

# **A New Instrument for Measuring the Human Skin Color - A noncontact-type spectrophotometer with a globe for light integration -**

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## **Abstract:**

Standard instruments used for measuring skin color have some problems: 1) they are affected by pores and wrinkles in the skin, 2) they are affected by various illuminant conditions and 3) they have the edge loss error caused by the semitransparency of skin.

We have developed a new measuring system for the color of skin based on a noncontact-type spectrophotometer equipped with a globe for light integration, and have succeeded in improving on these problems remarkably.

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## **1. Introduction**

Conventionally, skin color is often measured with a contact-type spectrophotometer usually used for measuring the color of a physical object (Fig. 1-6). Although it contains an illuminating unit and ensures high reproducibility, the contact-type spectrophotometer is not suitable for measuring the color of skin which has an indented surface, hairs, or a sore with wet secretion, or the color of an angioma which varies in color depending on the pressure applied to it. On the other hand, the noncontact-type spectrophotometer (Fig. 7,8) usually used for measuring the color of a light source cannot produce a constant illumination, nor offer sufficient precision to comply with international standards on the measurement of the color of a surface. We have therefore developed a noncontact-type spectrophotometer for measuring the color of skin, the illumination and precision of which are similar to those of the contact-type. This paper introduces the noncontact-type spectrophotometer that we have manufactured.



Figure 1 A contact-type spectroradiometer (CM-2022, Minolta)

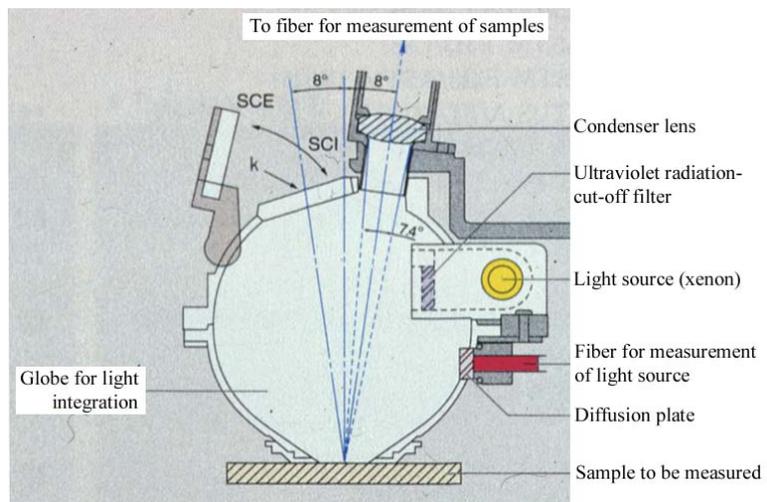
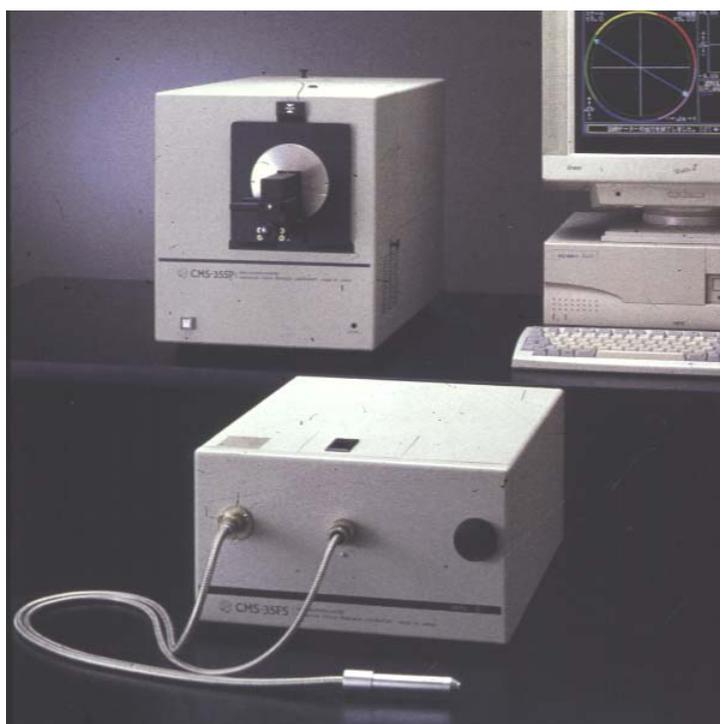


Figure 2 The mechanism of CM-2022



**Figure 3** Measurement using CM-2022

There is no way of confirming if the aperture of 4 mm diameter of CM-2022 is exactly aligned with a measuring skin area. Neither pressing the skin nor detaching the spectrophotometer should be an appropriate solution. Also tremors of limbs may affect measurement.



