

MULTISPECTRAL ASSESSMENT OF SKIN MALFORMATIONS
USING A MODIFIED VIDEO-MICROSCOPEA. Bekina¹, I. Diebele¹, U. Rubins¹,
J. Zaharans¹, A. Derjabo², J. Spigulis¹¹Biophotonics Laboratory, Institute of Atomic Physics and Spectroscopy,
University of Latvia,
19 Raina Blvd., Riga, LV-1586, LATVIA²Latvian Oncology Center,
4 Hipokrata Str., Riga, LV-1006, LATVIA
e-mail: abekina@gmail.com

A simplified method is proposed for alternative clinical diagnostics of skin malformations. A modified digital microscope, additionally equipped with a four-colour LED (450 nm, 545 nm, 660 nm and 940 nm) subsequent illumination system, was applied for assessment of skin cancerous lesions and cutaneous inflammations. Multispectral image analysis was performed to map distributions of skin erythema index, bilirubin index, melanoma/nevus differentiation parameter, and fluorescence indicator. The skin malformation monitoring has shown that it is possible to differentiate melanoma from other pathologies.

Key words: skin malformations, video-microscope *Dino-Lite Pro*.

1. INTRODUCTION

Incidences of benign and malignant skin lesions like common nevi, basal cell carcinomas and melanomas are increasing all over the world. Benign lesions mostly present only a cosmetic defect, while malignant lesions can be lethal for the patient; therefore, additional information about the pathology is important in order to determine the patient's further treatment.

The diffuse reflectance spectrum of skin contains absorption bands of different composition. Spectral differences between the normal and the pathological skin tissues can be used for early detection of melanoma and other pathologies. So far, the research using a multispectral imaging camera *Nuance EX* has shown that the melanoma differs from other pathologies with a higher erythema index and the melanoma/nevus differentiation parameter p values [1, 2]. Multispectral imaging technologies are well adapted for such applications [3]; however, the commercially available multispectral cameras with tuneable filters, confocal microscopes and Siascopes are too expensive for routine skin diagnostics. Alternatively, spectral images can be obtained by narrowband illumination of skin, e.g. using light-emitting diodes (LEDs) of different colours and inexpensive consumer cameras such as dermascopes.

2. METHODS AND EQUIPMENT

Figure 1 shows the measurement setup. The illumination system of a commercial video-microscope (model *Dino-Lite Pro*) was modified in order to obtain a set of images of the same skin location at different wavelengths: 450 nm (blue), 545 nm (green), 660 nm (red), and 940 nm (infrared); more detailed description of this device can be found in [4].

The wavelengths were chosen consciously. Blue light (450 nm) penetrates less than 1mm in depth and provides information about superficial layers of the skin [5]. Green light (545 nm) provides information about blood distribution in the skin. Red light (660 nm) penetrates into the skin tissue several millimetres in depth and provides information about melanin. Infrared light (940 nm) provides the information about deeper skin layers.

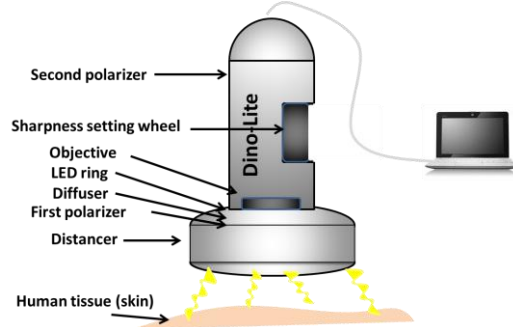


Fig. 1. The measurement setup: video-microscope *Dino-Lite Pro*, light source, diffuser, polarizer and computer.

Figure 2 illustrates structurally the measurement system. During a measurement the skin area is sequentially illuminated by light-emitting diodes at different wavelengths. The light from LEDs passes through a diffuser and a polarizing film. Reflected and back-scattered light from the skin passes through an objective lens into a video-microscope camera. To avoid artefacts caused by light reflection from the skin surface the polarization of illuminating light was orthogonal to the orientation of the polarizer located in a *Dino-Lite* video-microscope. To sequentially switch diodes a program module was created. The module written in MatLab application automatically controls the intensity of LED source and captures images at 450, 545, 660 and 940 nm wavelength [4]. In this simplified system various maps were calculated: the erythema index, the bilirubin index, the melanoma/nevus differentiation parameter and the fluorescence indicator.

