Automatic Malignant Melanoma recognition using a Dermatoscopy Imaging Tool

O.A. Melsitov[1], V.P. Sherendak[1], S.G. Konovalov[1], O.O. Myakinin[1]

[1]Samara National Research University, 34 Moskovskoe Shosse, Samara, Russia, 443086

Abstract. In this paper, we present the results of analysis of 56 in vivo multispectral dermatoscopy images of Malignant Melanoma and other benign and malignant skin tumors. The special own developed dermatoscopy tool analyzes pictures of suspicious skin areas and makes a decision using a special software based on texture and color analysis, which raise up the accuracy of diagnosis. Using our software, high accuracy (96% sensitivity and 89% specificity) in the personalized mode for melanoma has been achieved, which means a principal opportunity of effective excluding similar formations that are not melanoma. Additionally, considering to the high speed and accuracy of the automatic recognition, the proposed dermatoscopy tool can be used for screening procedures.

Keywords: Melanoma detection, dermatoscopy, melanoma recognition, image analysis.

1. Introduction

Due to disappointing statistics, cancer diseases show us one of the acute problems. According to the Global Burden of Disease (GBD) methodology, there were 17.5 million cancer cases, 8.7 million deaths, and 208.3 million DALYs (Disability-Adjusted Life Year) in 2015. Between 2005 and 2015, incident cancer cases increased by 33%, of which 12.6% were due to population growth, 16.4% due to an aging population, and 4.1% due to increasing age-specific incidence rates [1]. Skin cancer is the most common type of cancer in the United States. Each year, more than 68,000 Americans are diagnosed with melanoma, and another 48,000 are diagnosed with an early form of the disease that involves only the top layer of skin [2].

Malignant Melanoma (MM) is the most dangerous oncological skin disease and, as a rule, rapidly progresses, spreading metastases throughout the body. The problem of its recognition is still vital. For example, referral sensitivity, specificity, positive and negative predictive values for MM made by a physician without special diagnostic tools were 54.1%, 71.3%, 11.3%, and 95.8% respectively, and 79.2%, 71.8%, 16.1%, and 98.1% respectively using a dermatoscopy tool [3].

In this way, it is important to diagnose this neoplasm as early as possible, on early stages due to survival rates (Table 1, summarized from [4]).

However, this process requires a high skilled physician who does not always have enough time and experience to analyze the suspicious neoplasm.

Table 1. Melanoma survival rate.

Stage	5-year survival, %	10-year survival, %
IA	97	95
IB	92	86
IIA	81	67
IIB	70	57
IIC	53	40
IIIA	78	68
IIIB	59	43
IIIC	40	24
IV	15 to 20	10 to 15

There are a lot of different optical methods for the safe, painless, non-invasive diagnosis of cutaneous neoplasms, such as dermatoscopy [5], reflectance confocal microscopy (RCM) [6], Raman spectroscopy [7]. In addition, several non-invasive and completely safe methods of pigmented skin lesions differentiation, which have the similar dermatoscopy multispectral ways of recognition melanoma, may be found. For instance, MelaFind [8] has been developed to be very sensitive in detecting melanoma. However, MelaFind is not used on all skin lesions or all part of the body. According to the manufacturer's website, MelaFind is effective at finding melanomas ranging in size from 0.2 cm to 2.2 cm. Larger or smaller lesions are not readily imaged by the system's cameras. Another technology, Spectrophotometric Intracutaneous Analysis (SIA) [9] is a fast, non-invasive method of pigmented skin lesions differentiation with distinct advantages over clinical and dermatoscopic diagnosis of melanoma. It is easy to perform and allows to examine the skin lesions with great accuracy and in a highly objective manner. The sensitivity of the method reaches the value of 96%. The device, termed SIAscope operates by emission of radiation ranging from 400 to 950 nm. From the spectral measurements SIAscope extracts information regarding location, quantity and distribution of melanin, collagen and haemoglobin within the layers of the skin. The data are then displayed on a screen as the SIAgraphs, which are graphical representations of digital information.

In this paper, we present our first results of the own developed dermatoscopy tool with a built-in software for melanoma pattern recognition, based on Haar wavelet, Local Binary Patterns (LBP) and color analysis.

