Skin Lesion Diagnosis using Representations Inspired by Dermatologist Criteria

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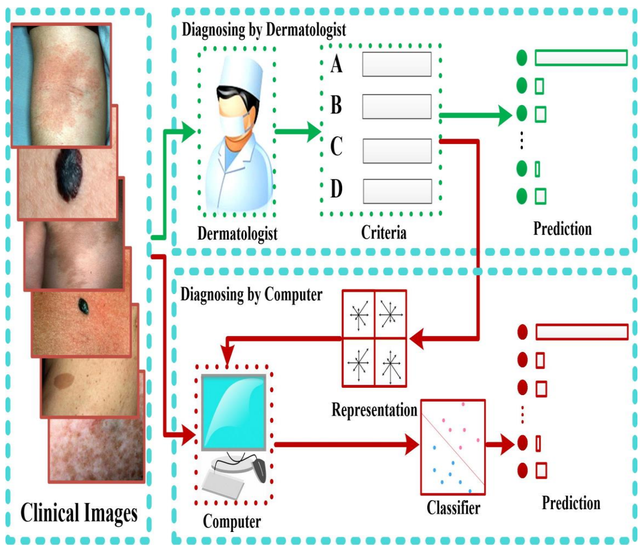
Abstract

We proposed medical representations inspired by the dermatological criteria for diagnosing clinical skin lesions. The dermatological criteria are highly correlated with measurable visual components, which cover three aspects: **structure**, **color** and **shape** of each skin disease. Major improvements includes:

- the interpretable representation for effectively capturing the manifestations of skin lesions;
- the integrated diagnostics of the diagnosis system for accurate recognizing.

The final performance on clinical images with 198 categories of skin disease is comparable with dermatologists

Motivation



For common skin disease (the **left** box):

(1) dermatologists make a diagnosis by observing the appearance of the lesions (the **top right** box).

(2) The designed skin disease recognition system (the **bottom right** box) based on clinical images and dermatological criteria has two major steps: firstly, the medical information observed by the doctors during diagnosis is exploited. Then, measurable medical representations for skin lesions are designed for diagnosis.

Accordingly, the designed representations for skin lesions relate to three aspects, i.e., **structure**, **color** and **shape** of the lesion.

Criteria of Skin Disease

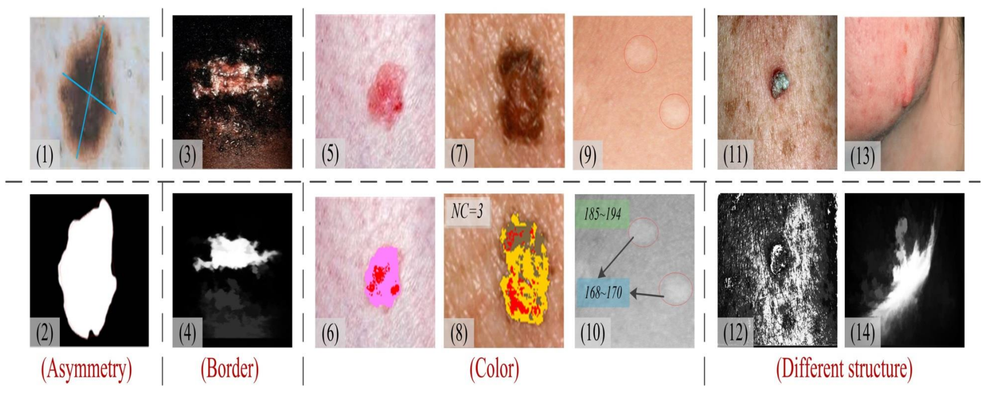
ABCD [1]criteria:

(A)symmetry: the property on shape, color, contour and structures;

