High sensitivity optical method for objective assessment of the gloss of human skin

Ezerskaia, A.; Ras, A.; Pereira, S. F.; Urbach, H. P.; Varghese, B.

DOI
10.1117/12.2305319

Publication date
2018

Document Version
Final published version

Published in
Proceedings of SPIE

Citation (APA)
Ezerskaia, A., Ras, A., Pereira, S. F., Urbach, H. P., & Varghese, B. (2018). High sensitivity optical method for objective assessment of the gloss of human skin. In H. Zeng, & B. Choi (Eds.), *Proceedings of SPIE: Photonics in Dermatology and Plastic Surgery 2018* (Vol. 10467). Article 104670Z (Progress in Biomedical Optics and Imaging - Proceedings of SPIE; Vol. 10467). SPIE. https://doi.org/10.1117/12.2305319

High sensitivity optical method for objective assessment of the gloss of human skin

A. Ezerskaia, A. Ras, S. F. Pereira, H. P. Urbach, B. Varghese

A. Ezerskaia, A. Ras, S. F. Pereira, H. P. Urbach, B. Varghese, "High sensitivity optical method for objective assessment of the gloss of human skin," Proc. SPIE 10467, Photonics in Dermatology and Plastic Surgery 2018, 104670Z (14 February 2018); doi: 10.1117/12.2305319

SPIE.

Event: SPIE BiOS, 2018, San Francisco, California, United States

High sensitivity optical method for objective assessment of the gloss of human skin

A. Ezerskaia[a,b], A. Ras[c], S. F. Pereira[b], H. P. Urbach[b], B. Varghese[a]
[a] Personal Care and Wellness Department, Philips Research, 5656AE, Eindhoven, The Netherlands
[b] Optics Research Group, Delft University of Technology, 2628 CH, Delft, The Netherlands
[c]Department of Multiphysics and Optics, Philips Research, 5656AE, Eindhoven, the Netherlands

ABSTRACT

We report a low-cost optical method with high sensitivity for the quantitative assessment of the gloss of human skin in the low gloss regime relevant for physiological skin gloss conditions. Using Monte Carlo simulations, experiments on gloss calibration standards and in-vivo skin gloss experiments using an optical prototype, we demonstrate the improved sensitivity of the proposed method in the low gloss regime compared to professional industrial and skin gloss measurement devices.

Keywords: Gloss, skin, dermatology, optical sensing, specular, diffuse, sebum, lipids, oily skin

1. INTRODUCTION

The appearance of the skin resulting from complex optical interactions involving surface specular and subsurface diffuse reflections has been a subject of great interest in the fields of dermatology, cosmetology, and computer graphics [1-5]. The degree of hydration of the stratum corneum and intercellular lipids are important factors for healthy appearance of skin. Recently we demonstrated short wave infrared spectroscopy as a novel, non-invasive and easy-to-apply method for analyzing the stratum corneum water and inter-cellular lipid components [6]. Subsequently, we reported preliminary results demonstrating the feasibility of a novel non-invasive optical method for simultaneously measuring the hydration and sebum retaining ability of the skin [6]. The methods rely on the detection of signals at three carefully selected wavelengths in the spectral region around 1720 nm, with ratio of sebum-to-water absorption coefficient greater than 1; lower than 1 and an ‘isobestic point’, where lipids and water absorb equally.

The presently used methods for skin gloss measurements are based on the ratio of specular to diffuse intensity and the sensitivity of this method in the low gloss regime compared to high gloss regime is rather limited. Even though gloss measurement is an established and standardized procedure in paint and surface coating industry, until now only very limited non-contact devices and methods have been reported for the quantitative measurement of skin gloss and visual grading method remains the main tool for evaluating the skin gloss attributes.

Recently we reported a high sensitivity optical method for measuring skin gloss in the low gloss regime based on number of pixels above a threshold weighted with intensity and slope of the intensity profile in the transition region from specular spot to diffuse background [7]. We have used Monte Carlo ray tracing simulations using the LightTools software to calculate the gloss for a full range samples from 100% specular (mirror) to 100% diffuse (Diffuse standard). We developed an optical prototype and performed experiments on ISO calibration standards in the low to high gloss regime, and compared the results with an Industrial gloss meter (Gardner G85). The temporal evolution of skin gloss during the application of different standards cream bases are compared with professional skin gloss measurement devices Skin gloss meter (Courage & Khazaka) and SAMBA Face gloss measurement system (Bossa Nova Technologies).