2. Materials and methods

2.1. Dermotoscopy tool

The own developed Dermatoscope (Figure 1) is based on the Basler acA1920-25uc camera (RGB, 12 bit/px, 1920*1080 px video mode). It has a resolution of ~13 μm/px on the surface of the skin. The device's body has been designed in OrCAD (Cadence Design Systems, USA) and printed in a 3D printer using ABS plastic. Tissue lighting is carried out by various LEDs:

- UV: 2 x LEUVA77V20RV00 (365 nm, 1 W, 9 nm half-width);
- White: 4 x LEDs FM-5630WDS-460W-R80 (39 lm, 4000 K) (two polarized LEDs and two unpolarized ones);
- Blue: 2 x CREE XREBLU-L1-0000-00K01 (30 lm, 465-485 nm);
- Green: 2 x CREE XRCGRN-L1-0000-00N01 (52 lm, 520-535 nm);
- Red: 2 x CREE XPCReD-L1-0000-00301 (46 lm, 620-630 nm).

The device takes six pictures during approximately 6 sec with different lights on user’s request. Used lights are white and polarized white for deeper skin layers visualization, UV for fluorescence analysis, three visible colored ones for skin visualization (red, green and blue), which could be used for oxyhemoglobin, deoxyhemoglobin and melanin chromophores mapping.

Using linear polarizing filter allows us glares filtering. Polarizing filter has been used with white light and visible colored lights. It allows us to visualize deeper skin layers and get light absorption at three visible wavelengths without glares influence. The second polarizing filter has been placed on the lens, so all of the filters placed on light sources must be oriented in one direction.

Figure 1. The prototype of the dermatoscopy device.

2.2. Data Analysis and color processing

The device is also equipped with software for automatic recognition of skin melanoma based on texture (Haar wavelet texture features, local Binary Patterns) and color analysis.

The algorithm was introduced before [10] and has the following main steps for an image:

1. an image pre-processing;
2. detecting of a region of interest - ROI;
3. extracting of color and texture features;
4. a classifier training by Support Vector Machines (SVM) method at learning stage or using the classifier to make a decision.

We consider the algorithm in detail now.

The image has converted to the grayscale space at a stage of pre-processing. And then a hair removal filter applies to the resulting image. This filter is implemented as a simple DoG-filter (Difference of Gaussians) described by the Equation. After removing hair to the image, a median filter with a dynamic window is applied to eliminate noise in the image. The size of the window is determined by the experimental formula.

Next, the algorithm is applied to the image clustering (in terms of brightness) ISODATA (Iterative Self-Organizing Data Analysis Technique).

The ISODATA algorithm is designed to divide a given set of images (in this case, two-dimensional space points) into subsets (clusters) bound by a certain property, for example based on the proximity of points along the geometric distance. The algorithm is heuristic, i.e. the result of the work largely depends on the given initial parameters.

After clustering, some additional classes are attributed to the area of growth, the rest ones are to the area of the skin. It is well known that the regions having the lowest brightness are related to neoplasm.

After clustering, the image is divided into blocks, for each of them pixel fraction is calculated, which are in the target clusters (corresponding to melanoma). If this the fraction of pixels exceeds 5%, the block is marked as a region of interest (ROI). Block-by-block definition of ROI is not only allows us to "grab" for analysis areas adjacent to the melanoma boundary, but also reduces the effect of noise.

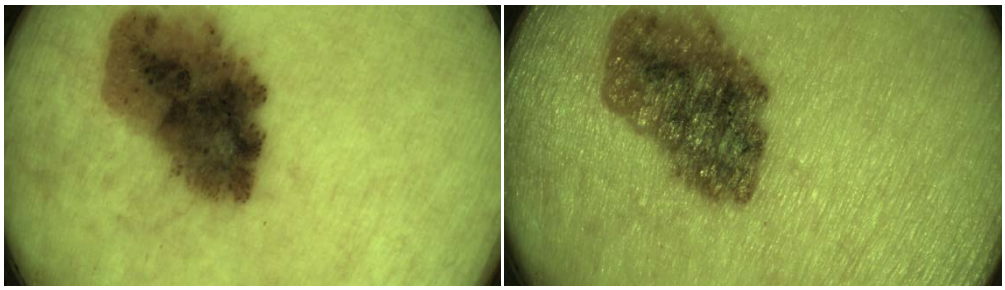
We used Discrete Haar Transform, Local Binary Patterns (LBP) and color histogram analysis to extract color and texture features from the image. Three-level Haar transform is calculated, which gives us the 10 sub-images. Next, a characteristic vector of statistical mean and variance of sub-images for each block from ROI is evaluated. As a result, for each image, we can obtain the number of feature vectors equal to the number of ROI blocks. The next step is the LBP (Local Binary Patterns) algorithm [2]:

- each image pixel is taken as a threshold, and then it is comparing to the brightness of p surrounding pixel;
- surrounding pixels are taken from the circle of radius r (algorithm's parameter). We used r = 2, and r = 3 (the subpixel bilinear interpolation has been used to determine the brightness values "between" image pixels);
- if a value of a surrounding pixel is greater than the threshold, then the pixel is set up to 1, otherwise is to 0;
- output of the algorithm for each pixel is p-bit number.

After that, we receive a set of vectors where each of them describes an appropriate image. We used a linear version of a SVM method for separation of these vectors into two classes (MM and all others). The main idea of SVM consists in translating of the original vectors in higher dimensional space and searching for a separating hyperplane with maximum margin distance between two classes in the space. Two parallel hyperplanes are constructed on both sides of a hyperplane separating our classes. Separating hyperplane is a hyperplane that maximizes the distance to two parallel hyperplanes. The algorithm works on the statement that greater distance between these parallel hyperplanes means smaller average error of the classifier.

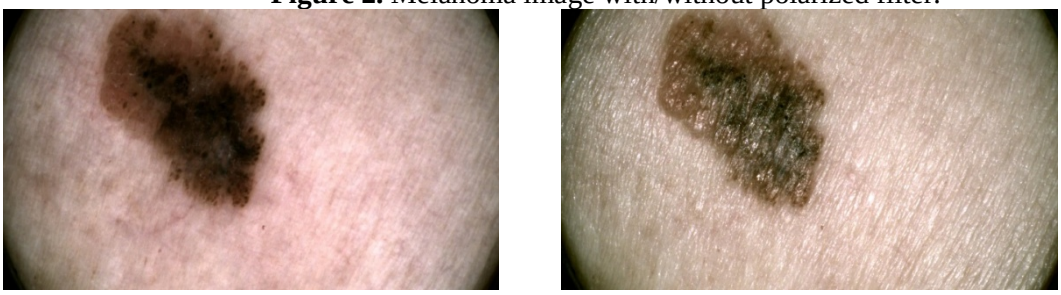
3. Results and discussion

We have analysed color correction image of melanoma (Fig. 1) and image without color correction (Fig. 2) and made several tests, where we had detected that images without color correction have had better results.



a-polarised b-nonpolarised

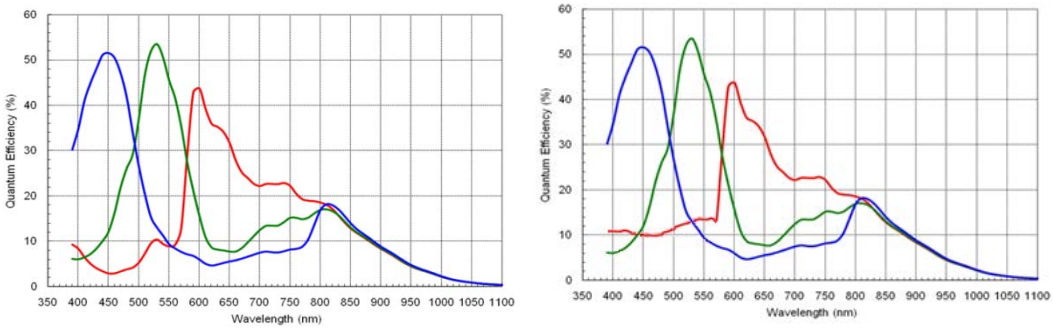
Figure 2. Melanoma image with/without polarized filter.



a-polarised b-nonpolarised

Figure 3. Color correction images of melanoma.

