MELANOMA CLASSIFICATION USING ENHANCED FUZZY CLUSTERING AND DCNN ON DERMOSCOPY IMAGES

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ABSTRACT

Identifying any type of disease at an earlier stage became an essential thing in the medical field. Cancer especially skin cancer is a major disease that affects humans at a higher rate in the current scenario. Early detection is a significant method to prevent death; treating at an earlier stage leads to the cure of cancer. Researchers proposed a different technique to detect skin cancer. This paper proposed an enhanced DCNN for classifying melanoma (skin cancer) as benign and malignant. The proposed method involves preprocessing, and enhanced fuzzy clustering for detecting melanoma, followed by enhanced DCNN(E-DCNN) for the classification of dermoscopy images. Enhanced fuzzy clustering is a method that combines modified region grow image segmentation along with fuzzy K-means clustering to provide more accurate classified results than other methods proposed by researchers.

Keywords: DCNN, Fuzzy K-means clustering, Modified Region-grow segmentation, Dermoscopy, Melanoma, Classification.

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1. INTRODUCTION

Melanoma is considered the most dreadful form of skin cancer. As per the World Health Organization (WHO) report, most people died all over the world due to skin cancer [8]. Many people are exposed to this type of skin cancer and get doubled in the upcoming year if we haven't been diagnosed properly [24-28]. Early detection of melanoma is essential to reduce the death rate in the current scenario [10]. Most people who have white skin or exposing to sunlight or have hereditary issues are easily affected by different types of skin cancer [3]. Melanoma produced in the skin pigments are irregular shapes and starts growing rapidly in a later stage [29-31]. Dermoscopy is for diagnosing melanoma and dermoscopy images are used for discriminating between cancer and non-cancer melanoma [2]. Dermatologists visualize the skin lesion to diagnose the melanoma or benign lesion. Distinguishing between melanoma and benign skin lesion is a difficult and also time-consuming process [4]. Visualizing using dermoscopy images for exact identification of the skin lesion needs experts rather than trainers. Expertise doctors also have difficulties in identifying melanoma and benign skin lesion [1].

Skin lesion usually starts growing like a mole in irregular shape. Generally, a new mole is in regular shape (round or oval shape) and smaller in size [32-38]. To detect skin cancer, based on skin color, shape (irregular shape) and larger size mole should be tested at first [5]. Asymmetry, border irregularity, color variegation, diameter larger than 6mm, evolution of the lesion's growth are the characteristics of melanoma which recognized by doctors and patients. The infected area or whole-body skin examining carried out carefully to identify the lesion as benign or severe [39]. Once lesion identified by oncologists, sometimes they prefer biopsy to proceed further treatment process. Melanoma has stage 0-4 depending upon the tumour thickness, stage 0 is only on the top layer of epidermis, stage 1 considered as low-risk, curable, stage 2 considerable but high-risk of reoccurrence, stage 3 spread to nearby areas, stage 4 dangerous or non-curable which spread to internal organs and all lymph nodes. Biopsy, CT scan, MRI scan, PET scan and blood test are the methods to treat the melanoma [40-45]. Melanoma treatment depends upon how-well it's affected in the skin. Early detection plays important role to minimize the risks involved in melanoma [46-51].

Early diagnosis of this disease leads not only to save a human from painful treatment such as biopsy, as well as the patient can survive in the world [52-59]. To solve the issues behind identifying melanoma or benign skin lesion many researchers proposed a different approach. Deep learning and fuzzy K-means clustering are used in [6] for melanoma detection; [7] demonstrate various classification methods for skin cancer detection. In [9], fuzzy color clustering is used to attain a 92.6% accuracy level [60-67].We have proposed a new model called the enhanced DCNN method for classifying melanoma as benign or malignant. E-DCNN provides high accuracy, sensitivity, and specificity with less processing time [68-74]. The following section is brief about related works and proposed methods with results [75-77].

2. RELATED WORKS

Early detection is most important in the medical field for any type of disease to reduce the severity and death rate. Several researchers research this early detection and achieved it with a lot of effort and money. Many techniques are proposed in image processing for early detection in different ways such as machine learning, deep learning, etc. Using dermoscopy images, different methods used different ways to train and classify melanoma.

