Introduction

Although morphological diagnosis requires reliable color reproduction, no digital imaging device is currently available that sufficiently reproduces the skin color quality, which could be applied in medicine.

Because illuminant in a university hospital has a wide range of color and some illuminants generate very low values on the color rendering index (Fig.1), simple chromatic adaptation or color constancy using the von Kries model will not solve this problem.

System description (Fig.2)

- A multi-spectral imaging technique was adopted for illuminant-independent color reproduction for practical use in medicine, dentistry and nursing.
- Flash photographs of skin were taken using a digital camera (DIMAGE 7i, Konica Minolta) and raw responses from its CCD were recorded.
- Spectral reflectance of each pixel of pictures was estimated based on these CCD responses by using the Wiener estimation technique and are converted into the tristimulus values by using the spectral radiant distribution of target illuminant.
- The characteristic of the LCD monitor used for displaying reproduced colors was measured beforehand by a spectrophotometer (CS-1000, Konica Minolta).
- Evaluation of the system

The developed system can adequately record the spectral reflectance of skin (Fig.3) and the maximum color difference between the value estimated by the proposed method and the value measured by the spectral radiometer was only 0.6 ∆E_a*.

Healthcare professionals asked to evaluate the reproduced skin color compared to the real skin and Table 1 shows the results.

Conclusion and Discussion

The significance of the system for medical applications was clearly identified and it could be widely used if a user-friendly system were available.

Because flash photography loses shading information that reflects the surface irregularities of objects and is indispensable for diagnosis on skin and mucosal lesions, an alternative method without a flash will be required.

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Table 1, Evaluation of Healthcare Professionals

| MO1 | “Almost satisfactory. The red color of gingival under three band fluorescent lesions is different from the red color under fluorescent.” |
| MO2 | “Satisfactory results were obtained with the white fluorescent lamp, but some red and green artificial dots were observed under three band fluorescent lamp. Under these two illuminants, a significant difference was found in the appearance of separate or homogenized patches. The observed color under three band fluorescent lamp was similar to the color rendered under the fluorescent lamp.” |
| MO3 | “Satisfactory results were obtained under the white fluorescent lamp. All observers said that the evaluation of tissue under the fluorescent lamp was similar to the evaluation of tissue under the fluorescent lamp.” |
| MO4 | “A red area is more yellowish than the reproduced picture, but the boundaries of an ashen type were less clear.” |

Answer for the question (5) Will you use this system for medical diagnosis or not?

- MO1: “It will be possible in limited cases. It can be used in screening for cases that should be consulted to specialists, dentists, and nurses.”
- MO2: “Although even evaluation cannot be made without directly observing disease skin, a more precise color reproduction than printed pictures is achieved. It will be applicable to diagnosis of lesions, but further investigation will be required for inflammatory lesions.”
- MO3: “Yes, I agree. If three-dimensional information is successfully reproduced, skin lesions will be visible more exactly. It will be applicable to the diagnosis of degree of tissue or inflammation of gingiva, namely, the diagnosis of periodontal.”
- MO4: “More information is required for nursing use. Slight histological difference observed in skin and swelling observed at clinical examination is well reproduced. Nearly the observers agreed. OK, but the appearance of objects with greater depth are not able to be recorded accurately.”

Answer for the question (35) Comments on the user interface.

- MO1: “Pursue user-friendlyness through repeated prototyping.”
- MO2: “Limit functions to minimum requirements, aiming at a single system. Although sufficient experience will increase any inconvenience, restricted functions should be limited.”
- MO3: “Make it easy to use.”

Answer for the question (36) Comments on the camera system.

- MO1: “The color reproduction is not precise.”
- MO2: “Focusing this camera is not easy. A single-lens reflex camera would be better. Mount type flash is more easily broken by accident than bulb types. Such accidents occurred very often in my university.”
- MO3: “About the shape of the flash power module, a horizontally long shape is preferred to present one because it can be slimmer more easy.”
- MO4: “Make it small and simple.”

Answer for the question (37) Comments on the display system.

- MO1: “A small, inexpensive light system is better.”
- MO2: “A notebook equipped with a fast panel display that has enough performance for color reproduction should be manufactured.”
- MO3: “A small, inexpensive light system is better.”
- MO4: “A notebook equipped with a fast panel display that has enough performance for color reproduction should be manufactured.”

Answer for the question (85) Other comments.

- MO1: “Red skin can be balanced and observed from multiple angles, but anachronism on a display can not. Focusing this system would be effective for these limitations. Although taking a photograph using ‘the four flashes system’ is not suitable for the methods mentioned in the question, some uses of this method may be available.”
- MO2: “If the three-dimensional appearance of gingival swelling and that of gingival staining are poorly reproduced, they may be overlapped. And because the appearance of a tooth-colored light cannot appropriately show its precise shading. A linear-source light may be adequate.”
- MO3: “Because the three-dimensional appearance of gingival swelling and that of gingival staining are poorly reproduced, they may be overlapped. And because the appearance of a tooth-colored light cannot appropriately show its precise shading. A linear-source light may be adequate.”
- MO4: “Because the appearance of a tooth-colored light cannot appropriately show its precise shading. A linear-source light may be adequate.”
We will demonstrate a **real-time capture & display software of:**

1. **Real Color Appearance Pictures** - reproduced as if a physician were observing the actual skin, regardless of the illuminating conditions.

2. **Spectral Color Pictures** - each pixel has spectral reflectance used for visualization of the skin distribution of melanin, hemoglobin and oxyhemoglobin.
a three band digital camera

A System Diagram

spectral information of illuminant + \( \downarrow \) \( \downarrow \leftarrow \) calculation of skin pigments