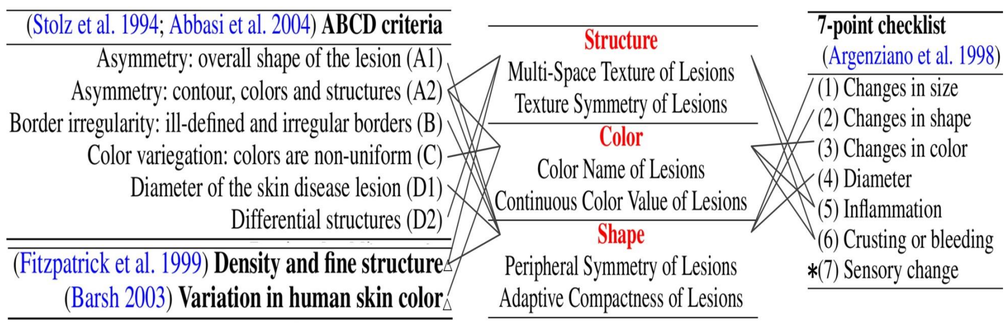
(B)order;

(C)olor;

(D)ifferent structure (Diameter): pustule, wrinkle, inflammation and so on:



The mapping to visual components from dermatological criteria: **ABCD[1-2], 7-point[3], and the two specialized criteria[4-5]** :



Medical Representations

Structure Representation:

(1) Multi-Space Texture of Lesion (MST-L): $MST(x) = [G_i(x)]_{i=1}^{K}$

($G_i(x)$ is the set of the texture features extracted from the i-th color channels and K denotes the number of spaces.)

(2) Texture Symmetry of Lesion (TS-L):

$$TS_i(x) = [G_i(L(x)_1), G_i(L(x)_2), S_i(x)]_{i=1}^{K}$$

($S_i(x) = \{|g_{ij}^1 - g_{ij}^2|\}_{j=1}^{d}$, d is the dimension of the extracted features, g_{ij}^1 and g_{ij}^2 are the j-th entry of $G_i(L(x)_1)$ and $G_i(L(x)_2)$.

The lesion region detected by MBD+ is divided into two parts $L(x)_1$ and $L(x)_2$ alone principal axes.)

Color Representation:

(1) Color Name of Lesion (CN-L): $CN(x) = \text{argmax}_{c_l}[p(c_l|c)]_{l=1}^{M}$

$[p(c_l|c)]_{l=1}^{M} \propto \sum_i^N p(c_l|c_i) g^{\sigma}(|c_i - c|_{Lab})$ where c denotes the original value of the color bin, c_i is $L*a*b$-value for c, $N = 389$ is the total number of the color bins and C is the set of basic colors used.

(2) Continuous Color Values of Lesion (CCV-L): $CCV(c) \propto p(C,c) \times \theta(c)$

where $p(C,c)$ indicates the probability of mapping the color bin c into its nearest color name C. The weighting value of the pixel $\theta(c) = \sum_{|c|} n(c)u(c)$. $n(c)$ is the frequency of the corresponding color in the image, $u(c)$ is the color value of c in the RGB space.

Shape Representation:

(1) Peripheral Symmetry of Lesion (PS-L): $PS(x) = F\left(A\left(L(x)^1\right), A\left(L(x)^2\right)\right)$

(2) Adaptive Compactness of Lesion (AC-L):

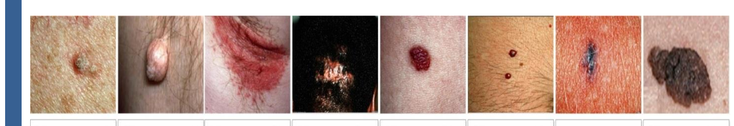
$$AL = \sum_{z \in L(x)} p(C|c,z), \; Com = \frac{4\pi AL}{P^2},$$

where z denotes the pixel in the lesion $L(x)$. $p(C|c,z)$ is the probability of mapping color to a specific color category in the Color Name feature. $A(\cdot)$ denotes the extracted feature of lesions and $F(\cdot,\cdot)$ denotes the concatenation function applied to the two features.

