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Skin disease prognosis from dermoscopic images with image processing and IoT

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ABSTRACT

Dermatology is one of the major fields of prescription which is worried about the analysis and treatment of skin disorders. Skin diseases are among the most widely recognized medical issues around the world. Regardless of being common, their determination is quite troublesome and requires broad knowledge and expertise in the area. Skin disease might cause severe health and monetary consequences for patients if not detected and controlled early. Early recognition can forestall the condition from worsening. The proposed work presents the development of an automated skin disease diagnosis system which takes images of a skin disease as an input by the user and predicts the type of skin disease. The system uses a dual stage approach for detection and displaying process which effectively uses image processing and IoT. In the 1st stage, the image of the skin condition is subject to numerous types of pre-processing techniques followed by feature extraction. The extracted features are fed to the SVM classifier to identify disease and predict accordingly. On training and testing for 5 diseases the system produces an overall prediction accuracy of 90%.

Keywords: Wiener filter, Boundary Tracing Algorithm, SVM Classifier.

INTRODUCTION

Dermatology is one of the most unpredictable and difficult terrains to diagnose due its complexity. In most developing countries, it is expensive for a large number of people to consult a dermatologist. The abundant use of smart phones in a developing country has opened up new avenues for inexpensive diagnosis of diseases. We can use the camera technology present in every smartphone and exploit the image processing capabilities of the device for diagnosis. We have developed an application that utilizes a two staged approach in order to tackle the problem. The first stage involves Image Processing for identification and the second stage involves Machine Learning for a near fool proof solution. Difficulty for the differential diagnosis is that a disease may show the features of one disease in the initial stage and may have the characteristic features of another in the following

stages. Usually a biopsy is necessary for the diagnosis but these diseases share many histopathological features as well. This issue is solved by using machine learning models on the clinically evaluated features which are determined by an analysis of the skin samples under the microscope. Owing to the subjective nature of diagnosis, medical students find it difficult to verify their diagnosis. This system acts as an effective learning tool, aiding verification of their results as they have access to clinical data. The training data set was obtained from the machine learning data repositories available online. We have achieved higher accuracies with the help of various pre-processing methods in image processing and with the help of SVM classifier. The system is capable of detecting five of the most commonly occurring diseases, namely – Psoriasis, wound, rashes, malignant and skin cancer.

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OBJECTIVE

To detect the five types of skin disease such as psoriasis, skin cancer, malignant, rashes and wound

with the combination of image processing and SVM classifier with high accuracy.

