Skin Erythema Assessment by an RGB Imaging Device: a Clinical Study

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Abstract

In this study, skin erythema assessment of 50 *rosacea* patients was estimated by a simple, low-cost RGB imaging device. RGB imaging can be used to estimate the level of redness by analyzing absorption in the green and red spectral channels of a simple RGB camera, as there is an increased absorption of skin chromophore hemoglobin in the spectral range of 500-600nm (corresponding to the green channel) and very little absorption of hemoglobin in the spectral range of 600-700nm (red channel). Different algorithms are used for comparison, and a new erythema index assessment algorithm is proposed and clinically validated. Comparison with dermatologist's visual assessment shows high correlation.

Introduction

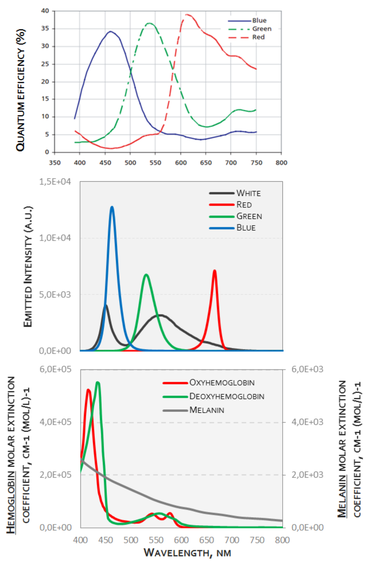
Rosacea is a chronic skin disorder affecting mostly central part of facial skin (cheeks, chin, nose and forehead) by increased redness, visible blood vessels, and can further develop to pimples. Although the cause of it is still unknown and it is not possible to completely cure it, there are methods that can reduce the redness of facial skin [1].

Different commercially available devices are already available and used in clinics (e.g. *Mexameter*®, *Chromameter*®, *DermaSpectrometer*®), however, there is still a need for a more precise and reliable technique for skin erythema estimation [2].

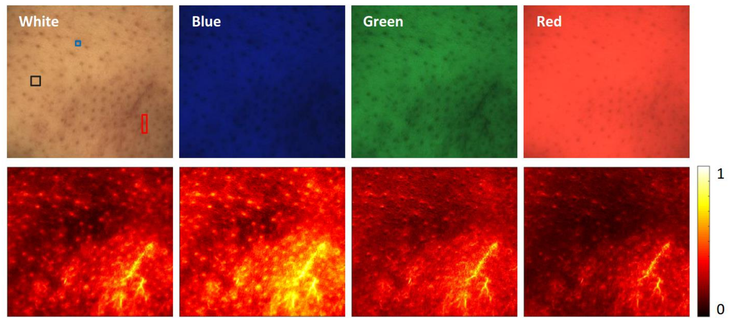
RGB Imaging Device

SkImager is a handheld wireless, battery-powered device that comprises a 3 Mpix CMOS sensor color camera (*Micron* MT9T031) surrounded by a ring-shaped LED illuminator emitting white, blue (460nm), green (530nm) and red (665nm) spectral bands, linear polarizers in front of the LEDs and the camera, oriented orthogonally to each other (in order to suppress the specular reflection, an on-chip microcomputer, a touchscreen and an SD memory card.

The distance between skin surface and the detector is kept constant at 50 mm and the device touches skin surface so that outside light does not reach the detector. Skin area of 30 mm in diameter can be evaluated.



