the shade of grey.

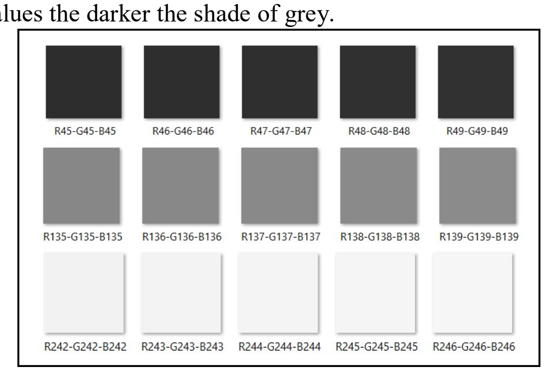

Figure 6. Screenshot of different shades of the grey where the values R, G, B are equal

From the colour database, it was observed however that the grey colour codes are not limited to equal values of red, green and blue. Figure 7 shows some grey colour appearance where the R, G, B values are not equal, but visually, they represent the grey colour. This shows that the proportion of red, green and blue must not be equal to give a visual appearance of the grey colour.

Figure 7. Shades of grey colour with varied RGB values

It was also observed that at some instances, blue has a neutralizing effect on red or put in another way, green is the most domineering colour. Perhaps because the human eye senses more green than any other colour which was what necessitated the arrangement of the CCDs in the Bayer filter [3]. In some other instances, it can be observed that the colour component with the highest value may not dominate the overall visual appearance of that colour. This effect can be seen from Figure 8 which shows some sections of the colour database. The first two rows show the section that portrays where the red component is higher than the green component; however the visual appearance of the colour appears more green than red. The last two rows also depict a situation where the green component is the highest however, the visual appearance is more blue than green. This shows that considering the RGB combination of a colour alone may be deceptive with respect to the visual appearance of that colour.

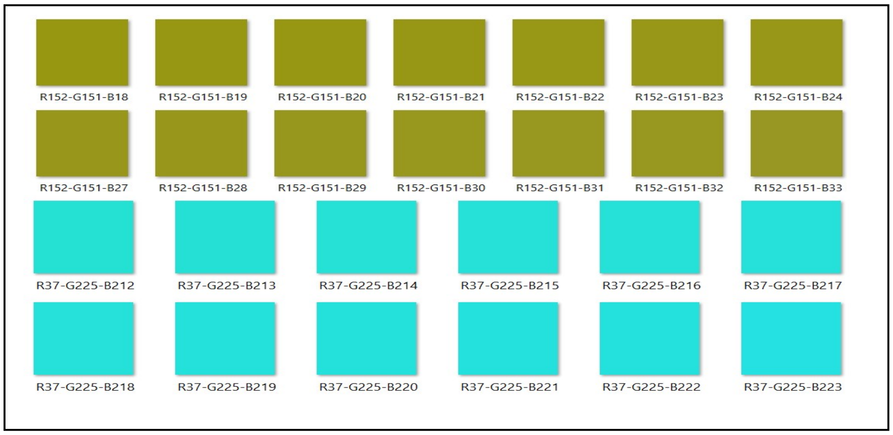

Figure 8. Some sections of the colour database

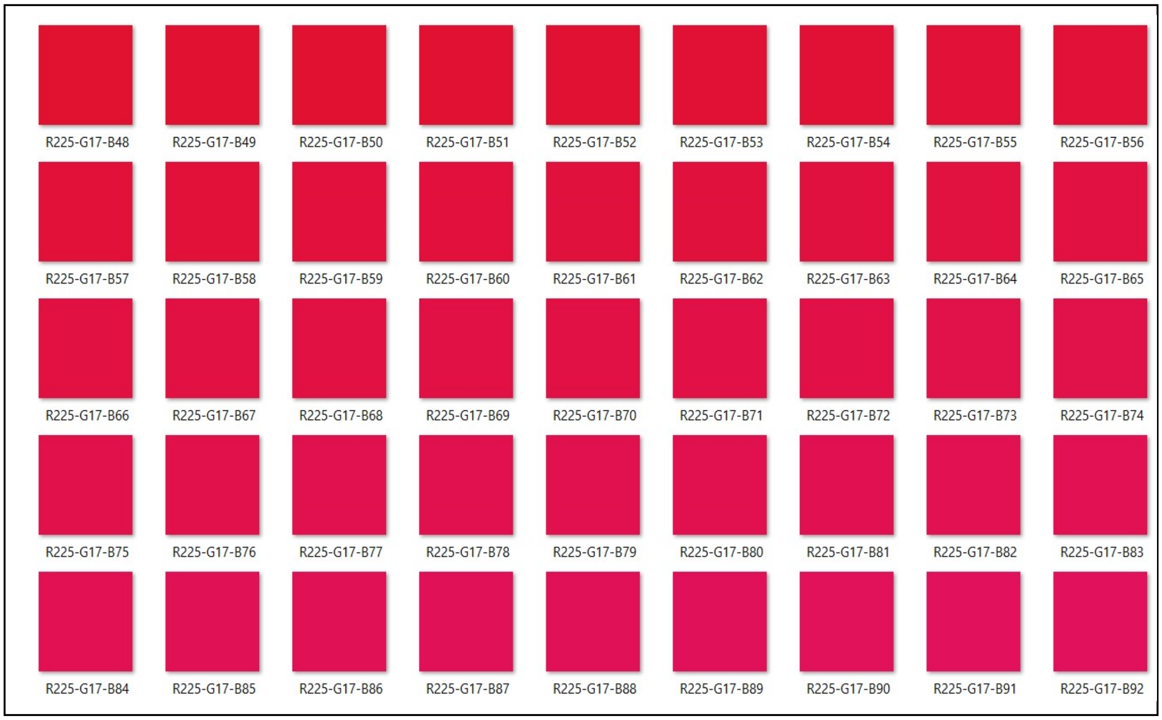

Figure 9. A cross section of the colour database showing the gradual change from 'red' to 'pink'

Looking at several sections of the colour database, it may be difficult to tell at which point to state that one colour has ended and another colour has started. For example, the section shown in Figure 9 is one of the sections between red and pink. At what point can one draw a line between colours red and pink. The first box in the matrix is 'red' while the last box in matrix is 'pink'. In the field of 'Fine Arts' the colour pink can be gotten by adding white to red. However, from Figure 9 it can be observed that as the value of the blue component of the RGB model is increased, while keeping the values of red and green constant, "red" gradually becomes "pink". This is just one the several sections for the various gradual changes from one colour to another.

V CONCLUSION

The complete colour database was created to store all the colours present in the RGB colour model as well as a matching technique. These enabled the verification of any recognised colour and will be advantageous in fetching the correct visual appearance of any RGB combination. The database created using the RGB colour model will greatly assist in the verification of colours, since all digital images are originally stored using this RGB colour model.

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