Detecting melanoma skin cancer using an automated melanoma pre-screened system was proposed in [11]. In this paper, the segmentation and classification of skin cancer were performed using the modified TDLS algorithm and SVM classifier respectively. The normal or skin lesion of image pixels are classified using the Statistical Region Merging algorithm. After classification, the image is converted into HSV color space and only the V channel is used for reflectance mapping. The segmentation uses Modified Texture Distinctiveness Lesion Segmentation (M-TDLS) algorithm to segment the images and the features are extracted to classify the melanoma using an SVM classifier [79-80].

Detection of melanoma skin cancer using a KNN classifier was proposed in [12]. In this paper, the detection of melanoma was performed using image acquisition, pre-processing, segmentation, feature extraction, and classification. The image data collected from the database was pre-processed to remove the noise and converted to a grayscale image. The segmentation process uses a region and edge-based thresholding algorithm; then the extracted features are fed into K-Nearest Neighbour (KNN) classifier to classify the melanoma with an accuracy level of 93.4%.

Detecting skin cancer at an early stage using machine learning and an image processing algorithm was proposed in [13]. In this paper, how computer technology plays an important role in detecting melanoma at early stages using image processing and machine learning algorithms was reviewed. The several steps with different algorithms are analyzed to improve the efficiency rate and improve the curing possibilities. Pre-processing, segmentation algorithms (thresholding, clustering, region-growing, etc.), feature extraction (ABCD rule, Menzies, etc.), and classification (naïve Bayes, K-nearestneighbor, Artificial Neural Network/Deep Learning) are explained in this paper to get higher accuracy and efficiency rate.

Detecting malignant melanoma using transfer learning and CNN was proposed in [14]. In this paper, a convolutional neural network and transfer learning was used for the classification of dermoscopy images. They reviewed many research papers to show that CNN is best for the classification process; the presence of blue ink and images with different resolutions in dermoscopy images impacts the performance and accuracy. Researchers should take care of these to improve performance and accuracy.

Detecting malignant melanoma from dermoscopy images using the deep learning method was proposed in [15]. In this paper, segmentation, feature extraction, and classification are not used to classify melanoma, instead, the CNN classifier along with xception architecture is used to detect the benign or malignant. Three optimizers were used for training the ISIC data of xception architecture.

Detecting the melanoma using an ensemble convolutional neural network was proposed in [16]. In this paper, a different pre-trained model such as xception, Inceptionv3, Densenet201, Densenet121, and InceptionResnet-v2 with transfer learning and fine-tuning was used to improve the accuracy level to 97.93%. CNN classifier identifies whether acral lentiginous melanoma is benign or not. It assists dermatologists to identify affected skin areas.

Detecting the skin cancer at an early stage for dermoscopic images using multi-scale classification was proposed in [17]. In this paper, the classifier is trained pixelwise with different resolution images for classifying the normal skin type and skin lesion. The border-based detection and lesion segmentation incorporatea supervised mechanism to provide the result at pixel level with less time and is cost-effective. Even though in presence of noise the accuracy level improved to 94% comparatively.

Detecting skin cancerat an early stage especially melanoma using neural networks was proposed in [18]. In this paper, new trends in detecting melanoma using neural network-based methodspart of Artificial Intelligence were reviewed. The neural network towards new trends to identify the melanoma with texture, shape, or color features.

Detecting skin cancer like melanoma and benign nevi, the segmentation and ensemble algorithm was proposed in [19]. In this paper, a deep learning algorithm called Predict Evaluate Correct K-fold (PECK) was proposed to diagnose the melanoma with limited trained data automatically. PECK combines a deep convolutional neural network and support vector machine with a random forest classifier to provide introspective learning.The segmentation algorithm Synthesis and Convergence of Intermediate Decaying Omni Gradients (SCIDOG) is also used along with PECK to diagnose benignly and melanoma. To boost the diagnosis classification accuracy, 10-fold cross-validationwas used for evaluation.

Detecting the skin cancer using morphology and color features for lesion border selection was proposed in [20]. In this paper, to assist computer-aided diagnosis of melanoma random forest border classifieris used toselectthe border lesion automatically. The proposed method predicts the border of skin lesionsat the rate of 96.38% compared to the single border algorithm.

