Classification of Dermatological Shape Asymmetry Measures of Skin Lesion

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***Анотація*—У роботі обговорюється класифікація асиметрії ураження шкіри за допомогою різних методів. Ми коротко представляємо дерматологічну міру асиметрії за формою (DASMShape) і показуємо її дві реалізації. Порівнюючи результати вимірювань DASMShape та асиметрію ураження, дані експертами в наборі даних PH2, ми досягли найкращої точності (83,2%), використовуючи SVM з функцією ядра RBF для DASMShape. Хоча результати NN знижуються на 9,5%, це завжди завищує асиметрію.**

***Abstract*—In the paper, a classification of the skin lesion asymmetry using different methods is discussed. We present shortly dermatological asymmetry measure in shape (*DASMShape*) and show its two implementations. Comparing the results of DASMShape measures and a lesion asymmetry given by the experts in PH2 dataset we achieved the best accuracy (83.2%) using SVM with RBF kernel function for the DASMShape. Although the NN results are lower by 9.5% it is always overestimating the asymmetry.**

Ключові слова—дерматологічна асиметрія ураження шкіри, сегментація дерматологічних особливостей; класифікація ураження шкіри, підтримка векторної машини, кНН, нейронних мереж;

Keywords—dermatological asymmetry of skin lesion, dermatological features segmentation; skin lesions classification, support vector machine, kNN, neural networks;

I. Introduction

American Cancer Society (ACS) reports that the risk of Americans developing cancer over their lifetime is 37.6% for woman and 39.7% for males, where the melanoma risk is 1 in 42 cases for woman and 1 in 27 cases for males [1]. Detection of the early stage of melanoma is a fundamental task for dermatologists, because with the early diagnosis, the patients probability of survival increases greatly. To correctly identify the lesion we need to assign specific methods for diagnosis of disease symptoms. Under the 2001 Consensus Net Meeting on Dermoscopy (Argenziano G., J Am Acad Dermatol 2003), it was assumed that a three-point checklist is sufficient to avoid melanoma unrecognition.

Studies show the effectiveness of this method in the case of non-experts who achieved 96.3 % detection of malignant lesions [2,3]. However, the specificity achieved by non-experts was 32.8% in comparison to 94.2% achieved by the experts [2]. The presence of more than one feature suggests that the lesion is suspect for malignancy.

Presented above statistics of malignant melanoma detection suggest that the non-experts that are usually general practitioners need support. One of the ways to support the non-experts in the diagnosis can be an automated expert system [4,5,6]. Several computer-aided diagnostic systems to facilitate the early detection of suspicious skin lesions have been developed. To correctly identify the lesion we need to assign specific methods for diagnosis of disease symptoms, a 3-point checklist of dermatology (3PCLD) [2,7] or 7-point checklist (7PCL) [8] are sufficient to avoid melanoma unrecognition [9].

The three-point checklist [7] is based on a simplified pattern analysis and is intended for use by non-experts as a screening technique. The three-point checklist does not differentiate between melanocytic and non-melanocytic lesions. Its aim is to identify all potentially malignant lesions, including basal cell carcinoma and melanoma, with a high degree of sensitivity.

The three-point checklist is based on three dermoscopic criteria: (a) asymmetry in shape, hue/color and structure; (b) atypical pigment network; and (c) blue-white structures. The presence of two or three features suggests that the lesion is suspect for malignancy.

The paper is organized as follows. In Section 2, a general approach to the skin lesions recognition and classification is presented. Section 3 shows dermoscopic datasets. In the next section, dermoscopic asymmetry measure as a function of a shape, hue/color and structure is presented. Section 5 describes the dermatological asymmetry measure of shape of the skin lesions. In addition, results and observations of different asymmetry of shape functions are shown in Section 7. Conclusions are also drawn in that final section.

II. General Approach To Skin Lesions Recognition

To achieve a final prediction computer-aided diagnostic system must perform three steps:

The first step is image processing to achieve lesions segmentation with their borders.

The second essential **step** is clinical feature segmentation [9] with resulting binary masks of clinical feature segments basing on the first step.
The final classification (**the third step**) is based on the feature selection and classifier model optimization taking into account two previous steps as well as patient dermographic data [10].

Skin lesion is most often characterized by a texture or color different than in normal skin. Segmentation of lesions

means finding lesions borders and it can be done by various well-known methods [11,12].

The raw images and dermographic data of the patient can be kept in a single or distributed database. Construction of classifier requires set of features characterizing the samples. Some features can be taken using dermoscopic images, but others have to be collected clinically. Final step is using this features in selected classification method. Commonly used classifiers are neural network, k-nearest neighbors or support vector.

There are a few publicly available databases of dermoscopy images. PH2 [13] and EDRA [14] image databases are most commonly used by the research communities. The other example is the ISIC Archive for the Melanoma project which is a large public database of dermoscopy images [15] created by International Skin Imaging Collaboration (ISIC).

