

Analysis of Skin Lesions in Multispectral Images using Texture Based Coin Segmentation and Artificial Neural Network

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Abstract—Skin cancer is due to the development of abnormal cells that have the ability to spread to other parts of the body. It is common among non-Hispanic white males and females. Due to costs for dermatologists to screen every patient is high, images captured from digital camera is used. To detect melanoma at early stages, an automated system using images captured from multispectral camera is proposed. This multispectral camera has advantage of capturing images at high resolution. Multispectral image contains biological structures beneath the outermost layer of skin. This can be implemented using Texture Based Coin Segmentation (TBCS) algorithm. There are two main stages, first stage comprises of segmenting damaged skin from normal skin. Steps involved in this process are preprocessing, which is performed using Gaussian filtering and coin segmentation. Second stage involves scanning process, which is done by using k-means clustering. Main contributions in second stage are sobel edge detection and spatial transformation. The scanned output is given as input to the Artificial Neural Network, which consists of input layer, hidden layer and output layer. It is useful in classifying cancer from non-cancerous, which is helpful in providing handheld devices for detecting cancer.

Keywords- Cancer, Multispectral image, k-means clustering, Artificial Neural Network.

I. INTRODUCTION

Dermoscopy is also termed as Epiluminescence microscopy (ELM), it is an in vivo method considered as a useful tool for the early recognition of malignant and benign melanoma. There are four different approaches for detection of melanoma in dermoscopy images which is the ABCD rule named as Asymmetry, Border, and Color variegation, Diameter greater than 6mm or growing. Segmentation algorithm consists of four types, they are edge based, neighbor based, histogram based, clustering based. The improved segmentation performance can be achieved by combination of several simple segmentation algorithms such as threshold and color clustering. This fusion concept helps for the extension of other segmentation algorithm such as texture analysis and color segmentation algorithms. Then automated system is required for diagnosis of melanoma, as specialists affirm that in the early stages of the evolution of malignant melanoma dermoscopy may be useless tool. This automated system deals with correcting illumination variation in image. Non-specialist, non-expert viewer such as physician not trained on dermatology requires having a qualified analysis of suspected skin lesion, in that stage only standard camera imaging is available in market. In such situations, telemedicine is justifiable, and the non-specialist can capture an image of the suspect skin lesion and send it to a specialist, who can analyze it in higher detail. Tele-dermatology consultation brings benefits, like the easier access to health care and faster clinical results. Due to this inconvenience and cost of dermoscopy for screening patient is high, images captured from standard camera is used. In this paper images captured using multispectral camera is used, this is implemented using modified texture based coin segmentation algorithm.

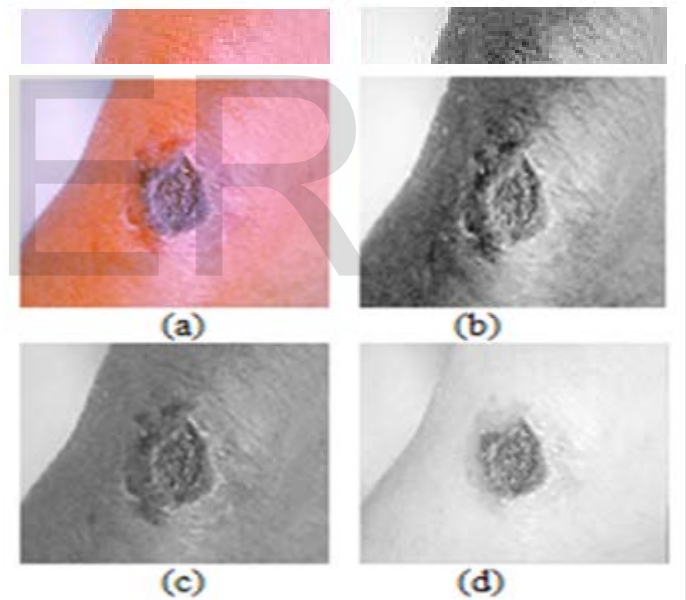


Fig. 1. In (a), Input multispectral image is shown. In (b), Input RGB image is converted to grey scale image. In (c), Grey scale image is smoothed using Gaussian filtering. In (d), Skin damage is segmented from normal skin.

