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# Review of Skin Cancer Detection Techniques Using Image Processing

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***Abstract*—** One of the most dangerous diseases in the world today is cancer. The brain, lung, skin, liver, and other organs have various cancers. Finding cancer has proven to be difficult. Cancer has a good possibility of being cured if it is discovered early. The dangerous disease can only be cured in large part by detection. Feature extraction, segmentation, pre-processing, and classification are all steps in the detection process. Pre-processing is the stage where noise removal is possible. Segmentation can assist in dividing the image into different fields, feature extraction can assist in extracting features, and classification can assist in classifying and detecting the final cells. This paper provides a comprehensive overview of skin cancer and the role that digital image processing plays in its early identification. All research papers are taken from reputable journals that cover this topic.

***Keywords*—**Skin cancer, Segmentation, Classification, Image Processing, ANN

## I. INTRODUCTION

The spread of cancer throughout an individual's bloodstream is a preventable disease. Millions of cells make up the human body; typically, they divide, grow, and then die. According to the human body's needs, old cells that expand or become aberrant die and are replaced by new ones. Cancer develops when the system malfunctions and an uncontrolled number of cells proliferates. A tumor is created when all cells join to generate additional bulk tissue. Not all cancers spread throughout the body, but others, like benign tumors, grow uncontrollably. There is no way to determine the precise cause of cancer, but there are some factors that can increase your risk, including smoking, eating poorly, and not exercising enough [1].

Cancer can start from anywhere in the human body, it is a genetic disease that can be hereditary from our Parents it can also arise during the lifetime of humans because cells divide or damage DNA, sometimes cells can detect and repair DNA damage. If it cannot repair it undergoes cell death or apoptosis.
Cancer is not limited to humans; livestock and other living organisms may be affected by this disease. The process of cancer cells leaving a portion of the body and expanding elsewhere is called metastatic spread or metastasis.

Skin cancer is a condition that originates in the skin cells and first results from cell division before later developing into cancer [2]. The lesion is the term used to describe the skin area with cancer [3]. There are several types of skin cancer, with Melanoma being the most dangerous. Non-Melanoma skin cancers include Kaposi sarcoma, Basal cell carcinoma, Squamous cell carcinoma, Markel cell carcinoma, and cutaneous T-cell lymphoma [3].

The largest organ in the body is said to be the skin. It offers defence against heat, infection, and harm. Additionally, it produces vitamin D and is utilized to store fat and water. It primarily consists of three layers: the Epidermis, the dermis, and the hypodermis (Innermost layer). Melanomas are specific tumors that develop from melanocytes, the skin cells that produce color. Although it generally looks brown or black, it could be blue, red, a mix of hues, or even have no color at all. Although it can develop anywhere on the body, it primarily affects the necks, faces, and legs of men and women as well as the trunks of both sexes. Though less frequent than non-melanoma skin cancer, it nevertheless causes less harm. Melanoma cancer spreads slowly and is mainly detectable in its early stages.

Figure 2.1 Melanoma and non-melanoma skin cancer [4]

Types of non-melanoma skin cancer

### *A. Basal cell carcinoma*

It is also known as basal cell cancer and is currently the most common type of skin cancer. It starts in the skin that is exposed to sunlight directly, such as the arms, hands, neck, face, and hands. Although all cancers begin shiny and small, this is not a guarantee because they can arise

 

from a variety of sources. They grow gradually and could sometimes spread to various places on the body. The majority of malignancies in this group may be cured or treated; they sporadically recur after therapy, but they seldom spread to other parts of the body. If it is not treated within a certain period, there is a potential that it will go all the way to the bone.

