Colour And Contrast Enhancement For Improved Skin Lesion Segmentation Using Retinex Theory

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ABSTRACT

Accurate extraction of lesion borders is a critical step in analysing dermoscopic skin lesion images. In this paper, we consider the problems of poor contrast and lack of colour calibration which are often encountered when analysing dermoscopy images. Different illumination or different devices will lead to different image colours of the same lesion and hence to difficulties in the segmentation stage. Similarly, low contrast makes accurate border detection difficult. We present an effective approach to improve the performance of lesion segmentation algorithms through a pre-processing step that enhances colour information and image contrast. We combine this enhancement stage with two different segmentation algorithms. One technique relies on analysis of the image background by iterative measurements of non-lesion pixels, while the other technique utilises co-operative neural networks for edge detection. Extensive experimental evaluation is carried out on a dataset of 10 dermoscopy images with known ground truths obtained from two expert dermatologists. The results show that both techniques are capable of providing good segmentation performance and that the colour enhancement step is indeed crucial as demonstrated by comparison with results obtained from the original RGB images.

A large number of the medical imaging systems have been developed to visualize parts of the body that cannot be seen from the outside. X-ray scans, magnetic resonance imaging (MRI), positron emission tomography (PET), X-ray computer tomography (CT) and ultra sound provide information such as tissue characteristics, functional information of organs and bone structures by means of non-invasive action. Skin cancer is the most common form of cancer and it is on the rise. Non-melanoma skin cancers account for half of all cancers and include basal cell carcinomas and squamous cell carcinomas. Basal cell carcinomas begin in the basal cell layer of the epidermis. The tumor cells

continue dividing but do not differentiate any further. Squamous cell carcinomas develop from dividing keratinocytes in a higher level of the epidermis. This paper covers skin cancer detection based on feature extraction and retinex theory.

Key-Words: - Skin Lesion, Image Segmentation , Asymmetry Analysis , Border Irregularity, Colour Variegation , Diameter Irregularity , Retinex Theory , Colour Restoration.

1 Introduction :

1.1Skin: The skin is the largest and one of the most versatile organs of the body, and it is vital in maintaining homeostasis. It is a turbid medium that has two distinct tissue layers (Figure 1). The outer layer, called the epidermis, is composed of stratified squamous epithelium. Its thickness ranges from 0.07 mm to 0.12 mm, and it is constantly renewing itself[5]. The epidermis consists of four cell types and five layers. The four cell types are keratinocytes, melanocytes, Merkel cells, and Langerhans cells. Keratinocytes (called squamous cells) produce keratin that helps protect the body, melanocytes produce the dark pigment melanin that provides skin color, Merkel cells associate with a disc-like sensory nerve ending to form the Merkel disc, and Langerhans cells aid in the defense against microorganisms[9]. The five layers are the stratum basale, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum. The stratum basale is the deepest layer, and is composed of a single row of melanocytes and cubodial or columnar cells that reproduce and grow[11]. The stratum spinosum is the next layer and is composed of many layers of cells with centrally located, large, oval nuclei and developing fibers of keratin. The stratum granulose is three to five layers of flattened granular cells that contain shrunken fibers of keratin and shriveled nuclei. The stratum lucidum, which is only on the soles and palms and is between the stratum corneum and stratum granulosum, has cells that appear clear and have nuclei, organelles, and cell membranes that are no longer visible[14]. The outer most layer, the stratum corneum, is composed of many layers of keratinized, dead epithelial cells that are flattened and no nucleated[15].

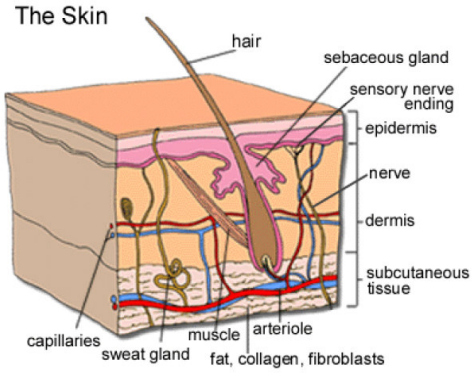

Fig 1: Skin Anatomy

Skin is composed of many light scattering and light polarization changing components, including numerous membrane-bound subcellular organelles such as the nuclei, mitochondria, secretory granules, melanosomes, and the highly laminated desmasomes[9]. Another source of light polarization change in the skin is the birefringence of epidermal keratin and dermal collagen. Cancerous tissue is characterized by disordered cell maturation and epithelial architecture, keratin composition, fibrillar packing and loss of cellular orientation, which could influence the transport and remittance of polarized light[10]. Also, differences in nuclei and mitochondrial size and concentration are often seen between normal and cancerous tissues that could be measured using the polarimetric approach. For every part of the body being checked there is two of such images. They are taken during two successive photo sessions[20]. The images of the first photo session are called reference images. The ones of the second session, which are taken some period of time later, are called match or follow up images.

