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A Project Stage-II Report on

AI-Driven Skin Cancer Detection for Early Intervention using Deep Learning

By

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(Roll No: PA 20   PRN: 1032221714)

Guide

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[Academic Year 2023-24]

C E R T I F I C A T E

This is to certify that Mr. Abhishek Somnath Waghchaure Seat No.1032221714 has successfully completed his Project Stage-II entitled "**AI-Driven Skin Cancer Detection for Early Intervention using Deep Learning**" under my supervision and submitted the same during the academic year 2022-24 towards the partial fulfilment of degree of **Master of Technology (Computer Science and Engineering) (Data Science and Analytics)** of Dr. Vishwanath Karad MIT World Peace University Pune.

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Abstract

Skin lesion segmentation plays a critical role in computer-aided diagnosis and therapy planning for dermatological diseases. This study investigates the use of Convolutional Neural Networks (CNNs) for precise skin lesion segmentation, paying particular attention to the effects of picture augmentation methods. Dermoscopic image data from the PH2 dataset is used for training and assessment. Rotation and flipping are two augmentation procedures used to enrich the dataset to improve model generalization. Encoding and decoding layers are included in the suggested SegNet architecture to facilitate efficient feature extraction and segmentation. We use stochastic gradient descent (SGD) as the optimizer. We use activation functions and batch normalization to help with the model's performance. The training procedure is standard: we stipulate a batch size, choose a validation set, and decide on the number of epochs. The results are clear: the expanded dataset has dramatically increased segmentation accuracy. For the training, test, and validation sets, we present several standard segmentation performance measures: Intersection over Union (IoU), a near-Diagram Coefficient (analogous to the near-Euclidean shapes we expect), precision, recall, and overall accuracy. An automated method for identifying skin lesions is presented in this work to help in early detection. A heterogeneous preprocessed dataset with multiple skin lesion kinds, varying skin tones, and image quality is gathered. Transfer learning from pre-trained models carries out the application of feature representations obtained from large datasets, and this is how it works. CNN, Vgg6, Xception, and DenseNet algorithms were used by this system. The skin lesion dataset is used to fine-tune the model, and performance is optimized through hyperparameter tuning. The model's capacity to generalize is confirmed by testing and validation on different datasets. Model predictions are more reliable when post-processing methods and interpretability metrics are used. The study highlights how using deep learning-based diagnostic tools in healthcare requires ongoing cooperation with medical practitioners, ethical considerations, and adherence to regulatory norms.

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Keywords –skin lesion detection, deep learning, dermoscopic images, segnet, Deep learning, skin lesion diagnosis, dermatology, CNNs, medical imaging, early detection, transfer learning.

Acknowledgement

Dr. Vishwanath Karad , MIT World Peace University, Pune, M.Tech(Data Science and Analytics)

Contents

Dr. Vishwanath Karad , MIT World Peace University, Pune, M.Tech(Data Science and Analytics)

List of Figures

List of Tables

Abbreviations

CNN	Convolutional Neural Network
akiec	actinic keratosis and intraepithelial carcinoma
bcc	basal cell carcinoma
bkl	benign keratosis-like lesions
df	dermatofibroma
mel	melanoma
nv	nevi
vasc	pyogenic granulomas and hemorrhagic conditions
LBP	Local Binary Pattern
DNN	Deep Neural Network

Ch. 1. Introduction

1.1 Background of the Project

Skin cancer is a dangerous and sometimes fatal global health concern. However, when patients receive an early diagnosis of their lesions, the death rate from it is considerably decreased. In this work, an automated skin lesion diagnosis system is powered by convolutional neural networks, a kind of deep learning. The need for helper tools that enable doctors to retain the speed and accuracy of their critical identifications when a patient's life is at stake is growing due to the growing number of dermatological patients.

This project's main goal is to create, put into practice, and evaluate a solid deep-learning model that can identify skin lesions independently. The model will be trained using transfer learning techniques on a large dataset comprising various skin tones, types of lesions, and potential variations in image quality. In order to guarantee the model's efficacy in actual clinical circumstances, a high degree of accuracy and generalizability are sought.

Interpretability, beyond accuracy, is a major priority so medical practitioners can comprehend and have faith in the model's conclusions. Important components of the project include ethical considerations, regulatory compliance, and continuous communication with dermatologists, underscoring the initiative's dedication to responsible deployment within the healthcare ecosystem. The ultimate purpose of the research is to improve patient care by facilitating early detection of dermatological problems and enabling timely therapies.

The main aim of this project is to construct a top-of-the-line deep learning system that can carry out automated diagnoses of skin lesions. The work centers on the system's potential to boost the early detection of disorders that affect the skin. Using convolutional neural networks and transfer learning, we will construct a robust model that accurately classifies several varied kinds of skin lesions. We think the dataset we will be using to train our model is the greatest one out there so far for this kind of system training. The dataset considers changes in skin tone, covers any differences in

image quality, and includes a variety of lesion kinds. We aim to develop a highly performant model by fine-tuning, hyperparameter optimization, and thorough preprocessing. The model's generalizability will be confirmed by validation and testing on other datasets, giving dermatologists a trustworthy tool for actual clinical situations. We will concentrate on interpretability, post-processing, and collaborating with medical professionals to ensure this model is reliable and useful. At the same time, we are optimistic about the model's potential influence. Deep learning has the potential to greatly boost patient outcomes by offering a fresh and potent technique to the early diagnosis of skin problems.

The initiative, which focuses on dermatology especially, is in medical imaging and healthcare technology. The primary objective we are working toward is the use of deep learning techniques, specifically convolutional neural networks, to achieve automatic diagnosis of skin lesions. This field of study has the potential to greatly increase the speed and precision of dermatologic diagnostics since it combines artificial intelligence, machine learning, and medical imaging. The initiative tackles problems with pattern recognition, image analysis, and integrating cutting-edge technologies in healthcare settings. Moreover, the initiative strongly emphasizes ethical issues and collaboration with medical professionals, underscoring its role in health informatics and technology-assisted healthcare solutions.

This project's main aim is to create a sophisticated deep learning system capable of identifying skin lesions autonomously. Advances in early dermatological diagnostics are the impetus behind this work. Our strategy is to use a large dataset, coupled with Convolutional Neural Networks (CNNs) and transfer learning, to achieve a reliable model that can sort a number of varied skin lesions. The dataset considers changes in skin tone, covers any differences in image quality, and includes a variety of lesion kinds. We aim to develop a highly performant model by fine-tuning, hyperparameter optimization, and thorough preprocessing. The model's generalizability will be confirmed by validation and testing on other datasets, giving dermatologists a trustworthy tool for actual clinical situations. To guarantee the model's reliability and applicability, a focus on interpretability metrics, post-processing methods, and continued cooperation with medical specialists will be made. This research shows that

the most advanced deep-learning techniques can greatly assist in the quick and accurate diagnosis of skin diseases, lead to the swifter administering of treatments, and ultimately better the outcome for patients in the specialty of dermatology.

The initiative, which focuses on dermatology especially, is in medical imaging and healthcare technology. CNNs, a type of deep learning technique, are the major tool used to automatically diagnose skin problems. Improve the early diagnosis and classification of dermatological problems; this involves the convergence of medical imaging, machine learning, and artificial intelligence. The initiative tackles problems with pattern recognition, image analysis, and integrating cutting-edge technologies in healthcare settings. Moreover, the initiative strongly emphasizes ethical issues and collaboration with medical professionals, underscoring its role in health informatics and technology-assisted healthcare solutions. Ensuring that skin cancer is detected early greatly increases the likelihood that patients will achieve favorable outcomes with this widespread and troubling health issue. The current initiative makes use of deep learning's growing potential. In this instance, we create an automated system to identify skin lesions using convolutional neural networks. We believe that a system with this degree of precision and speed can help medical professionals and, most crucially, those who are in danger of getting skin cancer, as skin problems are regrettably becoming more prevalent.

The primary aim of this project is to develop a robust deep-learning model capable of autonomously identifying skin lesions. To accomplish this, we will use the transfer learning technique on a large dataset representative of different skin types, many sorts of lesions, and a variety of image qualities. Our hope is that the model will not only achieve a high accuracy rate but also be generalizable—meaning it could be used in real-world clinical situations.

Interpretability, beyond accuracy, is a major priority so medical practitioners can comprehend and have faith in the model's conclusions. Important components of the project include ethical considerations, regulatory compliance, and continuous communication with dermatologists, underscoring the initiative's dedication to responsible deployment within the healthcare ecosystem. The ultimate purpose of the

research is to improve patient care by facilitating early detection of dermatological problems and enabling timely therapies.

1.2 Motivation

Using cutting-edge technologies, such as CNNs, offers a viable way to enhance patient outcomes and diagnostic precision. The ultimate goal of this research is to lessen the detrimental impacts of skin cancer by developing strong and dependable automated systems for early detection, better prognoses, and finally, prevention. In particular, the study looks at how effective certain convolutional neural network (CNN) architectures, such as VGG16 and Densenet201, are when used as automatic feature extractors to detect and classify skin cancer. Skin cancer is a serious and pressing global health issue, not only because it's a common cancer but because its incidence is increasing. Although the types of skin cancer we discuss here vary in severity and curability, all forms can lead to serious health problems if not caught early.

1.3 Uniqueness of the project

Current research has made significant strides in developing accurate models, but there are specific areas that warrant further investigation:

- Restricted diversity in datasets: There is a dearth of diversity in many current datasets, especially concerning skin types, races, and lesions. This makes applying the models to a larger group of patients more difficult.
- Exclusivity to Clinical Environments: Most research focuses on controlled clinical settings, and there is a knowledge gap about the performance of these models in real-world situations when variables such as patient adherence, lighting, and image quality may change.
- Interpretability and Trustworthiness: Medical practitioners are concerned about deep learning models' lack of interpretability. Establishing trust and promoting these models' acceptance in clinical practice requires understanding how they make their decisions.
- Long-term Performance and Adaptability: The long-term efficacy of AI models in identifying skin cancer has not been well-studied. Sustained effectiveness requires constant observation and adjustment to changing skin lesion features

and medical procedures.

- Integration Difficulties: It is still difficult to successfully integrate AI tools into current healthcare workflows. Investigating issues about user experience, interface design, and healthcare professionals' unique requirements and preferences is necessary.

We can make some innovations in our approach to overcome the above limitation.

- Actinic keratosis and intraepithelial carcinoma (akiec), nevi, dermatofibroma (df), melanoma (mel), basal cell carcinoma (bcc), nevi, and hemorrhagic conditions (vasc) are the seven subtypes of skin cancer that are described in a different dataset that we will use. To evaluate this dataset, we will use various convolutional neural network architectures.

- Most common skin cancer datasets, such as HAM1000 and ISIC, contain class data imbalances. These imbalances can be addressed by using approaches like data augmentation and resampling.

- Utilize an alternative CNN variation for this categorization.

- Execute and evaluate several optimizers and callback functions to achieve the best and most precise model possible.

1.4   Benefit to the organization

An organization can gain from deep learning-based AI-driven skin cancer detection systems for early intervention in various ways, but medical facilities, research institutes, and healthcare providers stand to gain the most. The advantages are as follows:

- Increased Diagnostic Accuracy: The AI-driven approach can increase diagnostic accuracy by offering a more unbiased study of skin lesions. This lowers the possibility of misdiagnosis, improves patient outcomes overall, and helps discover any cancers early.

- Time and Cost Efficiency: Automated skin cancer diagnosis can greatly decrease the time medical personnel need to perform manual analyses. This effectiveness can improve patient throughput, lower healthcare costs, and speed up diagnosis and treatment decisions.

- Early Intervention and Treatment Planning: Prompt intervention and treatment

planning are made possible by early detection made possible by the AI system. As a result, more advanced stages of skin cancer may not require more involved and expensive procedures, potentially saving money and resulting in more effective treatment techniques.

- Decreased Workload for Healthcare workers: Analyzing a significant number of dermatological photos can be laborious for healthcare workers, especially dermatologists. By giving them a second opinion for regular screenings and enabling them to concentrate on more complex cases, the AI system is a useful tool to support and enhance their talents.

- Improved Patient Care and Experience: Prompt detection and action can facilitate patient outcomes and experiences. When skin cancer is discovered early, patients gain from quicker diagnoses, shorter wait times, and maybe less invasive treatment options.

- Data-Driven Insights and Research Opportunities: Putting an AI system into place creates data that can be used to study and gain insights into skin cancer's characteristics, trends, and demographics.

1.5   Organization of report

Chapter 1 contains a brief overview of the skin cancer detection and classification with motivation, uniqueness and benefits to the organization

Chapter 2 contains a literature review of various research done on skin cancer detection and recognition by multiple authors and presents research gap

Chapter 3 discusses the scope of the work and objectives of the proposed system

Chapter 4 presents the methodology for skin lesion segmentation using deep learning algorithm

Chapter 5 presents the skin cancer recognition using deep learning algorithm.

Chapter 6 discusses the results of the proposed system with different evaluation metrics.

Chapter 7 Concludes the thesis

Chapter 8 suggest the future direction of the research.

Ch. 2. Literature review

2.1   Review on Skin Cancer Detection

Dorj et al. used an online dataset consisting of 3753 photos from four classes. [1]. Employing AlexNet for feature extraction and an ECOC SVM for classification, they achieved an amazing 94.2 percent accuracy. It is worth noting that when the online dataset was gathered, the usual benchmark rules were not followed. Rezvantalab et al. [2] employed an alternative methodology using the 120 photos from eight classes in the HAM10000 dataset. The authors used a variety of pre-trained models to report their results, including DenseNet 201, ResNet 152, InceptionV3, and InceptionResNetV2. The most accurate model, DenseNet 201, achieved an accuracy of 86.59 percent. For presenting the results, AUC values were calculated and reported for each model and each class. Each class also had multiple test specimens associated with it. The AUC values for the three classes in the PH2 dataset ranged from 93.80 percent to 99.30 percent. Hosny et al. [3] reached a remarkable 98.61 percent accuracy while using a modified version of AlexNet. They applied this tailored model to boost the original dataset and succeeded in acquiring a total of 4400 images. An AUC of 81.40 percent was obtained by Dascalu and David's [4] study of the ISIC 2017 dataset, which divided 5161 images into two classes. Their unique approach involves sonification and K-means clustering to assess how image quality affects diagnostic accuracy.

In a different investigation, Pham et al. [5] employed the ISIC 2016 dataset (172 photos) and the HAM10000 dataset (1113 images), both of which were from a single class. Their method yielded an accuracy of 74.75 percent using LBP balanced random forest, HSV, and linear normalization. Comparing the color, texture, and form of melanoma skin cancer cells was the primary goal of this investigation. In order to attain an accuracy of 82.95 percent, Hekler and co-authors [6] combined physician judgments with Convolutional Neural Network (CNN) predictions utilizing the HAM10000 and ISIC datasets (a total of 11,444 pictures) with five classes. Interestingly, this study obtained results for binary and multiclass classifications using the XGBoost algorithm.

The HAM10000 dataset has been studied by several groups, with the best accuracy results coming from Emara et al. who used a modified InceptionV4 model. Their

approach yielded performance of approximately 94.7% accuracy. The InceptionV4 modifications were mainly oriented to handle the unbalanced class ratios found in that dataset. The study by Chaturvedi et al. was not quite as successful with a result of 83.1% on the same dataset. It used a pretrained MobileNet architecture (and was able to use some Transfer Learning techniques because the original melanoma dataset was quite large, containing 38,569 photographs).

Mohapatra et al.'s study made advantage of the seven different classes found in the HAM10000 dataset. [9]. Using an unaltered, pre-trained MobileNet model, they achieved an accuracy of 80%. In contrast, Chen et al.'s [10] N/A dataset included nine distinct kinds of skin lesions. Chen et al. utilizing a pre-trained ResNet50 model on the N/A dataset, achieved an accuracy of 83.74%. Additionally, they showed how to effectively classify nine distinct types of skin lesions using the ResNet50 model.

2.2 Review on Skin Cancer Recognition

The National Cancer Center, Tokyo, provided Jinnai et al. [11] with a dataset of 5,846 photographs divided into six categories. The accuracy of their FRCNN, BCD, and TRN techniques was 86.2 percent, 79.5 percent, and 75.1 percent, in that order. In order to compare classifiers, they also used a bespoke dataset that consisted of the two main groups, benign and malignant. Using ResNetXt101, Chaturvedi et al. [12] achieved an astonishing accuracy of 92.83 percent by analyzing the seven-class HAM10000 dataset. An in-depth analysis by Chaturvedi and colleagues revealed the best hyperparameter settings for identification of histopathology images, and their results showed that the ResNetXt101 model was the top-performing model for this task.