In this manuscript, we demonstrate the feasibility for in-vivo skin gloss measurements by quantifying the temporal evolution of skin gloss after application of different standard cream bases on skin which are expected to impart different spatial and temporal gloss changes on skin. The results are compared with professional skin gloss measurement devices (SAMBA, C&K Skin gloss meter).

Photonics in Dermatology and Plastic Surgery 2018, edited by Bernard Choi, Haishan Zeng, Proc. of SPIE
Vol. 10467, 104670Z · © 2018 SPIE · CCC code: 1605-7422/18/$18 · doi: 10.1117/12.2305319

2. MATERIALS AND METHODS

Experimental set-up

The experimental set-up (fig. 1) is based on a low-cost raspberry pi camera module featured with unpolarized white light ring illumination. The sample is sequentially illuminated using four unpolarized white light sources (Luxeon Z white, Lumileds LXZ1-4070) at an angle of incidence with the normal of approximately 22°. A Pi camera utilizes 5-megapixel OmniVision OV5647 imaging sensor of a fixed focus. To achieve a field of view of about 10 × 7.5 mm and a focus at 10 mm, we placed a f = 10 mm lens on the top of this unit. The stop size of the camera is 1.16 mm and to achieve a larger depth of focus we mounted a stop of diameter 0.6 mm between the camera module lens and the f10 lens. The depth of focus and resolving power of the final prototype were 611 µm and 10 µm respectively.

- IMAGING OPTICS:
  - LOW-COST RASPBERRY PI CAMERA MODULE
  - UNPOLARIZED WHITE LIGHT ILLUMINATION
  - FIELD OF VIEW: 10 X 7.5 mm
  - DEPTH OF FOCUS: 611 µm
  - RESOLVING POWER: 10 µm

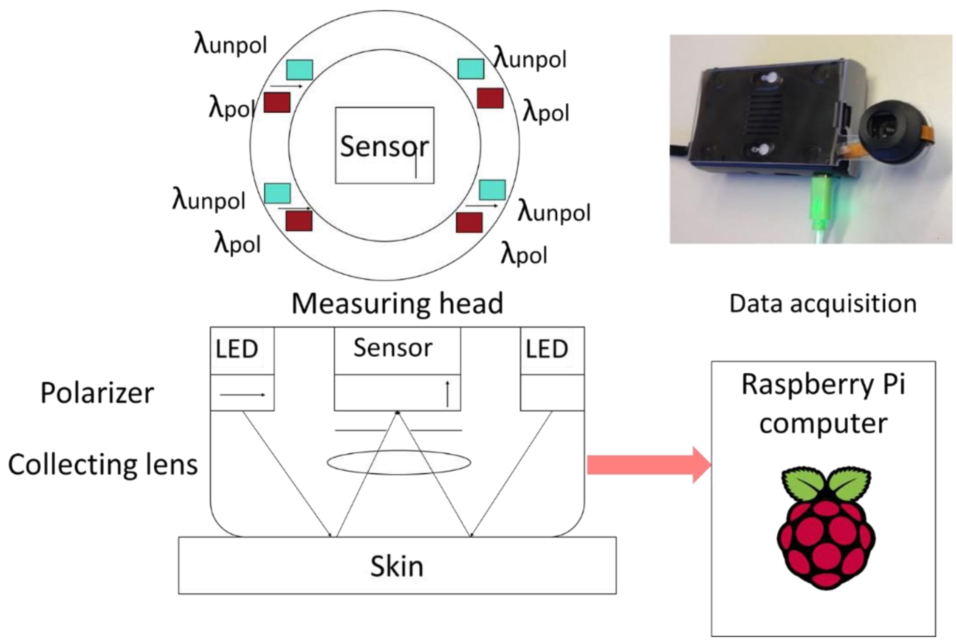

Figure 1. Schematic representation of the experimental set-up and illumination schemes.

Using the prototype, we measured the absorption kinetics of common cream bases: unguentum emulsificans aquosum, uecrin cum aqua, vaseline white, paraffinum perliquidum. The creams (0,5 g per 65,5 cm2) were applied on the forearm of a clinically healthy female volunteer (26 years). The measurements were taken immediately after application, 1 min, 10 min, 20 min and 30 min after application of the creams.