1) *Symptoms:* This sort of cancer often develops on the exposed body parts; the trunk and legs are uncommon sites. The body part that is shielded from the sun, such as the genitalia, cannot be detected in this way. The following signs and symptoms are listed for it:
   a) *Skin-colored, Pearly white, or pink bump:* Blood's small vessels are frequently visible. The affected area would be lighter but still somewhat opaque in people with lighter skin tones. This condition, the most typical kind of basal cell carcinoma, typically appears on the head, lips, or throat. The lesion may scab over, grow larger, and break.
   b) *Brown, black and blue lesions:* Cancerous tissue is shown by black patches on the body that have a thin transparent border.
   c) *Flat, scaly, reddish patch:* On the back and chest, where it commonly manifests, it may afterward get worse swiftly.
   d) *White, waxy, scar-like lesion:* This rarely occurs and is termed morphea from basal cell carcinoma. It has no visible border. It is easy to call attention to this, but there can also be certain cancer kinds present, such as invasive and disfiguring cancer.

2) *Causes:* The basal cell, which generates new skin cells, is found in the decreased epidermis region, i.e., the skin's outermost layer. A cell's Deoxyribonucleic Acid (DNA) predominates in this method of generating new skin cells (DNA). When a basal cell normally dies, the DNA alteration causes it to grow fast. Sometimes a cluster of unhealthy cells develops into a cancerous tumor; this form of lesion shows on the skin. The majority of DNA damage in basal cells is caused by ultraviolet (UV) radiation, which includes sunlight, artificial tanning lamps, and tanning beds. Skin cancer that develops on skin that is not typically exposed to sunlight cannot be detected by sun exposure.

3) *Prevention:*
   a) *Understand well about skin so you can observe changes as they occur:* To identify the changes that have happened in the portion of the body, one should study the skin.
   b) *To prevent exposure to the noon sun:* It needs to keep away from going outdoors when the rays are stronger. The majority of locations are open from 10:00 am to 4:00 pm, when the sun is at its strongest, even in the winter.
   c) *The use of protective clothing:* Wear tight clothing that covers the exposed parts of the body and a broad-brimmed hat, which offers greater protection than other hats, to protect yourself from UV radiation as sunscreen does not completely block them out.
   d) *Apply sunscreen.:* Use sunscreen with an SPF of at least 15 that protects against both UVA and UVB radiation from the sun. After a two-hour break, apply this sunscreen to the exposed areas of the body.
   e) *Stay away from tanning beds: this* can cause the UV radiation from these tanning beds to be released, hence raising the risk of skin cancer.

### *B. Squamous cell carcinoma*

This type of cancer is the second most common type of skin cancer. It begins from flat cells known as squamous cells in the upper portion of the epidermis. These cells account for 20% of skin cancer cases. Although it can sometimes be detected on skin that has previously been burnt, injured by some chemicals, or seen on x-rays, it is mostly caused by the sun's rays. The skin surrounding the mouth, the anus, and the lips are where it often manifests, although it can also start in other areas of the body, such as the skin around the genital area. Squamous cell carcinomas spread to other parts of the body in about 2–5 percent of cases.

### *C. Merkel cell carcinoma*

This cancer develops near the base of the skin and is seldom found. These cells at the nerves' endings help contact the skin gently. The aggressiveness or quick growth of this malignancy makes it potentially harmful. It can be exceedingly challenging to cure if it spreads to the skin. Only hormone-producing cells in the skin and hair follicles initiate it. Like basal cell carcinoma, it can also be observed on skin that has been exposed to the sun. However, they can begin anywhere on the body and are typically noticed as firm, shiny lumps that are painless. Any shade of lumps is possible. Skin neuroendocrine cancer and trabecular cancer are other names for Merkel cancer.

### *D. Cutaneous T-lymphoma*

This type of cancer starts in the blood cells known as the T- lymphocytes, the white blood cells, part of the immune system. The reason for this cancer is scaly patches or bumps, this cancer is also known as skin lymphoma, it is a form of non-Hodgkin lymphoma. This cancer is generally slow growing, it produces over many long years. It may be divided into the two most common types of Cezary syndrome and mycosis fungoides.

The paper is organized as follows; Section II gives different techniques used to extract features for optimization, section III gives different techniques used for the classification of skin cancer, section IV gives optimization techniques, and section V gives a literature review of work done in the field of skin cancer detection using image processing, and section V conclude the paper.