System Architecture

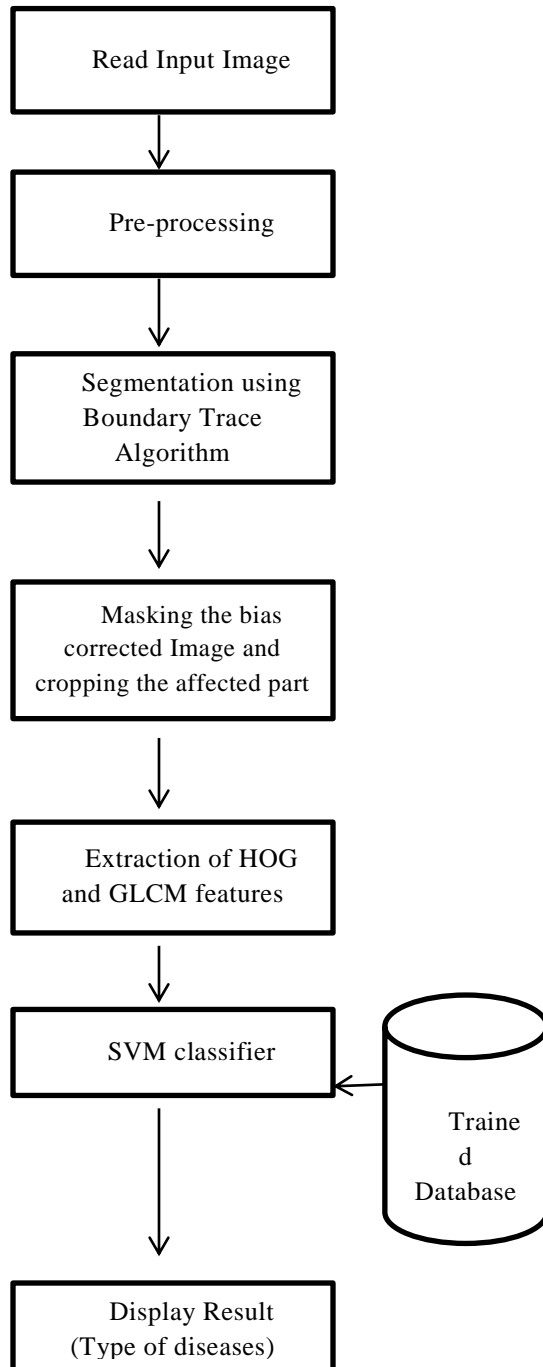


Fig. 1. Block Diagram of Skin Disease Prognosis System

Input image

Dermoscopic images for training the database are collected from the online resources. Nearly 44 images are collected now. In future 100 images for the different types of diseases will be added to the database for efficiency of the automated system.

Image preprocessing

Medical image analysis requires the preprocessing, because of the noise may be added to the MR images due to imaging devices. The Gaussian filter is used to improve the quality of the image by noise suppression, contrast enhancement, intensity equalization, outlier elimination. The Gaussian distribution in 1-D has the form:

$$G(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}} \quad \dots (1)$$

Where σ is the standard deviation of the distribution. It is assumed that the distribution has a mean of zero. In 2-D, an isotropic (i.e. circularly symmetric) Gaussian has the form:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad \dots (2)$$

Boundary tracing

Boundary tracing (also known as contour tracing) of a binary digital region can be thought of as segmentation technique that identifies the boundary pixels of the digital region. Boundary tracing is an important first step in the analysis of region. The main objectives: The purposes of this laboratory session are to extract the objects' contours using a border tracing algorithm; to represent efficiently each extracted contour using chain codes; to take advantage of using chain codes

in representing the objects' contours (border reconstruction, matching, merging etc.)

Border tracing algorithm

The border tracing algorithm is used to extract the contours of the objects (regions) from an image. When applying this algorithm it is assumed that the image with regions is either binary or those regions have been previously labelled. Algorithm's steps:

1. Search the image from top left until a pixel of a new region is found; this pixel P0 is the starting pixel of the region border. Define a variable dir which stores the direction of the previous move along the border from the previous border element to the current border element. Assign (a) dir = 0 if the border is detected in 4-connectivity (Fig. 1.2 a) (b) dir = 7 if the border is detected in 8-connectivity (Fig. 1.2 b)
2. Search the 3x3 neighbourhood of the current pixel in an anti-clockwise direction, beginning the neighbourhood search at the pixel positioned in the direction (a) (dir + 3) mod 4 (Fig. 1.2 c) (b) (dir + 7) mod 8 if dir is even (Fig. 1.2 d) (dir + 6) mod 8 if dir is odd (Fig. 1.2 e) The first pixel found with the same value as the current pixel is a new boundary element Pn. Update the dir value.
3. If the current boundary element Pn is equal to the second border element P1 and if the previous border element Pn-1 is equal to P0, stop. Otherwise repeat step (2). 4. The detected border is represented by pixels P0 ... Pn-2.