Image processing algorithms for gloss estimation

We propose two approaches for the gloss value estimation. The first method is based on the angle (slope) of the intensity profile as a function of distance in the transition region from specular reflection region to diffuse background. The second method is based on the number of pixels above a threshold weighted with the corresponding pixel intensity. Further details of the method are described in [7].

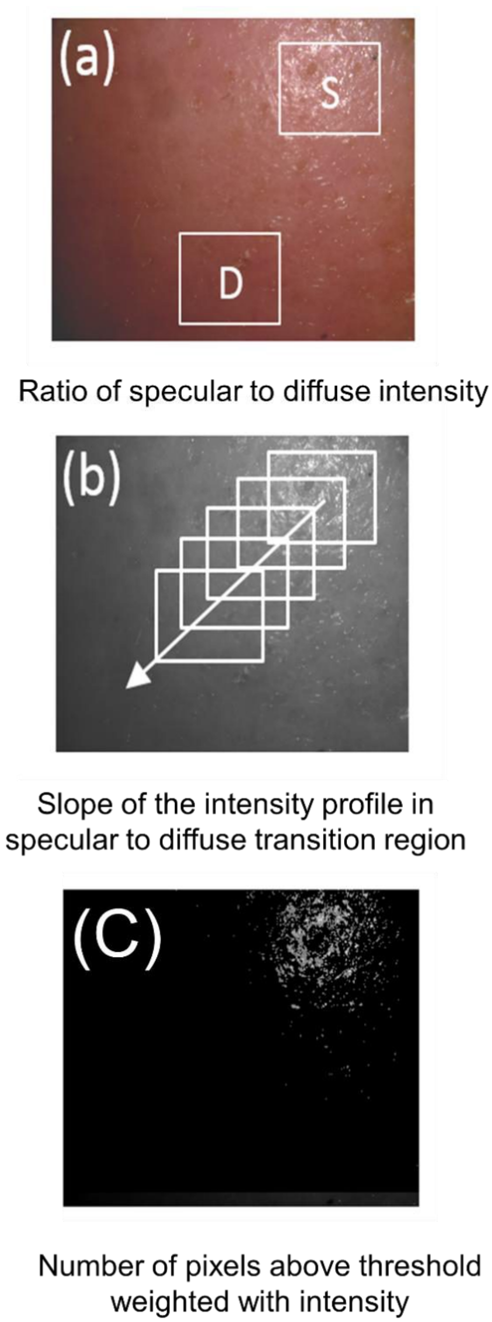

Figure 2. Schematic representation of gloss measurement methods based on specular to diffuse intensity, angle (slope) of the intensity profile in the transition region from specular spot (S) to diffuse background (D) and number of pixels weighted with intensity above a threshold.

The gloss value calculated using the proposed method are compared with the method based on the ratio of the specular to diffuse reflection, used in traditional gloss measurement devices such as Gardner Gloss meter (Micro-Tri-Gloss) and Skin gloss meter (Courage & Khazaka). Reference gloss measurements were performed using a professional gloss measurement device from Bossa Nova Technologies, SAMBA and industrial gloss meter from Gardner. SAMBA consists of a high resolution digital camera equipped with a liquid–crystal polarizer, the polarization angle of which can be electronically flipped from the direction parallel (P) to the plane of polarization of the polarizing filters on the illumination units to crossed (C) orientation. A Region of Interest (ROI) on the sample was chosen for the measurement. SAMBA device measures polarization state on each pixel in the entire ROI and then calculates the average value of calculate gloss (P-C) and gloss degree (P-C/P+C).

3. RESULTS AND DISCUSSION

Figure.3 shows the examples of images measured with the optical prototype for three different gloss values in the low gloss regime. As the gloss value of the sample is increased, the magnitude of the specularly reflected light increases whereas the diffuse background signal decreases. Figure.4 shows the gloss value estimated using the methods based on slope, weighted sum over pixels above threshold and specular to diffuse ratio. The results of comparing the proposed methods to the standard ratio between specular and diffuse reflection show that the sensitivity of the two novel methods is high for samples in the low gloss regime. Therefore we expect that our methods are very suitable for measuring gloss values of skin, since, unlike material surfaces in industry, these are low and change only within a very small range. On the other hand, the sensitivity of the traditional specular to diffuse intensity ratio method is high for high gloss samples.

