Image Enhancement Technique Pseudo Coloring

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Abstract: Pseudo coloring of gray scale images is used as a means of supplementing the information in various fields such as medicine, inspection, military, and several other data visualization applications. Many research efforts in pseudo coloring have been made over the past several decades.

We present here three techniques that implement pseudo coloring as follows :

1) **Hsv color mapping**
2) **Mathematical transformations mapping**
3) **Look-up table mapping**

We have described various real time applications where this technique is used. We implemented our project pseudo coloring using MATLAB, one of the premier commercially available technical computing language packages.

The main components of any image registration algorithm are geometrical transformation, similarity measure, optimization strategy, and interpolation method.

Keywords: Image, Pseudo Coloring, Computing, Matlab.

I. INTRODUCTION

The purpose of color-coding or pseudo coloring is to harness the perceptual capabilities of the human visual system to extract more information from a image. This provides a better qualitative overview of complex data sets and will assist in identifying regions of interest for more focused quantitative analysis by making similarly joined areas in the scene more distinguishable. By helping in differentiating objects of various densities, color-coding also minimizes the role of humans in monitoring and detection, reduces the time required to perform inspection, and lessens the probability of error due to fatigue. The term Pseudo color or false color is used to differentiate the process of assigning colors to monochrome images from the process associated with true color images. This process can significantly improve the detectability of weak features, structures, and patterns in an image by providing image details that otherwise would not be noticed. Most visualization techniques generally contain a step in which data values are mapped to color to make the overall range of data visible. Given the fact that the human eye is more sensitive to some parts of the visible spectrum of light than to others and that the brain may interpret color patterns differently. The interpretation of results produced by these visualization techniques depends crucially on the color mapping (color scale) applied.

II. COLOR

Color is very commonly used in various applications including visualization, graphical user interfaces, imaging, internet browsers and many other computer related applications. Color shapes the perception, interpretation and memory of everything visualized Color can be a powerful tool to improve the usefulness of an information display in a wide variety of areas if used properly. Conversely, the inappropriate use of color can seriously reduce the functionality of a display system. Color is a major component in GUI's. Appropriate color use can aid user memory and facilitate the formation of effective mental models. Color is used in a qualitative rather than a quantitative fashion, that is to show that one item is different from another rather than to display the relationship of degree. In order to create an expert system with effective colors the following questions have to be answered.

1) How effective colors can be chosen, which provide good differentiation between different objects?
2) How many colors can be displayed?
3) Which color space should be used?
4) What factors determine target element color relative to the non-target elements?

In an attempt to answer these questions, an extensive color study is carried out. The focus is directed towards physiological and psychological factors, which govern color perception.

III. FACTORS OF HUMAN PERCEPTION

Color is a particular sensation created in the brain, caused when light radiation of a certain wavelength reaches our eyes. The colors we perceive in an object are determined by the nature of the light reflected from the object .This definition is built up from two parts, which are quite different. The first is of a psychological nature. This portion deals with the way the sensation of color is processed by the mind. The second one is merely the eye's detection of physical radiant energy. Therefore, color is in fact a psychophysical phenomenon, inter-relating both psychological and physical processes.

Color is determined by an interaction among three photo pigments; the perceived color is a mixture of the relative responses of the red, green, and blue photo pigments, in much the same way as a television camera creates color. Given a dramatic imbalance among the percentages of cells containing red (approximately 64%), green (approximately 32%), and blue (approximately 2%) photo pigments, it is clear that the perception of color is both highly specialized and physiologically biased. Due to the structure of human eye, all colors are seen as variable combinations of the three so-called Primary colors Red, Green and Blue (RGB).

Color results from the interaction of light with the nervous system. There are several components that affect color perception, including the eye lens, the retina, and a color processing unit along the optic nerve. These areas are discussed in the following sections.