Simplified methods for the erythema index calculation are based on comparison of the skin optical density in green light (~ 560 nm), where the haemoglobin absorption is high, and red light (~ 650 nm), where the haemoglobin absorption is low [6]:

$$E = I_{660} / I_{545}, \quad (1)$$

where I_{660} and I_{545} are the intensities of diffuse red and green light, respectively, reflected from the skin.

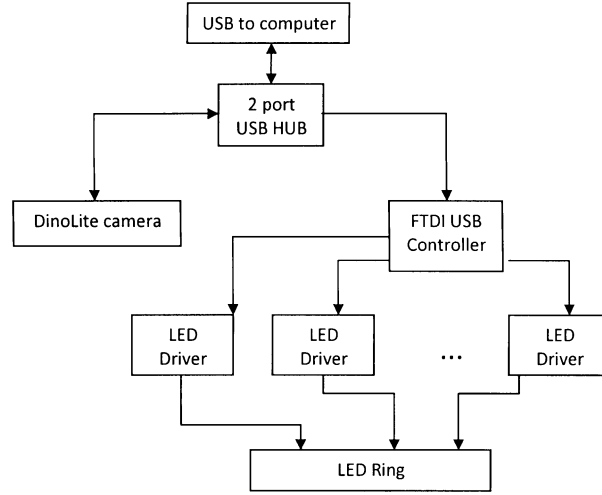


Fig. 2. Block diagram of Dino-Lite appendix.

Whereas the bilirubin absorption peak is at 450 nm while at 660 nm the absorption is close to zero [7], the bilirubin index was calculated using the formula:

$$B = I_{450} / I_{660}, \quad (2)$$

where I_{450} and I_{660} are the intensities of diffuse blue and red light reflected from the skin.

To calculate melanoma/nevus differentiation parameter p , the mathematical expression for the optical density [8] was converted for intensities of diffuse light reflected from the skin:

$$p = I_{545} / (I_{660} \times I_{940}), \quad (3)$$

where I_{545} , I_{660} and I_{940} are the intensities of diffuse green, red and infrared light, respectively, reflected from the skin.

The wavelength of 545 nm corresponds to the maximum absorption of blood [5], while at 650 nm the haemoglobin absorption is minimal, the melanin absorption is more pronounced [9], and 940 nm is the longest available wavelength corresponding to the deepest penetration under the skin surface [10].

The fluorescence mapping is obtained by irradiation with blue light, taking into consideration the changes in the green channel.

3. RESULTS AND DISCUSSION

Figure 3 shows the multispectral images at 450 nm, 545 nm, 660 nm, and 950 nm, the calculated erythema, bilirubin, parameter p and the fluorescence maps for a benign papilloma (histologically confirmed). The real-time maps show that the pathological tissue has higher blood content than the normal surrounded skin. The map of bilirubin index shows a low bilirubin concentration in this particular pathology. The low values of parameter p indicate the absence of melanoma, i.e. this is non-melanoma malformation. The fluorescence of this pathology is very low, which could be explained by the low intensity of blue LEDs.

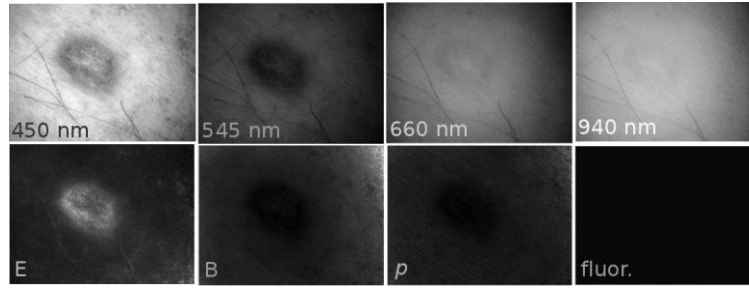


Fig. 3. Multispectral images and parametric maps of skin papilloma.
 Intensities of light reflected from skin: blue 450 nm, green 545 nm, red 660 nm, and infrared 940 nm.
 E: erythema index; B: bilirubin index; p : melanoma diagnostics parameter;
 fluor.: fluorescence indicator.