Multispectral imaging combines the advantage of both spatial resolution and spectral resolution. Initially conversion of RGB image to Gray image takes place. Algorithms employed in this process are coin segmentation, Gaussian filtering. This involves finding gradient vector and segmenting lesion from normal skin by applying threshold to gradient. Segmentation consists of three properties; they are color, intensity and texture. Color is used to represent real-valued RGB, a single channel real-value for intensity and a real-valued wavelength for texture. To exploit this color information k-means clustering is employed. Then Artificial neural network classifier is build.

II. METHODOLOGY

The proposed method of image segmentation is as follows

1. Read input multispectral image
2. Perform preprocessing
3. Detecting edge and performing spatial transformation
4. Scanning process
5. Artificial Neural Network classifier

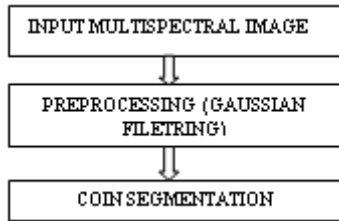


Fig. 2. Flow diagram for segmentation

The first stage in image processing is image acquisition stage. Multispectral image is taken as input image due to its high quality. Image is captured with three bands, which is an RGB image. The key function of the preprocessing is to improve the image in ways that increases the chances for success of other process. Smoothing of image is required before the image enters the segmentation stage. Gaussian filtering is required to remove noise in input image, which is due to camera electronics. Noise has Gaussian distribution so that Gaussian filtering is required. The 2D Gaussian smoothing filter is given by the equation

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

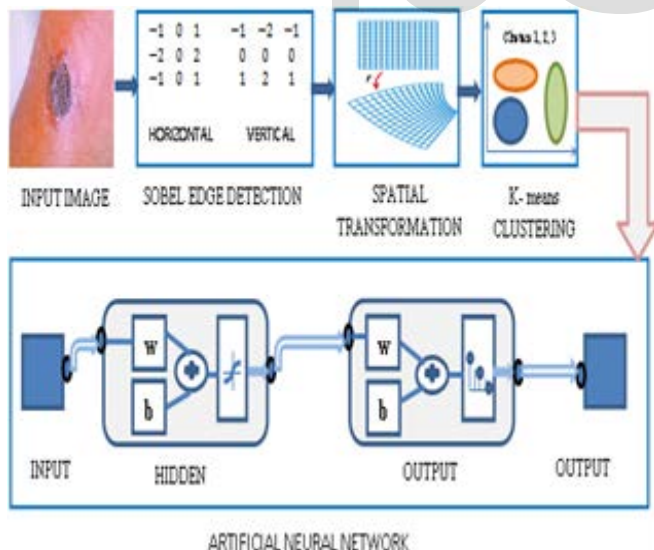


Fig. 3. Proposed flow chart displaying steps to achieve classification of cancer from non-cancerous

In equation (1), x is the distance from the origin in the horizontal axis, y is the distance from the origin in the vertical axis, σ is standard deviation. Coin segmentation is a simplest segmentation technique, which is based on thresholding gray values. This is based on an assumption that region of interest is brighter than the background. Hough transform is considered to be very robust segmentation

tool. We use Generalized Hough Transform (GHT) to segment skin damages from normal skin.

The algorithm behind this transform is shown below

1. Choose a reference point
2. Find the gradient value and apply threshold to gradient
3. Form an accumulator array to hold the location of reference point
4. In detecting lines Parameters ρ and θ are found.

The main advantage of Hough transform is high reliability.

Initially a reference point is selected, and then drawn a vector from the reference point to an edge point on the boundary. Form an accumulator array to hold the location of the reference point. This location is given by the highest value in accumulator array. The idea is to search for maximum integral given in equation (2)

$$P(x, r) = \int_{-\infty}^{\infty} \left(\delta \left(x + r \frac{\nabla(x,y)}{|\nabla(x,y)|} \right) + \delta \left(x - r \frac{\nabla(x,y)}{|\nabla(x,y)|} \right) \right) \|\nabla(x,y)\| dy \quad \text{--- (2)}$$

The gradient of an image is given by equation (3). The gradient points in the direction of most rapid increase in intensity.

$$\nabla f = \left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y} \right] \quad \text{--- (3)}$$

A. Sobel Edge Detection

Edge detection can be performed in many ways. There are two main categories, they are gradient and Laplacian. Sobel is a gradient based edge detection. The sobel operator uses two 3×3 kernels given in equation (4) which are convolved with the original image to calculate approximations of the derivatives, one for horizontal changes, and one for vertical changes. If A is defined as the source image, G_x and G_y are two images

which at each point contain the horizontal and vertical derivative approximations, the computations are as follows

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * A \text{ and } G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A \quad \text{--- (4)}$$

Where $*$ here denotes the 2- dimensional convolution operation.