Skin lesion segmentation using non-dermoscopy images using Fuzzy C-means clustering was proposed in [21]. In this paper, FCM with histogram is used for segmenting the skin lesion automatically.The proposed system provides 95.69% segmentation accuracy.Automated border detection using dermoscopy images is essential to increase the accuracy level in identifying skin lesions. [22] proposed a modified JSEG algorithm with an unsupervised approach to identify the borders in dermoscopy images thus providing fast and more accurate results than manual detection.

[23] proposed a deep learning method to overcome the challenges faced in melanoma region segmentation. The input dataset is refined and localization of the affected region is carried out by Fuzzy C-means clustering. The region-based convolutional neural network was proposed to segment the melanoma region more accurately. The same patient or even different patients affected with another skin type of disease werealso identified and segmented using this method.[24] proposed CNN and ensemble-based classification using hybrid learning particle swarm optimization algorithm which identifies new as well as an unseen skin lesions.

3. PROPOSED METHODOLOGY

Many researchers had proposed a different algorithm with different techniques to segment and classify skin cancer as melanoma or benign. Skin cancer is considered a life-threatening disease thatneeds attention to identify at an early stage, otherwise, it becomes hard to treat. As it's uncontrolled and increasing in the real world, image processing techniquescontributetoan analysis of dermoscopy images. Our proposed method involves data acquisition, pre-processing, and enhanced fuzzy clustering for detecting melanoma, followed by enhanced DCNN for the classification of dermoscopy images. Enhanced fuzzy clustering is a method that combines region grow image segmentation along with fuzzy K-means clustering. Figure 1 shows the proposed architecture for melanoma classification using enhanced DCNN (E-DCNN).

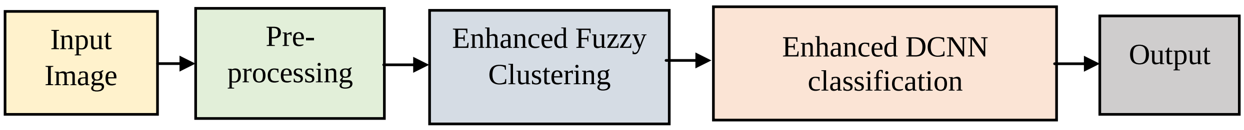

Figure 1 Proposed architecture using enhanced DCNN (E-DCNN)

A. Data acquisition:

The first step in the image processing method is data acquisition. Data acquisition is a process of collecting images for experimental analysis. We collect data from a medical centeror capture images using a mobile phone, DSLR camera, or any camera, and CT scan. A total of 120 images (50 melanoma images and 70 benign images) have been chosen for our experimental analysis. Acquired images have various resolutions that affect performance and accuracy levels. To avoid it, we obtained digital images from a high-quality camera. Figure 2 shows the acquired image set of melanoma skin cancer.

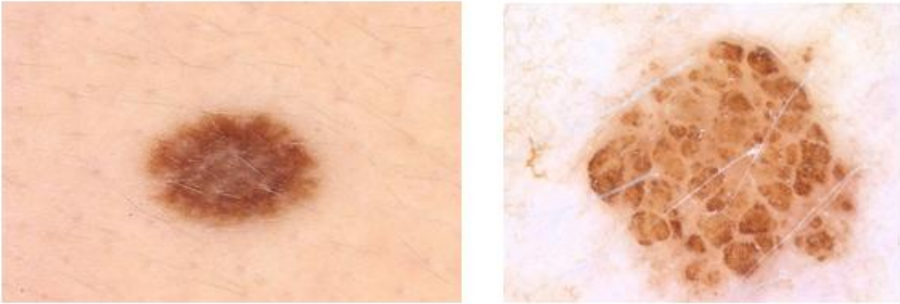

Figure 2 Image of melanoma skin cancer

B. Pre-processing:

Pre-processing is important in image processing techniques before segmentation. It enhances the performance of the image processing technique. Depending upon the application pre-processing steps can vary. Our proposed method, contains color space conversion, resizing, removal of noise, and reformatting for the next process called segmentation. The captured RGB image is converted into a grayscale image with fixed resolution. Then the image is resized to our requirement. The noise and unwanted regions are removed in this process using a median filter. A median filter eliminates the unnecessary signals obtained in images.Removal of noise avoids misclassification of skin lesions in the later stage. We label the class as 0 and 1 for melanoma and benign skin lesion respectively.Figure 3 shows the proposed pre-processing method.

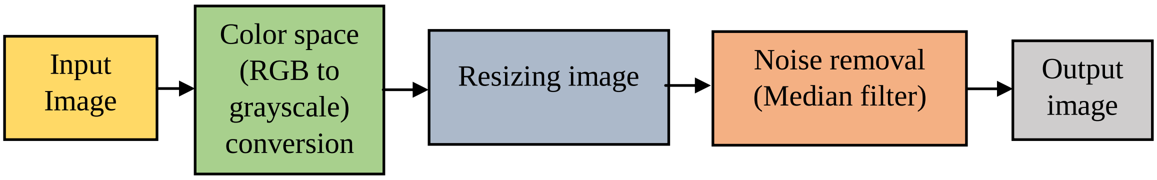

Figure 3 Proposed pre-processing method

C. Enhanced Fuzzy clustering:

We proposed a method called Enhanced fuzzy clustering to improve the segmentation accuracy compared to other researchers' proposed methods. Enhanced fuzzy clustering combines the modified region-grow segmentation along with fuzzy K-means clustering to overcome the challenges faced in the classification of dermoscopic images. Fuzzy K-means and fuzzy C-mean clustering have center redundancy disadvantages, to overcome that modified region grow segmentation is applied to fuzzy K-means clustered image. Fuzzy K-means clustering is mostly preferred in biomedical image segmentation. Figure 4 shows the enhanced fuzzy clustering method which uses fuzzy K-means clustering with modified region grow segmentation.

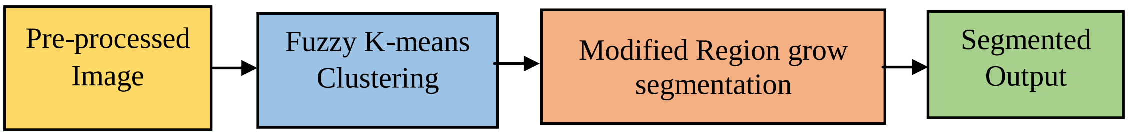

Figure 4Enhanced fuzzy clustering method

As compared to other algorithms, fuzzy clustering has a degree of belonging to clusters of each pixel. Sometimes the edge of the cluster point may be a lesser degree of belonging to the center cluster point. The co-efficient degree $v_k(x)$ of the belonging k^{th} cluster of each point x is calculated as,

$$\forall x \sum_{k=1}^{no.\ of\ clusters} v_k(x) = 1 \quad (1)$$

The cluster centroid $c_k$is calculated using weights of belonging cluster degree i.e., the mean of all points in the cluster. The $v_k(x)$ is calculated using the inverse of the distance to the center of the cluster from each point x.

$$c_k = \frac{\sum_x v_k(x)^m x}{\sum_x v_k(x)^m} \qquad (2)$$

$$v_k(x) = \frac{1}{d(c_k,x)} \qquad (3)$$

The fuzzy membership function is calculated using the parameter m, m>1 which determines the degree of fuzziness,

$$v_k(x) = \frac{1}{\sum_j \left(\frac{d(c_k,x)}{d(c_j,x)}\right)^{\frac{2}{(m-1)}}} \qquad (4)$$

The threshold value is calculated using the fuzzy K-means algorithm where the fuzzy membership function is used to find the closeness of the region [78]. Modified region grow segmentation uses threshold value as the center point and pixel by pixel scanning takes place to cover all the pixels value in an image.

Algorithm:

Method: Enhanced fuzzy clustering
Input: Pre-processed image
Output: Region segmented image
Step 1: Start the processing
Step 2: Obtain the image set
Step 3: Applying fuzzy K-means clustering to the image
Step 4: Finding the co-efficient degree $u_k(x)$ using belonging k^{th} cluster
Step 5: Based upon intensity and orientation threshold, all the belonging pixels start growing when both the conditions met
Step 6: Gridding, converting original image into small grids and based upon the threshold region growing formed by pixel-by-pixel scanning process
Step 7: Nearby pixels which satisfy the condition $||I_p-I_n||\leq T_I$& $||O_p-O_n||\leq T_O$,leads to region grow, otherwise region is not grown.
Step 8: Determining the nextpotential pixel for the next seed location
Step 9: Region growing process continues until all the pixels in an image is used
Step 10: Stop the process
Figure 5 shows the flow chart of enhanced fuzzy clustering method.

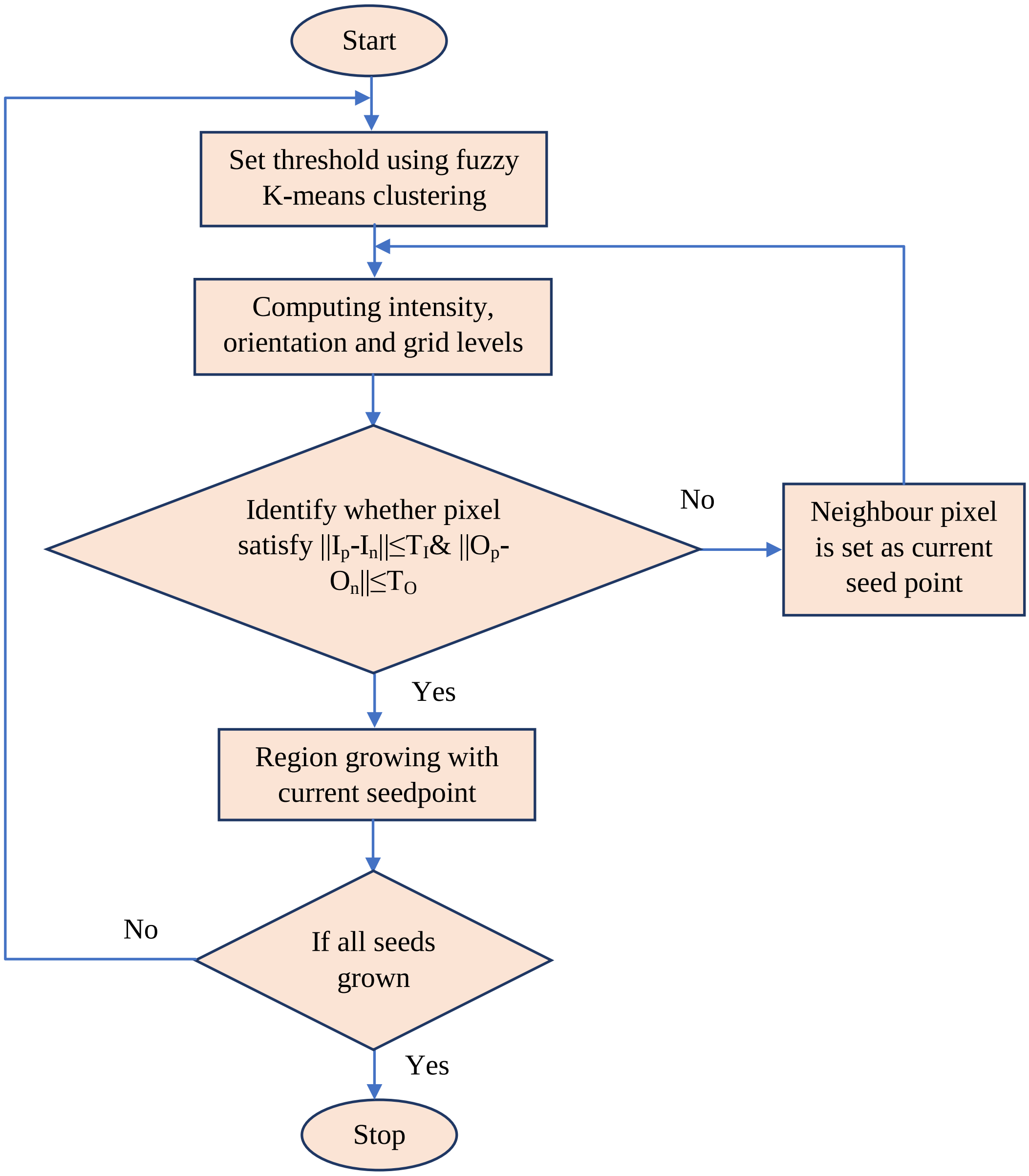

Figure 5 Flow chart of enhanced fuzzy clustering

D. Enhanced DCNN:

The proposed method uses the neural network classifier to detect the melanoma as early-stage or malignant in the input image data. Nowadays neural network plays a significant role in the classification of medical image applications. The neural network itself approximates function specifications to provide a great degree of accuracy. The proposed method uses an enhanced DCNN for the classification of dermoscopy images to provide better classification than other methods. Classification is a method to group the data with similar labels or properties [24]. Figure 6 show the E-DCNN network architecture.

