Supervised Classification of Dermoscopic Images Using Gaussian Mixture Model and Artificial Neural Network

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Abstract: In melanoma diagnosis, the segmentation and detection of the melanocytes in the epidermis area is an important step before the diagnosis is made. If the melanocytes can be found correctly, architectural and cellular features e.g. size, distribution, location etc. can be used to grade or determine the malignancy of the skin tissue. So border detection of the infected regions in this automated system is the major step as all other results depend on accuracy of detected area. In this work, we have proposed a neural network based segmentation system which can efficiently classify the pixels of the input images into infected or non-infected parts. In this we used the pixel surroundings which contain the neighborhood texture information of the pixels which helps in better classification of pixels into similar clusters depending upon the surroundings. For getting the features of these neighborhood Gaussian mixtures has been evaluated first from a few selected pixels from different intensity areas and then each pixel has been put into a particular cluster based on modeling of Gaussian mixtures. For further improving the segmentation results and to get results in two categories, neural network based classification has been preferred as they gave much better efficiency than the pre-segmentation done by Gaussian clustering. The proposed work has been tested on variety of images and the results shows that it gives higher accuracy in terms of sensitivity and specificity values.

1. Introduction

Today the most rapidly increasing cancer in the world is due to the together comprises of Invasive and in situ malignant melanoma. The estimated incidence of Invasive melanoma alone is 76 100 and an estimated deaths only in USA is total of 9710 in 2014 [1]. It is important to diagnose melanoma early since it can be cured with a simple excision if it is detected early. It is most rapidly increasing incidence and majority (75%) of deaths are caused related to skin cancer. In advanced stages it has signs of metastasis which is incurable, and the treatment of it as being solely is palliative also includes surgery, immunotherapy, chemotherapy, or radiation therapy [2]. It is unequivocally because of these grievous measurements that by far most of examination distributed in the field of computerized analysis of dermatological images is committed to creating programmed method for melanoma finding. Another purpose behind this research efforts is the way that early-organize melanoma is exceedingly treatable. This highlights the basic significance of auspicious conclusion and treatment of melanoma for patient survival. The most profitable prognostic element of dangerous melanoma is Breslow's depth or thickness. Alexander Breslow proposed this method for measuring the vertical development of melanoma in 1970. As a rule, the more profound the estimation (profundity of invasion), the more risks there are for metastasis and the more terrible the prognosis.

2. Dermoscopy

Dermoscopy, otherwise called epiluminescence microscopy, is a noninvasive skin imaging method that utilizations optical amplification and either fluid inundation and low edge of-rate lighting or cross-polarized lighting; this makes sub-surface structures all the more effortlessly obvious when contrasted and traditional clinical pictures. Dermoscopy permits the distinguishing proof of many morphological components, for example, atypical color systems, spots/globules, streaks, blue-white zones, and blotches. This lessens screening blunders and gives more noteworthy separation between troublesome sores, for example, pigmented Spitz nevi and little clinically obscure sores [3]. In any case, it has been exhibited that dermoscopy may really bring down the analytic precision in the hands of unpracticed dermatologists. Along these lines, to minimize the analytic mistakes that outcome from the trouble and subjectivity of visual translation, the advancement of electronic picture investigation strategies is of vital significance. Shading data is key for the clinical determination of melanoma. Melanins is the most essential chromophore in melanocytic neoplasms.
3. Causes of melanoma

Sun presentation, as UVB and UVA light, is a potential reason for melanoma. Proof recommends that few scenes of sunburn because of extraordinary, irregular sun introduction essentially build the danger of building up a melanoma further down the road [6]. There is rising confirmation that introduction to bright radiation using sun beds likewise expands the danger of melanoma. In 2009, the International Agency for Research on Cancer raised the characterization of bright transmitting tanning gadgets to "cancer-causing to people" in the most elevated danger class. This depends on confirmation that individuals who routinely utilize sun beds have a considerably higher danger of creating cutaneous melanoma. The latest meta-investigation presumed that the utilization of sun beds builds the danger of melanoma by 75%, particularly when utilized before the age of 35 [7]. Bright radiation seems to instigate melanoma through numerous instruments, including concealment of the insusceptible arrangement of the skin, prompting of melanocyte cell division and free radical generation. Free radicals are exceptionally receptive particles that are created in the body normally as a repercussion of digestion system, and as an aftereffect of presentation to poisons in the earth, for example, tobacco smoke and bright light. Free radicals contain an unpaired electron. Basically, they are in a consistent hunt to dilemma with another electron to settle themselves – a procedure that can harm DNA and different parts of human cells. This harm may assume a part in the advancement of tumor and different ailments, and also quickening the aging procedure [8].

