Visible-NIR multispectral imaging of whole-body human skin

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Motivation and Aim: To ensure efficient whole-body dermoscopy diagnostics and early screening of skin cancers, a laser multi-spectral-line imaging technique covering visible and near infrared (NIR) ranges has been developed.

Novelty: To our best knowledge, this is the first attempt to obtain and analyze a set of four spectral line images (three visible and one near-infrared), related to large areas or the whole body of human skin. Visible spectral images ensure sorting of malformations as pigmented or vascular, as well as mapping the distribution of three main skin chromophores over the malformations [1, 2]. In addition, the NIR images help to identify deeper (dermal) skin tumors, including malignant melanomas [3].

Methods: The snapshot multi-spectral-line imaging method [4] is applied in this study. Four laser spectral line (450 nm, 520 nm, 638 nm and 850 nm) illumination source is a side-emitting optical fiber spiral, Y-coupled to 3W RGB and 4W NIR lasers via SMA connectors – see Figure 1. High-resolution 61 Mpx Sony camera with removed infrared cut-off filter is placed within the illuminating fiber spiral. The camera-illuminator platform can be moved vertically up and down at typical heights 0.5 m and 1.5 m, while the patient changes his/her body position relatively to the camera, to enable imaging of any part of his/her skin with suspicious malformation(s). To avoid ambient illumination, the system and the patient are covered by a light-shielding tent. The system is operated from outside by means of Wi-Fi. Spectral line images are extracted from the camera digital image data set as described in [2].

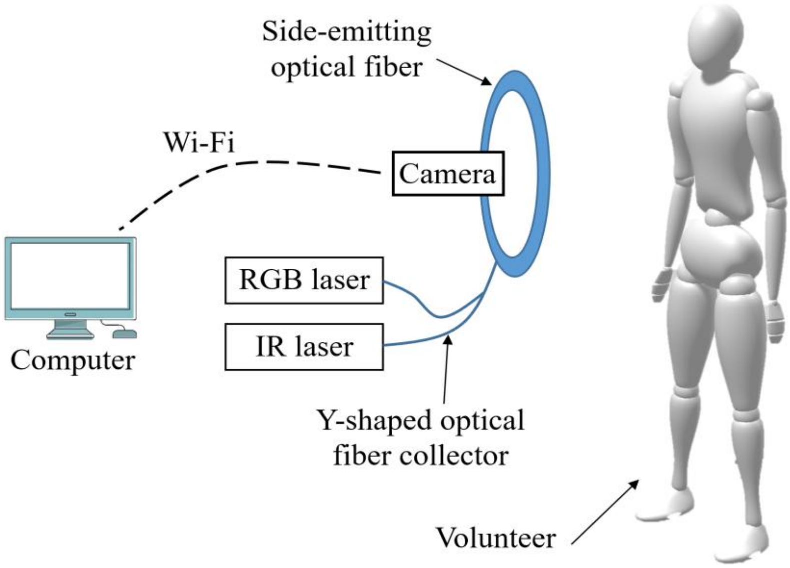

Figure 1. Schematic of the laser multispectral imaging setup.

Main results: Sets of four spectral line images (B - 450 nm, G - 520 nm, R – 638 nm, IR – 850 nm) of volunteer skin fragments comprising malformations in grayscale have been collected, the spectral image ratios were calculated, as well. In most cases, the number of malformations detected in the visible spectral images exceeded that detected in the 850 nm image, or all malformations disappeared at 850 nm; the image contrast always decreased with wavelength. A few malformations detected at all wavelengths most probably comprised higher chromophore concentration and/or were deeper penetrated in skin. At this stage of the project, only sets of distant skin spectral images of "relatively healthy" volunteers have been collected, without any clinical specifications of the imaged malformations. Clinical measurements with involvement of dermatologists are planned in March-August 2025, so by the time of conference enough oncology patient data would be available to discuss in more detail the potential advantages/disadvantages of this technology for skin cancer detection and early screening.

Conclusion: A new spectral imaging technology for distant assessment of skin tumors has been proposed, implemented and tested on volunteers. The set of combined 450/520/638/850 nm spectral images show a potential for advanced quantitative clinical diagnostics in dermatology.

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