 

## II. FEATURE EXTRACTION TECHNIQUES TO OPTIMIZE SKIN CANCER DETECTION

### *A. PCA (Principal Component Analysis)*

PCA is considered a statistical technique commonly utilized in statistics, signal processing, and image processing for data dimension reduction for data de-correlation. PCA is a method with a complex mathematical basis for transforming various correlated variables into tiny variables known as main parts. The aim of PCA is the reduction of observed variables (ample dimensionality data space) to independent variables (small intrinsic dimensionality feature space) required to define the data economically. It presents the data in the novel coordinate system with the basis vectors that follow the most significant variance modes in data. So, the computation of a new basis vector is done for a particular data set.

Some points to be noted in PCA for faces:

1. To compute vectors that give the best results for variation of face images in whole picture space.
2. The Eigenvectors are these vectors.
3. Construct a face space and transform the pictures into these Eigenfaces or face spaces.

### *B. Speed-Up Robust feature (SURF)*

SURF is a newly-developed methodology, mainly used for feature detection purposes of an image. To enhance the performance of the feature extraction problem, there is a need to fix two problems: firstly, there is necessary to focus on the importance of the number of feature pairs after recognition of the object. Because this number of features is already stored in the score of recognition. A set of pairs between the image and each database image can be generated by using the SURF algorithm. The SURF algorithm's strong feature, which includes invariance of scale, invariance of translation, invariance of illumination, invariance of comparison, and invariance of rotation, makes it helpful for object detection in images. This algorithm composes of mainly four parts:

- Integral Image Generation
- Point of interest detection
- Descriptor orientation assignment
- Descriptor generation

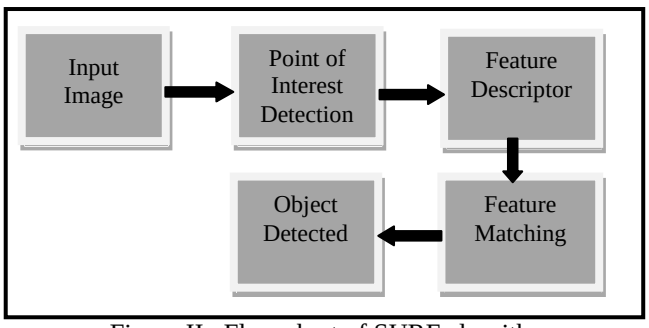


Figure II. Flow chart of SURF algorithm

The determinants of Hessian matrices are used by SURF to localize the corresponding point of pictures. By giving representative points random weights, it is possible to ensure that when the SURF algorithm is used, all of the representative points will have the same weight. Rarely will accurate representative points be produced; nonetheless, the following formula can be used to determine the weight of each representative point:

$$W_P = \frac{Number\ of\ detected\ images\ with\ respect\ to\ point\ P}{Number\ of\ training\ images\ in\ object} \quad (1)$$

## III. CLASSIFICATION OF SKIN CANCER

### *A. Machine Learning Mechanism*

Learning implies making and adapting the shift in itself as and when the environment changes. The most notable features of artificial neural networks are their ability to learn. Artificial neural networks can model the learning process by changing the weighted associations discovered in the network between neurons. In the training or learning stage, each training illustration is typically defined by a feature vector called the input vector which may be associated with the desired outcome known as the output vector. In each training cycle, an instance of the network is presented. It generates the output vector, which is compared with desired output vector. This way, each output unit's mistake is calculated and then used to update relevant weights.

In a multilayer network, the errors of hidden units are not observed directly but can be estimated with some heuristics. Each weight change is hoped to reduce the error. When all instances are examined, the network will start over the first instance and repeat. Iterations continue until the system performance has reached a satisfactory level [5,6].

