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Project: Improvement of the health service by means of IT technology in dermal and lungs cancer diagnostics.

Description of the skin cancer diagnostic algorithm.

Images acquired using dermatoscopes can be stored and analyzed further by digital computers. Some of such applications for clinical use are based on personal computers or laptop platforms (Burroni et al. 2004,). Newer versions can be connected even to an iPhone or hand-held device such as a palmtop computer. Several companies produce hardware solutions for dermatologic diagnosis – one of such popular solutions is proposed by DermLite.

In these techniques the digital image serves as a basis for medical analysis and diagnosis of lesions under consideration. As there is a general lack of precision in human interpretation of image content, advanced computerized techniques can assist doctors in the diagnostic process (European Consensus 2009). Several companies offer complex software solutions – let us mention here only a few, such as: Mole Expert, MoleMAX, and DDAX3.

Analysis these solutions, targeted as an aid for the practicing medical doctor, reveals they all contain data storage and manipulation software (multi-media database). Some provide also some basic tools for skin lesion images analysis. Analyzing the medical literature and textbooks one can find out that there are several standard approaches for analysis and diagnosis of cutaneous lesions (Johr 2002, European Consensus 2009). Let us shortly describe the characteristic features used in each method for classification of lesions.

1 Menzies scale

This scale is used to differentiate melanoma lesion from a non-melanoma one. Lack of negative features and the presence of at least one positive attribute suggest that the lesion should be diagnosed as melanoma. The features used for differentiation are presented in table 1.

Table 1. Menzies scale feature table.

Negative features	Positive features
• lesion axial symmetry • lesion color symmetry • the presence of one color	blue-white veil numerous brown dots pseudopodia radial streaks discoloration of a scar

	black dots-globules at the periphery many colors (5 or 6) numerous blue / gray dots extended network

2 Seven-point scale

This scale uses major and minor criteria to grade lesions in scale from 1 to 7. The presence of any major criteria adds two points, one point is for minor criteria. To diagnose a melanoma using this scale the lesion must score at least 3 points. Table 2 contains the scoring criteria.

Table 2. The 7-point scale criteria and scoring table.

Criteria	Points
Major • atypical net pigmentation • atypical vascular pattern • blue-white veil	 2 2 2
Minor • Irregular streaks(radial streaks) • Irregular pigmentation • irregular spots / globules • areas of regression	 1 1 1 1
Score	< 3 = non melanoma ≥ 3 = suspected melanoma

3 TDS score based on ABCD rule

TDS (Total Dermoscopy Score) – is a uniform system used for dermatoscopy assessment. Using a linear equation the ABCD rule (Nachbar et al. 1994) introduced the option to grade skin lesion depending on the degree of their malignancy. This degree is determined by the TDS value calculated from the following equation:

$$TDS = 1{,}3 \ast A + 0{,}1 \ast B + 0{,}5 \ast C + 0{,}5 \ast D \quad (1)$$

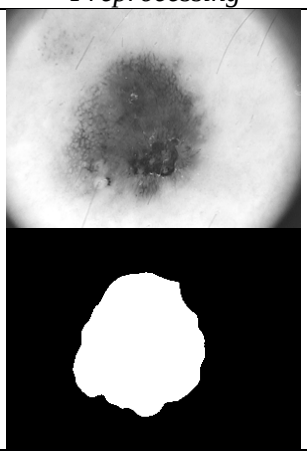
The ABCD (Asymmetry, Border, Color, Dermoscopic structures) rule is used for diagnosis of skin changes of melanocytic origin. It is used to assess lesion and brings an answer to the question whether it is a mild change, suspicious or malicious. The variables for the equation (1) are determined by visual assessment of: A - lesion shape asymmetry and color asymmetry, B – border shape and sharpness, C – presence of various colors (red, blue-gray, brown, black, white), D – presence of dermoscopic structures such as pigmentation net, regression regions, dots, globules and so on.

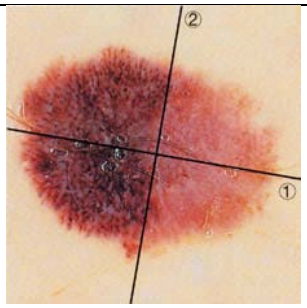
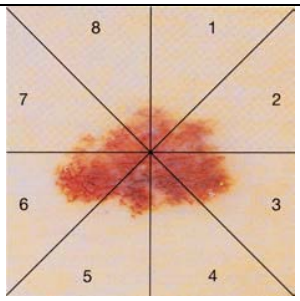
4 ABCDE rule