At each point in the image, the resulting gradient approximation can be combined to give the gradient magnitude, this is given in equation (5)

$$G = \sqrt{G_x^2 + G_y^2} \quad \text{--- (5)}$$

B. Spatial Transformation

Spatial transformation involves warping an image, forward mapping and inverse mapping,

$$[x, y] = [X(u, v), Y(u, v)] \quad \text{--- (6)}$$

$$[u, v] = [U(x, y), V(x, y)] \quad \text{--- (7)}$$

In equation (6) and (7), $[u, v]$ refers to the input image coordinates corresponding to output pixel $[x, y]$, and X, Y ,

U, and V are arbitrary mapping functions that uniquely specify the spatial transformation. Since X and Y map the input onto the output, they are referred to as the forward mapping. Similarly, the U and V functions are known as the inverse mapping since they map the output.

C. K- means Clustering

Clustering is the classification of objects into different groups, or partitioning of a dataset into clusters. K means is a partitional algorithm, which determines all clusters at once. Distance measure will determine the similarity between two elements and it influences the shape of the cluster. Algorithm begins with a decision on the value of K, which is number of clusters. Take the first training sample as single element clusters. After each of the remaining (N-K) training sample to the cluster with the nearest centroid. After assignment, centroid of the gaining cluster is recomputed. Take each sample in sequence and compute its distance from the centroid of each of the cluster.

D. Artificial Neural Network

An artificial Neural Network is an interconnected group of nodes. In this network, the information moves in only one direction, forward from the input nodes, through the hidden nodes and to the output nodes. Samples required for classification is taken from ovarian dataset. Initially feed forward neural network is build using MATLAB software. Back propagation algorithm is employed for training. Feed forward networks have one-way connections from input to output layers. They are most commonly used for prediction, pattern recognition, and non- linear function fitting. A two-layer feed forward network with sigmoid hidden neurons are used here.

III. EXPERIMENTAL RESULTS

The processing of multispectral image and above mentioned algorithms are implemented using MATLAB software. First initialize the arguments such as minimum region, maximum region, scaling parameter, threshold value and filter preprocessing value. Input image of size 800×533×3, which implies image captured at three bands.

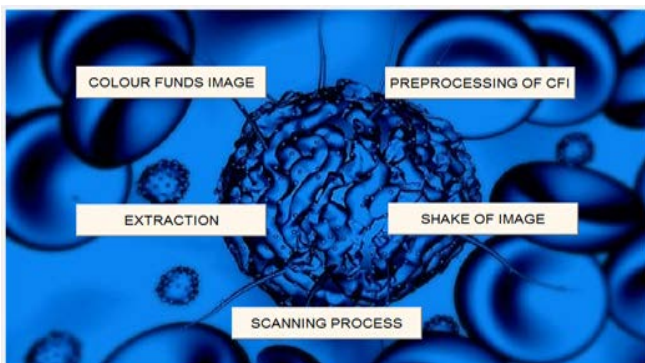


Fig. 4. Graphical user interface

In Fig 4 GUIDE (Graphical User Interface Design Environment) allows to create or edit GUIs interactively. This is created by typing guide at the MATLAB command prompt. This displays Quick Start Dialog Box. It contains two op-

tions create new GUI and opening existing GUI. By opening any one of this, push button can be inserted using layout editor. In Fig 5(a) – By pressing CFI preprocessing push button in GUIDE performs the process of preprocessing. Initially RGB image is converted to grey scale image. To this sobel edge detection is applied, using which edges are detected. This output shows that edges found in the affected part is highly accumulated. In Fig 5(b), Extraction push button is pressed, which performs the process of spatial transformation. This output is obtained by initially converting grey scale image to binary image, which is represented by 0,s and 1's. Threshold value is taken as 0.5.