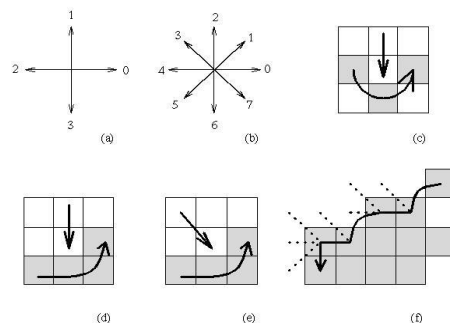


Fig. 2. (a) Direction notation, 4-connectivity, (b) 8-connectivity, (c) pixel neighbourhood search sequence is 4-connectivity, (d),(e) search sequence in 8-connectivity, (f) boundary tracing in 8-connectivity (dashed lines show pixels tested during the border tracing).

Binarization

A binarization method of binarizing an image by extracting lightness (brightness, density) as a feature amount from the image. When a pixel is selected in an image, a sensitivity is added to and/or subtracted from the value concerning the Y value of the selected pixel to set a threshold value range. Next, when another pixel is selected, the sensitivity is added to or subtracted from the value concerning the Y value of the selected pixel and a new threshold value range is set containing the calculation result and the already setup threshold value range. The pixel with the value concerning the Y value of any pixel in the image within the threshold value range is extracted as the same brightness as the selected pixel and the extraction result is displayed.

$$\sigma_B^2(k) = \frac{[\mu T\omega(k) - \mu(k)]^2}{\omega(k)[1 - \omega(k)]} \dots (3)$$

Image cropping and filtering

The first step in image pre-processing is image cropping. Some irrelevant parts of the image can be removed and the image region of interest is focused. This tool provides a user with the size information of the cropped image. Matlab function for image cropping realizes this operation interactively waiting for a user to specify the crop rectangle with the mouse and operates on the current axes. The output image is of the same class as the input image. This tool for pre-processing let the user to explore 2-D Finite Impulse Response filters. By changing the cut-off frequency and filter order, the user can design filter and can see the designed filter's coefficients and frequency response.

Wiener filter

The inverse filtering is a restoration technique for convolution, i.e., when the image is blurred by a known lowpass filter, it is possible to recover the image by inverse filtering or generalized inverse filtering. However, inverse filtering is very sensitive to additive noise. The approach of reducing one degradation at a time allows us to develop a restoration algorithm for each type of degradation and simply combine them. The Wiener

filtering executes an optimal tradeoff between inverse filtering and noise smoothing. It removes the additive noise and inverts the blurring simultaneously.

To implement the Wiener filter in practice we have to estimate the power spectra of the original image and the additive noise. For white additive noise the power spectrum is equal to the variance of the noise. To estimate the power spectrum of the original image many methods can be used. A direct estimate is the periodogram estimate of the power spectrum computed from the observation:

$$W = \frac{1}{H} \frac{S_{yy}^{per} - S_{\eta\eta}}{S_{yy}^{per}} \dots (4)$$

Gray level matrices (glcm)

Gray Level Co-occurrence Matrix (GLCM) is a widely used texture descriptor and it is proven that results obtained from the co-occurrence matrices are better than the other texture discriminations methods. GLCM computes the statistical features based on gray level intensities of the image. Such features of the GLCM are useful in texture recognition, image segmentation, image retrieval, color image analysis, image classification, object recognition and texture analysis methods etc. In addition to these parameters, the second order statistical parameters from the Gray level co-occurrence matrix of the texture contrast, energy, homogeneity and correlation, Legendre moments etc. are used to identify the transition temperatures of liquid crystals.

Texture features from glcm

A number of texture features may be extracted from the GLCM. We use the following notation:

G is the number of grey levels used.

μ is the mean value of P.

μ_x , μ_y , σ_x and σ_y are the mean and standard deviation of P_x and P_y .

$P_x(i)$ is the i^{th} entry in the marginal-probability matrix obtained by summing the rows of $P(i, j)$: the i^{th} entry in the marginal-probability matrix obtained by summing the rows of $P(i, j)$

$$P_{x+y}(k) = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} P(i, j) \quad i + j = k$$

for $k=0, 1, \dots, 2(G-1)$ (4)

$$P_{x+y}(k) = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} P(i, j) \quad |i + j| = k$$

for $k=0, 1, \dots, G-1$ (5)

Classification

A two layer feed forward network with sigmoid activation function is designed with 44 input neurons, 10 hidden neurons and 4 output neurons for the classification.