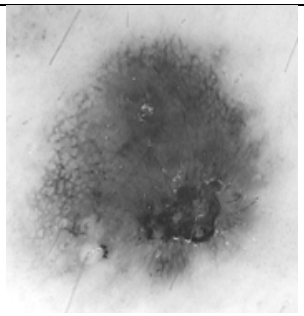
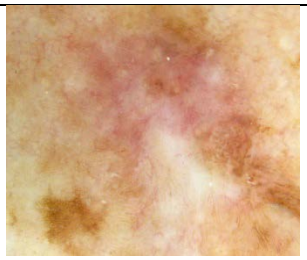
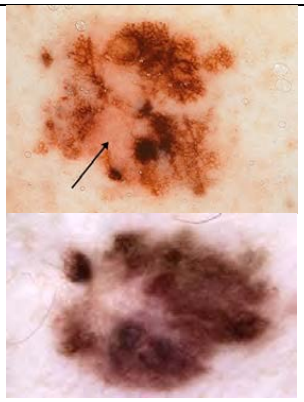
The ABCDE (Asymmetry, Border, Color, Diameter, Evolution) (Thomas et al. 1998) (Rigel etal. 2005) is a rule that evolved on ABCD scale used to calculate TDS value. According to this rule, the lesion is suspicious if visual assessment of the lesion is positive on any of the following features: A - lesion shape asymmetry and color asymmetry, B – border shape and sharpness, C – presence of various colors (red, blue-gray, brown, black, white), D – diameter of the lesion is greater than 6mm, E – elevation of lesion has grown over short period of time, or lesion has evolved rapidly.

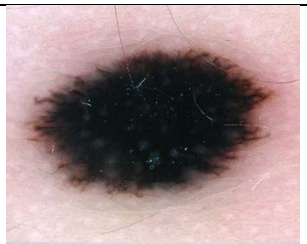
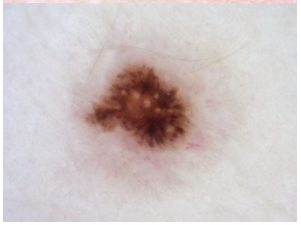
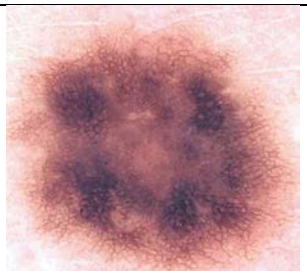
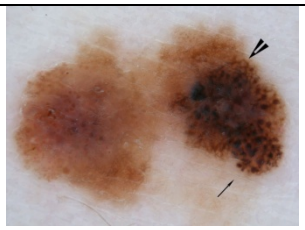
Proposed image preparation and analysis algorithms are presented in Table 3.

Table 3. Image processing algorithms‘ description for skin cancer diagnostics

Goal	**Description (use)**	**Examples**	**Implementation**
		Preprocessing	
Lesion segmentation	Is the very basic pre-processing step used by almost all the further processing algorithms.		The image is converted to gray-level, blurred and binarized using Otsu [1] thresholding method followed by morphological operations.
Hair detection and removal	Removing redundant objects		Hair detection is performed via a set of directional filters with corresponding parameters and Gaussian difference. To remove the detected hair in the image an algorithm of pixels inpainting [2] is used.
Reflections detection and removal	Removing redundant objects		The reflection detection algorithm is very simple. We classify a pixel as reflection if its intensity is high and if it is higher than the average intensity computed in a neighborhood of the pixel.

Feature extraction			
Asymmetry	Asymmetry may be considered in both shape and texture (ABCD, Menzies)		First the axes of symmetry are detected as axes of inertia. For measuring the shape asymmetry we calculate the intersection of regions, one of which is reflected over the corresponding axis. Textural asymmetry is the dissimilarity between textural features [3] of different region parts.
Edge sharpness	Sharpness of edge in each of 8 segments (ABCD)		For estimating this parameter the blurred gray-level image may be used. We can select different lesion edges by varying the gray-level threshold value which is used for segmentation. The edge is considered to be sharp if small variation of threshold causes big change of binary shape.
Blue-whitish veil	Presence of blue-white regions on image (ABCD, 7-point, Menzies)		The Hue component in the HSV color space is responsible for the pixel color; it ranges from 0 to 360. Blue veil can be detected using the proportion of pixels in the blue interval [210; 240]. More specific values will be fitted at the computational experiment stage.

