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International Journal of Clinical Case Reports and Investigations

Research Article

Two Methods to Color Radiology Images of The Brain as An Example: Encoding Hounsfield Units with Hexadecimal Codes to Assign Colors for Ct scan Or Using Prism in X-Ray Cassatas or Ct Detector to Convert the Light to The Real Colors in The X-Ray or Ct Images

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Received Date: June 28, 2024; **Accepted Date:** July 02, 2024; **Published Date:** July 08, 2024

Citation: Abdulwahab Alahmari. (2024). Two Methods to Color Radiology Images of The Brain as An Example: Encoding Hounsfield Units with Hexadecimal Codes to Assign Colors for Ct scan Or Using Prism in X-Ray Cassatas or Ct Detector to Convert the Light to The Real Colors in The X-Ray or Ct Images, J International Journal of Clinical Case Reports and Investigations. 1(1):3, DOI:10.31579/IJCCRI/003.

Abstract

The aim of this paper is to assign a color for each Hounsfield unit in order to color CT scan images. The purpose to do such thing is to give real colors as much as possible for medical and forensic applications. The color of organs play an important role in making the diagnosis of many conditions on autopsy by seeing the organ color.

Key words: hexadecimal code; color; computed tomography; hounsfield unit; brain

Introduction

Johann Goethe wrote a book in 1810 called Theory of Colors, where he stated that colors are generated in the eyes. Similarly, René Descartes claimed that colors are made by our human perception that why colors are seen different by human compared to animals and to insects. But if everything is monochrome and we use the color blind glasses, it will not show any colors. The eyes see things due to reflection of colors and objects have colors which reflect with the light to the human eyes based on their wavelength. The rod and three cons in the eye (Red, Blue, and Green (RBG)) collect these colors and show us these colors. According to Johann Goethe hyperchromatism can lead to monochromatism (Goethe, 1810). The depth of the image can be lighted by using darker colors which an old technique used since the renaissance era in arts. In order to make the image looks realistic, some details and colors might be added to give a real look to the CT scan images. In forensic medicine, the colors of the organs' indicate some pathologies by looking at the organ. By using a realistic coloring representation will eliminate the need for autopsy in few cases which the pathologist need to see signs for a disease that the pathologist suspect.

If coloring of the brain is done by assigning pseudo (fake) colors, then it will be useless since these pseudo colors will not represent what is the real color inside the scanned subject's brain. Follow of the blood inside the blood vessels of the brain will make the brain looks reddish due to the presence of blood. This issue can be solved by programming the scan by choosing if the person that will be scanned is deceased or still alive. If the person is deceased, then computer should apply a blue (cold) image scale of the image must be used to reflect what the brain looks like inside. If the person is still alive, then the computer must be use a red (hot) image scale of the image to reflect how the patient's brain looks like inside the skull. This representation is not accurate 100%, but it represent how the brain looks like from inside the skull to some extent.

In order to get the real colors exactly, it is very challenging task for many reasons. To do the coloring task, a CT scan must be done for a group of dead bodies who died by diseases which did not affect the brain then do autopsy for those cadavers. A HU measurements must be taken for every part of the brain like; brain surface, gray matter, white matter, meninges, and cerebrospinal fluid (CSF). The brains' colors must be imaged with a camera to document the colors. Bear in mind, brains' colors will change by death and by exposure to air. Therefore, achieving the real colors will be impossible. What is possible is to try to make the most realistic colors possible to represents what is inside the skull of the scanned subject.

Programing the CT scan software must be made by the manufacturing companies of the CT scanners. This paper will help in directing what images should look like in most precise way possible. Pale colors could give a realistic picture of how organs looks like inside a dead victim. There are view exception for this rule in many organs and many scenarios.

Another issue is that, there might be two organs and both have the same HU, but one looks brown and one looks pale red. This will be very difficult to differentiate between them by coloring them based on the HU only. As well, HU might not change in organs affected by a disease and remains the same as a healthy organ. The color of the organ might change due to the disease, but the HU remains the same. As well air and fluid have the same HU and both look dark on CT and both are transparent in real-life. Another example, is salt water and fresh water are different, but both have the same HU. Theoretically, in drowning cases, salt water will be thicker than salt water, but in reality they can't be differentiated on a CT scan of the chest. The blood is not differentiated from fluid in hemopneumothorax and pneumothorax based on HU in CT scan images, but they are differentiated by other radiological and clinical signs.

As well, glass inside the body is not easy to be detected by CT if it is a transplant glass. The glass which has low silica and lead does not appear on CT, while colored and thick glass with high silica and lead levels appear on CT images (Alahmari, 2023). Colors look-up table can't help in detecting them (Alahmari, 2023). As well, colors look-up table is not useful to differentiate between healthy tissue (Alahmari, 2023). But colors look-up table could help in detecting abnormal tissues like in cases of prostate cancer (Alahmari, 2023). Another issue is that there are different diseases that change the organ color. For example, disease X causes the liver to look yellowish, disease Y causes the liver to look red, and disease Z causes the liver to look dark blue and all of them have the same HU. There are two papers proposed before to color CT images (Alahmari, 2020; 2022). The level of gray scale might be helpful to differentiate between structures. For example, air is very dark and fluid is less dark, so this level of difference on grey scale can be used to detect which is which?

