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WYSIWYG METHOD OF MAP COLOR

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Abstract: Color is an important map visual variable. Different color-presenting mechanisms, physical properties or application conditions will lead to marked different color capabilities for different map-carrying mediums. Even the color range of homogeneous carrying mediums are different because of their different use conditions and lifetime. On the other hand, Different visual perceptions for one map will be presented due to different lighting conditions, viewing conditions, background colors, ambient light and etc during map-reading. Some phenomena like color-lost and color-cast may happen for map transmission in different media due to color's device and environment dependence. This might affect the visual performance for map, or even lead to transmit false property, quantity and the level information. First, similarities and differences among SRGB, ICC and Microsoft color management system will be analyzed. Second, a WYSIWYG method of map color based on the map color features will be proposed. Finally, prototype system will be developed to validate the feasibility of this method.

Key words: Map Color; WYSIWYG ; Color Management ; Color Appearance Model

1. INTRODUCTION

Color is a kind of widely accepted visual language, as well as the reader's first visual perception from map [1]. It is also an information carrier because it could be distinguished through our eyes. Grade, quantity and spatial distribution for map objects can be reflected by the change of hue, lightness and chroma. The flexible application of color will also make a clear and distinct map, and improve transmission for map information.

Paper maps are the main and traditional visual expression media of map [2]. With the development of computer technology, some new types of map like electronic map and network map have emerged by combining computer technology with map visual expressing [3]. Therefore, the three main approaches, including paper media, digital media, and network media, are serving widely for map publishing and spreading nowadays. Mediums for map also evolves from paper to computer screen, projector, printer, and printing machine, etc. Thus, the overall trend is to achieve fast and high quality mapping of geographic information based on computer technology, in order to bridge the social and economic development requirements.

However, color capabilities for different map-carrying mediums are different due to each color-presenting mechanism, physical property or application condition. Even the color range of homogeneous carrying mediums are different because of their different use conditions and lifetime. On the other hand, Different visual perceptions for one map will be presented due to different lighting conditions, viewing conditions, background colors, ambient light and etc during map-reading. Some phenomena like color-lost and color-cast may happen for map transmission in different media due to color's device and environment dependence. This might affect the visual performance for map, or even lead to transmit false property, quantity and the level information.

This paper analyzes the similarities and differences among SRGB, ICC and Microsoft color management system. Then a method for WYSIWYG of maps color is brought up and the experiment was performed to validate the feasibility of this method.

2. COLOR MANAGEMENT

Color management aims at maintaining color appearance when the color information is transferring from one color space into another. SRGB, ICC color management framework and the Microsoft color management technology are currently the primary color management technologies.

2.1 SRGB Color Management

Computers and their ancillary equipments often adopt RGB color mode, such as digital cameras, scanners, monitors, printers. If all of these devices use a common RGB color space, they can directly communicate color without conversion. So, a standard named SRGB was proposed by HP and Microsoft in 1996. They wanted to bring a simple but strong RGB color space which was device-independent as the standard. Then, there was not need to use color management system to transfer colors in desktop environment if all of the operating systems and device manufacturers support SRGB.

2.2 ICC Color Management

International Color Consortium, called "ICC" for short, was initiated and established by Apple and Adobe, AGFA, Kodak, FOGRA, Microsoft, Silicon, Sun and Taliget and other companies in 1993. Now ICC has over more than 70 device manufacturers and software developer members who come from various fields of imaging technology and computer industry. ICC aims at standardizing the color management system of open type and cross-platform, ensuring the color information's accurate transmission between different software and hardware of different manufacturers [4]. ICC Color Management Framework including three elements, as is shown in Fig1.

