Medical Application of Multispectral Imaging

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Abstract: Multispectral imaging is an excellent solution to color problems in medicine, and two promising medical applications are proposed; digital images with spectral reflectance for each pixel, and digital images that are very accurate reproductions of real objects. The first technology will lead to new morphological diagnostic methods more powerful than human visual perception alone, while the second advance will lead to a major improvement in the diagnostic reliability of digital color images and wider clinical adoption of digital imaging.

Keywords: color reproduction, medical imaging, morphological diagnosis, multispectral imaging

1 INTRODUCTION

Multispectral imaging, which can capture, record and reproduce spectral reflectance of objects, is surely one of the most promising technologies. Through intensive inter−disciplinary research collaborating between engineering and medical field [1], two models have emerged; spectral color pictures, which include spectral reflectance information for each pixel, and absolute appearance pictures, which provide a highly accurate reproduction of real objects and are never affected by devices or illumination conditions.

2 SPECTRAL COLOR PICTURES

The spectral reflectance provides a lot of biological and medical information about the human body. However, current imaging systems record only a small part of this reflectance, and do so inaccurately. Therefore, a variety of new diagnostic methods based on information not detectable by human sensation may be developed if the spectral reflectance of skin or mucosa can be recorded as a picture. A specific range of wavelengths can be adaptively enhanced to reveal previously undetectable medical findings.

Several multiband cameras have been developed to test these possibilities, and their medical use is currently under investigation. Although a multiband camera usually means a camera that has more than three color-channels, there is the possibility that common three color-channels will be sufficient for some applications.

An example of some of the promising applications is visualization of the distribution of the three major skin pigments, melanin, total hemoglobin and oxyhemoglobin [2]. The spectral reflectance of each pixel of a skin picture used to calculate the distribution of these pigments can be estimated by observation from a picture taken using a common digital camera because the three principal components are sufficient to approximate the reflectance spectra of normal skin [3].

If hypoxia of skin visualized by this method predicts areas where diabetic gangrene or decubital ulcers are developing, a non-invasive diagnostic method of visualizing latent lesions will be realized and will play a key role to eliminate these diseases.

Because spectral color pictures are completely new in medicine, the demand for this technology will initially be very low, but can be expected to increase when the full potential of the technique is realized. Although the impact of these medical applications may be quite significant, most applications will require a lot of further investigation using highly advanced technologies.

3 REAL COLOR APPEARANCE PICTURES

When a physician makes a diagnosis of a lesion, the medical findings should be recorded and reproduced as if the physician were observing the actual lesion, regardless of the illuminating conditions. Such an ideal image is considered to represent the absolute appearance. The quality of absolute appearance pictures will be determined by factors such as sharpness, graininess, tone reproduction, and color reproduction [4]. Although spectral color pictures may be an ideal solution for realistic color reproduction, other factors should also be satisfied.

As mentioned before, reflectance spectra of skin can be estimated from a picture taken by a three-band digital camera. Thanks to the characteristics of three kinds of human cone cells, colorimetric color reproduction using the three primary colors will reproduce most colors of skin with good accuracy. In other words, the spectral reflectance of each pixel of a skin picture can be obtained using a current digital camera and the color appearance under any illumination can be reproduced using any current three-band color display [5].

A multiband camera coupled with a multiband display can reproduce a much wider range of colors more accurately, independent of both devices and illumination. Although even a multiband display will have differences in color appearance caused by differences between the color-matching functions

of individuals, a calibration method should be readily available. This premise can also be applied for displays that provide color-blind users with the same apparent color appearance as other users.

Presently, digital color imaging has been adopted in fields that do not require high accuracy of color reproduction. No current digital imaging device has sufficient quality of skin color reproduction to be applied in dermatology or nursing. The same situation is observed for oral mucosa and teeth in dentistry. One of major reasons of these situations is that colorimetric color calibration, which is used to compensate for differences between the optical characteristics of cameras and displays, is not capable of compensating for differences in color appearance caused by differences in illumination.

Therefore, the development of real color appearance pictures using multispectral imaging can be expected to give rise to a huge demand for the technology in telemedicine, electronic patient records and e-learning on medicine. In addition, our recent study showed we have so various illuminant conditions in a hospital that a reliable imaging system capable of compensating for differences in color appearance caused by differences in illumination is indispensable.

As most clinical cases do not require high fidelity of image recording and reproduction, an imaging system that provides partially device- and illumination-independent color reproduction using common equipment will have extensive practical and general effects throughout medicine. The adoption of this minor technology can be expected to generate demand for multispectral imaging in many other fields, fueling the dissemination of other related technologies. Therefore, the first group to successfully develop and implement absolute appearance pictures may secure both a significant investment and a place in history as a pioneer of the practical application of multispectral imaging.

An imaging system that the spectral reflectance of skin and mucosa is obtained using a current digital camera and its color appearance under any illumination is reproduced using a current three-band color display was developed by the author and co-researchers.

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REFERENCES

1) Nishibori M, Tsumura N, Miyake Y (2004), Why Multispectral Imaging In Medicine?. Journal of Imaging Science and Technology 48, pp.125-129

2) Tsumura N, Miyake Y, Imai F (2001), Medical Vision: measurement of skin absolute spectral-reflectance image and the application to component analysis. Proceedings of the 3rd International Conference on Multispectral Color Science (MCS'01), pp.25-28

3) Miyake Y, Tsumura N, Takeya M, et al (2001), Applications of Color Image Processing Based on Spectral Information. In: Tanaka H, Miyake Y, Nishibori M and Mukhopadhyay D, ed. Digital Color Imaging in Biomedicine. Tokyo: ID Corporation, pp.15-32

4) Miyake Y, Inoue S, Inui M, Kubo S (1986), An Evaluation of Image Quality for Quantized Continuous Tone Image. Journal of Imaging Technology 12, pp.25-34

5) Imai FH, Tsumura N, Miyake Y, et al (1997), Prediction of color reproduction for skin color under different illuminants based on the color appearance models. Journal of Imaging Science and Technology 41, pp.166-173