Have you seen any cartoon show on TV? Usually when someone cry the tears will be colored white or aqua color. They color them white or aqua color because they can't draw transparent color (i.e. the computer hexadecimal code of colors does not have the color transparent). According to Johann Goethe, white color is the darkest shade of transparent (Goethe, 1810). He provide many evidences and observations in his book to support this claim. So white will be the closest to illustrate fluid on CT more than aqua color.

Colors in human body change with change of normal physiology due to diseases. When blood stop circulating, it turns from dark red to dark blue (cyanotic). When the bile do not secrete due to an obstructed then the nails and eyes turn yellowish. So change of body's colors indicates a pathology.

There are two ways of coloring the human body of CT scan. The first is assigning hexadecimal code and the second is using a prism. Let's try both method. In the first method we will pick a body part and try to assign hexadecimal code for normal appearance and pathological appearance.

A Case Study of Coloring the Brain: Assigning a Hexadecimal Code

When hexadecimal code is assign to brain parts, the following table could be the closest to real representation of how the brain looks like;

Area	HU	Gray Scale Color	Real Color	Hex code
Gray matter	+30-40	White	Reddish-pink dark edges and depth white myelination	#FFC0CB #000000 #FFFFFF
White matter	+35	Gray	Whitish beige shadow	#808080 #9b870c
Brain exposed to air		Grey	Grey	
Acute Blood	+60-70	White	Blood red	#BBOA1E
Chronic blood 2 weeks	+40	Grey	Dark red	#8B0000
Chronic blood	+1-25	Dark less than fluid	Transparent/on the system used aqua color	#00FFFFFF
CSF	0	Darker than blood	Transparent /on the system used aqua color	#00FFFFFF
Air	0	Darker than CSF	Transparent	-
CSF meningitis	-100		Pale yellow	#FFFFBF
Meninges		Whiter than the brain matter	Pale Green/gray	#B7E1A1 #8B0000
Skull bones	+1000	Bright White	Creamy white	#FFFDE4
Blood Vessels Arteries Veins	Calcified +45-75 Normal +30-40 With contrast +100	-Bright (with pathology) -iso (normal) to surrounding brain structure -Very bright	Pale red pale blue	#E78587 #D7E5F0

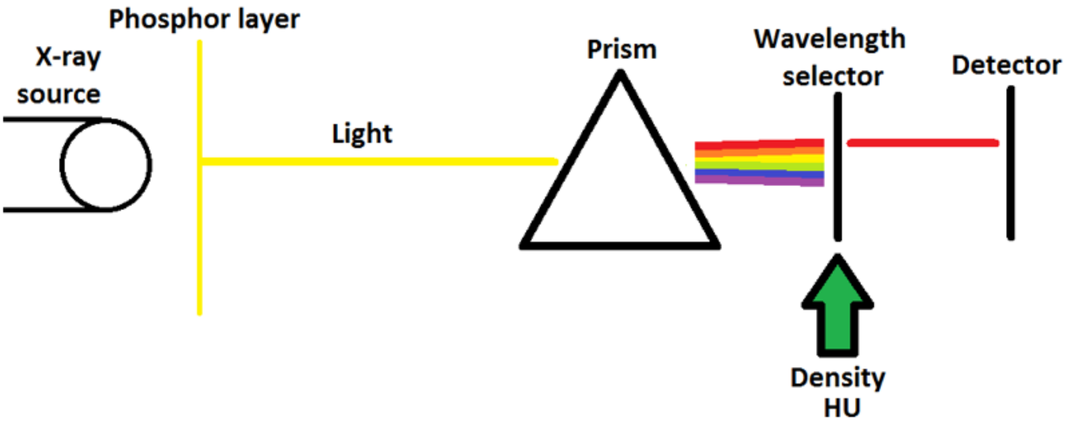
Table 1: Hexadecimal code assigned to brain structure to see how far brain coloring could be done.

HU: Hounsfield Unit, **Hex**: Hexadecimal code, and **CSF**: cerebrospinal fluid. Note: Transparent color is not available on Hexadecimal Code (i.e. it can't be done).

As presented above, the real colors can't be achieved 100% accurately, but the closest coloring assigned, could be a good start.

Theoretical Idea: The Prism Method

Another method is using the prism to convert the light generated from the phosphor layer in the cassette after absorbing the X-ray to convert it to the real colors. This is a theoretical idea that can represent the real colors from the light to the cassette, but making the prism to fit into the cassette or CT detector will need good engineering. Prism can be made in small size then the wavelength of colors in the generated image can be assigned with HU or density of the X-ray to generate the real colors and the wavelength selector can block other colors from reaching the detector. Many small prism are manufactured and spread on the detector or the receptor to convert all colors.



This method needs to be tested in order to see would it work or not? The combination of the two methods might help in achieving the real colors.

Conclusion:

These two methods are theoretical and both need further testing in order to achieve near real colors. Achieving the real colors inside the body without opening the body, it would be an impossible goal to achieve.

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