Development of Computer-Aided Diagnosis for Early Detection of Skin Cancer: A Review

Abstract- **Melanoma is the deadliest type of skin cancer in humans. Hence, early detection of melanoma has the potential to reduce morbidity and mortality. Image-based computer aided diagnosis (CAD) systems have proven to be quite effective for screening and early detection of malignant melanoma, as well as to classify various skin lesions. In this paper, we review the recent development of CAD systems. We report the current practices, prospects of image acquisition, functionalities like image processing, feature extraction, segmentation used in the recent studies, and classification of dermoscopic images. The deficiencies in some of the existing studies are highlighted and suggestions for future research are provided.**

Keywords- ***melanoma, computer-aided diagnosis, image processing, dermoscopic images, classification.***

I. INTRODUCTION

Malignant melanoma is a lethal form of skin cancer with an estimated mortality rate of 14% worldwide [1]. This type of cancer occurs due to improper synthesis of melanin in melanocytic cells in the basal cell of epidermis layer of the skin [2]. People with many moles on their skin are at risk of developing melanoma. Sun exposure, genetic history, skin type, and immune system are certain factors to determine the risk of developing melanoma [3]. The rising incidence of melanoma, the benefits or early diagnosis, and limited access to dermatologic services in some countries lead to increased efforts to develop CAD systems [4].

To develop such systems and CAD tools, the characteristics of skin lesions are taken into consideration to determine the type of skin lesion. If the skin lesion is diagnosed as melanoma, it will be asymmetric, its borders will be notched, its colour will not be uniform, it will greater than a quarter inch, and it will also evolve with time. This is known as the "ABCDE" rule.

Application of computational intelligence methods helps physicians as well as dermatologists in faster data process to give better and more reliable diagnoses [5] . Early studies on CAD of skin lesions relied on hand-crafted feature engineering and segmentation mask. Although these methods showed promising results, the accuracy of the automated diagnostic system was lower than expected. Recent advances in computer science and the introduction of convolutional networks and deep learning approaches have revolutionized the classification of medical image analysis.

The aim of this paper is to review, summarize, and compare advanced algorithms used for CAD system development. It also contains deficiencies found in the current studies, as well as

suggestions for future work. The paper is organized as follows: (i) a comprehensive review of the available literature (ii) scheme of a general CAD system is provided (iii) concluding comments.

II. Literature Review

Sl. No	Authors	No. of samples	Segmentation method	Extracted features	Feature selection	Classifier	Performance
1.	Lin Li et al (2014)	187 (19 Melanoma and 168 Benign)	The line with pixels having significant intensities was picked to visualize spectra.	10 statistical measures of intensity (mean, standard deviation, L_1 norm, and L_2 norm) for P and V scans.	Not specified	Non-linear Support Vector Machine (SVM) by applying the radial basis function (RBF) Kernel	Accuracy=92% Specificity=92% Sensitivity=100%
2.	Ashwini C. S et al (2017)	200 (80 atypical, 80 benign, 40 melanoma)	ROI was segmented using thresholding technique, region and edge based	Texture, color, shape, smoothness, aspect ratio, location parameters, and compactness features	Not specified	SVM	Classifier A gave an accuracy of 90.4%, 93.5% and 94.3% to classify atypical, benign and melanoma. Classifier B gave an accuracy of 97.5%, 95.7% and 96.3% to classify melanoma, atypical and benign.
3.	Habeba Mahmoud et al (2018)	200 (80 common nevi, 80 dysplastic nevi and 40 melanomas)	Not specified	Texture orientation, GLCM features, gradient orientation using HOG, LBP feature vector and LDN feature vector	Not specified	Multi-layer perceptron (MLP)	AUC= 97.8% (between melanoma and common nevi) AUC= 95.4% (between melanoma and dysplastic nevi)

4.	Daniel S. Morais et al (2020)	200 (160 non-melanoma, 40 melanomas)	Mask application using AND operation.	Symmetry, diameter, mean, and variance	Not specified	Multi-layer perceptron (MLP)	Accuracy=90% Specificity=90.9% Sensitivity=87.5%
5.	Ebrahim Mohammed Senan et al (2021)	200 (80 Benign, 80 Atypical Nevi and 40 Melanoma)	Active Contour Technique (ACT)	Asymmetry, border irregularity, color, diameter parameter using ABCD rule	Not specified	Total Dermoscopy Score (TDS)	Accuracy=84% Specificity=89.5% Sensitivity=60.5%

III. Methodology

A. Data Set/Image Acquisition

Notable increase in the number of deaths due to skin cancer has led many research centres to create databases. A PH^2 dermoscopy database image database was created to assist researchers. It was created through a research collaboration between the Dermatology service of Hospital Pedro Hispano in Matosinhos, Portugal and the Univeridade do Porto, ecnico Lisboa. For image acquisition, skin scans can be collected by optical sprectroscopic device with combined single and multiple-scattered light measurement. An iPhone camera attached with a dermoscope can also be used for satisfactory image acquisition.

B. Pre-Processing and Segmentation

The main processing step is to differentiate the lesions from healthy skin. The images contain noise in the form of hairs and air bubbles. Hence, to remove noise, algorithms like Dull Razor algorithm are used, morphological bottom-hat filter is applied, Median filter is used.

Segmentation is the process of determining the region of interest (ROI) by the separation of the skin lesion from the rest of the image. It is achieved using image properties such as edges, texture. The ROI is obtained by classifying the group of pixels which are homogeneous. It is based on the method of thresholding. Other techniques are also implemented for segmentation such as Active Contour Technique or Mask application. Manual segmentation can also be carried out by the dermatologists.

Morphological operators are implemented after segmentation to remove very small objects from the digital images, and to obtain enhanced digital images.

C. Feature Extraction

The purpose of feature extraction is to reduce the original data set by measuring certain properties or features, that differentiate one input pattern from another. Different feature extraction methods found in the literature include statistical and model-based and filtering-based methods. Method based on ABCD-E rule of dermoscopy images is used because of its effectiveness, efficiency, and simplicity. Gabor filters, Histogram of oriented gradients (HOG) Grey level co-occurrence matrix, Local binary pattern (LBP), and Local directional number pattern (LDN) are also important methods to extract features.

D. Classification

Classification is the process of making inferences from the extracted features to produce a diagnostic about the input image. Classifiers like Support vector machine (SVM) and multilayer perceptron (MLP) are used for this process. Hold-out validation method and Total Dermoscopy Score (TDS) are methods for classification. In this process, the dataset is divided into training and testing sets. In training, the classification model is developed based on the training samples using machine learning technique. In testing, accuracy of the learned model is measured using the test dataset.

IV. Conclusion & Future Work

In this paper, we combine and examine the research being done to develop computer-aided diagnosis system for skin cancer detection and classification. After examining, we found certain steps for future work. Enhancing accuracy and applying proposed systems to more databases can help prevent bias classification. Moreover, there work must be done on systems to detect Melanoma of homogenous color and regular shape since it cannot be detected using ABCD rule. Apart from this, in order to judge the performance of the CAD systems, it is important to know who is going to use these systems. If it will be used by general practitioners, then these systems must have very high sensitivity and excellent specificity. High sensitivity would guarantee all patients with melanoma can be identified, while excellent specificity would allow clinicians rule out most patients with benign lesions from performing the painful and expensive biopsies.

Although the accuracy of CAD for melanoma detection is comparable to that of experts, the real-world applicability is unknown and potentially limited to overfitting and the risk of bias of the current studies. Nevertheless, logic dictates that with better training and robust algorithms, automated systems will overcome its shortcomings and help our goal of significant reduction in skin cancer mortality rates.

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