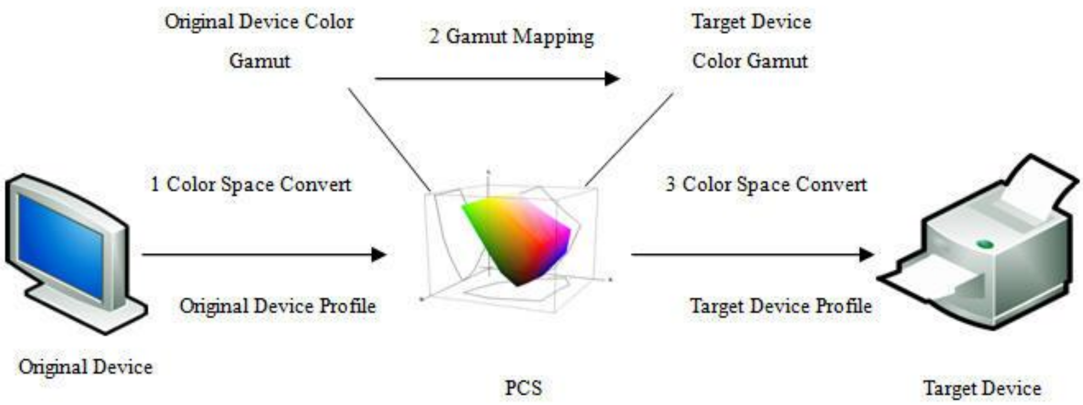


Fig 1. Color Transmission between ICC devices

1) PCS (Profile Connection Space) is a device independent reference color space for describing the color character of devices. All the colorific characteristic value of devices defines the corresponding sense of color by using the corresponding PCS value. According to ICC, PCS should use CIEXYZ color space or CIElab color space.

2) Profile is a standard file format defined by ICC. As a standard of color transmission between devices, it serves for recording the color character, and memorizing the colorific transformational relation between devices and PCS.

3) Color Management Module (CMM) is supported by the operating system and application software, aims at transforming the device's color value into PCS value, or transforming the PCS value into the device's color value.

2.3 Microsoft Color Management system

The color management Scheme in Microsoft Windows operating system is called ICM (Image Color Management) [5] which is based on ICC color management system. In 2005, Microsoft and Canon announced that, for a new generation of the Windows operating system, they would develop together WCS (Windows Color System) instead of ICM. However WCS, which is based on ICC color management framework, made the following adjustments:

PCS uses CIECAM02 color appearance model. It adopts CIECAM02 color appearance model as a standard color space and all the color transformations is made in it which can calculate the color appearance attributes with the use of tristimulus values of color samples and actual viewing conditions. Thereby, the color visual attribute under different visual conditions can be predicted.

WCS properties files are written by XML (Extensible Markup Language) XML which can simplify the process of creation, testing and editing of properties files.

The biggest difference between WCS and ICC color management systems is following [7]:

1) Real-time color transformation. When device files are created by ICC, device transformation, color appearance transformation and color gamut mapping have been completed. So the relationship between device values and PCS values color gamut mappinged are stored in the profile files and CMM just simply extracts the transformational relation from profile files to do image transformation. This approach is known as pre-defined color transformation. However, these processes are done by CITE (Color Infrastructure and Translation Engine) instantly for WCS. WCS introduces color appearance model into

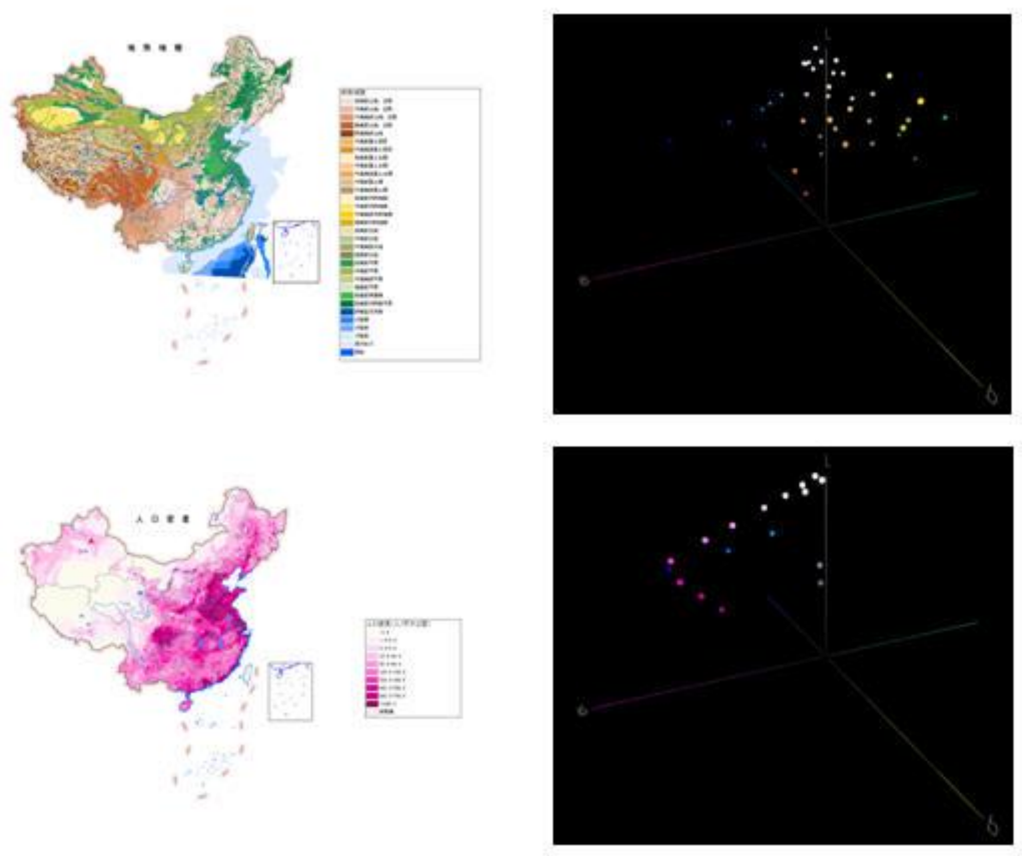
color management system for the first time, and it can predict color visual attribute under different visual conditions.

3. MAP COLOR WYSIWYG

By a standard color space, SRGB makes devices follow it to achieve the color transmission directly. However, the deivces can not accord with it fully as their physical characteristics. So SRGB can only achieve the 'same' approximately and it doesn't support CMYK, HSV or other common color spaces used for map transmission. ICC and Microsoft color management are the common color management technologies, they aim at achieving the device to device color transmission and reproduction. However, all of the above color management methods cannot be applied to map directly because the frequency and spatial characteristics of map color are relevant to the spatial distribution and differentiation of mapping objects. It mainly shows in the following aspects:

3.1 Map Color Gamut Features

Color has a profound meaning to map. On the one hand, the color of map itself is designed according to the guidance of spatial cognition science of map. Hue, lightness and chroma are available to represent positioning, quantitative and qualitative geographic information. On the other hand, the spatial correlation of map contents determines that the visual effect of map is different from space-independent graphs or images. As is shown in Fig2, taking the geomorphologic map and population density map from "China's Atlas of Population Environment and Sustainable Development" for example, in the map of physiognomy, various color areas were used to represent different landform and physiognomy, such as mountain land, hill, flatland, lake, continental shelf, and submarine topography, etc. In the population density map, chroma was used to describe the distribution pattern of population density, different grades of chroma indicates different population density. Some conclusions can be made from the two typical maps above:



1) Distribution pattern of map color gamut appears discrete spots. Color range defined by general color management technology as continuous color space, namely Color Gamut, such as color gamut of the original device and the target device. Corresponding gamut mapping methods are all from continuous color gamut to continuous color gamut. The distribution pattern of map color gamut appears discrete spots, and continuous color gamut mapping method is inappropriate for the map color data.

2) Color gamut range in a map is less than that of a device. On a map, color is always used to describe the attribute, quantity, classification, distribution, and differentiation information of geographic objects.

Because of the restriction of human's short-term memory ability, color categories and color grades are limited. In the processes of mapping, data item is classified into 5 to 9 grades. Too much color categories or grades will reduce the readability of a map, and make it hard to be identified. Color interpolation is necessary for physiognomy and contour line's color-setting. Color's quantity on map is limited, and much less than the color gamut of carrying medium. Most current color management technologies focus on the gamut mapping method from device to device, and concentrating on color gamut's accurate transmission and reproduction of the whole device. However, mapping method from device to device cannot guarantee accurate transmission and reproduction of all color, and not suitable for map due to the shape differences of color gamut.

3.2 Map Color Appearance Phenomena

In map application, color perception has to be maintained in map transfer among devices. However, ICC color management theories are based on color matching under the same materials and viewing conditions. Visual perception of two colors are the same only when they have common viewing conditions such as surrounding environment, background, sample size, sample shape, sample surface properties and lighting conditions. If they under the different viewing conditions, visual perceptions are changed though three values in color such as R, G and B are still the same.