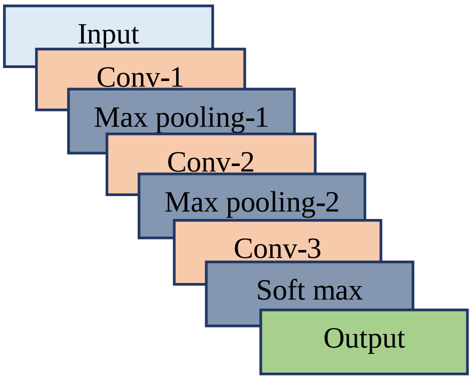

Figure 6 E-DCNN network architecture

4. EXPERIMENTAL RESULTS

The proposed method used an enhanced DCNN for the classification with an enhanced fuzzy clustering method to classify the melanoma at an early stage. The experiment results were obtained with the help of MATLAB software. The image set obtained from medical data was chosen as the input image. Due to the less accuracy and processing time of CNN, DCNN algorithms, E-DCNN enhances the performance of classification. To obtain the more accuracy level with less time consumption, E-DCNN performs processing methods toanalysis the features and segmenting the image. Finally, the classifier identifies malignant or early proliferative.

Data acquisition plays major role in image processing, using the acquired image is the first step involved in processing. The acquired image should be more clarity with less noise. Figure 7 shows the acquired input image of the skin lesion.

Figure 7 Input image data of the skin lesion

Pre-processing the image which yields better outcome of the procedure. Pre-processing method convert the color image to gray level image, eliminate the excessive noise, reshaping and resizing the image to next stage. Figure 8 shows the pre-processed image of the skin lesion.

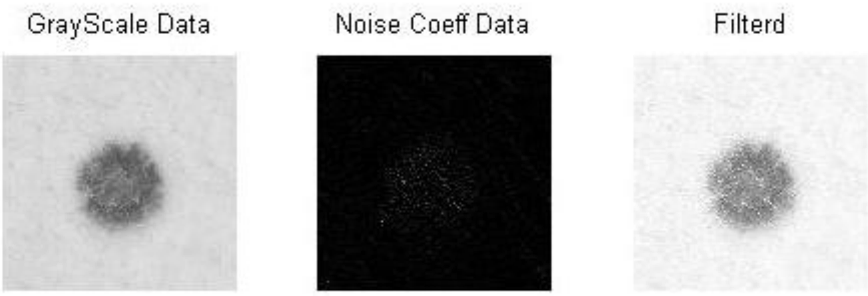

Figure 8 Pre-processed image of skin lesion

Enhanced fuzzy clustering method proposed to overcome the disadvantages of other clustering techniques. Enhanced fuzzy clustering method less immune to noise level and reduce the complexity in recovering process. Figure 9 shows the enhanced fuzzy clustering image of skin lesions with fuzzy K-means clustering and figure 10 shows the modified region grow segmentation.

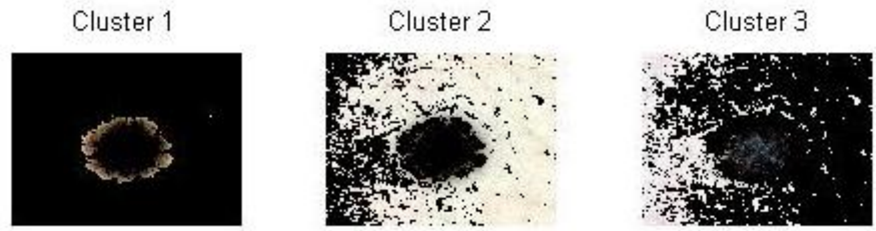

Figure 9 Fuzzy K-means clustered image

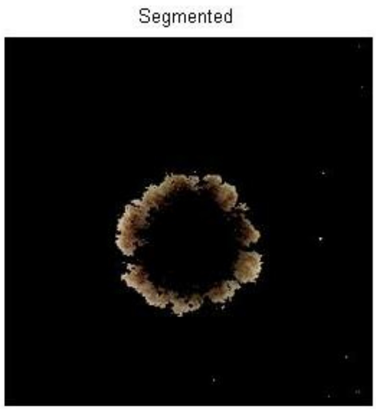

Figure 10 Modified region grow segmented image

E-DCNN provide faster classification with less computational time. E-DCNN has three stages with convolution layer block and max pooling layer and finally soft max layer. It has three convolution layer blocks and two max pooling layer and one soft max. The output classifies the melanoma as early stage or malignant. Figure 11 shows the enhanced DCNN classifier output of skin lesions.