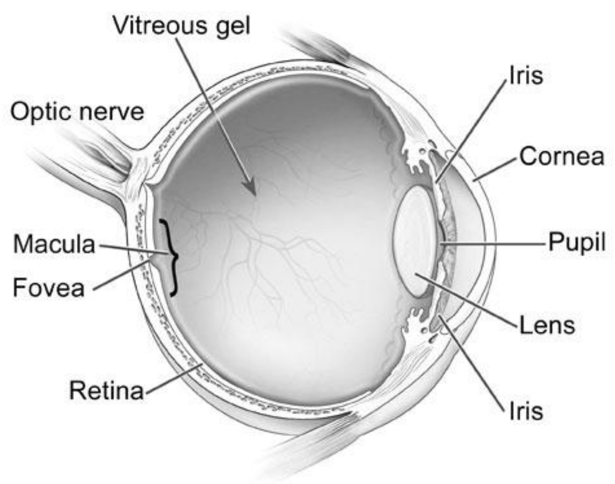

Fig. 1: The human eye

IV. COLOR MODEL OR COLOR SPACE

A color space (or model) is a specification of a coordinate system and a subspace within that system where each color is represented by a single point. Color spaces provide a rational method to specify order, manipulate, and effectively display an object's colors. Color spaces may be used to define colors, discriminate between colors, judge similarity between colors, or identify color categories for a number of applications .The process of selecting the proper color space involves knowing how the color signals are generated and what information is needed from these signals.

Several color models are organized into two basic divisions. These divisions are perceptually based models and display based models. As the names suggest, the first is organized similar to the way color is perceived, and the second is based on the characteristics of a display device. RGB and HSI are two widely used color spaces referred to in the design of the color transforms.

V.GENERAL GUIDELINES FOR COLOR SPACE

Guidelines drawn for usage of color space are

1. RGB display signals are device-dependent, and the color they produce will generally differ from one display to another.
2. When colors are to be rendered accurately, a calibrated display and gamma correction software should be used for best results.
3. Use perceptual color models based on CIE uniform color spaces instead of the simplistic color models based on device-dependent RGB signals.

The RGB space does not correspond to the human color perception and does not separate the luminance component from the chromatic ones. Thus, HSV space is preferred. HSV space is naturally intuitive and approximately, perceptual uniform. It is characterized by the coordinates of hue, saturation and value (brightness) based upon human color perception organization.

VI. GENERAL GUIDELINES FOR COLOR SPACE

In this method, mathematical functions are utilized to perform the required transformation from gray scale to color. This is performed in the RGB color space. The idea underlying this approach is to perform three independent transformations of the gray level of any input pixel . The three results are combined together as red, green and blue channel to produce a color -coded image. The output images color content is modulated by the nature of the transformation functions.

Figure 2 explains the approach, using a functional block diagram. Channel1, channel 2 and channel 3 correspond to red, green and blue channel respectively. Trigonometric functions were used as the transformation function. Sine and cosine functions are used and in each channel and the gray values are transformed. By varying the phase and freque3ncy of cycles different color-coding is achieved. Figure 3 shows the transformation used for implementing sine map

Similar method is implemented using a cosine function. Figure 4 shows the transformation involved.

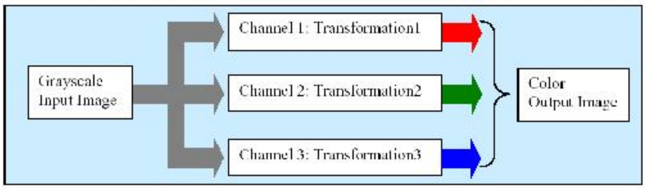

Fig. 2: Functional block diagram for color-coding using transformation

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$$\text{RGB (channel1)} = \sin(2*\pi*\text{gray-value}/65535)+(\pi/2)$$
$$\text{RGB (channel2)} = \sin(2*\pi*\text{gray-value}/65535)+(\pi/4)$$
$$\text{RGB (channel3)} = \sin(2*\pi*\text{gray-value}/65535)+(\pi/6)$$

Fig. 3.Transformation used to create sine map

The range of value in each channel should be between 0 and 1. Since the input image is a 16-bit image, the value is normalized by dividing it with 65535. If the value produced by transformation in each channel are equal (channel1=channel2=channel3) then the output image will be monochrome.

F = 0.9 Frequency
P = 0.2 Phase

RGB (channel1) = cos(2* π *F* gray-value)
RGB (channel2) = cos(2* π *F* gray-value + 0.5*P)
RGB (channel3) = cos(2* π *F* gray-value + P)

Fig. 4: Transformation used to create cosine map

Again, the phase and the frequency can be varied to achieve different color combinations. After a series of trails, the efficient values are found. At these values, the lower pixels (dark) from original grayscale image are enhanced and easily visible. Figure 5 (a) and (b) shows the input original image and its corresponding output after applying cosine transformation.