### *B. ANN (Artificial Neural Network)*

An Artificial Neural Network (ANN) is an information processing paradigm excellent in the process observed in the natural biological neuron networks of the brain. ANN is one of the most effective ways to execute pattern recognition and classification of data. A significant characteristic of these networks is their adaptive nature, where "learning by instance" replaces "programming" to solve issues. This makes computational models very appealing in apps where one has little or incomplete understanding of the problem to be solved but where training data is readily available. ANNs are acknowledged in the classification and prediction field, where the regression model and other related statistical techniques have traditionally been used

An artificial neural network may be called a neural network or neural net (NN). They are strong modeling instruments, particularly when the underlying information connection is unknown. ANN is primarily composed of interconnected neurons where each unit capture an input, applies a function (often non-linear) to it and then proceeds with the output. The output signals feed into other units along with the links known as weight. The weights

 

generally excite or prevent the signal from being transmitted. One of the specialties of neural networks is the hidden unit's factors. To interfere with the network output and external input, concealed units, hidden cells, or hidden neurons play these roles. The network that introduced a neural network in it effectively can extract higher-order statistics by incorporating one or more hidden layers.

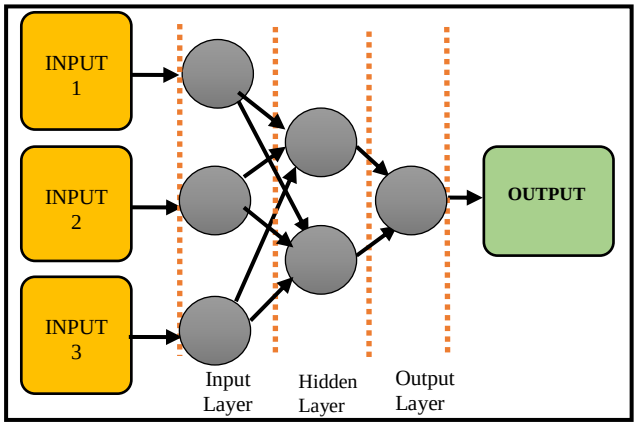


Figure 2. Representing Layered Architecture of ANN

ANN generally comprises layered architecture as manifested in figure 2. In that framework, some of the neurons interact with the actual globe to obtain their inputs. This output may be a specific personality the network believes it has scanned or viewed the specific picture it believes is being viewed. All the rest of the neurons are out of sight. But a neural network is more than a bunch of neurons. ANN comprises three main layers i.e., the input layer, the hidden layer, and the output layer. The input layer gets input in real-time apps either from input files or directly from electronic detectors. The output layer directly sends data to the outside world, a secondary computer process, or other equipment such as a mechanical control system. There can be many hidden layers between these two layers. These inner layers comprise many of the neurons in different interconnected buildings. Each of these concealed neurons ' inputs and outputs merely goes to other neurons. Choosing the right number of nodes and layers is important later on when optimizing the neural network to work well in a given problem. The demonstration in the figure is a feed-forward network because of how the signals are transmitted in one direction through the layers of the neural network [7,8].

The following are some of the advantages of employing a neural network:

- Unlike rule-based or programmable systems, neural networks are adaptable to changing circumstances. Rule-based systems are constrained to the circumstances for which they were developed. They are unable to function in a changing environment if the circumstance changes.
- Because the system is constructed by teaching rather than programming, neural networks train themselves in the pattern. It may be used in any application without any problems.
- Pattern Recognition is an effective tool for data collecting and generalization. A neural network learns to recognize patterns in an information set.
- Unlike traditional approaches such as programming logic, neural networks can readily develop useful models since they can handle very complicated circumstances and data.
- Neural networks perform effectively with low-cost computer hardware.
- Even if a component fails, a neural network can continue to function normally.

*1) Limitations of neural network*

- The key constraint of the neural network is its inability to explain how the network was built. The neural network receives a better response, but it's difficult to explain how they got there.
- It is hard to extract laws from the neural network.
- Time-consuming method of training the neural network from complicated information collection.
- The neural network requires to be trained to function.
- Neural network architecture is separate from microprocessor architecture and must therefore be emulated.
- Requires elevated processing times for big networks

The general classification mechanism involves two steps namely the training part and the classification part. The training part is further subordinated by feature extraction and normalization or optimization. The optimization process reduces the irrelevant value and neutralizes the features so that the training can be linear. A brief of optimization techniques is as follows.