We have made series of transformations, for example, added blue color to red to get a better picture, in order to get a proper RGB sensitivity as shown in the Figure 4.



(a) (b)

Figure 4. RGB camera sensitivities: (a) Basler camera and (b) after color correcting.

We have analyzed 56 melanoma and non-melanoma images: 28-with melanoma, 28-other types of skin cancer or melanoma. After several tests with and without color correction we have detected the sensitivity is 0.96 and the specificity is 0.89.

Our own designed device will help to make a fairly rapid analysis of skin pictures, which will help the doctor immediately separate nevi and other non-melanoma tumor.

4. Acknowledgments

This research was supported by the Ministry of Education and Science of the Russian Federation.

5. References

[1] Fitzmaurice, C. Global, Regional, and National Cancer Incidence, Mortality, Years of Life Lost, Years Lived With Disability, and Disability-Adjusted Life-years for 32 Cancer Groups, 1990 to 2015: A Systematic Analysis for the Global Burden of Disease Study / C. Fitzmaurice // American Medical Association. – 2017. – Vol. 3(4). – P. 524-548.

[2] Melanoma and Other Skin Cancers National Cancer Institute [Electronic resource]. - Access mode: https://www.cancer.gov/publications/patient-education/skin.pdf (15.11.2017).

[3] Argenziano, G. Dermoscopy Improves Accuracy of Primary Care Physicians to Triage Lesions Suggestive of Skin Cancer / G. Argenziano, S. Puig, I. Zalaudek, F. Sera, R. Corona, M. Alsina, F. Barbato, C. Carrera, G. Ferrara, A. Guilabert, D. Massi, Juan A. Moreno-Romero, C. Muñoz-Santos, G. Petrillo, S. Segura, H. Peter Soyer, R. Zanchini, J. Malvehy // Journal of Clinical Oncology. – 2006. – Vol. 24(12). – P. 1877-1882.

[4] American Cancer Society [Electronic resource]. - Access mode: https://www.cancer.org/cancer/melanoma-skin-cancer/detection-diagnosis-staging/survival-rates-for-melanoma-skin-cancer-by-stage.html (22.11.2017).

[5] Rao, B.K. Dermatoscopy for melanoma and pigmented lesions / B.K. Rao, CS. Ahn // Dermatologic clinics. – 2012. – Vol. 30(3). – P. 413-34.

[6] Witkowski, A.M. Non-invasive diagnosis of pink basal cell carcinoma: how much can we rely on dermoscopy and reflectance confocal microscopy? / A.M. Witkowski, J. Łudzik, N. De Carvalho, S. Ciardo, C. Longo, A. DiNardo, G. Pellacani // Official journal of international society for bioengineering and the skin (ISBS). – 2016. – Vol. 22(2). – P. 230-237.

[7] Bratchenko, I.A. Combined Raman and autofluorescence ex vivo diagnostics of skin cancer in near-infrared and visible regions / I.A. Bratchenko, D.N. Artemyev, O.O. Myakinin, Y.A. Khristoforova, A.A. Moryatov, S.V. Kozlov, V.P. Zakharov // J. Biomed. Opt. – 2017. – Vol. 22(2). – P. 027005.

[8] Monheit, G. The performance of MelaFind: a prospective multicenter study. / G. Monheit, A.B. Cognetta, L. Ferris, H. Rabinovitz, K. Gross, M. Martini, J.M. Grichnik, M. Mihm, V.G. Prieto, P. Googe, R. King, A. Toledano, N. Kabelev, M. Wojton, D. Gutkowicz-Krusin // Arch Dermatol. – 2011. – Vol. 147(2). – P. 188-194.

[9] Michalska, M. SIAscopy - a new non-invasive technique of melanoma diagnosis / M. Michalska, G. Chodorowska, D. Krasowska // Ann Univ Mariae Curie Sklodowska Med. – 2004. – Vol. 59(2). – P. 421-31.

[10] Myakinin, O.O. Dermoscopy analysis of RGB-images based on comparative features / O.O. Myakinin, V.P. Zakharov, I.A. Bratchenko, D.N. Artemyev, E. Y. Neretin, S.V. Kozlov // SPIE Proceedings. – 2015. – Vol. 9599. – P. 95992B.