In our research we use PH2 [13] as the reference datasets. It contains 200 dermoscopic 8-bit RBG color images with a resolution of 768x560 pixels along with the corresponding medical annotations, comprising 80 common nevi, 80 atypical nevi, and 40 malignant melanomas acquired using a magnification of 20x under unchanged conditions.

III. The Three-Point Checklist of Dermoscopy (3PCLD)

To correctly identify the lesion we need to assign specific methods for diagnosis of disease symptoms. Such methods are ABCD evaluation scale, 3-point checklist of dermoscopy (3PCLD) and 7-point checklist (7PCL).

Calculating asymmetry of shape, structures, and hue is one of the most important factors of correct diagnosis process of skin lesion [16]. In the paper, we focus on calculating asymmetry of shape. It is a starting point to asses asymmetry of the lesion because it is defined as asymmetry of shape, structures and hue.

3-point checklist of dermoscopy, 3PCLD is defined as:

- Asymmetry of shape, hue and structures in 1 or 2 perpendicular axes;
- Atypical pigment network with thickened lines and irregular distribution;
- Blue-white structures (veil) - any blue and/or white color within the lesion.

Two or more points suggest the diagnosis of atypical/malignant lesion.

IV. Dermatological Asymmetry Measure, DASM

In [17] Dermatological Asymmetry Measure (DASM) have introduced – integral asymmetry measure depending on shape, hue/color and structure.

In the above mentioned databases, especially PH2 the values for calculating asymmetry are given as follows encountered value 0 means fully symmetric, 1 means symmetric in 1 axes, 2 means fully asymmetric.

To achieve more precision we have proposed specific values to perform DASM (Dermatological Asymmetry Measure). These values are continuous and are described as follows:

- •Shape < 0, 2 >
- •Color/hue < 0, 2 >
- •Structure < 0, 2 >

We have also increased the asymmetry count by adding the asymmetry of hue and structure. Our method predicts the asymmetry division into asymmetry of shape, hue/color and structure.

V. Dermatological Asymmetry Measure of Shape, DASMShape

After segmentation of the lesion and the features in the lesion, we have acquired binary masks. The next step is to select features for the classification of the lesion. One of the features is asymmetry of the shape, hue and structure. In the [17] we proposed a new measure to estimate the asymmetry of the shape of the lesion. The shape of the lesion in our case means a binary mask of the lesion. We propose the dermatological asymmetry as a real value from <0,2>.

In the paper, we use the following definitions and abbreviations defined in [17]:

- DAS – Dermatological Asymmetry, it is asymmetry of the shape, hue and structure. In dermatology, as we mentioned above, the value of the asymmetry can be: 0 for fully symmetric shapes; 1 for symmetric ones in one axis or 2 for asymmetric ones.
- DASM – Dermatological Asymmetry Measure – real asymmetry measure depending on shape, hue/color and structure;
- DASMShape – Dermatological Asymmetry Measure of Shape symmetry/asymmetry;
- DASMHue – Dermatological Asymmetry Measure of Hue/Color symmetry/asymmetry distribution;
- DASMStruct – Dermatological Asymmetry Measure of Structure symmetry/asymmetry distribution;
- GSSPT - a geometrical shape symmetry precision threshold of binary mask of the lesion is a threshold that after the axial transformation the original binary mask and mirror are the same in at least threshold value. GSSPT values are real values from <0,1>, e.g. 0.95 threshold means that the mirrored images are in 95% cover each other. The bigger the threshold the bigger similarity between mirrored images. The symmetry axis, SAx, depends on the GSSPT as well as the number of the symmetry axes for a given shape.
- NSA – number of symmetry axes depending on GSSPT.
- VoSS – a vector of shape symmetry, it as a vector which coefficients are equal to the number of symmetry axes.

Figures 2a-c show different masks for lesions with their corresponding dermatological asymmetry values assessed by the dermatology experts [13].

TABLE I. THE EXAMPLES OF **W** VECTOR FOR IMAGES FROM PH2 DATASET

Image ID from PH2	VoSS vector W coefficient values					*DAS* (PH2)	DASMShape values for f(W) and coefficients a				
	n(0.9)	*n*(0.93)	*n*(0.94)	*n*(0.95)	*n*(0.97)		a_x	a_y	a_z	a_k	a_m
IMD075	1	1	1	0	0	**2**	1.80666	1.86479	1.66943	1.78412	1.25000
IMD211	2	1	1	1	0	**1**	1.25627	1.48164	1.18193	1.31406	0.90909
IMD406	13	6	5	2	0	**2**	0.00747	0.02969	0.00290	0.61862	0.28571

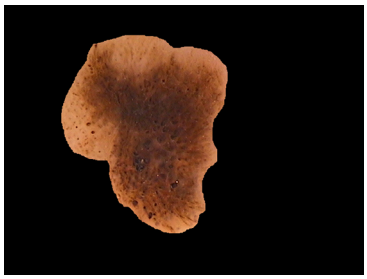
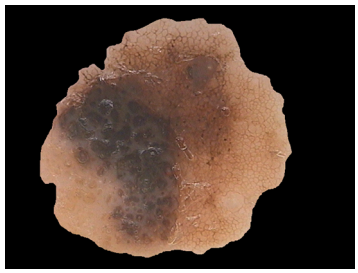
a)  b)  c) 