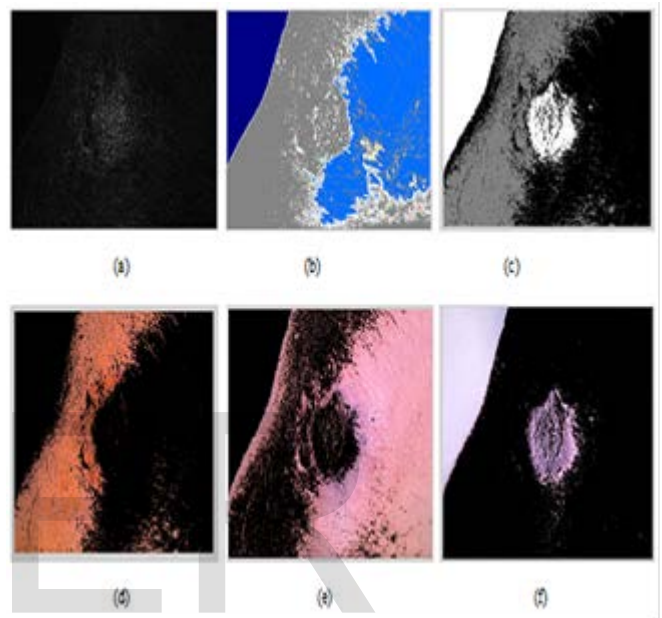


Fig. 5. In (a), Performing Sobel edge detection is shown. In (b), Performing spatial transformation. In (c), Image labeled by cluster index is shown. In (d), Color Based Segmentation Using K- Means Clustering (Red) is shown. In (e), Color Based Segmentation Using K- Means Clustering (Green) is shown. In (f), Color Based Segmentation Using K- Means Clustering (Blue)

Then boundaries in the image are traced, in which non zero pixels belong to a object and zero pixels belong to background. Once the labeled objects are found they are displayed by using colormap. Here colormap choosed is jet, which ranges from blue to red. This is done by using spatial transformation in MATLAB. Fig 5(c), First, RGB color space is converted to Lab color space. Then value for k is taken as 3, which implies number of clusters. It is selected as 3 as the number of colors contained in image is 3 (captured with 3 band). Initially partition the skin lesion image into 3 subsets (clusters). Cluster with one element is considered initially (3 training samples). After that, look for remaining (N-3) training samples to the cluster with nearest centroid. Compute the distance from the centroid of each of the clusters. If the sample is not currently in the cluster with closest centroid, switch this sample to that cluster. This forms three clusters in image using k means clustering. Fig 5(d), 5(e), 5(f) shows the cluster partitioned using K means clustering. These clusters are separated depending on color attributes (Red, Green, Blue). The scaled conjugate gradient

algorithm (SCG) is used for training, to avoid the time consuming line search. In fig (6) trainscg is a network training function that updates weight and bias values according to the scaled conjugate gradient method. Cross entropy error is measure of error between computed outputs and the desired target outputs of the training data. In fig (7) the gradients are used to adjust the values of the NN's weights and biases, so that the computed outputs will be closer to the target outputs.

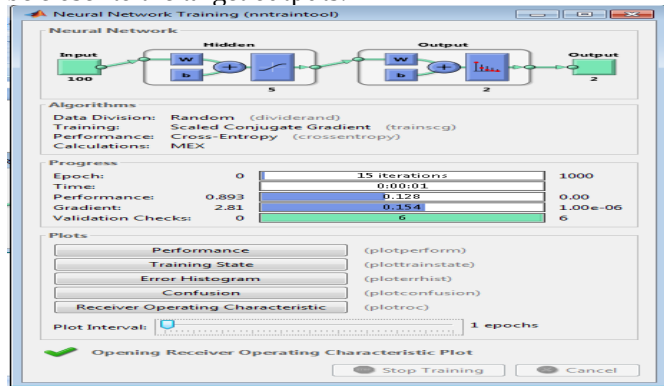


Fig. 6. Neural network pattern recognition.

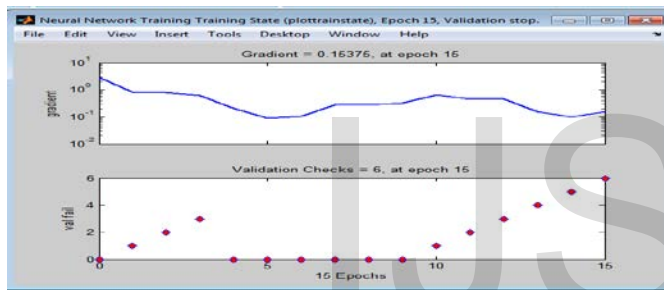


Fig. 7. Neural network training state.