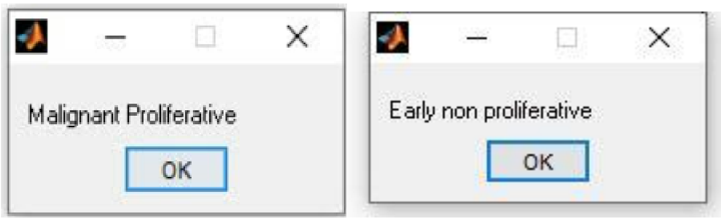

Figure 11 Classification results of the proposed method

The proposed method compares features such as energy, entropy, contrast, correlation, homogeneity, and variance with the existing CNN method. Figure 12 shows the comparison chart of feature analysis based on the segmentation of CNN and the E-DCNN method.

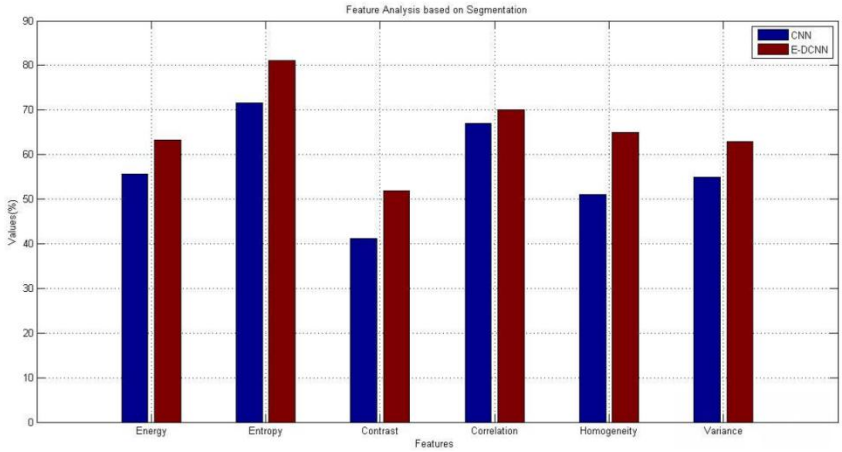

Figure 12 Comparison chart of feature analysis – CNN and E-DCNN

Figure 13 shows the specificity analysis of different classifiers to compare the proposed E-DCNN. The proposed E-DCNN provides a better specificity rate even number of images increased for analysis than other classifier techniques such as SVM, ANN, and CNN.

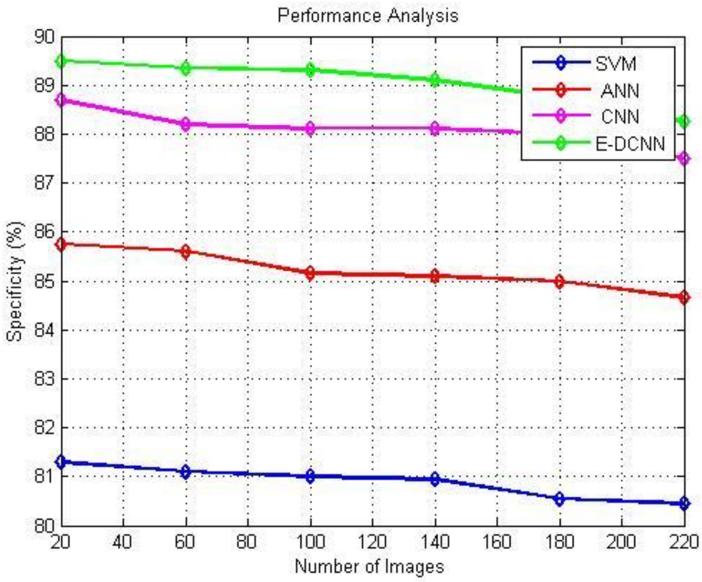

Figure 13 Comparison chart of Specificity analysis

Figure 14 shows the sensitivity analysis of different classifiers to compare the proposed E-DCNN. The proposed E-DCNN provides a better sensitivity rate even number of images increased for analysis than other classifier techniques such as SVM, ANN, and CNN.