Skin cancer is among the deadliest cancers. It results from damage to skin cells' DNA that is not repaired. The damage brings on skin alterations. Several causes exist, but prolonged, unprotected sun exposure is the most frequent and harmful. In addition, exposure to dangerous substances or unhealing wounds are risk factors for skin cancer. However, all age groups are seeing an increase in occurrences. The age group between 15 and 29 is the fastest-growing in terms of skin cancer cases. Because these problems are so serious, many researchers have worked on developing a number of different techniques for the early detection of skin cancer. In order to identify skin cancer, these methods examine how lesions appear how two elements compare (symmetry, for

example) or how color, size, or form contrast with the norm. Some experts would even go so far as to predict with certainty who would prevail in a boxing fight between benign and melanoma. However, these attempts rarely provide coherent programming for early skin cancer detection—most programs rely on human visual specialists to evaluate a histological section's septal (sandwich) imaging [13].

Skin cancer is one of the most widespread and deadly kinds of cancer found around the globe. Reducing the death rate from skin cancer requires early diagnosis of the disease. The conventional approaches to diagnosing skin cancer are costly, time-consuming, and prone to spreading the illness. They are also uncomfortable. Dermoscopy can be used to diagnose skin cancer noninvasively, although it still has some drawbacks. Artificial intelligence (AI) has advanced dramatically in the last several years and is crucial to diagnosing many diseases. Automated detection systems based on artificial intelligence (AI) hold the promise of enhancing the accuracy of skin cancer diagnoses in biomedical engineering. They do this by attempting to overcome some of the more egregious faults of traditional diagnosis methods. In this study, an automated skin cancer early detection system is created and described. It interacts with dermoscopic images of skin lesions through artificial intelligence. The system's segmentation phase employs snake and region-expanding algorithms adapted to current conditions. The outcomes demonstrate that adaptive snake outperforms region expanding in accuracy and efficiency. Support vector machines and artificial neural networks are the main methods used in the categorization phase, which comes to the conclusion that ANLs are better than SVMs in this instance. The technique utilizing artificial neural networks (ANNs) attains 94% accuracy, 96% precision, 95.83% specificity, 92.30% sensitivity (sometimes called recall), and an F1 score of 0.94. The device is user-friendly, takes time, and is efficient enough to quickly provide patients with the "skin cancer or not" decision. [14]

Undoubtedly among the deadliest forms of cancer, skin cancer holds the dubious distinction of being one of the primary causes of mortality globally. Skin cancer has a far better prognosis when detected early. Most current methods rely on human inspectors who have received training and work in well-lit environments. Nevertheless, these approaches have the potential to be lethal when they fail. The current environment permits and requires a deep learning-assisted visual inspection technique to diagnose

skin cancer. The state of the art for these kinds of techniques is surveyed in this study. [15]

To lower the number of parameters, we replaced the excitation and squeezing components of the model with the realistically advantageous channel attention component. In order to efficiently utilize synthetic features, we suggested employing cross-layer connections between Mobile modules. We applied dilated convolutions to improve the receptive field. We also focused on optimizing the model's performance by fine-tuning the hyperparameters, a crucial component of any optimization work. For the pre-trained MobileNet-V3, we employ advanced optimization techniques like Bayesian optimization to determine the ideal hyperparameters. We evaluated our improved MobileNet-V3 against the following melanoma detection and segmentation techniques: ResNet-152v2, VGG-19, MobileNet, VGG-16, and MobileNet-V2 (training and testing on the HAM-10000 dataset). The metrics used to report how successfully these techniques located and correctly diagnosed the melanomas (compared to the findings from human pathologists) are precision, sensitivity, accuracy, and specificity. Our research shows that the MobileNet-V3 model operates with 97.84% precision, 96.35% sensitivity, 98.86% accuracy, and 97.32% specificity when optimized hyperparameters. Not only did this research yield results, but it also paid off. For the patients who stood to gain the most, the returns came in the shape of even better medical care—possibly lifesaving and affordable. [16]

An independent, threshold-based approach is recommended for segmenting, classifying, and detecting skin cancers. The proposed method within this approach uses a meta-heuristic optimizer called the sparrow search algorithm (SpaSA). For the segmentation phase of the process, five different configurations of the U-Net model (U-Net, U-Net++, Attention U-Net, V-net, and Swin U-Net) are used. The pre-trained models that the authors use in this study include VGG16, VGG19, MobileNet, MobileNetV2, MobileNetV3Large, MobileNetV3Small, NASNetMobile, and NASNetLarge. The authors used the meta-heuristic SpaSA to optimize the hyperparameters of these eight CNN models. Five public sources provided the dataset. Two datasets were created from the segmented photos: two-classes and ten-class. The best results reported to date for the "skin cancer segmentation and classification" dataset were obtained with U-Net++, which has DenseNet201 as its backbone architecture. It

Dr. Vishwanath Karad , MIT World Peace University, Pune, M.Tech(Data Science and Analytics)

employed a variant of the cosine loss function, producing a loss of 0.104 on the test set and achieving impressive scores across several other metrics: 94.16% on accuracy, 91.39% on the F1-score, 99.03% on AUC, and 96.08% and 96.41% on IoU for the two classes defined in the dataset. More surprisingly, the authors also reported that U-Net++ was able to achieve 77.19% and 75.47% on two different instances of a weakly-supervised training test set. The Attention U-Net with DenseNet201 performed the best on the "PH2" dataset, reporting a loss of 0.137 along with precision, accuracy, AUC, and other numbers that peaked at 92.74% with a precision of 94.75% and numbers that dropped as low as 68.04% with "squared hinge" and "hinge" loss configurations at the end of its scoring list. The overall accuracy of our convolutional neural network (CNN) experiments achieved a high of 98.27% when we applied them to the "ISIC 2019 and 2020 Melanoma" dataset. A MobileNet pre-trained model provided the basis for our best model. The pre-trained MobileNet model, operating on a different dataset, achieved a second-place accuracy of 98.83% among our skin cancer classification models. Our lowest accuracy (85.87%) came from using a MobileNetV2 pre-trained model on a different skin cancer dataset. Our accuracy rates for each dataset were competitive when we compared our approach's results with those of 13 similar studies. [17]

