Smartphone single-snapshot mapping of skin chromophores

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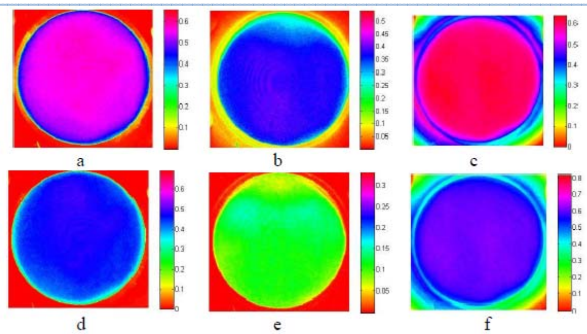
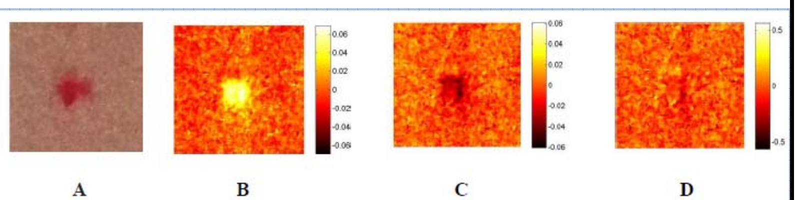
Suitability of smartphone for single-snapshot mapping of skin melanin, oxy-hemoglobin and deoxy-hemoglobin under 3-wavelengths illumination was demonstrated. Simultaneous 448-532-659 nm illumination was provided by a portable laser-based prototype.

Monochromatic spectral imaging at several fixed wavelengths is a promising technology for fast and reliable parametric mapping of skin. Three monochromatic spectral images can be extracted from a single RGB image data set at simultaneous 3-wavelength illumination, which makes possible to map three different chromophores by a single snapshot [1]. Previously, a table-top RGB camera setup was used to provide simultaneous illumination of skin by the 473nm, 532 nm and 659 nm laser lines; physiologically reasonable distribution maps of melanin, oxy-hemoglobin and deoxy-hemoglobin in pigmented and vascular skin lesions have been obtained [2]. Here we present the first data obtained by a portable smartphone-based system [3].

Three pairs of laser modules emitting at 448 nm, 532 nm and 659 nm (models *PGL-DF-450nm-20mW-15011564, PGL-VI-1-532nm-20mW-15030443* and *PGL-DF-655nm-20mW-150302232*, CNI) were exploited as emitters for skin illumination. Lasers of each pair were mounted at opposite sides on the internal wall of a hollow cylinder 6. All six collinear laser beams were directed to the 45-degree sloped reflecting edge of the disc 3. Its internal part comprised a ring-shaped diffuser 4 that mixed all the incident beams and served as a 3-wavelength illuminator of skin at the bottom of this cylinder. The smartphone (model *Google Nexus5*) was placed on sticky flat platform 5 with a window for the rear camera. The opening was covered by a film polarizer; another film with orthogonal direction of polarization covered the diffuser from bottom, so avoiding detection of the skin surface-reflected light. Electronic circuits and batteries were placed in the compartment 6 below the platform 5.



Uniformity of white paper illumination at different illumination-detection combinations: a – R-image at 659nm; b – G-image at 532nm; c – B-image at 448nm; d, e and f – R-, G- and B-images at simultaneous 3-wavelength illumination.



RGB image (A) and the corresponding chromophore maps of skin hemangioma: B – oxy-hemoglobin, C – deoxy-hemoglobin, D – melanin.

Results and Conclusions

The mobile system passed the first clinical tests; 64 vascular and pigmented skin lesions were examined. For illustration, a color photo of skin hemangioma (vascular pathology) taken under the 3-wavelength illumination (A) is compared with the calculated concentration distribution maps of the three main skin chromophores, relatively to the adjacent healthy skin. As expected, increased content of oxy-hemoglobin in the vascular pathology region due to enhanced arterial blood supply has been recorded (B); correspondingly decreased relative content of deoxy-hemoglobin in hemangioma appears (C), while the content of epidermal melanin remains practically unchanged (D).
This study seems to be the first attempt of mapping skin chromophores by smartphone camera under combined spectral line illumination. Physiologicaly adequate data on chromophore distribution in skin pathologies have been obtained. The proposed relatively simple and inexpensive approach might find real clinical and forensic applications.
Future work: (i) to minimize laser speckle artefacts at the illumination area; (ii) to improve the image processing algorithm with respect to light scattering in skin; (iii) to expand the range of chromophores to be mapped – e.g. to add bilirubin which shows up in skin bruises and cases of hyperbilirubinemia (eventually, by a double-snapshot technique).

References
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