2 Types of Scan Cancer: There are three types of skin cancer present. Basal cell carcinoma, Squamous cell carcinoma, and Melanoma.

Basal cell carcinoma is the most common form of skin cancer, affecting more than 800,000. It is also the most common form of all cancers. Basal cell carcinomas arise in the basal cells, which are at the bottom of the epidermis.

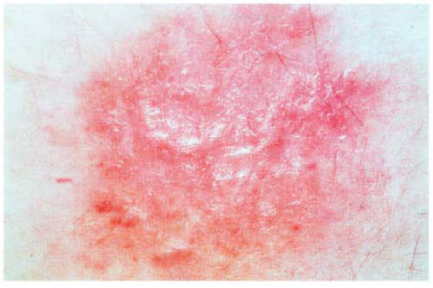

Figure 2: Basal cell carcinoma.

Squamous cell carcinoma, the second most common skin cancer, afflicts more than 200,000[6].It arises from the epidermis and resembles the squamous cells that comprise most of the upper layers of the skin.

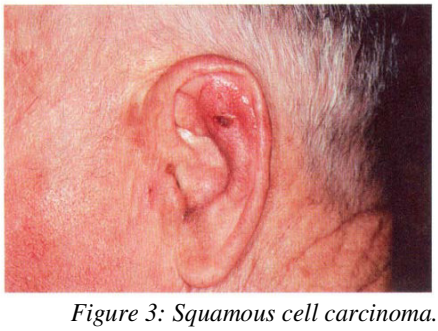

Figure 3: Squamous cell carcinoma.

Melanoma is the most serious form of skin cancer. During the past 10 years the number of cases of melanoma has increased more rapidly than that of any other cancer. Early detection of melanoma is crucial to the patient's survival. If melanoma is left undiagnosed, it will metastasize to other parts of the body[3]. Melanoma is a malignant tumor that originates in the melanocytes, the cells that produce the pigment melanin that colors the skin, hair, and eyes.

Melanoma falls into four basic categories: superficial spreading melanoma: Superficial spreading melanoma, which spreads laterally before it invades the deeper tissues, is the most common type and may produce tumors on any part of the body[1].

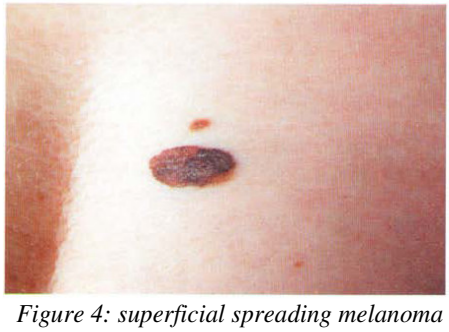

Figure 4: superficial spreading melanoma

Nodular melanoma: Nodular melanomas invade deeper tissues earlier than superficial spreading melanomas and tend to have a poorer prognosis.

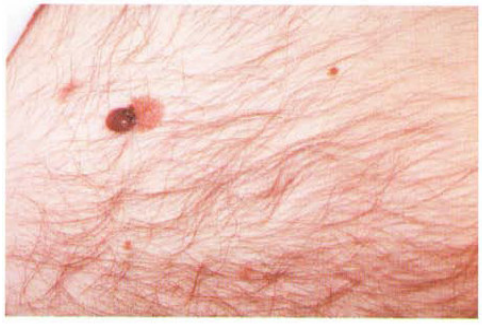

Figure 5: Nodular melanoma with an existing nevus

Acral lentiginous melanoma: Acral lentiginous melanoma is most commonly found in dark-skinned people and has the poorest prognosis.

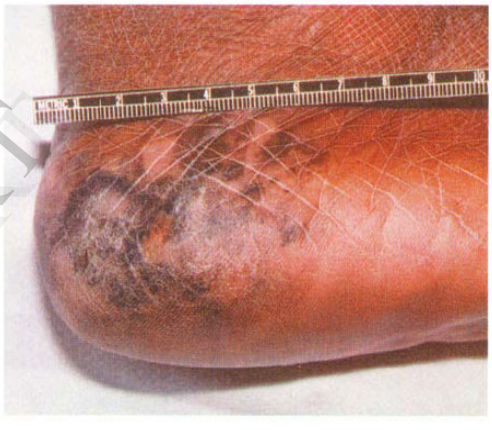

Figure 6: Acral lentiginous

Lentigo maligna melanoma: Lentigo maligna melanoma is the slowest growing form of melanoma and occurs on sun-damaged skin of elderly patients[7].