## IV. OPTIMIZATION TECHNIQUES

It is the process of either maximization or minimization of a function under any set of restrictions. Optimization strategies work together to judge enhanced explanations or unconstrained maxima/continuous and minima of differentiable functions, which may be classed as optimization problems based on the presence of restrictions, the type of the equation involved, the allowable value of decision variables, and a large number of objective functions based on three components:

- **Objective function:** The objective function displays the number of amounts that are optimized with particular constraints and variables that must be lowered or maximized using a nonlinear programming approach.
- **Variable:** It may be used to describe the objective function as well as the restrictions, which can be discrete, continuous, or Boolean. A set of decision variable values for which the objective function

 

extends its optimal value can solve the optimization issue.

- **Constraints:** These are the variables that allow the unknown variable to receive certain values while rejecting others. Furthermore, a group of restrictions might limit the value of decision variables.

*A. SVM (Support Vector System):*

SVM works by discovering a hyper-surface in the room of feasible inputs. The hyper-surface aim to divide positive examples from negative examples by maximizing the distance to the hyper-surface between the nearest positive and negative examples. Intuitively, this makes the classification correct to test information that is near but not identical to the training data. Working Mode: A decision hyper-plane can be defined by an intercept term 'b' and a decision hyper-plane, a normal vector 'w', perpendicular to the hyper-plane. This vector is frequently referred to as the eight vectors. Choose from all the hyper-planes that are perpendicular to the normal vector [9].

## V. GENERAL STUDIES ABOUT SKIN CANCER DETECTION USING IMAGE PROCESSING

**Mustafa et al. (2018)** proposed an automated system for identifying skin cancer melanoma from simple pictures of impacted skin areas. Melanoma is the deadliest type of skin cancer and its incidence continues to increase. The technique includes standard image processing steps (picture enhancements, Grab Cut coupled with mean shift segmentation algorithm, and extraction/calculation function), as well as an SVM classification model. The experiment's findings demonstrate that we were able to obtain great accuracy using only a small number of pertinent datasets. The main disadvantage of this method is the potential increase in skin cancer cases among those with darker skin tones. [10].

**Didona et al. (2018)** focused on molecular and genetic factors and analyzed several non-melanoma skin cancer variables in detail. Non-melanoma skin cancer (NMSC) is the most common type of cancer in the world, with 99% of cases either basal cell carcinomas (BCCs) or squamous cell carcinomas (SCCs) (SCCs). NMSCs are not documented in most cancer registries worldwide because they are relatively non-lethal and surgically curable, but they are presently posing a significant global health hazard due to increased occurrence. Keratinocyte cancer is also known as BCC and SCC since basal cells and squamous neurons are both keratinocytes. [11].

**Islami et al. (2018)** estimated the percentage and number of invasive cancer cases and fatalities in 2014 non-melanoma skin cancers were excluded here and 26 types of cancer in individuals 30 years of age and younger in the United States attributable to significant, potentially modifiable exposures Cancer patient numbers were obtained from the Centers for Disease Control and Prevention (CDC) and the National Cancer Institute; death numbers were obtained from the CDC; the expected incidence of the risk factor was obtained from nationally representative research, and related comparative cancer hazards were obtained from published large-scale meta-analyses[12].

**Tang et al. (2017)** presented a pin content analysis that follows the agenda-setting theory's rule structure (A theory focused on specific targets and their related areas). Sun's harmful rays have a significant negative impact on skin and immunity, which can even be dangerous. [13].

**Khatami et al. (2017)** developed a melanoma clustering technique based on swarms to detect the affected areas. The extraction process was based on the color texture and other related features. The suggested method specifically comprises three primary stages. To reduce the area's redundancy, a linear transformation-based Particle Swarm Optimization approach was proposed. [14].