Fig. 5: (a) Original grayscale image (b) Output image obtained after applying cosine transformation clearly showing the threats (dark red and purple glass knives)

As mentioned earlier, the various parameters can be changed to obtain different color- coding schemes. In order to make this task easier a graphical user interface was created where the parameters can be comfortably adjusted to produce corresponding coding schemes.

The GUI has adjustable provisions for setting phase and setting the frequency of cycles .It shows the input x-ray image in two formats original grayscale and negative of that image. The transformation is also plotted in an x-y scale, which helps us to study how the function varies. Using this GUI, different images from the x-ray image database are tested. The combination of values for which the threat objects were best detected was noted.

This color scheme is implemented in RGB space and the major draw back is that the colors used are not controlled and the output image is based on the type of transformation used.

The application of image thresholding techniques for the selective visualization of certain gray-level brackets, leads to isolated and enhanced threat representations. This method is developed based on the results derived from the color study discussed earlier.

The basic procedure is as follows:

(1). The thresholds are set

(2). The number of colors to be used is defined

(3). The hues to be used are defined

(4). In the HSV space the hues are set for each threshold, the saturation is set to one and the value is set to the intensity value of the pixel

(5). Step 4 is repeated for all the thresholds

(6). Then the HSV image is transformed to RGB space for display

Figure 6.9 shows a pictorial representation of thresholding. This can be achieved in various ways. Automatic thresholding can be done but is not considered in this study.

There are numerous examples where fiber traces from DWI have successfully revealed fiber tracts in the human brain, see for instance. Stream-tubes have often been used for visualization, sometimes in combination with coloring schemes and variation of the stream-tube thickness according to some aspect of the underlying local diffusion descriptor. The idea of using fiber traces to obtain segmentations of white matter fiber tracts, as well as gray matter areas, have been explored in a number of pa-pers recently. In a segmentation of deep gray matter structures is performed using probabilistic fiber tracking, which connects pre-segmented areas of the human cortex with the thalamus. There also exist manual approaches to organize fiber traces into fiber bundles, such as the virtual dissection proposed in. In the idea of pseudo-coloring (soft clustering) fiber traces to enhance the perception of connectivity in visualizations of human brain white matter was presented. Some unsupervised approaches to clustering of fiber traces, similar to the one in this paper, have also been reported. For instance fuzzy c-means clustering and K nearest neighbors. Outside the area of medical image processing, clustering of curves has been reported.

Many clustering methods, including the N Cut being used in this paper, operate on a graph with undirected weighted edges describing the pairwise similarity of the objects to be clustered. This graph may be described using a weight matrix W , which is symmetric and has values ranging from 0 (dissimilar) to 1 (similar).

A fiber trace, represented as an ordered set of points in space, is a fairly high dimensional object. Therefore the pair wise comparison of all fiber traces could poten tially be a time-demanding task if fiber trace similarity is cumbersome to calculate and the number of fiber traces is high. In this paper we propose to split the computation of similarity into two steps:

1. Mapping high-dimensional fiber traces to a relatively low-dimensional Euclidean feature space, preserving some but not all information about fiber shape and fiber connectivity. This mapping is oblivious, acting on each fiber separately.
2. The use of a Gaussian kernel for comparison of points in the Euclidean feature space. This function acts on pairs of fiber traces.

It is important to point out early that even though the above mapping to a feature space may seem to be crude at a first glance, it works surprisingly well for fiber traces in practice. For a set of N fiber traces the first calculation above cost O(N), while the second calculation cost O(N^2) operations. This is also the reason for pre-processing the fiber data in the first step, making the second calculation more computationally efficient.