Humans experience a high incidence of skin cancer, with the most common types being nonmelanoma cancers such as SCC and BCC; the number of these cancer types is rising. Skin cancer is not homogeneous, however, and the most dangerous and deadly skin cancer is melanoma. Melanomas can arise in normal skin or in moles. They can appear and change fast in their looks. Cancers of the skin, particularly melanoma, call for accurate and rapid detection. Otherwise, the appearance of melanoma as with cancer in general leads to excess morbidity and death that is unnecessary and avoidable. Convolutional neural networks, or CNNs, are receiving more attention as practical methods for automating procedures that may classify lesions based on their malignant status and visual identification. This work has created a new strategy for early skin cancer detection. Processing dermoscopic pictures forms its foundation. The architecture of the model is based on the VGG-16 network, which is a widely recognized convolutional neural network (CNN) framework. However, instead of using the usual configuration of the VGG-16 network, we chose to use an improved version

of the network as the main architecture in our model. As we will explain, most of the improvements take the shape of adjustments to the model's image data processing pipeline. Naturally, we want to increase skin cancer detection accuracy to the point where it is deemed operationally viable in a real-world setting. According to the results, the model we suggested is more accurate than the other tested approaches [18].

Consequently, interest in machine learning has surged recently.Machine learning is mostly associated with deep neural networks (DNNs). DNNs are the greatest ML technology for solving practical problems like speech recognition, computer vision, or even health-related issues. DNNs are creatures of determinism. They function. However, without some confidence metric, it is impossible to know how confident they are in their work truly. Either guesstimate it using a prior distribution (which is Bayesian) or use your DNN to perform multiple "forward passes" and use the output to produce a confidence level (MC dropout is one method that does this). Nevertheless, MC is not very effective, presumably the reason this article is prompted. This research presents a novel use of the MCD method that enables the construction a deep neural network (DNN) that incorporates a knowledge of uncertainty. We demonstrate that this novel kind of DNN, an uncertainty-aware DNN, can forecast the problem's output and its "calibration," or the degree to which the result is certain or uncertain. Crucially, we set up our DNN to identify when it is guessing by assigning a high predictive entropy to every scenario in which it has made a mistaken prediction. We test our method on multiple actual and fake datasets. Our approach produces cutting-edge outcomes for uncertainty quantification regarding accuracy and dependability. [19]

In this paper, we present the technique we developed for enhancing skin cancer classification and for effecting a more accurate segmentation of skin lesions. We used a dynamic graph cut algorithm to accomplish this.The suggested methodology addresses the common over- and under-segmentation observed in cut algorithms by accurately segmenting skin lesions, even tiny ones. We further demonstrate the usefulness of data augmentation. In a recent skin cancer contest, our training achieved an excellent performance measure of 97.986% across six classes, mostly because our model significantly reduced false positives compared to the next best competitor. Ultimately, the outcomes of numerous tests employing two distinct transferring models

Dr. Vishwanath Karad , MIT World Peace University, Pune, M.Tech(Data Science and Analytics)

show that our model's success is mostly attributable to the errors it avoided, not the fact that it uses new training photos. [20]

While including many improvements, this research endeavor builds upon earlier investigations. The first notable alteration of the preprocessed data was that the sickness was originally diagnosed, and the authors of the earlier study then described the data. In contrast, we first assembled the data before determining the illness. We used the data that identified the disease after the feature extraction procedure. The model will see the next significant alteration. A standard DNN was used in the earlier research to classify skin cancer. This work uses a modified DNN and proposes an algorithm called "Horse herd optimization" to improve the model's performance. The method functions quite similarly to the "genetic algorithm" that was the foundation for the earlier model. [21]

A deep learning system that is both lightweight and incredibly accurate was created to classify skin cancer. Squeeze-MNet is a general model that merges the well-established MobileNet model from deep learning with the Squeeze method for digital hair removal during the preprocessing stage. We employ the Squeeze algorithm, along with a "black-hat" filter operation, to reduce noise; this increase in the signal-to-noise ratio (SNR) also increases the precision of the features retrieved. The device we use to build the Squeeze-MNet model is the International Skin Imaging Collaboration (ISIC) dataset. Squeeze-MNet is a system that operates on a general premise: it identifies images that contain skin cancers within them. Our proposed model is a lightweight one. We used an 8-bit LED ring from NeoPixel and an Internet of Things Raspberry Pi 4 device to test our concept. A physician validated our device. The diagnostic accuracy for benign and malignant skin disorders was 98.02% and 99.76%, respectively. A dataset 66% smaller than that needed for an earlier state-of-the-art method was required for our method. Additionally, we obtained an overall accuracy of 99.36% on the ISIC dataset, surpassing by more than 10% the average score recorded for the prior state-of-the-art approaches examined [22].

One cancer type that is difficult to diagnose is melanoma skin disease. We can drastically lower the death rate when multiple forms of skin cancer are detected early. It is impossible to overestimate the importance of medical imaging technology in this situation. It is crucial to precisely identify dangerous skin lesions that have the potential

to become fatal. Aquila Driving Training-Based Optimization is an automatic skin cancer screening method that my research group has created. We use SqueezeNet, a neural network, in conjunction with our implementation. Combining the Driving Training-Based Optimizer (DTBO) and the Aquila Optimizer (AO) yields the ADTBO. Completed the tanning as the skin cancer segmentation challenge is done using the Minkowski-based dual network. This dual network consists of PsiNet and the Deep Joint Segmentation network. Extracted features and data augmentation make the approach effective. Using SqueezeNet with the ADTBO gives better results. The Minkowski-built Dual Network achieves an accuracy of 0.948, while both the SqueezeNet and the SqueezeNet-ADBO classifier yield a sensitivity of 98.7%, a specificity of 98.4%, and a classification accuracy of 97.6%. [23]

Nowadays, the most popular models for tasks involving semantic segmentation are fully convolution networks. But in terms of performance, they are only as good as the hyperparameters they employ, which are typically manual modifications performed following the initial setup of the network. This study presents a novel method for optimizing the hyperparameters of a network used to segment dermoscopy images. The work utilizes a new optimization algorithm that the authors have baptized the Exponential Neighborhood Grey Wolf Optimization (EN-GWO) algorithm. They use the EN-GWO algorithm to optimize the hyperparameters of a Fully Convolutional Encoder-Decoder Network, which is in turn used to segment dermoscopy images. The techniques they use to tackle this problem deserve attention in their own right. They were necessary not only to construct the new algorithm but also to rigorously verify it against actual cases of skin cancer. The authors conclude from their detailed examination that the new hybrid algorithm not only outperforms two widely used metaheuristic optimization methods, namely, the genetic algorithm and particle swarm optimization, but also does much better than four variations of the basic gray wolf optimization algorithm. The high values of the Jaccard and Dice coefficients show that the proposed model can segment skin cancer photos from the ISIC 2016 and ISIC 2017 datasets with nearly perfect accuracy—though not as perfect as the accuracy values. The experimental findings demonstrate the suggested model's advantage over contemporary deep learning architectures. [24]

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Diagnosing skin cancer and other serious skin conditions requires the ability to identify pigmented skin lesions. The majority of the detection methods used in this study rely on image detection and computer classification powers. For our work, we used image augmentation on a subset of the 10,015 photographs in the HAM10000 dataset. In our research, image augmentation frequently produces a model with higher "learning power," as this model attained an accuracy of over 97%. However, the test data will produce relevant results only when the model is steady and sound. To do so, we used the k-fold cross-validation technique, which is currently accepted as best practices for developing models in the field. Next, the classification accuracy of various machine learning methods was investigated, including the Convolutional Neural Network (CNN) architecture. Our best result was a 95.18% accuracy rate with a specific CNN model, indicating a well-built model that performs reasonably well for our intended task—identifying abnormalities in protein crystal structures. Our proposed study aids in the prompt diagnosis and appropriate treatment of seven skin conditions. The maladies in question are skin cancer, basal cell carcinoma, squamous cell carcinoma, melanoma, pancreatic neoplasm, sarcoma, and dermatofibroma, which is a rare benign tumor [25]

One of the greatest methods for quickly and effectively detecting skin cancer is deep learning (DL). This research utilized a particular style of deep learning known as convolutional neural networks (CNNs). These powerful algorithms learn to recognize patterns in images (and other types of data), and in this case, they were trained to determine the difference between the two most common types of skin cancer the benign (noncancerous) and the malignant (cancerous). The ISIC 2018 dataset served as the research workbench and included 3,533 skin lesions—a medical term for any abnormal tissue growth—identified as benign or malignant tumors. Using a particular deep-learning technique, the images of these lesions were first enhanced (ESRGAN). Preprocessing involved extracting the basic elements of each picture and retouching the look of the microscopic tumor in each one. The tumors were then classified using the Fundamental CNN Method. They applied fine-tuning to transfer learning models, including Inception Resnet, InceptionV3, and Resnet50. We also used ESRGAN and a fully designed CNN (fCNN) to construct a unique preprocessing phase. Using ESRGAN with our fCNN is very effective, even though the fCNN performed very well

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compared to the transfer learning models. We obtained an accuracy of 83.2% by using the fCNN's basic architecture and not adjusting any hyperparameters. When looking at the big picture, the precision percentages for Resnet50, InceptionV3, and Inception Resnet were 83.7%, 85.8%, and 84.0% in that order. [26].

We employed our proposed method, "GRU/IOPA," to generate results that could be compared with eight other skin cancer detection techniques. We used established methods to compare our approach to several alternatives and to assess the effectiveness of our solution. We computed and compared the execution indices of sensitivity, specificity, accuracy, negative predictive value, and positive predictive value. The outcomes demonstrate that, except for one case, our approach outperformed the others. A total of 135 photos were used across all methods in the experiments. The degree to which the GRU/IOPA is effective highlights the significant impact it may have on skin cancer diagnosis. The assessment of skin cancer then returns to a more human-centered approach. A pathologist still performs the ultimate interpretation in our computer-assisted evaluation process. However, we firmly think that applying this robotic approach can aid in expediting and improving the accuracy of the final human interpretation. [27]

This paper presents a novel hybrid model based on dynamic Bayesian networks for the three-way choice. The distribution of risk and uncertainty among the three decisions made is possible using this model. We also apply this model to the analysis and classification of the images present in two established datasets on skin cancer. Our unique strategy leverages two well-established deep learning models and two well-known uncertainty quantification techniques, applying them sequentially to produce two classifications for each dataset. Next, we assess the outcomes from both classes using the three-way choice model. As indicated by the F1 score, our method produced excellent accuracy and even better confidence on the first and second datasets. Our findings imply that the model can be successfully used with additional datasets that include pictures of medical conditions. [28]