4. Signs of melanoma cancer
I. Alteration in color: the mole has reddish edge. It may become shadier or appear to have different shades of color, usually brown and black mixture.
II. Alteration in size – the mole may spread over the skin and can become lumpy
III. Alteration in the shape – moles have a flat, regular outline mostly but a melanoma is more likely to have an irregular, shabby edge
IV. Due to inflammation, Melanomas are red, and can also have blue-white tinge, this is due to partial clearing in the centre.

5. Automated system for Melanoma detection

Early work on automated systems to assess the risk of melanoma used dermoscopy images. These are images that are obtained via a digital dermascope, which is a device that assists dermatologists by magnifying surface detail and filtering surface reflectance.

6. Existed work

Parihar et al. [9] proposes a picture classification framework for untimely Skin malignancy location grasps distinctive stages: pre-and Post-handling, division, highlight extraction and classifier. By resizing the image increase the speed to perform and expels the additional features like noise and fine hair. Post-preparing upgrades the image greatness and hones the structure of the cancer cell. Various another methods are compared and evaluated in this contemporary research for getting acceptable segments of dermatoscopic images, all apt for consolidation in a programmed dermoscopic picture analyzer.

Figure 1: (a) A dermoscopic image with common nevi; (b)-(c) Two dermoscopic images with melanoma; (d) A dermoscopic image with an atypical nevi [9].

In any case, just 48% of honing dermatologists in the U.S. use dermascopes, so the proposed automated frameworks are hard to broadly receive. Late frameworks use pictures taken by a standard advanced camera, which is more open to dermatologists. The photos are fragmented to recognize the injury territory, elements are extricated from the sore, and the sore is arranged as far as danger of melanoma. The issue is that enlightenment from skin surface reflectance affects each of the three of those strides. Subsequently, sound skin regions impeded by shadows seem comparative in shading as the skin injury, which results in misclassification of those territories. As said over an ordinary nevi has been separated from melanoma Illumination redress is a vital preprocessing venture for skin injury photos preceding division and order calculations. In division, fluffy c-implies has been utilized by Parihar et al. [9]. For characterization of dermoscopy pictures, they utilized simulated neural system approach. In this paper, we have give an enhanced calculation keeping in mind the end goal to expand accuracy rate of division.
Clausi et al. [10] proposed a novel multistage brightening displaying algorithm to revise the fundamental enlightenment variety in skin injury photos. The main stage is to process an underlying evaluation of the enlightenment guide of the photo utilizing a Monte Carlo nonparametric modeling strategy. The second stage is to acquire a last gauge of the brightening map by means of a parametric displaying system, where the underlying nonparametric appraisal is utilized as an earlier. At long last, the revised photo is gotten utilizing the last enlightenment map gauge. The proposed calculation indicates better visual, division, and characterization results when contrasted with three other brightening rectification calculations, one of which is planned particularly for lesion analysis.

Sulaiman et al. [11] proposed Adaptive Fuzzy-K-means clustering algorithm for image segmentation which could be connected on general pictures and/or particular pictures caught utilizing diverse shopper electronic items. The calculation utilizes the ideas of fuzziness and belongingness to give a superior and more versatile clustering process when compared with other clustering techniques. Both subjective and quantitative examinations support the proposed AFKM calculation as far as giving a improved segmentation performance to different sorts of pictures and different number of segmented regions. In light of the outcomes acquired, the proposed calculation gives better visual quality when contrasted with a few other clustering techniques.