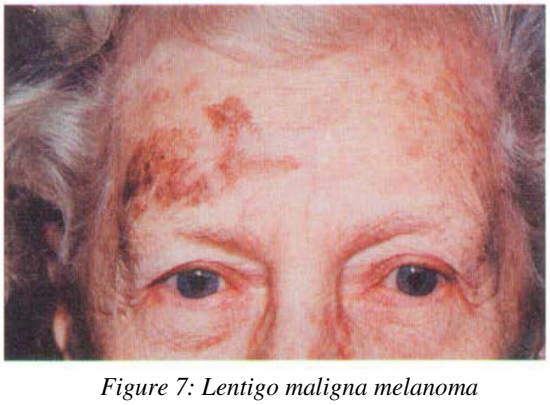

Figure 7: Lentigo maligna melanoma

3: The skin cancer detection system: System compares the two images and searches for changed and newly appeared moles. First it Figures out where the moles are in both images by a process called segmentation, which produces positional and feature (such area, perimeter, colour etc.) information for all the moles in both images. After this the images are registered or matched, such that moles that represent the same mole in the two images are labelled as the same mole[13]. Moles with the same label form a so-called mole pair. Moles that were not paired with another mole are new moles and are possible skin cancer candidates[4]. Finally the moles that do from a pair with another mole are compared on their features to see if they have changed over a period of time between the two photo sessions[12]. The moles that have changed are also possible skin cancer candidates.

The attention image is a compilation of the input images in which the moles that are new or have changed are indicated by a certain marker[8].

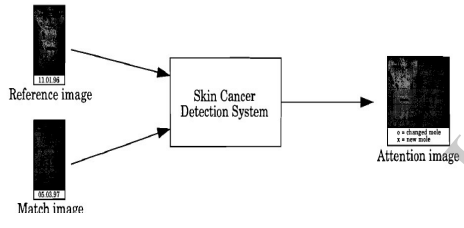

Figure 8: Skin Cancer Detection System

4: System Architecture

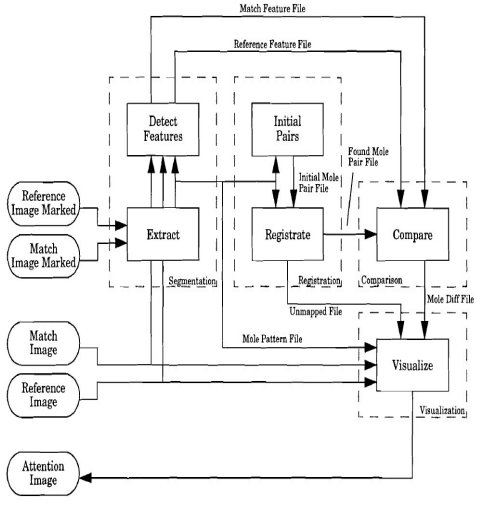

Figure 9: System Architecture

In this process registration is more important part because it determines which moles in the reference and match image represent the same mole [2]. The mole pairs it finds are written to the Found Mole Pair File for further processing. The moles of which no corresponding mole in the other image is found are written to the Unmapped File, to be displayed as possible skin cancer candidates[11].

4.1 Comparison:

The moles, of the mole pairs found by the registration process, have to be compared to see if they have changed, i.e. might have become cancerous. This is done by the comparison process which is implemented by the Khoros program Compare[6]. This program recalls the features of the paired reference and match mole in the reference and match features file and checks if the features are different. If the features in the successive reference and match image have changed more than a certain threshold then the mole is labelled as "changed". The results are written to the Mole Difference File.

4.2 Visualization

The final stage of the Skin Cancer detection system is visualizing which moles might have become cancerous so that the attending physician can subject them to a closer inspection[19]. The visualization process is performed by the program Visualize.

4.3 Features

Feature detection after registering. The moles of the reference and match image, it is known which moles in the reference image correspond to which moles in the match image[11]. The next step in the SCDS is to check whether or not a mole in the match image has changed during the time between the first photo session and the follow up session[12]. The segmentation process only gives information as to which pixels belong to the mole and which pixels is normal skin. A very crude approach to detect changes could be to subtract the reference mole pixels from the match mole pixels and calculate an overall error using the pixel differences[10]. A mole would be defined as changed if the overall error exceeded a certain threshold. In practice, however, this will not be a reliable method

because, among other things, the lighting conditions can vary from image to image. The approach taken here is to characterize the moles using features such as area, perimeter, colour variations etc. These features are then used to check if a mole has changed. Thus a feature that measures the irregularity of the mole border can be used to discern between a malignant and a benign mole[13]. These tailor-made features for the diagnosis of moles are also very useful when comparing moles for changes because if a mole changes from benign to malignant, it will certainly be one of these features that will change drastically [12]. Most diagnostic features can be summarized in the ABCD-rule which was introduced by Friedman et al. to improve the diagnostic accuracy when diagnosing moles. The mnemonic ABCD stands for features that describe early malignant melanoma:

- Asymmetry: One half of the mole does not match the other half;
- Border irregularity: The edges are ragged, notched and blurred;
- Colour: The pigmentation is uniform. Shades of tan, brown and black are present;
- Diameter: Bigger than 6 mm and growing.

The most basic features of a mole are its area and perimeter, using these features the compactness and irregularity index can be calculated[6]. The compactness of an object is defined as the ratio of area to perimeter and it measures if the object is strongly concentrated around a point or whether it has a more elongated structure. The irregularity of the mole border is measured by the irregularity index which is defined as the ratio of the area and the square of the perimeter[9]. Both features are defined in such a way that higher values, indicate a higher chance that the mole is malignant. In fractal dimensions are used to describe the irregularity of the mole border. Other features can be calculated if the centre of mass of the mole is known. Polar distances are distances from the centre of mass to the boundary of the mole. Especially, a high variance in the polar distances correlates with the existence of a melanoma. another feature is the ratio of the minimum to the maximum polar distance, called eccentricity[8]. The distance between the centre of mass and the centre of the minimum area surrounding rectangle of the mole, called "distance rectangle" can also serve as a very discriminating feature. The asymmetry of the mole, captured in a feature called the asymmetry index, is also used as a discriminative feature [20]. Some very important features are extracted from the colour components because the homogeneity or irregularity of the colors inside the mole is indicative of the malignity of that mole[4]. Malignant moles tend to have many different tones of colors, where as benign mole are very uniform in their coloring. This results in a high variance in the colour components of the pixels in a malignant mole[5]. Ercal use relative colour components to measure the colour of the mole relative to the colour of the surrounding skin to equalize variations caused by lighting, photography or the digitalization process.

4.4 Detecting Features: In the Skin Cancer detection system the features of the moles in the reference and match images are calculated by the Khoros program Detect Features. It uses the mole positions in the Mole Pattern File to locate where the moles are in the images and then copies the mole into a smaller image to increase processing speed[4]. Using the marker information in the Mole Pattern File, the mole images are scaled such that the reference and match mole images have the same scale. Otherwise it is not possible to compare the features of the reference and the corresponding match mole. Meter this features are calculated [5]. This process of copying, scaling and feature calculation is done for every mole in the reference and match image. The features of the reference moles are written to the Reference Feature File and the match mole features are written to the Match Feature File [6].

5 Retinex Theory: By using of retinex theory we can improve the performance of our Skin cancer detection system[23]. When we acquire the image from any external source like digital camera, medical equipment, etc. Then some possibility occurs for image degradation which cause features cannot be calculated more preciously. To avoid this problem we adopt retinex theory which is based on lightness for improve the quality of image[22]. There are various retinex algorithms for image enhancement like single scale retinex, multi scale retinex, multi scale retinex with color restoration, etc[21].

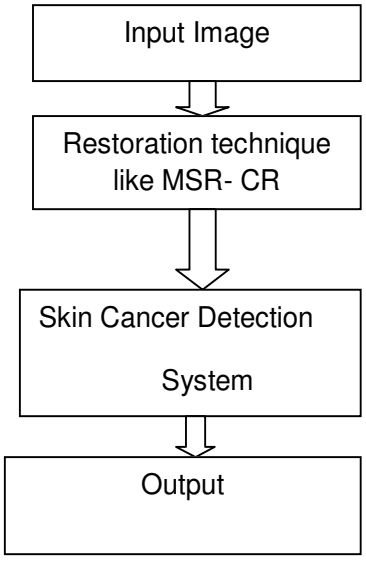

Fig 10 : proposed Approach

6 Conclusion: The medical profession mentions the increasing epidemic of skin cancer but the unique nature of the visibility and accessibility of the skin allows easy and rapid assessment of potentially malignant lesions. The only tools required are clinical acumen and a through knowledgeable approach. If more medical professional practice these strategies regularly and routine, a reduction in this epidemic is certainly an achievable goal.