**Kavitha et al. (2017)** proposed different extraction strategies for the global and local texture functions. The co-occurrence matrix of grey level (GLCM) is used to calculate the global texture features for an image, including energy, homogeneity, entropy, contrast, correlation, dissimilarity, and maximum likelihood. The success is judged using some criteria, including sensitivity, specificity, accuracy, and F1 score. When compared to global feature extraction, the testing results show that the local texture feature obtained via SURF performs at the greatest level [15].

**Kharazmi et al. (2017)** presented a method for the detection and segmentation of cutaneous vasculature from dermoscopy images. For the classification of skin cancer, the next features of extracted vascular have been disclosed. First of all, perform image decomposition with help of independent component analysis (ICA) which converts it into components of melanin and hemoglobin. ICA removes the impact of pigmentation on the visibility of blood vessels. The component of hemoglobin is clustered into normal, pigmented, and areas of erythema through K-means clustering. Sensitivity and specificity segmentation have 90% and 86% accomplished on manually 500000 datasets collected pixels by experts [16]

**Taufiq et al. (2017)** provided a method for extracting cutaneous vascular information from dermoscopy images. The following characteristics of the extracted vasculature have been revealed for the classification of skin cancer. First, perform image decomposition using independent component analysis (ICA), which breaks the image down into its parts for hemoglobin and melanin. The effect of pigmentation on blood vessel visibility is eliminated by ICA. Through K-means clustering, the hemoglobin component is divided into normal, pigmented, and erythematous portions. On manually gathered 500000 datasets of pixels by experts, sensitivity and specificity segmentation have achieved 90% and 86%, respectively. [17].

 

Mane et al. (2017) have explored many methods for spotting skin cancer. Each method includes procedures for feature extraction, segmentation, and classification after picture pre-processing. Based on feature extraction, segmentation, classification, and pre-processing of four parameters, five strategies are taken into consideration for comparison. These procedures operate on the picture; therefore, there is no actual touch with any part of the body, making them non-intrusive [18].

**Pennisi et al. (2016)** presented an Automatic skin lesion picture segmentation technique, designed to cope with various kinds of lesion forms, sizes, colors, and hair. The suggested algorithm, called ASLM, is fully automatic, does not involve any phase training, and is computationally quick. ASLM utilizes distinct parameters to perform segmentation, but most of them are linked to image size input and regarded skin types, so they can be predefined. The results of the experimental evaluation show that the suggested strategy is extremely precise when dealing with benign lesions, while the precision of segmentation reduces considerably when melanoma pictures are processed [19].

**Nasr-Esfahani et al. (2016)** presented a Complex computational technique based on deep learning that was introduced using clinical images. This scheme was able to detect melanoma instances from benign ones. In the proposed scheme, clinical input pictures, Images have been pre-processed to reduce artifacts caused by illumination and noise. Our proposed technique left the process of extracting characteristics to CNN whereas conventional learning methods try to extract characteristics from the data. The experimental results provide better accuracy than other detection algorithms [20].

**Sagar et al. (2016)** proposed a simple and computationally easy technique based on altered histogram thresholds coupled with morphological operations. The presented algorithm corrects these limitations with the original pre-processing steps of c1inical picture adjustment. 175 photos from various government internet databases were used to evaluate the algorithm. During image acquisition, skin images with lesions touching the borders or corners of the images were dismissed. About 94% precision is provided for the L * RGB color channel created from digital images by the experimental results obtained by comparing the segmented lesion with the manually selected region. [21].

**Soumya et al. (2016)** suggested a sophisticated color correlogram and texture analysis melanoma detection system. With the use of a color correlogram and SFTA function vectors, the Bayesian classifier is utilized to recognize aberrant skin cells. The advantage of the method being provided is that there is no need to study the ABCDE parameters, which would make the evaluation more challenging. The experimental outcome shows that, with a precision of 91.5%, the combination of color correlogram and texture analysis produces better results [22].