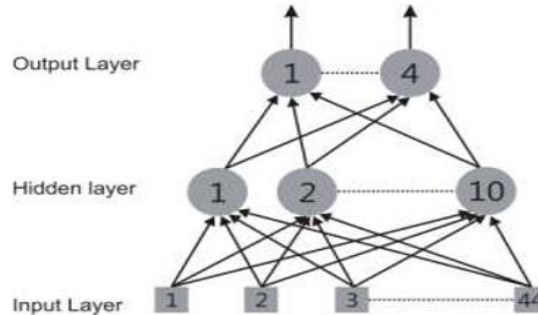


Fig. 3. Network architecture

The Levenberg-Marquardt algorithm is used for the training the neural network which is a very simple, but robust, method for approximating a function.

$$(J^T + \lambda I) \delta = J^T E \quad \dots (6)$$

Where J is the Jacobian matrix for the system, λ is the Levenberg's damping factor, δ is the weight update vector that we want to find and E is the error vector containing the output errors for each input vector used on training the network. The δ tells us by how much we should change our network weights to achieve a (possibly) better solution. The $J^T J$ matrix can also be known as the approximated Hessian. The λ damping factor is adjusted at each iteration, and guides the optimization process. If reduction of E is rapid, a smaller value can be used, insufficient reduction in the residual, λ can be increased, giving a step closer to the gradient descent direction. The 56 samples, 16 samples for validation and 8 samples for the testing are used for the training purpose. The training stops when a classifier gives a higher accuracy value with minimum training and testing errors.

Support vector machine

Support vector machines are supervised learning models with associated learning algorithms that analyze data and recognize patterns,

used for classification and regression analysis. Given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the making it a non-probabilistic binary linear classifier. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap+. they fall on.

In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces.

Properties of support vector machine

SVMs belong to a family of generalized linear classifiers and can be interpreted as an extension of the perceptron. They can also be considered a special case of Tikhonov regularization. A special property is that they simultaneously minimize the empirical classification error and maximize the geometric margin; hence they are also known as maximum margin classifiers.

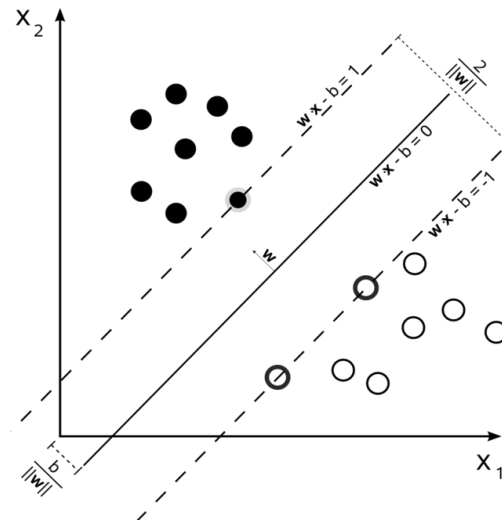


Fig. 4. SVM Hyperplane Images

Maximum-margin hyperplane and margins for an SVM trained with samples from two classes. Samples on the margin are called the support vectors.

RESULTS AND DISCUSSION

The system uses the boundary trace algorithm. The algorithm segments the diseased part of the

patient's skin image which is the input and by doing so it is very easy to accurately find the skin disease. The diseased part is taken and the image is enhanced to improve the accuracy of the symptoms of a particular disease. This enhanced image is further given as input to the trained database to find the type of skin disease using the SVM classifier.

Fig. 5 is the input image which is used for the detection of skin disease.



Fig. 5. Original Input Image

Fig. 6 shows the output for the Wiener filterization process.