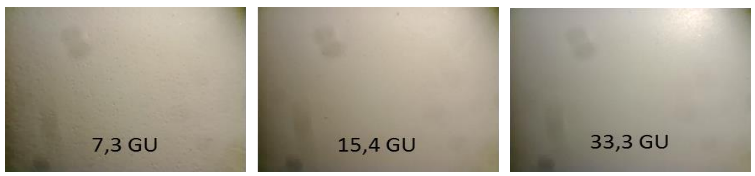

Figure 3. Sample photo of low-gloss standards measured with optical prototype

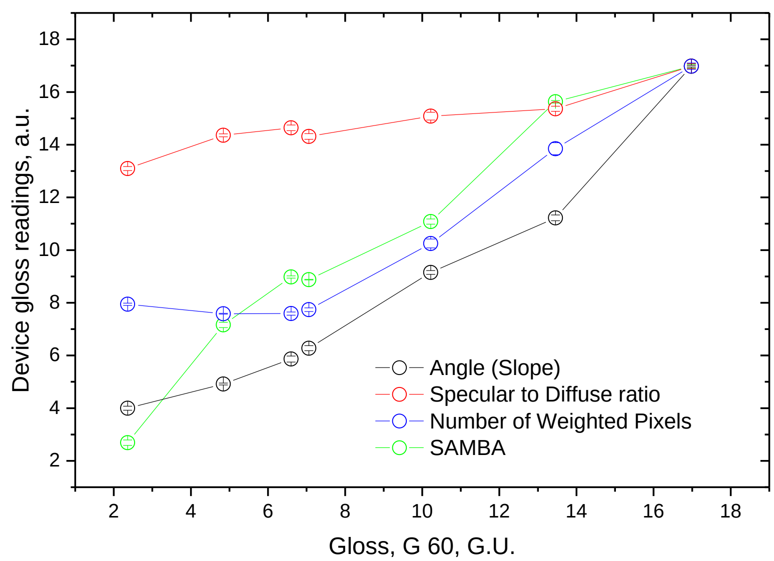

Figure 4. The gloss values estimated on gloss papers in the low gloss regime using different methods and its comparison to professional gloss measurement devices.

Figures.5 shows the temporal evolution of skin gloss value after the application of paraffin and vaseline creams to the skin. The results obtained using our optical prototype are compared with professional gloss measurements devices such as Courage & Khazaka and SAMBA. All measurement methods give increased gloss value within the first minute after the application of paraffin or Vaseline. Even though both paraffin and Vaseline are water-free bases, the temporal evolution of the gloss value of the skin are significantly different due to the difference in the physical properties and lipid profile [8]. Vaseline is applied in solid form, which prevent it from spreading. It is preserved as a thin layer with nearly uniform thickness which does not change with time during the measurements. Therefore the in-vivo gloss values do not vary significantly during the study. Paraffin is applied in a liquid form, which spreads on the skin surface beyond the application area. Such a behavior ensures a decrease in the gloss value with time in the area of interest. The performance and linearity of the method compared with different conventional professional gloss measurement devices showed improved sensitivity for quantifying the temporal evolution of skin gloss as an indicator of resorption kinetics.