**Ghavami et al. (2016)** introduced the UWB microwave imaging method based on the Huygens principle (HP), which has appeal to a multi-layered skin model with an inclusion demonstrate a tumor. Forward propagation of the waves using the HP procedure eliminates the need to fix inverse problems and matrix generation/inversion. The HP technique is capable of providing a resolution of roughly one-quarter of the shortest wavelength in the dielectric medium while having bandwidths and energy concentrations that meet UWB rules and energy safety constraints, respectively [23].

**Mehta et al. (2016)** discussed the entire stage of computer-aided skin cancer diagnosis and its effective techniques. An automatic skin cancer diagnosis is one of the main challenges in the processing of medical images. The proposed method concludes that AFINN provides more precise results than a neural network and a Fuzzy rule-based system and computer-aided diagnosis are more suitable than the traditional biopsy technique. Patient data plays a significant role in diagnostic processes [24].

## VI. CONCLUSION

In this paper, we studied several non-invasive techniques for detecting and classifying skin cancer. Pre-processing, segmentation, feature extraction, and classification are only a few of the stages involved in the identification of skin cancer. This research concentrates on several methods, including Genetic Algorithms, SVM, CNN, etc. Each algorithm has been found to have benefits and drawbacks, based on the analysis. Segmentation plays a vital role in the correct classification of cancerous images. The segmented portion is then followed by the step of feature extraction and the classification architecture simultaneously. Unfortunately, the segmentation process has not gained a lot of attention in this area. Certain segmentation techniques are studied in the paper but they serve with limitations and processing issues and also every segmentation technique is not suitable for every type of image. In order to enhance skin cancer detection using image processing, researchers might focus on the segmentation and classification phase in the future.

## REFERENCES

[1] S. H. Hassanpour, M. Dehghani, *"Review of cancer from perspective of molecular"*, Journal of Cancer Research and Practice, Vol. **4,** Issue**. 4,** pp. **127-129, 2017.**

[2] S. Jain, V. jagtap, N. Pise,*" Computer Aided Melanoma Skin Cancer Detection Using Image Processing"*, Procedia Computer Science, Vol. **48**, **pp. 735-740,2015.**

[3] S. R. Silpa, V. Chidvila**,** *"A Review On Skin Cancer*", International Research Journal of Pharmacy, Vol**. 4**, pp. **83-88, 2013.**

[4] R. Maurya, A. Singh, V. Srivastava, R. Yadav, *"A Comparative Review of Various Approaches for Skin Cancer Detection"*, International Journal of Computer Sciences and Engineering, Vol. **5,** Issue **10**, pp. **146-152, 2017.**

[5] E. Jana, R. Subban, S. Saraswathi, *"Research on Skin Cancer Cell Detection Using Image Processing,* ", In the Proceedings of the 2017 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), **pp. 1-8, 2017**

 

[6] A. Kwasigroch, A. Mikołajczyk, M. Grochowski, *"Deep neural networks approach to skin lesions classification—A comparative analysis"*, In the Proceedings of the 2017 22nd International Conference on Methods and Models in Automation and Robotics, pp. **1069-1074, 2017.**

[7] R. B. Aswin, J. A. Jaleel, S. Salim, *"Hybrid genetic algorithm Artificial neural network classifier for skin cancer detection"*, 2014 International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT), pp. **1304-1309, 2014.**

[8] A. Esteva, B. Kuprel, R. Novoa, et al*.," Dermatologist-level classification of skin cancer with deep neural networks"*, Nature 542, pp. **115–118, 2017.**

[9] H. Alquran, *"The melanoma skin cancer detection and classification using support vector machine"*, In the Proceedings of the 2017 IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies (AEECT), Aqaba, pp. **1-5, 2017.**

[10] S. Mustafa, A. Kimura*," An SVM-based diagnosis of melanoma using only useful image features"*, In the Proceedings of the 2018 IEEE International Workshop on Advanced Image Technology (IWAIT), pp. **1-4, 2018.**

[11] D.Didona, G. Paolino, U. Bottoni, C. Cantisani, *"Nonmelanoma skin cancer pathogenesis overview. Biomedicines"*, Vol **6**, Issue **6**, pp. **1-15 2018**.