Fig. 1. The masks of the selected lesions from PH2 dataset [13] with dermatological asymmetry DAS:
a) IMD075 (Atypical nevus) DAS=2; b) IMD211 (Nodular Melanoma) DAS=1; c) IMD406 (Nodular Melanoma) DAS= 2

The method of deriving and estimating the new dermatological asymmetry measure value can be described as follows:

1. Calculate the number of symmetry axes for a given set of GSSPT thresholds $n(t_i)$, where t_i is a given threshold. After our experimental research we propose to choose the threshold values as a subset of a set of:

   {0.9, 0.91, 0.92, 0.93, 0.94, 0.95, 0.96, 0.97, 0.98}.

2. From the values of $n(t_i)$ construct a vector of shape symmetry (VoSS) **W**:

$$\mathbf{W} = [n(t_1), n(t_2),\ldots, n(t_k)] , \qquad (1)$$

   where k≥2.

3. Design the DASMShape, Dermatological Asymmetry Measure of Shape, as a function of VoSS. Because the values of DASM and DASMShape are real value from <0,2> we propose two types of functions that have positive, normalized to maximum value of 2 and are continuous measures.

   a. The first type defined as an exponent of function depending on a VoSS vector **W**:

$$DASMShape(\mathbf{W}) = 2 \exp (-f (\mathbf{W})) , \qquad (2)$$

   where function f: $R^k \rightarrow R^+ \cup \{0\}$.

   b. The second type defined as rational function depending on a VoSS vector **W**:

$$DASMShape(W) = \frac{2}{f(W)} \qquad (3)$$

   where inner function f: $R^k \rightarrow <1, \infty)$.

For each of the DASMShape functions let us introduce a set of two crisp shape thresholds (ST): ST={lst, ust}, where

TABLE II. SKIN LESION ASYMMETRY CLASSIFICATION RATE USING THE BEST CLASSIFIERS

Classifier	Type of DAS/ DASMShape	Number of Corr. Classified Instances	Number of Incorr. Classified Instances	Class. ratio	TP rate for a class			FP rate for a class		
					0	1	2	0	1	2
3NN	DAS(PH2)	57	110	34.1	18.7	61.3	62.1	10.0	55.9	20.3
	DASMShape1	97	70	58.1	30.2	100	82.1	0.0	49.3	0.0
	DASMShape2	100	67	59.9	28.9	96.7	95.7	0.0	48.2	0.8
SVM (RBF)	DAS(PH2)	83	84	49.7	48.6	41.9	62.1	23.3	31.6	19.6
	DASMShape1	134	33	80.2	75.6	96.0	80.4	1.2	22.5	0.0
	DASMShape2	139	28	83.2	71.1	100	95.7	2.6	19.0	0.0
NN	DAS(PH2)	76	91	45.5	40.2	45.2	65.5	16.7	33.8	25.4
	DASMShape1	107	60	64.1	53.5	60.0	82.1	8.6	31.7	7.2
	DASMShape2	123	44	73.7	58.9	76.7	100	0.0	27.0	5.8

$$ST(DASMShape(W)) = \begin{cases} 0 \Leftrightarrow DASMShape(W) < lst \\ 1 \Leftrightarrow lst \le DASMShape(W) < ust \\ 2 \Leftrightarrow DASMShape(W) > ust \end{cases} \quad (4)$$

The values of *lst* and *ust* will depend on the DASMShape function type and will be derived after optimization of results. The number of misclassified images should have minimum value parallely with the number of underestimated cases.

VI. Results and Conclusions

In our experimental research we have tested several versions of function $f(\mathbf{W})$ in (2) and (3) with different coefficients and for a different subset of GSSPT thresholds. The smaller the number of thresholds values the faster deriving of VoSS vector **W** defined as in (1). We have achieved the best results for the following subset of threshold values:

$$\{0.9, 0.93, 0.94, 0.95, 0.97\} . \quad (4)$$

In our experiments we have tested three versions of kNN (1NN, 3NN, 5NN), 2 versions of SVM (RBF and linear function) and NN classifiers with different set of properties. We have prepared the training set containing 38 cases of shape symmetry (VoSS) **W** vectors. The training set cross-validation accuracy was 86.8% for 3NN, 97.4% for NN and 100% for SVM.

In the Tab. II, the best classification ratios as well as true positive and false positive classification ones are presented. We achieved the best results for 3NN, SVM with radial basis kernel function (RBF) and neural network with one hidden layer with 10 nodes. Although for the DASMShape2 measure, the SVM with RBF is achieving the best results (83.2% accuracy), the NN classifier (73.7%) always overestimated the asymmetry of the lesion while SVM was underestimating the classification results in two asymmetric cases (DASM=2) and gave them the asymmetry equal 0. DAS measure from PH2 is giving the lowest results but that measure takes also into account color and structure asymmetry.

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