**Figure 4** A contact-type spectrophotometer (CMS-35FS, Murakami Shikisai Technology)

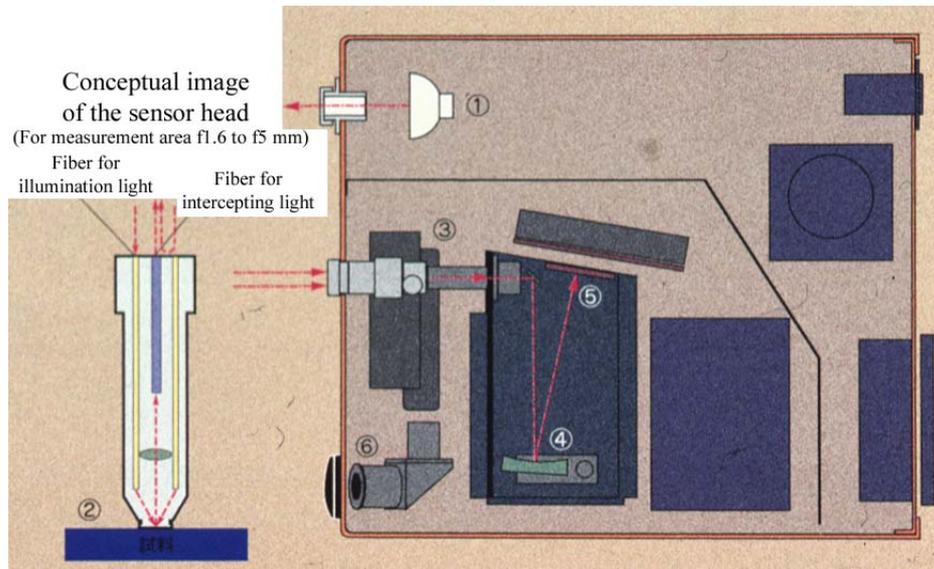
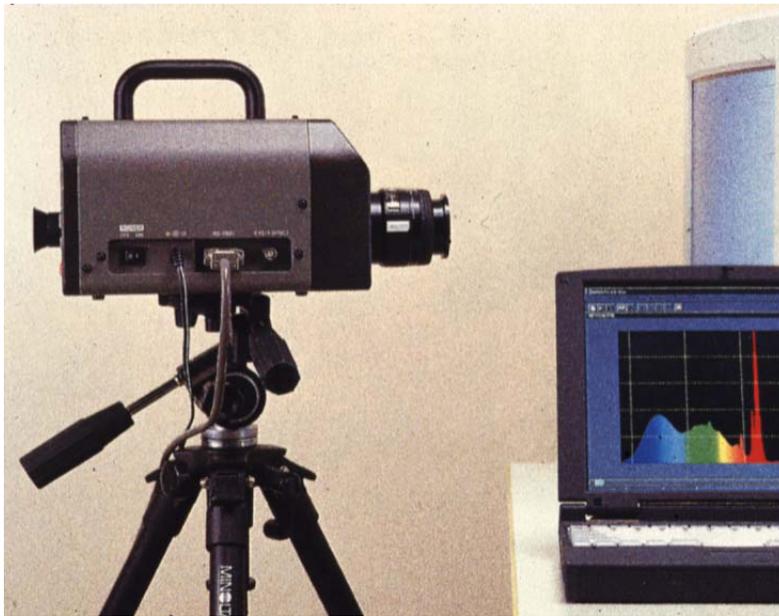