Atypical pigment network	Black, brown or gray network on a lighter background. It may be typical, atypical or be absent at all. (ABCD, 7-point, Menzies)	 	In order to characterize the network, the color of the network lines (see thin dark streaks going over a lighter background) and their spatial organization should be considered. Both these features, color and geometric pattern will be examined with the help of corresponding automatic network detection algorithm. To this end, we first apply a bunch of directional filters to detect the dark lines with the help of the Gaussians difference. On the second step we assume that the pigment network is connected. Thus, we extract all the connected components in the binary image. [4] Alternative method is used for specifying. Sharp changes of intensity are detected using the Laplacian of Gaussian(LOG) filter. The result of this edge detection step is subsequently converted into a graph to find cyclic structures. After finding loops or cyclic subgraphs a graph of the pigment network is created using the extracted cyclic structures. After identifying these substructures we use several chromatic, structural, geometric and textual features suitable for classification. [5]
Atypical vessels	Linear vessels in regression areas (7-point, Menzies)		Considering the shape of a skin lesion sub-region, which differs by color from the surrounding background. This supposes color segmentation inside the lesion region first. Then the next step would be to detect white blobs and define their location
Regression areas	White regions without pigmentation inside the spot. (ABCD, 7-point)		For the automatic detection of the regression structures a procedure with 2 main stages is planned to be examined. The procedure includes: 1) partition of the lesion into color homogenous regions; 2) recognition of the lesion using region of interest in the map received on the previous step utilizing statistical moments. In case of failure, no attempt will be made for automation of the analysis of such cases.

Atypical stripes	Black or brown stripes near the lesion border (ABCD, 7-point, Menzies)	 	After a pre-processing step, multi-scale Laplacian of Gaussian is applied to detect dermoscopy structures with Gaussian cross-sectional profile. After finding linear structures, the orientation flow of the image is analyzed to determine the orientation of detected objects in the orientation flow to select linear structures of candidate streaks. Finally, chromatic and textural features of detected line segments are used to classify the lesions into images.
Irregular dots and globules	Black, brown oval and round granules of different size (ABCD, 7-point, Menzies)		Dots and globules may be considered as small dark structures with bright shape on a lighter background. Thus we may extract connected edges with suitable edge detector (like [6–8]) Next step is shape analysis of the remaining elements through which we identify shapes from the circle to the oval. For estimation location irregularity we use the distance between globules, number of them and the lesion size.
Irregular blotches	Black, brown, gray irregular blotches (ABCD, 7-point, Menzies)		We plan to use relative color thresholds and subtract the observed pixel value within the lesion from the background skin color before applying relative thresholds. Then, several blotch indices will be computed, including the scaled distance between the largest blotch centroid and the lesion centroid, ratio of total blotch areas to lesion area, ratio of largest blotch area to lesion area, total number of blotches, size of largest blotch, and irregularity of largest blotch.
Pseudopods	Bulbous and often kinked projections that are found at the edge of a lesion directly connected to either the tumor body or pigmented network. (Menzies)		They can never be seen distributed regularly or symmetrically around the lesion. When connected directly to the tumor body, they must have an acute angle to the tumor edge (B and C, not E) or arise from linear or curvilinear extensions (A). When connected to the network (F), the width of the bulbous ending must be greater than the width of any part of the surrounding network (therefore not G) and at least double that of its directly connected network projection (therefore not H).

Scar-like depigmentation	Areas of white, distinct, irregular extensions (Menzies)		Areas of white, distinct, irregular extensions (true scarring), which should not be confused with hypo- or depigmentation due to simple loss of melanin.
Broadened network	A network made up of irregular, thick "cords", often seen focally thicker. (Menzies)		While a pseudo-broadened network can be seen on the face, here a true broadened network is found because the holes of the net are not entirely formed by the follicular openings.
Content-based image retrieval (CBIR)	Finding dermatoscopy images in a big image database which are most similar to the tested image. Using the features of most similar images may improve the efficiency of diagnosis.		The key points of developing the CBIR are: 1) calculating suitable image descriptor with needed properties; 2) evaluating the measure of dissimilarity (distance) of dermatoscopy images. Thus having enough big database of images with known parameters and verified diagnoses one can employ information on the images from DB which are similar to the tested one for the diagnostic purposes. [9]

In addition to improve accuracy of features recognition system another class of local image features can be applied. The features are invariant to image scaling, translation, and rotation, and partially invariant to illumination changes.

The recognition proceeds by matching individual features to a database of features from known objects using a fast nearest-neighbor algorithm, followed by a Hough transform to identify clusters belonging to a single object, and finally performing verification through least-squares solution for consistent pose parameters. This approach to recognition can robustly identify objects among clutter.

Correctness of suchlike methods depends on the quality of obtained images. In view of the fact that all future images would be received from high quality dermatoscopes with identical CMOS sensors this approach presume to produce results of sufficient quality [10].

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