The magnitude of the gradient and the number of validation checks are used to terminate the training. The number of validation checks represents the number of successive iterations. In fig (8) blue line denotes the decreasing error on the training data. Green line denotes the validation error and training starts decreasing as the validation error decreases. Red lines how the network is generalised to data.

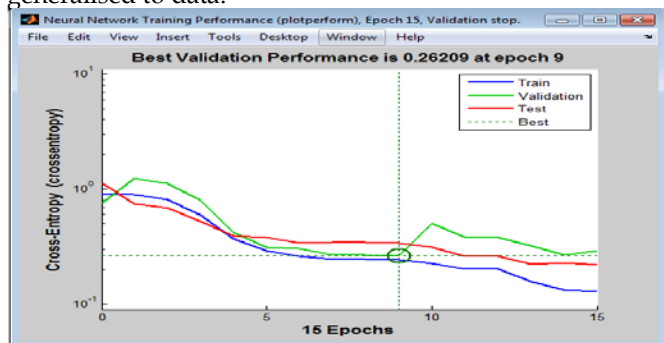


Fig. 8. Neural network network performance.

Dataset containing samples of 216 members are acquired from net. From them 116 samples contains the symptoms of cancer and remaining 100 samples has no cancer. In fig (11), Class 1 denotes 100 patients. Class 2 denotes 216 patients. Artificial neural network built using

MATLAB has ability to correctly the cancer data from non-cancerous with accuracy of 84%.

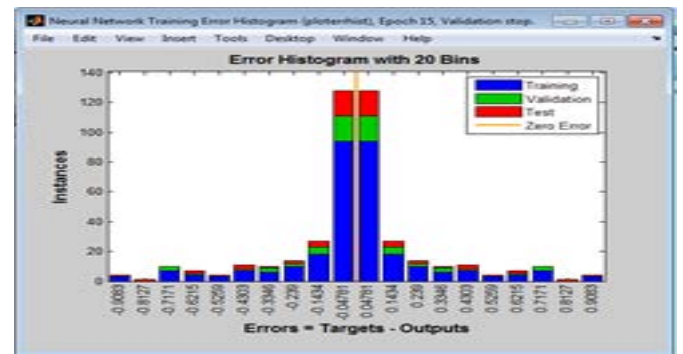


Fig. 9. Neural network error histogram.

Objective of training is to reduce global error.

$$E = \frac{1}{P} \sum_{p=1}^P E_p$$

P = Total number of training patterns.

E_p = Error for training patterns



Fig. 10. Neural network confusion matrix.

Confusion matrix of the test image, which gives accuracy of 84%.

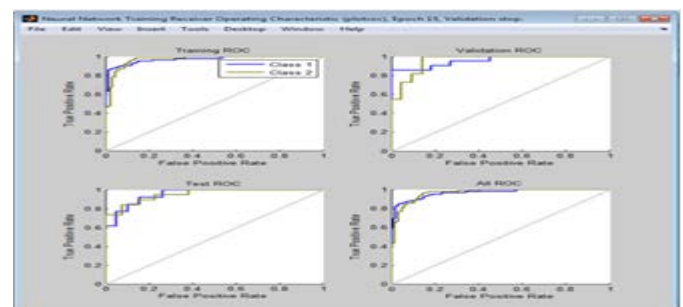


Fig. 11. Reciever operating characteristics.

IV. CONCLUSION

Skin lesion is segmented from an input multispectral image using Texture Based Coin Segmentation (TBCS). Image acquired is captured with three bands. Algorithms employed in this process are coin segmentation, Gaussian filtering. Gaussian Filtering provides smoothing effect, which is effective in removing noise produced in electronics camera is used. Processing time for search is reduced by using coin segmentation. Second stage includes feature extraction from segmented result and scanning process. GUIDE, the

MATLAB graphical user interface development environment, provides a set of tools for creating graphical user interfaces (GUIs). These tools simplify the process of laying out and programming GUIs. The main contribution of proposed work is to detect melanoma at early stages, which helps clinicians. This processed image is carried out for classifying malignant cancer from benign, which is implemented using Artificial Neural Network classifier in MATLAB achieving accuracy of 84%.

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