Use Of The Multispectral Light Source For The Processing and Analysis Of Skin Pathologies Images

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***Abstract*— The article deals with the problems arising in the malignant skin neoplasms diagnosis. The inconsistency of modern methods of diagnostics on the basis of data obtained while visual assessment of skin conditions is shown. The necessity of new means for early diagnostics of skin pathologies realization, for example, on the basis of a multispectral radiation source in the short-wave optical, ultraviolet and infra-red ranges proposed in the work is proved. A series of images of the skin area with a benign neoplasm were taken in selected optical bands, and differences in the images when illuminated with the used wavelengths were analyzed. The need in digital processing of the obtained images is demonstrated to minimize disturbances caused by irregularities in the skin covering as well as by the presence of non-informative skin structures such as hairs, keratinized epithelium, etc. The images were improved by means of their equalization as well as the complex use of the Laplace filter and the spatial maximum filter. Intensity distribution graphs are plotted to demonstrate the image enhancement as well as to confirm the necessity of the realized light source for the early diagnosis of skin pathologies. Conclusions are made about the possibility of using this method in the diagnosis of malignant neoplasms and the practical relevance of the research in medicine and oncology.**

Keywords— diagnosis of skin abnormalities, skin malignancies, infrared range, ultraviolet range, shortwave optical range, MATLAB, Image Processing Toolbox, intensity distribution, Laplace-filter, spatial filter.

I. Introduction (*Heading 1*)

WHO data for 2022 [1] show a steady increase in the number of cases of skin cancer and an increase in late-stage diagnoses, so that diagnosis of skin malignancies remains an urgent problem. The problems encountered in making a diagnosis are primarily due to the insufficient informative value of the results obtained during visual inspection of skin pathologies, as the optical range of the human eye is limited [2-3]. In addition, analysis and processing of information is hampered by the presence of irregular skin layers, hairs, keratinized epithelium, etc. One solution may be to develop a unique method for image processing of skin neoplasms based on an advanced multispectral light source in the short-wavelength optical, ultraviolet (UV) and infrared (IR) bands. As shown in [4], the short-wavelength optical band is actively absorbed by the chromophore melanin, which is abundant in neoplasm structures and associated pigmentation, which may contribute to the early diagnosis of skin pathologies during image processing and analysis. In addition, near-infrared is of diagnostic interest due to the narrow absorption band [5-6]. This makes analysis of internal tissues and skin structures possible, as the IR passes through the surface layers of the epithelium. Processing images in the short wavelength range is difficult because melanin, which is not only found in the area of neoplasms and pigmentation but also in other skin structures, absorbs the wavelengths used, making computer analysis of the images difficult. This problem can be solved by applying digital image processing including histogram equalisation, which expands the gradational scale of brightness and improves the image, and complex spatial filtering which minimises interference [7]. Thus, the aim of this work is to study skin areas with neoplasms using a multispectral radiation source with a software-controlled spectrum developed in the laboratory of radio- and optoelectronic devices for early diagnosis of pathologies of living systems of IAI RAS under the supervision of Prof. K.V. Zaichenko, Doctor of Technical Sciences.

II. Description of the light source layout

The experimental setup used in this study, shown in Figure 1, consists of two LED boards placed at a 90° angle to the object (6). The LEDs on both boards are arranged radially to provide a uniform shadowless illumination.

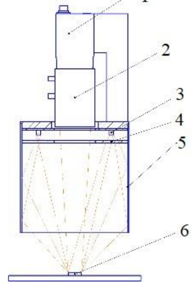

Fig. 1. Experimental setup including: 1 – TV camera, 2 – lens, 3 – light source, 4 – frosted glass, 5–matte reflector, 6– object

One of the boards (3) contains LEDs with wavelengths of 500 nm (green), 470 nm (blue-green), 415 nm (blue), 385 nm (near ultraviolet 1), 370 nm (near ultraviolet 2). Software control of the wavelength is achieved by switching the LEDs by feeding the current from the microcontroller connected via USB to the selected LED. The light source is additionally equipped with frosted glass (4) and a frosted side reflector (5) to minimise light scattering and the influence of shadows from skin topography. The study uses a TV camera (1) with a long-focus lens (2) to capture two-dimensional black-and-white images.

III. Experimental results:

Two series of experiments were carried out in this study: 1) – a study of an area of skin with a benign neoplasm in the abdominal region using short- wavelength optical and near-ultraviolet light, and 2) – a study of the same area using near-IR light. For the shortwave optical images, digital processing was carried out to enhance the images and intensity distribution graphs were plotted for a sample of pixels in the neoplasm area.

A. Optical and UV bands

Figure 2 shows the images obtained for the above wavelengths in the optical and UV bands. From the above images we can judge that additional pigment spots around the neoplasm appear as the wavelength decreases, which is of interest for early diagnosis of malignant skin neoplasms, as this type of pathology is almost always accompanied by pigmentation. Thus it is possible to judge the possibility of early diagnosis of skin abnormalities using the short-wavelength radiation spectrum.

Fig. 2. Images of a neoplasm when illuminated with (a) green, (b) blue, (c) near-ultraviolet 1

B. Near-infrared illumination

Figure three shows an image of a skin area using near-infrared illumination.

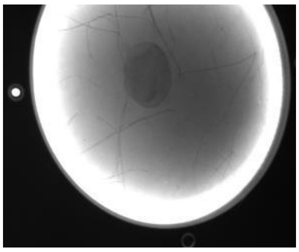

Fig. 3. Images of a neoplasm when illuminated with near-infrared

From the above image, the presence of a mass that is invisible in the visual diagnosis and in the optical wavelength range can be judged. The results are of particular interest for the early diagnosis of skin cancer.

IV. Digital Image Processing

Figure 3 (a) shows an image of a skin area with a neoplasm under 385 nm illumination after applying a complex spatial filter including a Laplace filter and a maximum filter. The filter has eliminated the interference of skin hairs. The contours of the pigment spots are blurred, which should be considered in further processing. Figure 3 (b) shows intensity distribution plots for a sample of pixels in the neoplasm area before and after filtering. In addition to the intensity dip corresponding to the neoplasm, a minimum in the area of associated pigmentation, unnoticeable on visual diagnosis, is noticeable.

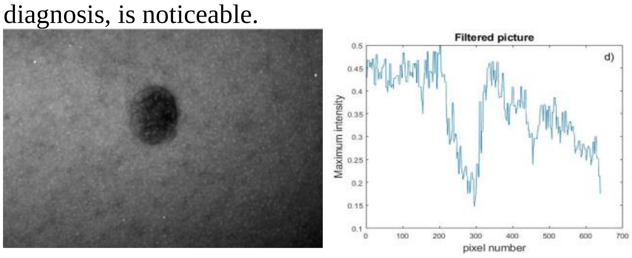

Fig. 4. (a) Images of a neoplasm after filtering, (b) – intensity distribution

V. Conclusion

Based on the series of experiments performed, it can be concluded that a comprehensive examination of cutaneous neoplasms by illumination with both short- wavelength optical and near-UV and near-infrared wavelengths is necessary. It is concluded that digital image processing is necessary to minimise interference caused by keratinised epithelium, hairs and skin irregularities. These studies contribute to the development of a new unique method of multispectral diagnosis of skin cancer.

Acknowledgment *(Heading 5)*

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