Figure 5 The mechanism of CMS-35FS

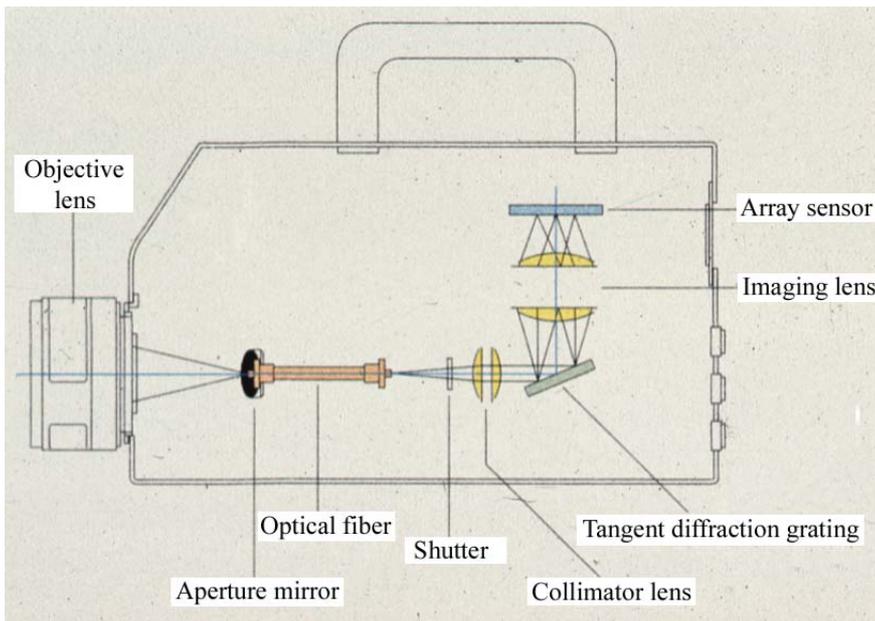


Figure 6 Measurement using CMS-35FS

Using only one hand, the probe can be easily held steadily and to skin. This spectroradiometer gives good performance on data reproduction in repeated measurements, but the illuminant conditions and the edge loss errors may affect measurement.



**Figure 7** A spectroradiometer (CS-1000, Minolta)



**Figure 8** The mechanism of CS-1000

## 2. Methods

An 8-inch globe for light integration is attached to the aperture of a spectroradiometer (CS-1000, Minolta). A 150-watt xenon fiber light source was inserted. The tip of the globe for light integration is opened approximately 5 cm to the target, or skin surface. The center of the measured area (4 mm diameter) is not in any contact such as with the transparent plates (Fig. 9). Using this device, skin of various conditions was measured and reproducibility was evaluated. Measured values were compared with those obtained by contact-type colorimeters (CM-2022, Minolta; CMS-35FS, Murakami Color Technology).



**Figure 9** A noncontact-type spectroradiometer with a globe for light integration developed at Tsukuba University

Although the physical size is fairly large, the targets of measurement can be checked visually, and limitations of measurement according to the surface condition of the targets are greatly reduced. An attached globe for light integration realizes the illuminant which has a perfect radiant distribution. Furthermore, a large ratio of the illuminated area to the measured area eliminates the edge loss error, and this merit is preferable for measuring the color of semitransparent objects such as human skin.

### 3. Results

Compared with the two contact-type spectroradiometers, reflectance curves of the noncontact-type spectroradiometer with a globe were sharper. The reproducibility of data in repeated measurements was highest in this order: contact-type CMS-35FS, noncontact-type spectroradiometer with a globe, contact-type CM-2022. When flared-up skin several days after sunburn was measured, only the noncontact-type spectroradiometer with a globe measured significantly high reflectance, particularly that of the long wavelength area. Figure 10 shows the contrast of the reflectance curves acquired from human skin using the three types of spectroradiometers. Each color of the line indicates the following: black lines, a posterior part of a forearm; orange lines, an anterior part of a forearm; blue lines, a nevus; pink lines, an anterior part of a forearm; and green lines, sunburnt skin of a shoulder.