[12] F.Islami, A. S. Goding, K. D. Miller, R. L. Siegel, S. A. Fedewa, E. J. Jacobs, M. L. McCullough, A. V. Patel, J. Ma, I. Soerjomataram, W. D. Flanders, O. W. Brawley, S. M. Gapstur, A. Jemal, *"Proportion and number of cancer cases and deaths attributable to potentially modifiable risk factors in the United States"* CA: a cancer journal for clinicians, Vol **68**, Issue **1**,pp. **31-54. 2018**.

[13] L. Tang, S. E. Park, *"Sun Exposure, Tanning Beds, and Herbs That Cure: An Examination of Skin Cancer on Pinterest"*, Health Communication, Vol. **32**, Issue. **10**, pp. **1192–1200, 2017.**

[14] A. Khatami, S. Mirghasemi, A. C. P. Khosravi, Lim, H. S. Asadi, Nahavandi, *"A Swarm Optimization-Based Kmedoids Clustering Technique for Extracting Melanoma Cancer Features"*, ", In the Proceedings of the International Conference on Neural Information Processing**, pp. 307-316.** Springer, Cham, **2017.**

[15] J. C. Kavitha, A. Suruliandi, D. Nagarajan, T. Nadu, *"Melanoma detection in dermoscopic images using global and local feature extraction"*, International Journal of Multimedia and Ubiquitous Engineering, Vol**.12,** Issue. **5**, pp. **19-28. 2017.**

[16] P. Kharazmi, M. I. AlJasser, H. Lui, Z. J.Wang, T. K. Lee, *"Automated detection and segmentation of vascular structures of skin lesions seen in Dermoscopy, with an application to basal cell carcinoma classification"*, IEEE journal of biomedical and health informatics, Vol**. 21,** Issue. **6**, pp**.1675-1684, 2017.**

[17] M. A. Taufiq, N. Hameed, A. Anjum, F. Hameed, *"m-Skin Doctor: a mobile-enabled system for early melanoma skin cancer detection using a support vector machine"*, In eHealth 360°, Springer, Cham, pp. **468-475, 2017.**

[18] S.S. Mane, S.V. Shinde, *"Different Techniques for Skin Cancer Detection Using Dermoscopy Images"*, International Journal of Computer Sciences and Engineering, Vol.**5**, Issue.**12**, pp.**159-163, 2017.**

[19] A. Pennisi, D. D. Bloisi, D. Nardi, A. R. Giampetruzzi, C. Mondino, A. Facchiano, *"Skin lesion image segmentation using Delaunay Triangulation for melanoma detection"*, Computerized Medical Imaging and Graphics, Vol. **52**, pp**. 89-103, 2016.**

[20] E. Nasr-Esfahani, S. Samavi, N. Karimi, S. M. R. Soroushmehr, M. H. Jafari, K. Ward, K. Najarian*," Melanoma detection by analysis of clinical images using a convolutional neural network"*, In the Proceedings of 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp. **1373-1376, 2016.**

[21] C. Sagar, L. M. Saini*," Color channel-based segmentation of skin lesion from clinical images for the detection of melanoma"*, In the Proceedings of IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES), pp. **1-5, 2016.**

[22] R. S. Soumya, S. Neethu, T. S. Niju, A. Renjini, R. P. Aneesh, *"Advanced earlier melanoma detection algorithm using color correlogram"*, In the Proceedings of 2016 International Conference on Communication Systems and Networks (ComNet), pp. **190- 194, 2016.**

[23] N. Ghavami, G. Tiberi, M. Ghavami, S. Dudley, M. Lane, *"Huygens principle-based UWB microwave imaging method for skin cancer detection"*, In the Proceedings of IEEE 10th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP**),** pp**. 1-4, 2016.**

[24] P. Mehta, B. Shah, *"Review on techniques and steps of a computer-aided skin cancer diagnosis"*, In the Proceedings of Procedia Computer Science85, pp. **309-316. 2016.**

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