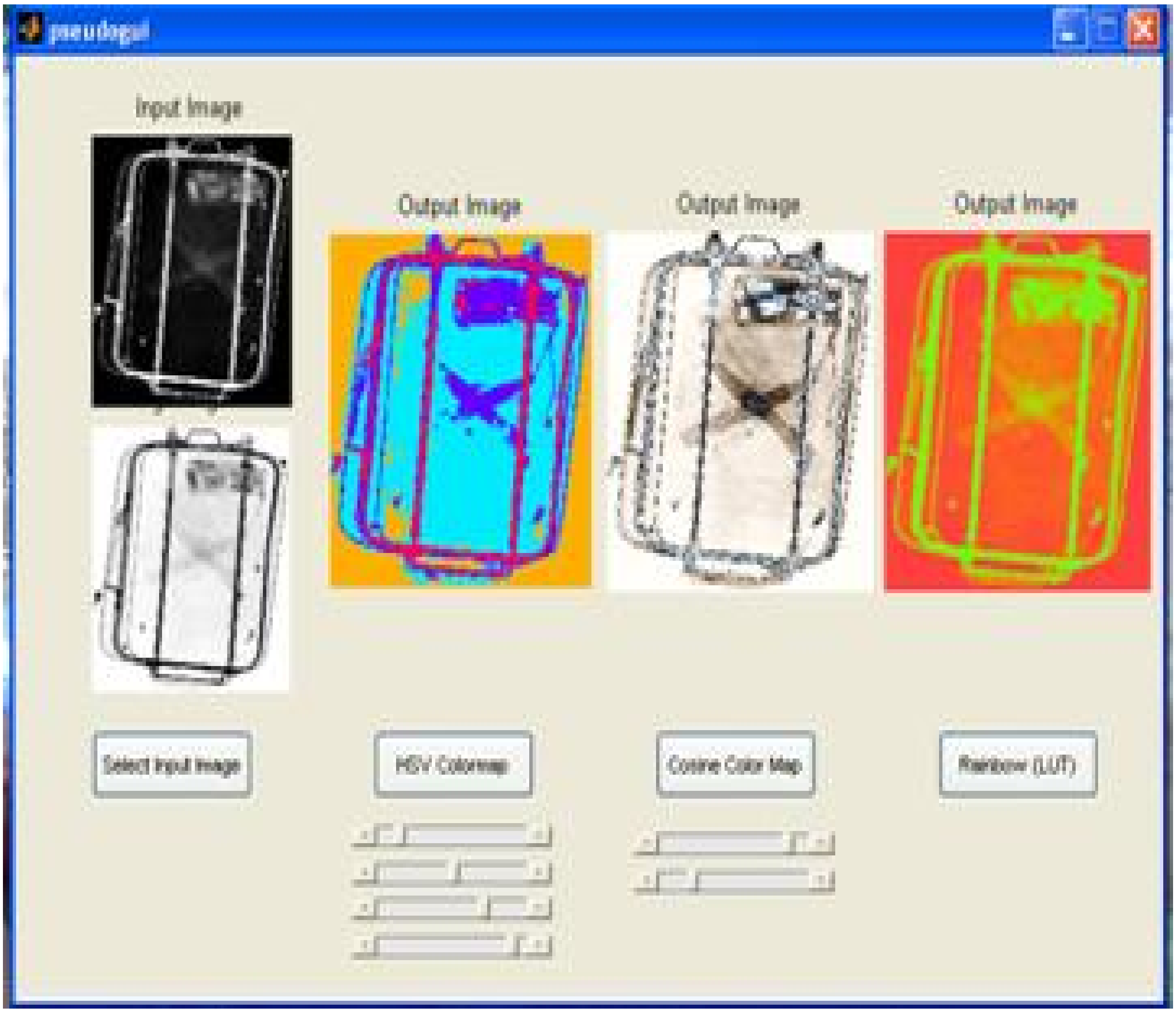

Fig. 6:.Graphical user interface for generating color-coding schemes

VII. CONCLUSION

From the survey results, color has been shown superior to grayscale for effective information processing time and for memory performance. The ability to detect and identify details from the image is inherently increased by using color. Among the different coloring schemes the HSV scheme that was developed based on the color survey result was ranked highest by the greatest number of people. However, the other color maps were ranked very close to the HSV map. The cosine color map results were impressive. The difficulty with the HSV map is to set or pick the threshold. This can be solved by establishing an auto thresholding algorithm. The cosine color map produced very continuous and smooth results when compared to the other maps. In addition, color-coding already enhanced images may produce better results. Currently color-coding is applied directly to the intensity stretched image. The survey was carried out with relatively few people. In the future, this study should be completed with more people to acquire statistically significant results. Also, the images should be presented in a pseudo random fashion to avoid the influence of other images in detecting the threat. False positives should be evaluated by introducing images without any threat. For more reliable results this survey should also be carried out with airport screeners.

Color should be used sparingly, consistently, and with clarity to aid in the formation of efficient mental models. Finally, use of the techniques and guidelines developed by Murch, Marcus and others. These rules, which were established from research, describe how colors fit together effectively.

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