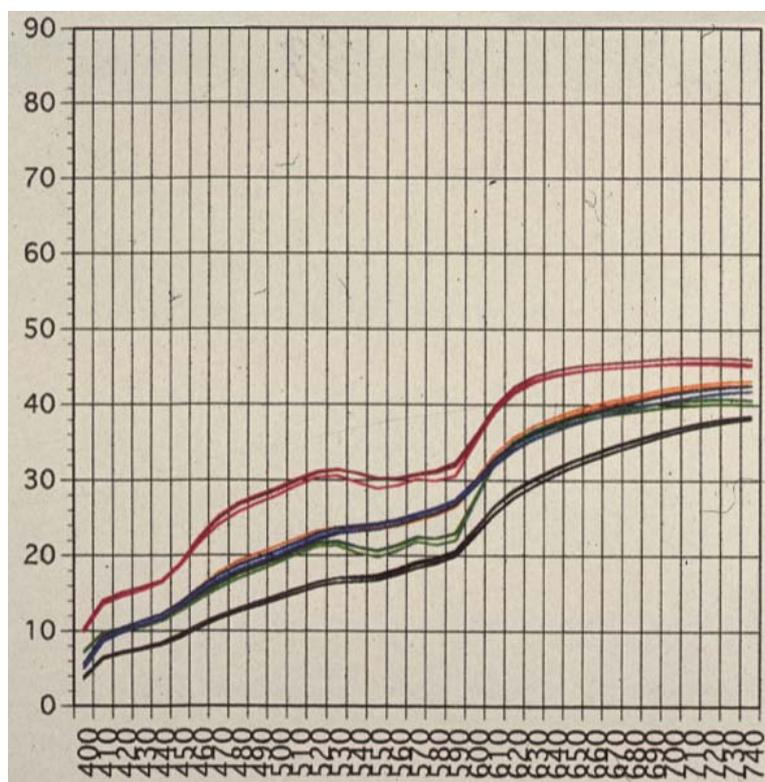


Figure 10 (a) Curves acquired by CM-2022

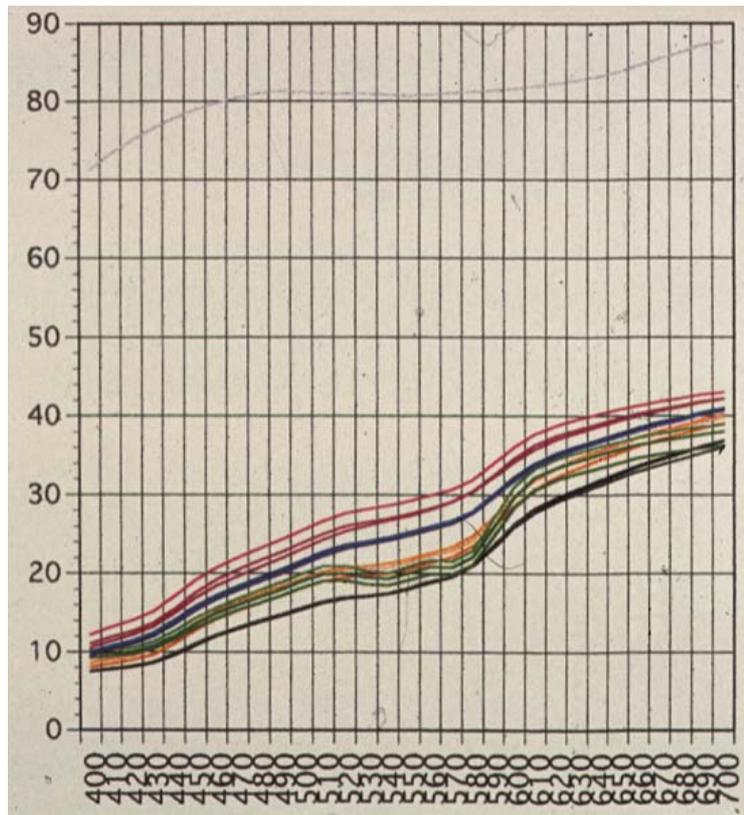


Figure 10 (b) Curves acquired by CMS-35FS

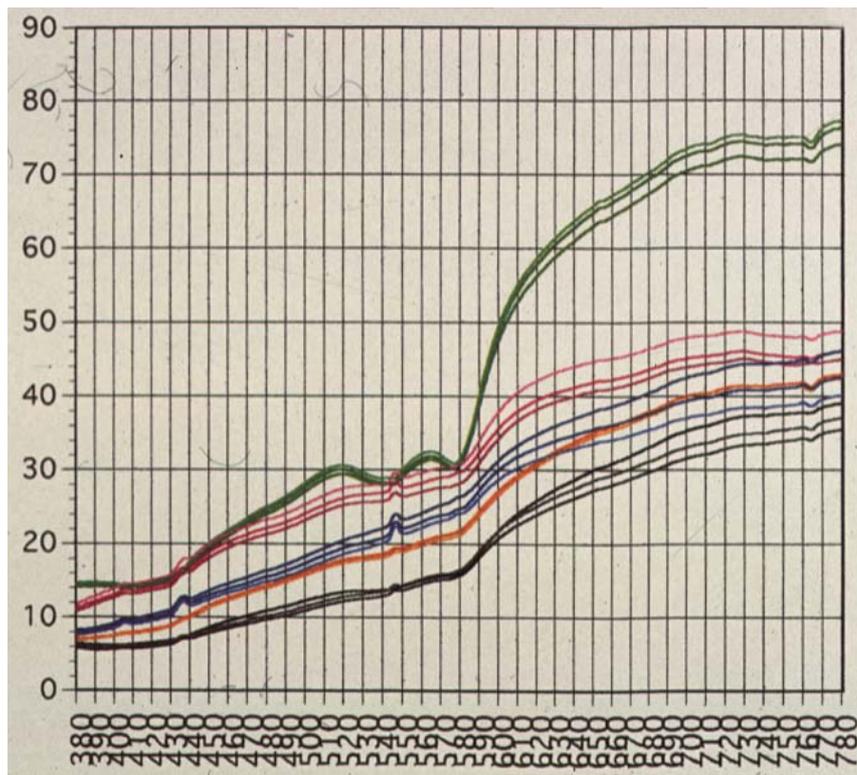


Figure 10 (c) Curves acquired by the noncontact-type spectroradiometer with a globe

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## 4. Discussion

When semitransparent skin is measured by a conventional contact-type colorimeter, because of the partial lack of reflected light inside the skin, measured values tended to have reduced luminosity and saturation at peripheral portions of measured areas (edge loss error).

Because the noncontact-type spectrophotometer with a globe has a sufficient illumination area (diameter 50 mm) relative to the measured area (diameter 4 mm), the edge loss error can be eliminated. Consequently, skin color that is more natural and closer to that visually observed is reproduced. Furthermore, the globe for light integration produces a perfectly radiant distribution of illumination. Because reflected light is measured, conditions are closer to those of visual observation than those of 45-degree illumination or ring illumination, and stability is also higher.

The CMS-35FS is a pen-type hand piece. It is easy to hold the instrument steadily and to measure areas. The measuring time is only 3 seconds. With the other two spectrophotometers, minor tremors of spectrophotometers and patients produced a shift in measured areas.

Measurement of skin color several days after sunburn was affected by optical factors in the cortical layer such as angioectasia of the dermis, appearance of sunburn cells in the epidermis, increased secretion of melanin granules, activation of division of epidermal cells and ablation of the cuticle.

It is inferred that the reason why values of sunburned skin measured by the noncontact-type spectrophotometer were markedly different from those measured by other types of colorimeter is that the former spectrophotometer has a structure that can intercept spectral light in the skin cortex as mentioned above. We plan to conduct experiments on depth and directional disassimilation.

## 5. Conclusion

This measuring system improved the dispersion of measured values caused by skin conditions such as wrinkles and pores, which are a problem with conventional contact-type colorimeters. Noncontact-type colorimeters used to have the weakness of being easily influenced by the measurement environment. The attachment of a globe for light integration has solved this problem by producing a radiant distribution of illumination and light sources with changeable intensity. The new spectrophotometer eliminates the problem of fading of skin capillary due to pressure on the measured area, as well as the problem of edge loss error in the measurement of color of semitransparent objects.

We plan to conduct further studies and obtain reliable data on the size of the globe for light integration, intercepting angle, intensity of radiation light and improvement of data reproducibility by repeated measurements to achieve optical conditions that meet JIS.