also been used for constructing the model where first dense layer consists of 128 neurons and the later one 64 neurons. Finally, the sigmoid activation function was used in the fully connected layer to classify the images into two categories: benign (0) and malignant (1). The proposed CNN model was trained through 100 epochs and binary cross-entropy was set as loss function. For training, ISIC Challenge 2016 training dataset [16] used. The dataset was split into 80:20 ratio where 80% images were used for training and remaining 20% images were used for validation test.

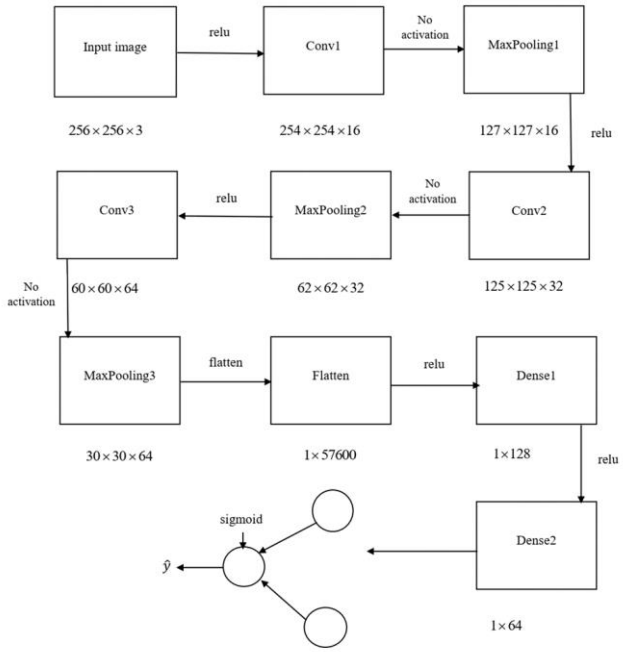

Figure 5. CNN architecture

ii. Mathematical Explanation of Proposed CNN Model

The architecture of our proposed CNN model of figure-5 is explained below with mathematical explanation that shows the different output sizes for different layers of our constructed CNN model. For determining the output sizes, the following formula has been used as discussed in [23],

$$n_{out} = \frac{(n_{in} + (2 \times p) - k)}{s} + 1 \quad (1)$$

were,

n_{in} = input, p = padding, k = kernel size, s = stride and n_{out} = output

For conv2d_1,
Number of filters = 16, $s = 1$, $p = 0$, $k = 3$,

$$n_{out} = \frac{(256 + (2 \times 0) - 3)}{1} + 1 = 254$$

So, output size = $(254,254,16)$

For max_pooling2d_1,
$s = 2$, $p = 0$, $k = 2$,

$$n_{out} = \frac{(254 + (2 \times 0) - 2)}{2} + 1 = 127$$

So, output size = $(127,127,16)$

For conv2d_2,
Number of filters = 32, $s = 1$, $p = 0$, $k = 3$,

$$n_{out} = \frac{(127 + (2 \times 0) - 3)}{1} + 1 = 125$$

So, output size = $(125,125,32)$

For max_pooling2d_2,
$s = 2$, $p = 0$, $k = 2$,

$$n_{out} = \frac{(125 + (2 \times 0) - 2)}{2} + 1 = 62.5 \approx 62$$

So, output size = $(62,62,32)$

For conv2d_3,
Number of filters = 64, $s = 1$, $p = 0$, $k = 3$,

$$n_{out} = \frac{(62 + (2 \times 0) - 3)}{1} + 1 = 60$$

So, output size = $(60,60,64)$

For max_pooling2d_3,
$s = 2$, $p = 0$, $k = 2$,

$$n_{out} = \frac{(60 + (2 \times 0) - 2)}{2} + 1 = 30$$

So, output size = $(30,30,64)$

For flatten,
Output = $(30 \times 30 \times 64) = 57600$

III. RESULTS

The performance of our proposed model has been evaluated based on accuracy, sensitivity, and specificity. For this purpose, ISIC Challenge 2016 test dataset [16] was used and accuracy, sensitivity and specificity were determined based on confusion matrices as follows:

$$Accuracy = \frac{(TP + TN)}{(TP + FP + TN + FN)} \quad (2)$$

$$Sensitivity = \frac{TP}{(TP + FN)} \quad (3)$$

$$Specificity = \frac{TN}{(TN + FP)} \quad (4)$$

where TP represents True Positive, TN represents True Negative, FP represents False Positive and FN represents False Negative.

In table 1, the performance of our proposed method has been compared with other existing state-of-the-art methods that also attempted to automatically detect skin cancer from skin lesion images.

TABLE I
UNITS FOR MAGNETIC PROPERTIES

Methods	Sensitivity	Specificity	Accuracy
MED-NODE Texture Descriptor [25]	0.62	0.85	0.76
ANN [17]	0.751	.831	0.791
KNN [26]	.6827	.6251	.6539
Random Forest [26]	.7685	.7179	.7432
Proposed	0.8194	0.5263	0.8047

From the above table, it is clearly seen that our proposed method gives highest accuracy result comparing to the

existing methods to detect skin cancers from skin lesion images.

To deploy our trained deep learning model, we have developed a graphical user interface (GUI) that will automatically detect skin cancer. The system first asks the user to give a dermoscopic image as input and later preprocesses and segmented the image and prepare it for classification. Next, with the help of our trained model, it can successfully classify the images into either 'benign' or 'malignant' category as shown in figure 6.

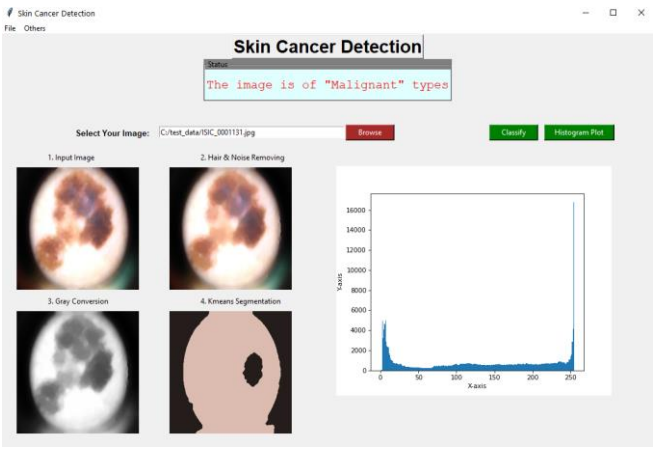

Figure 6. Detecting 'malignant' type skin cancer in our computer aided skin cancer diagnosis system

IV. CONCLUSIONS

In this paper, development of a skin cancer risk diagnosis system is shown based on CNN. The model is used for detecting the risk of skin cancer occurrence. In our developed system, an input of Dermoscopic image is provided after preprocessing and then k-means algorithm is applied for segmentation purposes. Next, the segmented image is fed to our proposed CNN model to classify the dermoscopic image either into benign or malignant type. Overall, we have got 52.63% specificity, 81.94% sensitivity, and 80.47% accuracy from our proposed model which is an improved result comparing with the ones yielded by previous methodologies demonstrated in table 1. Implementing machine learning method in segmentation and deep learning for feature extraction and classification are to be credited for the improved result comparing to the existing systems since most of the existing systems applied machine learning algorithms only for classification.

Our research is limited to only detecting 'benign' and 'malignant' types of skin cancer. In future, our aim will be to adding additional features of detecting more specific types of skin cancers than limiting it to only detecting benign and malignant types of skin cancers in our system in addition to improving the current accuracy rate of our proposed model.

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