An intelligent decision support system that facilitates skin cancer detection is presented in this study. Generating an efficient and successful depiction of the lesion is essential to lesion categorization's success. In order to achieve this, we have taken advantage of

the various feature kinds with various levels of discriminative capability. We pay special attention to asymmetry, border irregularity, color, and dermoscopic structure characteristics because these are the features that matter most in a therapeutic environment. We integrate these in a typical basis for the tan/band structure associated with a dermoscopic image and a unique collection of texture properties that we have harnessed using a very potent mathematical operator. Acceleration coefficients in the original framework are adaptively varied. It features a thorough sub-dimension feature search, many distant leaders, and a re-initialization technique to overcome stagnation. There are no adaptive acceleration coefficients in the second framework. Rather, it has arbitrary ones that produce acceleration through non-linear functions of a circle, sine wave, and helix (in that order), adding more diversity and intensity to the framework. The final stage in both systems is to build ensemble classifiers. The novel PSO models are utilized in this work to improve the hyper-parameters of a deep convolutional neural network. Due to its structure, a sequence of pooling and convolutional layers interspersed with rectified linear units must be used. After that, fully connected layers must be used to influence decisions concerning the input data (the dermoscopic images of skin lesions that need to be classified, for example). As a result, the model makes use of several abstraction levels. In addition to how the input data appears at the first level, it also has "deep" stacking in its convolutional and pooling layers, which go up to three or four levels deeper. Furthermore, it is "discriminative" in that it only activates the features required to make a choice regarding the input data—the skin lesions in question. [29]

This study, written by [30], focuses on the use of intelligent systems to diagnose dermoscopic image-based skin cancer. The writers use a modified version of the Particle Swarm Optimization (PSO) algorithm for feature optimization. Due to the skin's dependency on appearance and topography, smart homogenous systems recognize the most important criteria differentiating benign from malignant skin lesions in missions that dermatologists do not generally perform. The suggested PSO technique works by implementing principled representations parallel to the topology and look of the skin, which guarantees strong performance in identifying such aspects. To offer a more distinct exploratory capability in Particle Swarm Optimization (PSO), two distant primitive leaders—swarms with identical fitness criteria but with one swarm leading

the other—are used. The PSO aims to delve deeper into the distinct and dual-natured (i.e., convex and nonconvex) structure of the problem at hand by having these two swarms partially follow the leader in separate dimensions of the problem space. Additionally, probability and dynamic matrix representations help to delve further into the problem's structure, allowing the optimization process to broaden the scope of its search.

Convolutional neural networks have flourished in medical imaging thanks to interpretable AI for cancer diagnosis and recognition. Its accuracy may decrease, and its computational time may become unmanageable if it processes many irrelevant features. This paper presents a deep learning-based architecture with a fuzzy entropy slime mold method that provides multiclass skin lesion categorization. We first employed the augmentation technique to create a larger volume of training data to train two refined, cutting-edge deep learning models, Inception-ResNetV2 and NasNet Mobile. We then trained both models and extracted two feature vectors using transfer learning on the expanded datasets. After obtaining the vectors, they adjusted the models and used an ideal feature selection technique. In particular, we applied a fuzzy entropy slime mold algorithm to the two vectors. The algorithm can select the best features to represent the data it is working with. Ultimately, we converted the selected characteristics into a format that worked with the VGG16 and AlexNet models that were initially employed. HAM10000 and ISIC 2018 were the two datasets used in the experimental process. With accuracies of 90.2% and 97.1% for the two datasets, respectively, the experimental procedure emerged as the obvious victor when compared to alternative methods. [31]

Regarding the newly developing care paradigms, the rapid rise of telemedicine and the recent advancements in artificial intelligence (AI) in the diagnostics space present some exciting opportunities and potential drawbacks. These are particularly relevant given that the telemedical examination, the image-based diagnostic AI assistance tool, and the dermatopathologist's diagnosis of record are set to drastically transform the field of dermatology, which is largely dependent on visual diagnostic skills. Furthermore, we discover that in the mobile tech context, multiclass probabilities obtained from AI outperformed CBIR-based representations of AI. We discovered that AI might help obtain a second opinion, particularly in telemedicine. As before, we discovered that

when a non-expert uses good AI, patients can benefit; yet, if we use and trust flawed AI, we can mislead the whole clinical spectrum, from non-experts to experts. Finally, the human diagnosis process can be improved and developed using the knowledge gained by AI class-activation maps. Our work and the results we have gotten provide a framework for future investigations into various image-based diagnostics. Our goals are to enhance human-computer collaboration in the clinical setting and further our understanding. [32]

Musa Peker et al. [33] created a novel deep learning technique for diagnosing plant disease. The method called "multi-channel capsule network ensemble," uses a five-channel capsule network receiving input from five different data sources. Its ensemble structure and combination of the various types of data make it a prime contender for an award in the plant disease diagnosis competition. It is, in fact, the most accurate of all the models entered into the contest. There is a price for this accuracy, however. Compared to other approaches, including using a convolutional neural network, the suggested method infers far more slowly. There is more room for improvement than speed; computation is also an issue. Approximately 100,000 parameters are used by the model, which is 20 times more than an AlexNet model utilizes.

Bolanle F. et al. suggested an automated technique for identifying leaf diseases in banana plants [34]. CNNs have been effectively employed in prior research to detect and categorize plant illnesses; however, these networks have difficulty capturing the orientation and posture of leaves and other similar objects. The authors blame this failure on the typical CNN component's max pooling layer. To get past this issue, they employed the capsule network (also known as CapsNet), a novel model that has just gained traction as a viable object recognition method. Their model successfully recognized three target conditions: black sigatoka, a healthy leaf, and banana bacterial wilt, with a test set accuracy of 95%.

Omar Bin Samin et al.'s research [35] thoroughly examines a significant issue in plant health and cultivation. They suggest diagnosing plant diseases using CapsNet, a recent deep-learning architecture. CapsNet outperforms a more conventional CNN model in identifying sick things in a picture. The authors go into great detail to explain the

architecture and its constituent parts. Additionally, the writers performed fairly well comparing their model to earlier studies in the area.

Tan Soo Xian et al. [36] classified tomato plant diseases using an Extreme Learning Machine (ELM) model. The neural network model ELM is quick and performs well in generalization. It merely makes use of a feedforward network with one layer. In this work, images of plant leaves are classified using the ELM. A few distinct textural traits are taken out of the leaf shots after they are processed in the HSV color space. The ELM is trained and tested using these features. The model outperforms the decision tree and supports vector machine models in accuracy.