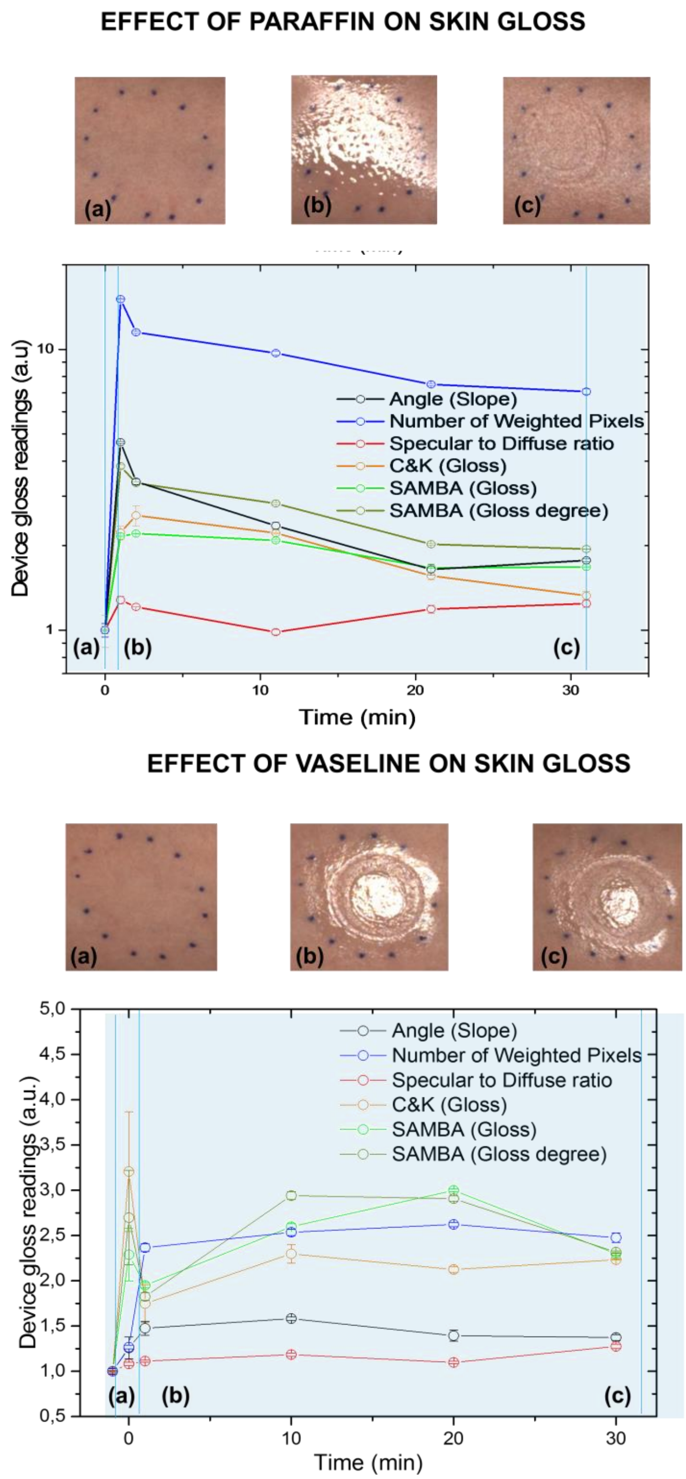

Figure 5. The temporal evolution of skin gloss values after application of paraffin (top) and Vaseline (bottom) creams. Experimental results obtained with the camera prototype are compared with professional devices for skin gloss measurements.

4. CONCLUSIONS

We demonstrate a low-cost optical method with improved sensitivity for the quantitative assessment of the gloss of human skin in the low gloss regime relevant for skin gloss conditions. Temporal quantification of skin gloss using the novel methods showed improved sensitivity in the low gloss regime relevant for skin gloss conditions. The proposed method opportunities in the fields of cosmetology and dermatopharmacology: quantitative, fast, contactless assessment of skin gloss in measuring the resorption kinetics and pharmacodynamics of various external agents.

REFERENCES

[1] J. Ripoll, D. Yessayan, G. Zacharakis, V. Ntziachristos, "Experimental determination of photon propagation in highly absorbing and scattering media," JOSA A 22(3), 546-551 (2005).

[2] W. Ji, M. Pointer, R. Luo, J. Dakin, “Gloss as an aspect of the measurement of Appearance,” JOSA A 23 (1), 22–33 (2006).

[3] T. Igarashi, K. Nishino and S. K. Nayar, “The Appearance of Human Skin: A Survey, Foundations and Trends in Computer Graphics and Vision,” Foundations and Trends® in Computer Graphics and Vision, 3(1), 1–95 (now Publishers Inc, 2007).

[4] K. Xiao, N. Liao, F. Zardawi, H. Liu, R.Van Noort, Z. Yang, M. Huang, J. Yates, “Investigation of Chinese skin colour and appearance for skin colour reproduction,” OSA, 10(8), 083301 (2012).

[5] M. Gupta, A. Gupta, “Dissatisfaction with skin appearance among patients with eating disorders and non-clinical controls,” Br J Dermatol, 145(1), 110–113 (2001).

[6] A. Ezerskaia, S. Pereira, P. Urbach, R. Verhagen, B. Varghese, “Quantitative and simultaneous non-invasive measurement of skin hydration and sebum levels,” Biomed Opt Express, 7(6), 2311–2320 (2016).

[7] A. Ezerskaia, A. Ras, P. Bloemen, S. Pereira, P. Urbach, B. Varghese, “High sensitivity optical measurement of skin gloss,” OSA, 8(9), 3981–3992 (2017).

[8] A. Lentner, V. Wienert, “Ä new method for assessing the gloss of human skin,” J Skin Pharmac, 9, 184–189 (1996).