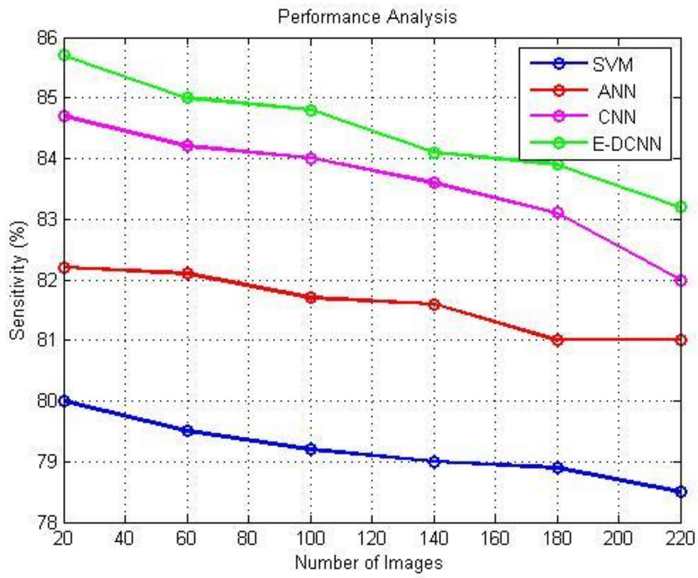

Figure 14 Comparison chart of Sensitivity analysis

Figure 15 shows the accuracy analysis of different classifiers to compare the proposed E-DCNN. The proposed E-DCNN provides a better accuracy rate even number of images increased for analysis than other classifier techniques such as SVM, ANN, and CNN.

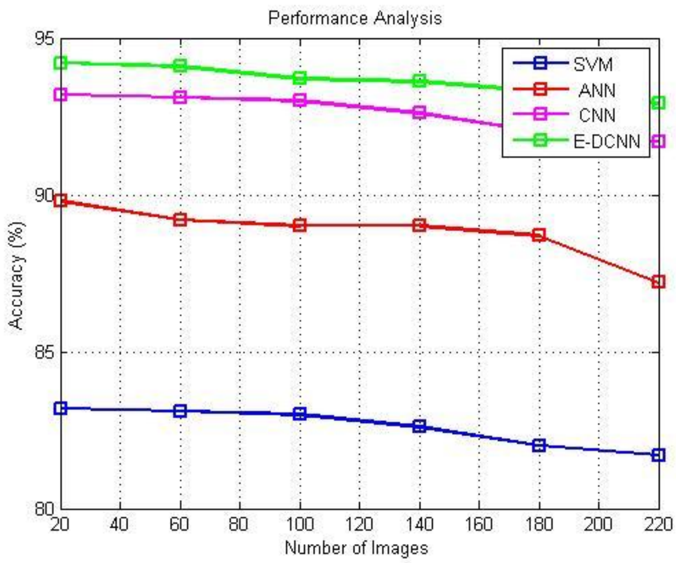

Figure 15Comparison chart of Accuracy analysis

5. CONCLUSION

Early detection is important in identifying any disease. Especially, melanoma type of skin cancer needs kind attention in identifying at an early stage. Melanoma is curable at an early stage and even becomes dreadful at later stages. This paper proposed an enhanced DCNN to safeguard people by classifying melanoma as benign and malignant. The pre-processing method removes unwanted noiseand enhanced fuzzy clustering for detecting melanoma, which segments the image using fuzzy K-means and modified region grow segmentation. Our proposed E-DCNN method provides more accurate classified results than other methods such as SVM, ANN, and CNN. The segmentation feature analysis (energy, entropy, contrast, correlation, homogeneity, and variance) compared with the CNN method. The specificity and sensitivity rates are also analyzed with SVM, ANN, and CNN classifiers. In this paper we have taken 20-220 images for comparison analysis, in the future we would extend our work with more images and improve the accuracy level above 95% than the present level.

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