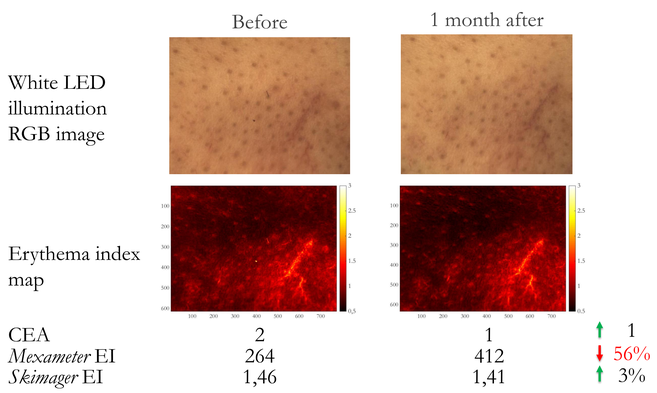
Erythema Index assessment



$$EI_{RG} = \frac{I(R)}{I(G)} \qquad EI_{BC} = \frac{I(G) - I(R)}{I(G) + I(R)} \qquad EI_{BRG} = \frac{\sqrt{I(B) \cdot I(R)}}{I(G)} \qquad \mathrm{EI_{BG}} = 100 \cdot \frac{I(B)}{[I(G)]^2}$$

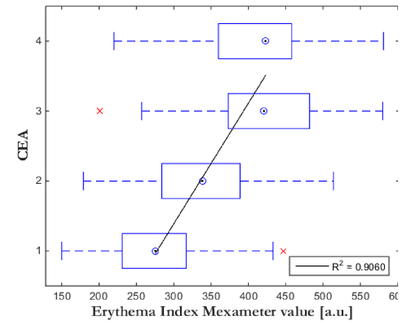
	Normal skin	Blood vessels	Pigmentation	Contrast of Blood vessels and Normal skin	Contrast of Pigmentation and Normal skin
EI_{RG}	0,11 ± 0,01	0,91 ± 0,05	0,61 ± 0,12	8,64 ± 0,43	5,81 ± 0,70
EI_{BC}	0,18 ± 0,02	0,95 ± 0,03	0,75 ± 0,10	5,15 ± 0,16	4,04 ± 0,41
EI_{BRG}	0,17 ± 0,02	0,90 ± 0,05	0,58 ± 0,13	5,40 ± 0,31	3,44 ± 0,45
EI_{BG}	0,09 ± 0,01	0,89 ± 0,06	0,48 ± 0,13	10,29 ± 0,67	5,53 ± 0,72

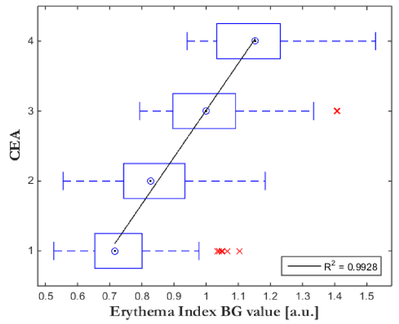
Example



Results

For 500 total measurements three data sets were analysed: CEA, *Mexameter* and *SkImager* erythema estimation values. All 500 measurements were divided in four groups, depending on the corresponding CEA value of each measurement, and boxplots, created with *Matlab*, show the correlation of CEA and EI_M values, acquired by *Mexameter*. The box in the plot represents all data of 25th to 75th percentiles; the lines include 99,3% of all the data, and the red crosses represent outliners. The blue dots in the box represent the medians, and linear fitting of medians and CEA values was done to acquire the coefficient of determination R^2.





Conclusions

In this study, for the first time in authors' knowledge, different in literature available erythema index estimations are compared in terms of how well they distinguish skin region of increased redness and normal skin. Commonly used method of visual assessment of facial erythema by an experienced dermatologist (CEA) is compared to commonly used single-spot optical measurement device (*Mexameter*). In addition, an RGB imaging technique is proposed and clinically validated for a more accurate and reliable estimation of skin erythema; also a new erythema index estimation algorithm is proposed using only blue and green spectral images. In conclusion, this study shows that single-spot measurements might not be very reliable when compared to the RGB imaging even though they are often used in clinical studies. RGB imaging shows a much better correlation with dermatologists' estimation and shows more reliable results. A new erythema index estimation algorithm was proposed, and it demonstrates a better contrast between blood vessel and normal skin regions than other algorithms.

References

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Acknowledgements

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