Figure 4 presents the multispectral images at 450 nm, 545 nm, 660 nm, and 950 nm, the calculated erythema, bilirubin, parameter p and fluorescence maps for a malignant melanoma (histologically confirmed). It is clearly seen that the melanoma has higher erythema and bilirubin indices than the normal skin around the pathology. The high parameter p values indicate that the pathology is melanoma, which coincides with the histological data. The fluorescence map shows very low values, which could be explained by the low intensity of blue LEDs.

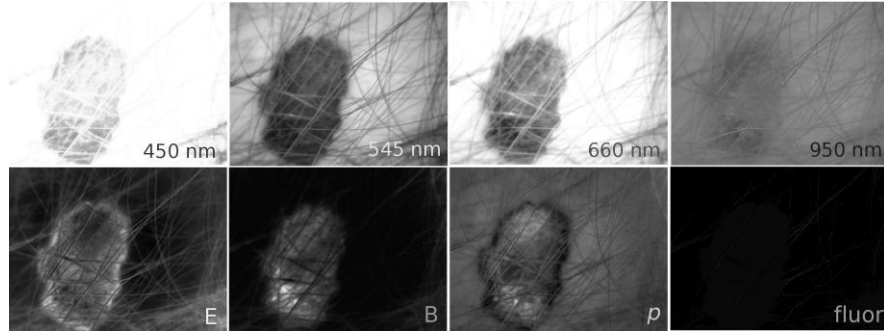


Fig. 4. Multispectral images and parametric maps of malignant melanoma.
 Intensities of light reflected from skin: blue 450 nm, green 545 nm, red 660 nm, and infrared 940 nm.
 E: erythema index; B: bilirubin index; p : melanoma diagnostics parameter;
 fluor.: fluorescence indicator.

4. CONCLUSIONS

The measurements have been performed on a small number of patients, however the first results show that it is possible to detect erythema and bilirubin in skin pathologies as well as calculate the melanoma diagnostics parameter p . The results evidence that melanomas differ from other pathologies with higher p values. All pathology cases show that the blood content in a malformation is higher than in healthy skin around the pathology. It is necessary to determine how well the calculated bilirubin maps correlate with the actual bilirubin concentration in the pathologies.

The obtained fluorescence indicator map shows a low fluorescence signal. It is possible that the blue LED intensity is too low to excite fluorescence of the skin.

The modified commercial video-microscope (Dino- Lite Pro) allows obtaining the parameters that characterize the nature of a particular malformation. The proposed simple and inexpensive system shows a potential for clinical diagnostics. To realize it, further investigations are required.

ACKNOWLEDGEMENTS

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ĀDAS VEIDOJUMU MULTISPEKTRĀLS NOVĒRTĒJUMS, IZMANTOJOT PĀRVEIDOTU VIDEOMIKROSKOPU

A. Bekina, I. Diebele, U. Rubins, J. Zaharans, A. Derjabo, J. Spigulis

Kopsavilkums

Darba mērķis bija pārbaudīt pārveidoto Dino-Lite iekārtu uz dažādām ādas patoloģijām- gan labdabīgām, gan ļaundabīgām. Tika iegūti multispektrāli attēli pie dažāda viļņa garuma apgaismojumiem, kā arī aprēķinātas eritēmas indeksa, bilirubīna indeksa, melanomas diagnostikas parametra p un fluorescences kartes. Tas ļaus neinvazīvi diagnosticēt iespējamo patoloģiju īsā laikā, kas atvieglos darbu dermatologiem, lai neveiktu biopsiju, pēc kuras palielinās melanomas metastāzes risks. Attēli tika uzņemti brīvprātīgiem Onkoloģiskā Centra pacientiem ar dažādām ādas patoloģijām pie viļņu garumiem – 450 nm (zilais spektra apgabals), 545 nm (zaļais), 660 nm (sarkanais) un 940 nm (infrasarkanais).