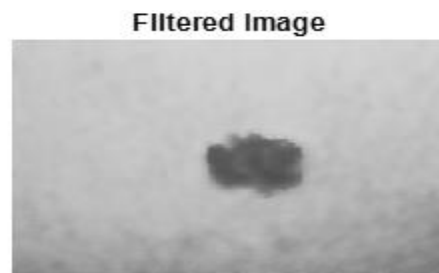


Fig.6. Filtered Image

The output for the Boundary Trace Algorithm is shown in Fig.7

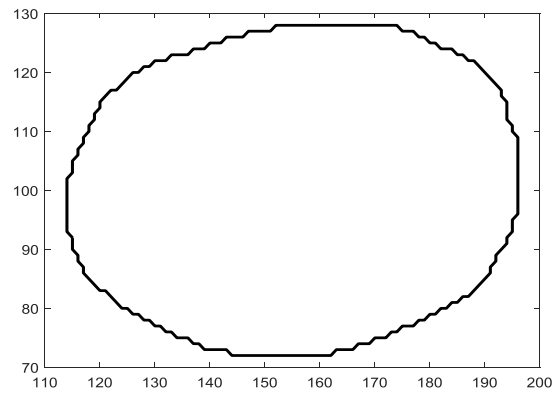


Fig.7. Contoured Image

From the contoured image the diseased part from the original input image is traced and which is shown in Fig.8.



Fig.8. Traced Image

Fig.9 shows the image after enhancing the features of the image using Binarization and GLCM.

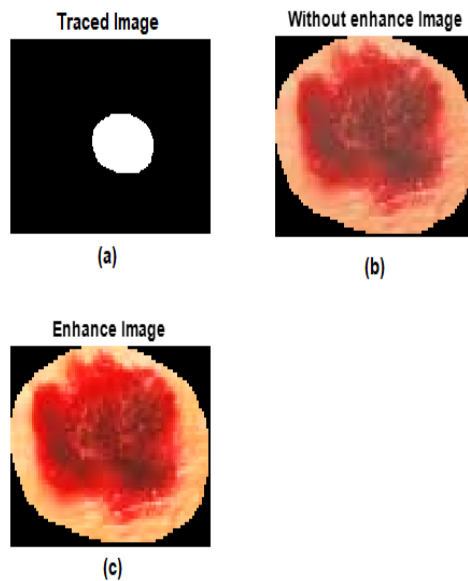


Fig.9. (a) Diseased part of binary image, (b) Diseased part of original image without enhancement, (c) Diseased part of original image with enhancement

The enhanced image is given to the SVM classifier to detect the type of disease and the result

will be displayed as skin cancer which is shown in the Fig.10.

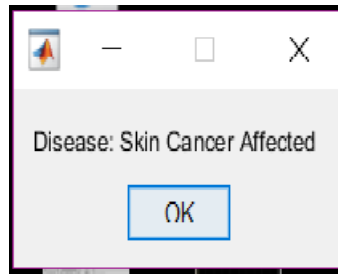


Fig.10. Output of Skin disease Prognosis System

The system is trained to detect the other types of skin disease like malignant, Psoriasis, Rashes, Wound which has shown in the following table.

		Number of Images collected
S. No	Disease Name	
1	Skin Cancer	15
2	Malignant	4
3	Rashes	12
4	Wound	4
5	Psoriasis	9
6	Total	44

SUMMARY

The project is to detect the five types of skin disease using Image Processing and IoT. The diseased area of the skin image is taken using mobile camera and is filtered using Weiner filter. Then it is segmented using Boundary Trace Algorithm and converted into a binary image. Feature extraction is performed on the binary image

using GLCM. The extracted features are given to the SVM classifier which is a kind of trained database to detect the type of skin disease with high accuracy. In future, the result will be displayed using the IoT server. The IoT server helps the patient, doctor and the patient's family members to access the result using mobile device from anyplace and at anytime.

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