Experiment Results

	Components	#	Features	Dimension	KNN		SVM		RF	
					ACC	SE	ACC	SE	ACC	SE
Baseline	Texture	1	SIFT	21000	20.35	19.17	25.55	24.75	21.42	21.25
		2	HOG	12400	19.14	17.85	17.62	14.45	10.54	10.66
		3	LBP	23200	15.13	14.80	18.89	14.69	14.61	13.24
		4	BRIEF	19200	16.74	15.62	12.21	8.39	15.67	15.03
		5	SURF	38400	17.47	16.50	31.17	25.35	27.34	26.52
		6	Wavelet	256	15.94	15.52	14.82	12.73	13.37	14.02
		7	ORB	19200	20.53	21.44	23.21	22.94	18.86	17.46
	Color	8	CH	256	12.33	12.58	4.19	4.41	18.77	16.81
		9	CN	21000	20.02	20.10	20.23	21.62	27.64	28.73
		10	ColorSIFT	21000	21.29	19.62	22.51	21.43	28.49	27.24
	Border	11	GIST	512	21.93	21.52	16.49	17.19	15.01	12.33
		12	Gabor	4000	13.67	13.00	10.15	8.62	13.73	12.43
		13	Prewitt	900	12.55	13.14	11.91	10.76	11.27	10.87
		14	Sobel	10000	12.27	12.03	10.42	10.18	13.46	12.46
		15	Canny	10000	15.22	17.16	13.91	14.51	16.46	15.20
	Integration	16	1&10&11	2500	47.36	47.23	46.84	47.24	48.06	46.73
Ours	Structure	17	MST-L	21000	44.99	45.62	48.06	46.38	43.23	42.73
		18	TS-L	21000	47.30	47.80	48.94	47.21	43.92	43.07
	Color	19	CN-L	21000	42.50	43.24	38.91	39.78	44.59	46.21
		20	CCV-L	21000	42.80	43.97	40.13	39.22	45.32	45.70
	Shape	21	PS-L	10000	30.04	30.47	38.58	38.29	38.94	36.87
		22	AC-L	10000	31.50	29.75	39.73	38.92	37.61	35.42
	Integration	23	18&20&22	3000	**57.62**	**56.41**	**56.47**	**53.15**	**57.81**	**56.65**

Comparison with CNN & Doctors



GT: 5	GT: 46	GT: 31	GT 1	GT: 15	GT : 15	GT: 92	GT: 56
General D: 5	General D: 67	General D: 68	General D: --	General D: 35	General D: 44	General D: 81	General D: 167
Junior D: 5	Junior D: 46	Junior D: 183	Junior D: 155	Junior D: 35	Junior D: 15	Junior D: 81	Junior D: 56
Expert 5	Expert 46	Expert 55	Expert 1	Expert 35	Expert 15	Expert 92	Expert 56
Rank1: 5	Rank1: 46	Rank1: 68	Rank1: 155	Rank1: 35	Rank1: 87	Rank1: 92	Rank1: 56
Rank2: 119	Rank2: 39	Rank2: 178	Rank2: 87	Rank2: 115	Rank2: 124	Rank2: 27	Rank2: 176
Rank3: 49	Rank3: 67	Rank3: 31	Rank3: 1	Rank3: 15	Rank3: 26	Rank3: 115	Rank3: 67

Method		ACC	SE
Deep features [33]	CaffeNet	42.31	41.57
	CaffeNet + ft	46.69	45.18
	VGGNet	37.91	37.25
	VGGNet + ft	50.27	48.25
	GoogleNet	35.33	35.21
	GoogleNet + ft	46.48	45.86
	ResNet	48.78	47.62
	ResNet + ft	53.35	51.24
Doctors	General D	49.00	47.50
	Junior D	52.00	53.40
	Expert	83.29	85.00
Ours		**56.47**	**53.15**

'GT' is the ground-truth; the number represents a class of skin disease. '–' denotes that the doctor cannot provide a diagnosis. 'General D' is general doctor who does not focus on one specific kind of disease. 'Junior D' is junior dermatologist and 'Expert' is an expert for diagnosing skin lesions.

Dataset:

Demo:

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