Mondal et al. [12] proposed a fuzzy principle guided approach, which is useful without any outer intervention during the execution. Test results recommend that this methodology is a proficient one in contrast with various different other techniques. They take response to viable measurements like Mean Squared Error (MSE), Mean Absolute Error (MAE), Peak Signal to Noise Ratio (PSNR).

Rudzsky et al. [13] use fuzzy classification engine for nuclei cell segmentation. The fuzzy tenets depended on shape and shading highlights. These classifications were set up with measurably evaluated dispersion parameters of picture components and confirmed on an extensive magnifying instrument picture information set. The results have shown better segmentation in fuzzy method then segmentation based on crisp rules.

Mehta Et al. [14] use efficient supervised learning approach to propose the tasks of extracting, classifying and segmenting the Dermoscopic image, i.e., Multi-Layer Feed-forward Neural Network for more precise and computationally effective division. The components are extricated from the Dermoscopic picture utilizing Genetically Optimized Fuzzy C-implies grouping approach and these exact elements are utilized to prepare the multilayer classifier. The prepared system is utilized for division of dangerous melanoma from the skin. They contrast the outcomes and the ground truth pictures and assess the execution of calculation of algorithm with it.

Nagaraj et al. [15] have proposed a automatic segmentation of skin lesion in traditional naturally visible pictures. Numerous methodologies have been proposed to illustrate the skin cancer. A broad writing review is done to concentrate on the condition of-workmanship systems for skin tumor recognition; Various techniques has given very impressive results like level set active contours (LSAC), skin lesion segmentation (SLS) and multidirectional inclination vector stream (MGVF). In this method they also propose a system in light of stochastic region merging (SRM) and region adjacency graph (RAG). Dividing the skin sore from image is an extremely difficult issue because of some element, for example, enlightenment variety, hair presence, sporadic skin shading variety and different unfortunate skin districts. To explain every one of these elements we have presented another methodology called novel iterative stochastic region merging likelihood for illustrating the skin injury from images by macro scope in light of the discrete wavelet transformation (DWT).

Jain et al. [16] present another methodology for Skin Cancer detection and examination from given images of patient's tumor influenced region, which can be utilized to computerize the diagnosis and therapeutic treatment of skin cancer. The proposed technique is utilizing Wavelet Transformation for picture change, de-noising and Histogram Analysis though ABCD principle with great indicative precision worldwide is utilized as a part of diagnosis framework as a base lastly Fuzzy Inference System for Final choice of skin sort in light of the pixel color seriousness for definite choice of Benign or Malignant Skin Cancer.

Amelio et al. [17] proposed a color image segmentation technique taking into account Genetic Algorithms in separating skin injuries. Results demonstrate that this approach can distinguish lesion borders in very accurat way, therefore combined with a merging technique of the detecting region could uncover a promising technique for detaching skin tumor.
7. Proposed approach for dermoscopic image segmentation

A. System Model

The system model for the proposed work is shown in figure below:

![Flowchart of the proposed work](image)

#### 7.1 System model for proposed neural network based classifier

The proposed neural object is trained from the rough classes of normal skin and melanoma which are determined by using fuzzy c-means clustering algorithm and Gaussian mixtures outputs. The database images we used, comprehends both digital photo and dermoscopy images. An RGB color space is any additive color space based on the RGB color model and Lab colour space determined by RGB values has been used in segmentation purposes. Feature extraction is the procedure that takes out the concealed properties or the raw data from the image that is auxiliary used in the classifier. A large clan of fuzzy clustering algorithms is based on minimization of the fuzzy c-means functional. Fuzzy c-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters. It is based on minimization of the following objective function:

\[
J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ij}^m \|x_i - c_j\|^2
\]

\[1 \leq m < \infty\]

where \(m\) is any real number greater than 1, \(u_{ij}\) is the degree of membership of \(x_i\) in the cluster \(j\), \(x_i\) is the \(i\)th of \(d\)-dimensional measured data, \(c_j\) is the \(d\)-dimension center of the cluster, and \(||*||\) is any norm expressing the similarity between any measured data and the center. Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership \(u_{ij}\) and the cluster centers \(c_j\) by:

\[
u_{ij} = \frac{1}{\sum_{k=1}^{C} \left( \frac{\|x_i - c_j\|^2}{\|x_i - c_k\|^2} \right)^{\frac{m-1}{2}}} \]

\[\text{...2}\]

\[
c_j = \frac{\sum_{i=1}^{N} u_{ij}^m x_i}{\sum_{i=1}^{N} u_{ij}^m} \]

\[\text{...3}\]

This iteration will stop when

\[
\max_{y} \left( u_{y}^{(k+1)} - u_{y}^{(k)} \right) < \epsilon
\]

where \(\epsilon\) is a termination criterion between 0 and 1, whereas \(k\) are the iteration steps. This procedure converges to a local minimum or a saddle point of \(J_m\); this algorithm has been used to get a few distinctive pixels from the image which have different neighborhood properties i.e. intensity etc. After this GM models has been evaluated for those pixels and segmentation step has been carried by posterior evaluation of neighborhood properties of each pixel location

A Gaussian mixture model is a probabilistic model that assumes all the data points are generated from
a mixture of a finite number of Gaussian distributions with unknown parameters. One can think of mixture models as generalizing k-means clustering to incorporate information about the covariance structure of the data as well as the centers of the latent Gaussians. The GMM object implements the expectation maximization algorithm for fitting mixture-of-Gaussian models. It can also draw confidence ellipsoids for multivariate models, and compute the Bayesian Information Criterion to assess the number of clusters in the data. A GMM.fit method is provided that learns a Gaussian Mixture Model from train data. Given test data, it can assign to each sample the class of the Gaussian it mostly probably belong to using the GMM.predict method. The GMM comes with different options to constrain the covariance of the difference classes estimated: spherical, diagonal, tied or full covariance. In this work we use it as pre-classifier to get the rough idea of the normal skin and its separation from melanoma pixels. Finally Ann classifier has been used to get the final segmentation results.

8. Results and discussion

Parameters used

(i) Sensitivity is the proportion of patients with disease who test positive. In probability notation: \( P(T^+|D^+) = \frac{TP}{(TP+FN)} \).

(ii) Specificity is the proportion of patients without disease who test negative. In probability notation: \( P(T^-|D^-) = \frac{TN}{(TN+FP)} \).

![Figure 3: Input image from the dataset used in parihar et al. [9]](image)

![Figure 4: Segmentation results by the proposed algorithm.](image)

As seen above, the proposed algorithm is able to detect those pixels also which are not connected to main melanoma region. This is the positivity of the proposed algorithm that as most segmentation algorithms carried out segmentation for single melanoma region this can detect the minor changes in the skin, which will be helpful for better classification in stages of infected region. Accuracy results on few of the images from the dataset have been shown in bar graphs below.

![Figure 5: Image showing sensitivity and specificity graphs](image)

9. CONCLUSION

The accuracy of border detection impacts heavily on the implementation of the subsequent parts of the diagnostic system, i.e., feature extraction and classification, for the fact that features such as asymmetry and border irregularity are highly dependent on border detection. In this work, we have explored the segmentation step which is required for better classification of melanoma images. Results described in previous chapter
shows that the proposed algorithm gives high accuracy rates in finding the infected melanoma pixels in the image which can be noticed from high sensitivity and specificity values. As most of existed algorithms and the base paper results, they worked efficiently on single region melanoma images and even in that behave poorly in boundary pixels of the images. As Gaussian mixture are trained with neighborhood pixel texture they help in good pre-segmentation in which rough idea of clusters help in making two classes called infected and non-infected regions. The drawback or shortcoming of Gaussian mixture segmentation has been widely improved when the input images are tested with trained ANN objects of the same image and by thresholding good segmentation results are achieved which are considered as final output of the algorithm. Experimental results show that the proposed algorithm provides 95-98% accuracy on tested images.

References:


