

# **m-Skin Doctor: A Mobile Enabled System for Early Melanoma Skin Cancer Detection Using Support Vector Machine**

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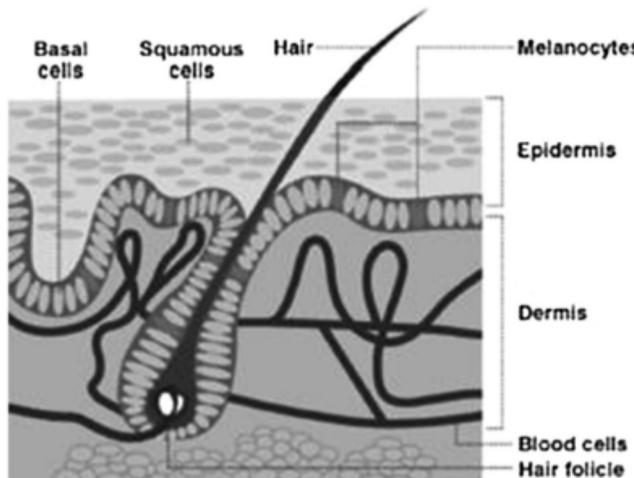
**Abstract.** Early detection of skin cancer is very important as it is one of the dangerous form of cancer spreading vigorously among humans. With the advancement of mobile technology; mobile enabled skin cancer detection systems are really demanding but currently very few real time skin cancer detection systems are available for general public and mostly available are the paid. In this paper authors proposed a real time mobile enabled health care system for the detection of skin melanoma for general users. Proposed system is developed using computer vision and image processing techniques. Noise is removed by applying the Gaussian filter. For segmentation Grab Cut algorithm is used. Support Vector Machine (SVM) is applied as a classification technique on the texture features like area, perimeter, eccentricity etc. The sensitivity and specificity rate achieved by the m-Skin Doctor is 80% and 75% respectively. The average time consumed by the application for classifying one image is 14938 ms.

**Keywords:** Skin cancer · Melanoma · Computer aided systems · Mobile application · Health care systems · Machine learning

## **1 Introduction**

Human skin consists of different layers with unique, distinct functions and optical properties. Epidermis being an outermost layer protects the human from harmful sunlight and ultraviolet (UV) radiations. It largely composes of the connecting tissues and also contains melanin producing cells, melanocytes and melanin; product of melanocytes and its producing cells as shown in Fig. 1. Melanin is the pigment which absorbs the light in the ultra violet spectrum and protects the deeper layers of the skin. Then come the dermis layer; which is made up of collagen fibers and it contains sensors, receptors, nerve ends and the blood vessels [1].

Skin cancer is the abnormal growth of tissues in the skin. At present the skin abnormal tissues are mainly classified in two types: benign and malignant. Benign



**Fig. 1.** Skin layers and their components [1]

tissues are not cancerous whereas the malignant skin tissues are dangerous and can invade their neighbouring tissues. In benign lesions, melanin is normally present in the epidermis layer and is not life threatening. When this melanin penetrates into the dermis layer, it becomes life threatening [2, 3].

In United States, approximately 73,870 new malignant skin cancer cases were estimated in year 2015. Out of these 73,870 cases, 9,940 death cases were found [4]. Therefore its early detection is very much important. The most and the frequent method used for the skin cancer detection are the ABCD rule of dermoscopy [5, 6], the 7-point checklist [7], image processing and pattern analysis and the Menzies method [8, 9].

Currently mostly skin cancer detection systems are based on combination of image processing and machine learning techniques [1]. These systems are not the replacement of the dermatologists but really helpful to dermatologists in diagnosing the skin cancer. Most of the world population lives in the backward and rural areas and they don't have an easy access to the skin specialists. To the best of our knowledge currently there are very few smartphone application for skin cancer. There are some short coming in these existing applications. Firstly, majority of applications are IOS based [10] and people living in the backward areas don't have easy access to IOS devices because IOS devices are costly then android [11]. Secondly majority of applications only provide the news and skin cancer information [12, 13]. Other applications asks for a skin lesion image and then send the image to any dermatologists for expert opinion. Patient has to wait for a long time for the results [14–16] and because of these delays, strength of the disease may increase. These types of systems are not very effective for the people living in remote areas. Only few applications are available for real time skin analysis and mostly are the paid. Nowadays a wide variety of android based smart phone applications with high processing speed and advanced operating systems are available in the market and everybody has an easy access to smartphones; therefore there should be some automated healthcare diagnostic systems for these areas. Healthcare applications should be provided to the general public living in the rural as well as urban areas. Therefore smartphone based skin cancer detection applications are required for general

public. The main contribution of the authors is the real time mobile base skin cancer detection system named m-Skin Doctor.

The rest of the paper is organized as follows. State of the art literature review is described in Sect. 2. In Sect. 3 proposed methodologies is explained in detail. In Sect. 4 the implementation and experimentation details are discussed and results are discussed in Sect. 5. Last but not the least conclusion and future research is summarized in Sect. 6.

## 2 Literature Review

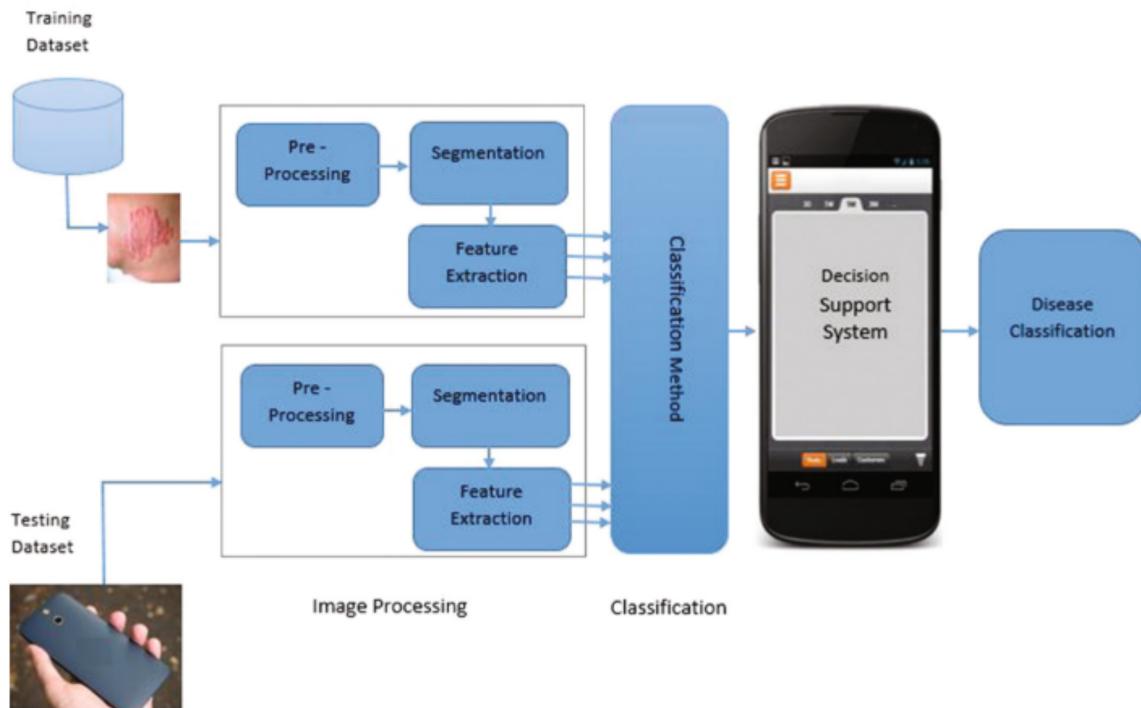
Different authors are exploring and inventing new techniques to diagnose the skin cancer. One of the prominent and widely method proposed is ABCD by Nachbar et al. Asymmetry, Border irregularity, colour and diameter are the key features used in ABCD rule. In [17] Jain et al. have used image processing techniques to find the melanoma. Karargyris et al. [18] propose an iOS application for the detection of the skin cancer. The proposed technique starts with the identification of the ROI. In the pre-processing step the original RGB color is transferred into the HSV color space. Afterwards the image is binarized by setting the H-V threshold values followed by applying SVM on extracted features.

Classification algorithm proposed by Abuzaghleh et al. [19] has been divided into two main parts. In the first part authors have introduced a novel equation to compute the time for skin burn and developed a real-time alert system. Second component is an automated image analysis module which classify the skin cancer. Abderrahim et al. have described an innovative mobile based health care system for detecting the skin cancer. Multilayer perceptron is used for the detection purpose [20]. A mobile application has been developed by Doukas et al. that can acquire, identify and classify the moles into benign, nevus and melanoma. The proposed system also includes a cloud infrastructure for better storage and computation [21]. An Android application has been developed by Kiran et al. for early melanoma detection [22]. In the proposed algorithm the skin image is converted to the monochrome image. Main purpose of this conversion is the outline contour detection. Shape and color features were extracted. KNN is used as the classifying algorithm.

Setiawan et al. proposed an automated algorithm for early detection of melanoma with an accuracy rate of 83% [23]. Proposed system was divided into three stages. In segmentation, several color spaces can be selected by the user followed by learning algorithms. Noise is removed by applying morphological filters in filtering steps. In the localization step, connected component labelling and K-means technique are used for objects classification.

## 3 Proposed Methodology

In this papers authors have proposed an efficient real time skin cancer detection technique for smartphone applications. Proposed methodology is divided into three main steps i.e. pre-processing, segmentation, feature extraction and classification (Fig. 2).



**Fig. 2.** Proposed Methodology for m-skin Doctor

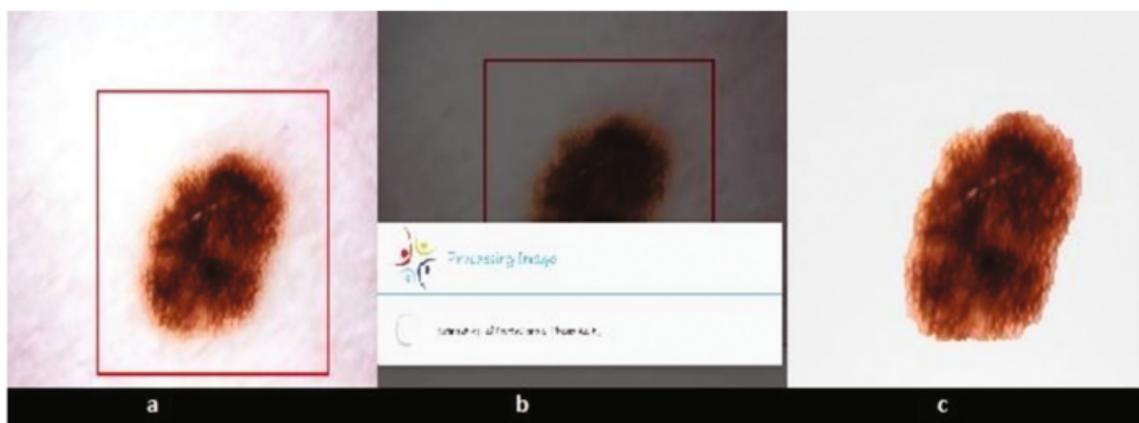
Dermoscopic images of skin lesion from Klinik und Poliklinik für Dermatologie und Allergologie, Technische Universität München, Germany is used for training and testing purpose.

### 3.1 Pre-processing Step

The first stage of the proposed methodology aims to enhance the image quality. All the images are in RGB format. All images should be of same dimension and noise free before segmentation so that better segmentation results should be achieved and so as the main task of our technique pre-processing step. All images are resized first to  $640 \times 480$  dimensions and then Gaussian filter with window size 3 has been applied on the resized images to remove the noise.