Maps are affected by the map-reading environment inevitably, such as electronic maps are often read in the environment of artificial lighting indoor and some of them are read in a dark environment(for example by projectors), mobile and PDA maps are read under natural conditions outdoor, and navigation maps often have day and night map-reading modes. For map readers, they do not care about RGB values of map color under different conditions are the same, but only care about the same visual perceptions. In the cross-media map sharing, we must consider not only color samples and illumination sources, but also effects of lighting conditions, background color, ambient light and color adaptation on color perception. Therefore, color appearance model will be introduced.

3.3 Map Color Gamut Mapping

In cross-media map symbols sharing, gamut mapping is inevitable because of different coloring mechanism. Mapping algorithms designed according to color gamut of original and target color, image content, and user's objective and preference are optimal. Whether the rendering intents of ICC or the description model of color gamut of devices, they are all specific to print and monitors. For maps, symbol colors are space correlated and their spatial and frequency domain are associated with map objects. However, sensitivity to map color which have different spatial frequency is different for human visual system. So, color gamut approaches may different even the colors for symbols from different palces are the same. Therefore, color gamut mapping method aiming at map spatial characteristics need to be designed.

Human visual perceptual experiments show that human vision is sensitive to lightness changes of high spatial frequency and saturation changes of low spatial frequency. It is insensitive to low-frequency lightness changes and high-frequency saturation changes. This illustrates that during the gamut mapping, it is more important to maintain lightness in the high spatial frequency region and maintaining saturation in the low spatial frequency region. This can acquire the ideal effect of matching.

4. MAP COLOR MANAGEMENT

WYSIWYG method of Map Color proposed in the paper includes five parts: device transformation, color appearance transformation, spatial frequency computation—color gamut mapping, inverse color appearance transformation and inverse device transformation.

1) Device transformation

Device transformation is to achieve the corresponding relationship between the device's color values and tristimulus values. That is, according to the characteristics of the device itself, to transform the device color values into device-independent color values in order to make color calculations under a uniform color space.

2) Color appearance transformation

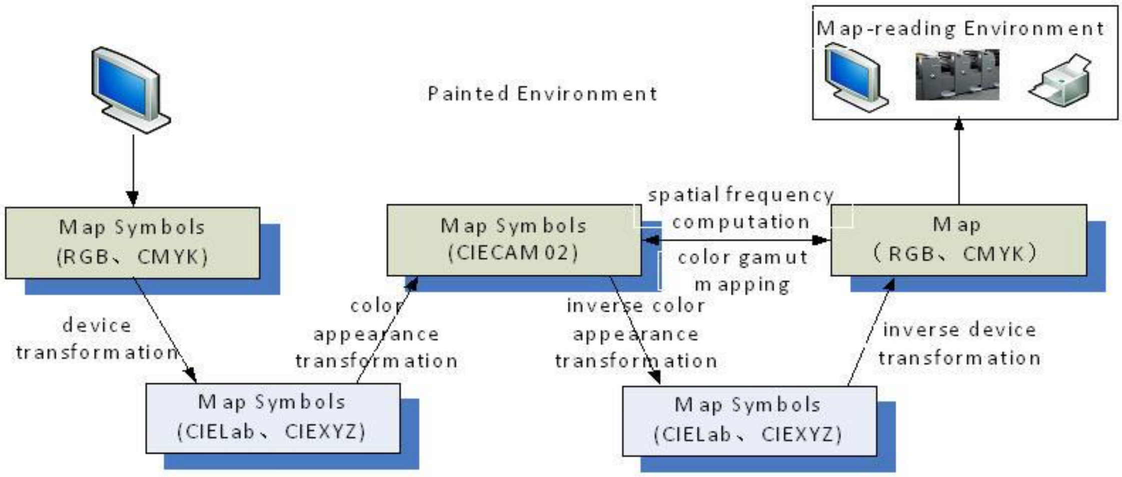
Based on the viewing conditions, color appearance transformation is to transform tristimulus values into color appearance model to calculate the color appearance attributes of color. We selects CIECAM02 color appearance model as the standard color model of the designing and computing environment of map symbols color. Based on the parameter variables of map-reading environment, inverse color appearance transformation is to transform map symbols color values described by color appearance model into the tristimulus values under the target viewing conditions.