7 References:

[1]Dhawan, A.P. A review on biomedical image processing and future trends. Computer Methods and Programs in Biomedicine, Vol 31 (1990), p. 141-183.

[2] Stoecker W.V.; Moss, RH.
Editorial: Digital imaging in dermatology. Computerized Medical Imaging and Graphics, Vol. 16 (1992), No.3, p. 145 - 150

[3] Friedman R; Rigel D.; Kopf, A. Early detection of malignant melanoma: The role of physician examination
and self examination of skin. Ca-A J. Clinicians, Vol. 35 (1985), p. 130-151.

[4] Nilles, M.; Boedeker, RH.; Schill, W.B. Surface microscopy of naevi and melanomas: clues to melanoma.
British Journal of Dermatology (1994) Vol. 130, p. 349-355.

[5] Umbaugh, S.E.; Moss, RH.; Stoecker W.V. Automatic color segmentation of images with application to detection ofvariegated\ coloring in skin tumors. IEEE Engineering in Medicine and Biology Magazine, Dec. 1989, p. 43-52.

[6] Ercal, F.; Chawla, A.; Stoecker, W.V.; Hsi-Chieh Lee; Moss, RH. Neural network diagnosis of malignant melanoma from color images. IEEE Transactions on Biomedical Engineering, Vol. 41 (Sept. 1994), No.9, p.837-845.

[7] Claridge, E.; Hall, P.N.; Keefe, M.; Allen, J.P. Shape analysis for classification of malignant melanoma Journal of Biomedical Engineering, Vol. 14 (May 1992), p. 229-234.

[8] Cancer facts and figures 2002, "American cancer society", Atlanta, Georgia, 2002.

[9] Claridge E., Hall P. N., Keefe M., and Allen J. P., "Shape analysis for classification of malignant melanomas", J. Biomed. Eng., vol. 16, no. 3, 191-197, 1992.

[10] DeCoste S. D., and Stern R. S., "Diagnosis and treatment of nevomelanocytic lesions of the skin. A community based study", Arch. of Dermatology, vol. 129, no. 1, 57-62, 1993.

[11] Detmar M., "Tumor angiogenesis", J. Investig. Dermatology Symp. Proc., vol. 5, 20-23, 2000

[12] Dhawan A. P., Gordon R., and Rangayyan R. M., "Nevoscopy: Three-dimensional computed tomography for nevy and melanoma by side-transillumination", IEEE Trans. in Med. Imaging, MI-3, 54-61, 1984.

[13] Dhawan A. P., "Apparatus and method for skin lesion examination", US Patent Number 5,146,923, 1992.

[14] Dhawan, A. P., Gordon R., and Rangayyan R. M., "Computed tomography by side-transillumination to detect early melanoma", IEEE Annual Conf. Proc. of Eng. in Med., 518-522, 1984.

[15] Dhawan A. P. and Sicsu A., "Segmentation of images of skin lesions using color and texture information of surface pigmentation", Computerized Med. Imaging and Graphics, vol. 16, no. 3, 163-177, 1992.

[16] Doshi M., Duvic M., Mullani N., and Zouridakis G., "Early diagnosis of skin cancer based on measuring vascularization and pigmentation in Nevoscope images". Abstracts of the Annual Houston Conf. on Biomed. Eng., 2004.

[17] Duda R., Hart P. and Stork D. "Pattern Classification", Wiley Publication, second edition, 2000.

[18] Ganster H., Pinz A., Rohrer R., Wildling E., Binder M., and Kittler H., "Automated Melanoma Recognition", IEEE Trans. on Med. Imaging, vol. 20, no. 3, 233-239, 2001.
[19] Gee M. S., Saunders H. M., Lee J. C., Sanzo J. F., Jenkins W. T., Evans S. M., Trinchieri G., Sehgal C. M., Felman M. D., and Lee W. M., "Doppler ultrasound imaging detects changes in tumor perfusion during antivascular therapy associated with vascular anatomic alterations", Cancer research, vol. 61, 2974-2982, 2001.
[20] Giovagnorio F., Andreoli C., and De Cicco M. L., "Color doppler sonography of focal lesion of the skin and subcutaneous tissue", J. Ultrasound Med., vol. 18, 89-93, 1999.
[21]. Land, E. H. & McCann, J. J. (1971) J. Opt. Soc. Am. 61, 1-11.
[22]. McCann, J., McKee, S. & Taylor, T. (1976) Vision Res. 16, 445- 458.
[23]. Land, E., Hubel, D., Livingstone, M., Perry, S. & Burns, M. (1983) Nature (London) 303, 616-618. Zeki, S. (1980) Nature (London) 284, 412-418.