### 3.2 Segmentation

For efficient training the suspected skin image should be segmented from the healthy skin portion. For segmentation of images Grab Cut algorithm is used. Grab cut algorithm is an interactive segmentation technique for images [24] and divide the image in the image into four portions, i.e. Exactly Background, Probably Background, Exactly Foreground and Probably Foreground. The main reason of selecting the grabcut algorithm is that it provide good segmentation results in real time. While keeping the easiness of user's, authors provide the facility to select the cancerous area. User can draw the rectangle around the lesion part. The segmentation process is a bit long and



**Fig. 3.** (a) Lesion selection by user (b) m-Skin is applying the grabcut algorithm (c) segmented image after applying Grab Cut algorithm

took 4-5 s, the authors have used AsyncTask to do all the processes in the background thread. Main advantage of AsyncTask is avoidance against application crash. The results of the segmentation process are graphically shown in Fig. 3.

### 3.3 Feature Extraction and Classification

After extracting the region of extract (ROI) from segmentation process, meaningful features have been extracted. While proposing the melanoma detection algorithm for mobile applications, memory consumption and processing time are most important factors to consider. There are many features that can be extracted from the segmented image but the main challenge was to select the features while considering the processing time. While considering the mobile limitations authors have selected minimal features so that processing speed will not be affected. Mainly histogram and ABCD features have been used. Authors have extracted area of lesion, perimeter of lesion, eccentricity, mean, standard deviation, L1 norm, L2 norm angle of lesion, major and minor axis of lesion from the segmented image. We randomly split the dataset images into training and testing images. The system was trained using the SVM classifier. Main reason for selecting SVM is that is empirically proved that SVM outperforms among different machine learning techniques for skin cancer segmentation.

## 4 Implementations Details

Android is an operating system developed by Google and offers a wide selection of functions to the developers. For our application we have also used some of the build in libraries. For image processing authors have used open source computer vision library (OpenCV). OpenCV offers impressive computer vision and machine learning capabilities [25]. OpenCV provides a common infrastructure for computer vision and it was first developed by Intel Inc. Initially OpenCV was developed for the personal computers but later on its libraries were ported for mobile phones thus making mobile

phones a powerful device and yet the replacement for the personal computers. Minimum version to run the m-Skin Doctor is Android 4.0. Authors have used Extensible Mark-up Language (XML) to create the layouts and have used java for all the business logics. For capturing the skin images by default android camera application has been used.

## 5 Results and Discussion

Dataset from Klinik und Poliklinik für Dermatologie und Allergologie, Technische Universität München, Germany is used for training and testing purpose. All images are without any distracting elements like jewellery, clothes and any background. For each image the region of interest was manually selected that contains both normal and malignant skin pigments. We randomly split the dataset into two parts i.e. training and testing part with ratio 70%|30%. Support vector machine is used for classification purpose. 84 images consisting both melanoma and non-melanoma images with same proportion are used for the training purpose of the support vector machine and other 36 images with same proportion of melanoma and non-melanoma images are used for testing. Through testing 80% images predicted correctly as melanoma and 75% non-melanoma images correctly identified by our application. All the images were pre-processed in advance. The overview of the obtained accuracy is shown in Table 1 below. The average time consumed by the application for classifying one image is 14938 ms. Average time classifier consumed for training is 30405 ms.

**Table 1.** Accuracy results achieved by m-Skin Doctor

	Melanoma	Non-melanoma
Melanoma	80%	20%
Non-melanoma	25%	75%

## 6 Conclusion and Future Research

In this paper author's have developed real time application for skin cancer detection. In the pre-processing step the images are resized and the noise has been removed from the skin images. Grab cut algorithm is used for the segmentation purpose. Reason of choosing the grab cut algorithm is that it provides good segmentation in real time. Area, perimeter, eccentricity, mean, standard deviation, L1 norm, L2 norm angle of lesion, major and minor axis of lesion are the main features that have been extracted in the feature extraction phase. For classification purpose Support Vector Machine has been used. Reason of choosing the support vector machine is that it provides good classification results in real time on smart phone. The smartphone application has been tested on the dataset provided by the München University Germany.

Still there are a lot of research issues that need to be addressed on the smart phone based skin health care systems. Mostly work has been done on the skin melanoma. Proposed application can be extended by including other skin diseases like psoriasis,

eczema, skin rashes, skin burns etc. Mobile based health care systems should consume less power and deliver efficient results in real time. Optimal feature selection for smartphone based systems is another open area of research for researchers.

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