3) Spatial frequency computation—color gamut mapping

Color gamut among devices is often inconsistent when tranfering color, it need to proceed color gamut mapping. However, according to the human visual perceptual experiments, sensitivity to map color which have different spatial frequency is different for human visual system. Therefore, our model need to carry on color gamut processing based on the map spatial frequency before inverse color appearance transformation. For high-frequency color, lightness is maintained, and for low-frequency color, saturation is maintained.

4) Inverse color appearance transformation and inverse device transformation

After obtaining the tristimulus values under the target viewing conditions, we can get the color of target map symbols through inverse color appearance transformation and inverse device transformation. Then map colors according with visual perception and allowing for designing and reading environment will be generated through connection with spatial data.

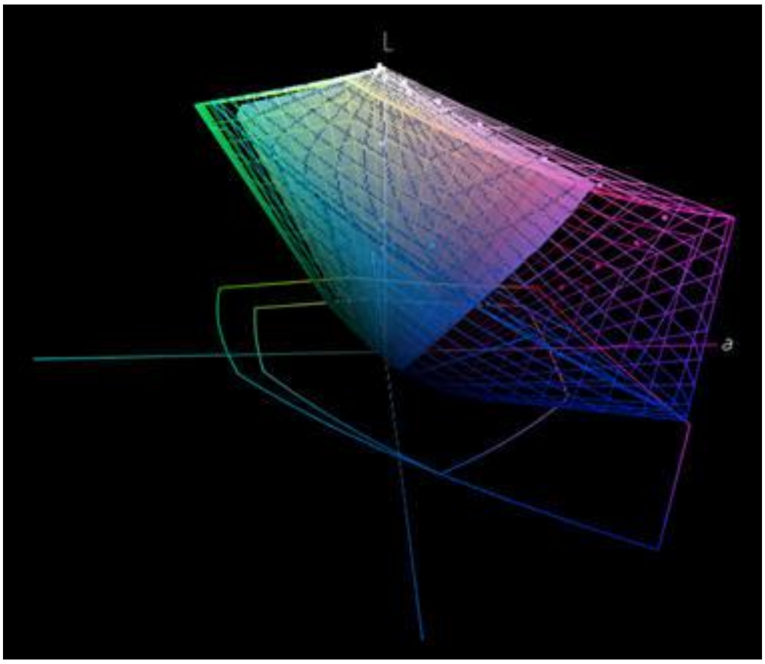


5. EXPERIMENTS

We use population density data of China as experiments data. It was collected from “China’s Atlas of Population Environment and Sustainable Development”. The ICC profile of original device (Dell Desktop) and objective device (IBM Thinkpad T43) were obtained using X-Rite Eye-One. Color gamut of map was compared with that of two kinds of devices. Color gamut for original device was displayed in wireframe mode while that for objective device was displayed in fill mode, and color gamut for map using discrete points. As is shown in Fig4, color gamut range for objective device is less than that for original device, and most map color gamut falls in middle of them.

This experiment selects the two map-reading environments---A and B. As the source map-reading environment. for A-environment, viewing condition is average, adaptive field brightness is 50cd/m2, background brightness is 40cd/m2 and white field (XYZ) is 0.3-0.3-0.3. As the target map-reading environment, for B-environment, viewing condition is average, adaptive field brightness is 52cd/m2, background brightness is 45cd/m2 and white field (XYZ) is 0.3-0.31-0.3.

According to the two map-reading environments---A and B and two color gamut, for the map, the process of device transformation, color appearance transformation, spatial frequency computation—color gamut mapping, inverse color appearance transformation and inverse device transformation are conducted. Color appearance transformation calculates brightness adaptation factors, color adaptation transformation, nonlinear response compression and etc. The results is shown in Fig5. Based on CIECAM02 color appearance theory, RGB values before and after the transformation are different, but their visual perception is indeed consistent, which ensures the accordance of color perception during the process of cross media map transmission. This improves quality of map display and avoids the error message transmission caused by color distortion.



6. CONCLUSION

With the development of electronic and web map, map carrying mediums are tending to diversification. Accurate transfer and reproduction for map color are required during the cross media transmission. Color for map is different from general images and graphs. Map color designing has its own rule and its colors stand for various geographic objects with characteristic of distribution and differentiation. A WYSIWYG method of map color had been proposed. It can improve accuracy for map color transmission and reproduction. Next steps include optimizing the speed for solving problems and evaluation methods of the map color transmission and reproduction results.

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