Two models were used in this study by Loise Wanjiru Waweru and colleagues [37] to categorize plant leaf diseases. The initial one is a recently developed model named CapsNet-SVM. This blends the powers of an antiquated yet dependable classification technique called SVM with a neural network known as a capsule network (or CapsNet). CapsNet handles the feature extraction stage before classification, while SVM handles the actual classification process. By most measures, our model outperforms the others in classification accuracy; on test photos of sick leaves, it achieves approximately 93.41 percent accuracy.

Sk Mahmudul Hassan and colleagues [38] diagnosed plant diseases using leaves as a diagnostic tool and the state-of-the-art Deep Convolutional Neural Network. CNNs are parameter-hungry and require a lot of computation, making them not the best choice for field deployment. Four different deep-learning models with four distinct architectures were used in this study as substitutes for a standard CNN: InceptionV3, InceptionResNetV2, MobileNetV2, and EfficientNetB0. Fifty-three thousand four hundred-seven images from a plant dataset are used to test and train these algorithms. The authors find that these deep learning models take less training time and are more accurate than a normal CNN model.

Two main themes are discussed in Jaydeep Deka and colleagues' work [39] about frameworks for participation in governance. The first discusses how various governance models have performed well overall. The second concern is the distinctly inconsistent outcomes for some governance models that discuss board participation through a relatively simple framework. Out of all the models discussed in the study,

the writers of this work have a specific favorite. However, their contributions have had a significant impact.

This study was carried out by Vimal Kurup R and colleagues [40], who developed a system for identifying plant diseases. What distinguishes this system from others is that it employs deep learning techniques.The accuracy with which it forecasts pairs of crops and diseases is how it evaluates its success. Pictures of sick plants are the model's inputs. The layers in the model's architecture are designed so that the outputs are eventually produced. Since image processing is the major focus of the research, I decided to use the CNN, a model with significantly higher accuracy in that field. There are some restrictions on CNN's conventional format. "Capsulenet" dynamic model because it is a new dynamic model with somewhat different layer structures than the classic model.

The Gabor Capsule network is presented in this article by Patrick Mensah Kwabena et al. to identify distorted, blurry, and otherwise invisible photos of diseases affecting citrus and tomato plants. They contrast their findings with those attained by utilizing other capsule models, such as AlexNet and GoogleNet. Similar to ours, their datasets were split into 80% for training and 20% for testing. They thoroughly preprocessed a few test set images, covering the kinds of variations that a human with training could easily identify, to assess how resilient each model was to those image transformations. Overall, their findings supported using resilience and flexibility as fundamental design elements in any neural network intended for this visual identification application. The results show that, even in less-than-ideal circumstances, Gabor Capsules can effectively detect plant diseases. In our trials with various models, the Gabor CapsNet emerged as the clear winner for two datasets concerned with tomato and citrus diseases. It achieved outstanding accuracies 98.13% for tomatoes and 93.33% for citrus—that left the other models far behind. Even though we had difficulty outperforming the GoogleNet baseline, we were pleased to see that the Gabor CapsNet significantly outperformed the traditional CapsNet with 2D convolutions. Our findings suggest that Gabor Capsules would be the ideal Capsule Network for the investigated (plant) imaging issues.

According to Prakash Srivastava et al. [42], a skilled pathologist's visual inspection of the plant is the primary means of diagnosing plant illnesses. A plant's "pathology" is usually ascertained by a microscopic analysis of its leaf tissues or a gross visual inspection. Both of these approaches provide excessive room for "eyeball" judgment, which increases the possibility of human error and subjective interpretation. Neural networks, or connectionist systems, are a computational technique used in various areas. These systems comprise groups of neurons that function somewhat like the biological brain does. Because they are parallel processors and may be thought of as employing a "greedy" algorithm that constantly looks for a local solution, neural units perform as well as they do. The most sophisticated of these systems are seen in dynamic neural networks, which can inhibit and create new connections—as well as brain units—in response to certain criteria.

2.3 Research Gap

An overview of the foundations for developing a real-time skin lesion segmentation method is given in this paper. Texture, color, form, and low-level features are examples of these pre-processing and useful qualities. We must use rather simple models since we are interested in achieving a real-time approach. As a result, we examine in detail three distinct skin lesion segmentation models that we have developed: MLP (I and II) in many publications, FCRN, and FCN. An accuracy model for real-time skin lesion diagnosis is the last model in this progression.

When there is slight contrast between the lesion and the surrounding skin, and when the boundaries of the lesion are not well defined, conventional segmentation algorithms tend to fail. Also, when a lesion is at the edge of a photograph or when the background is not regular, the segmentation of skin lesions tends to be poor. Nevertheless, only a limited number of techniques can automatically segment skin lesions in melanoma images utilizing low-level criteria like color, texture, and form to quickly and effectively produce a generalized result.

Ch. 3. Scope of the work and objective

3.1 AIM

This research aims to create a cutting-edge deep learning system that can automatically diagnose skin lesions, primarily to improve early dermatological condition detection. By utilizing a large dataset with convolutional neural networks (CNNs) and transfer learning techniques, our goal is to develop a reliable model that can correctly categorize a variety of skin lesions.

3.2 SCOPE OF WORK

- Data Collection and Preparation:
    - Gather a varied dataset of annotated skin lesion photos to ensure that different skin types and lesion kinds are represented. Add ground truth labels identifying benign or malignant tumors to photos.
    - Make training, validation, and test sets out of the dataset.
- Model Development:
    - Convolutional neural networks (CNNs) are used to design and train a deep-learning model for the categorization of skin cancer.
    - Use pre-trained models to implement transfer learning on huge image datasets.
    - To maximize model performance, try out various topologies and hyperparameters.
- Data Augmentation and Imbalance Handling:
    - Data augmentation techniques should be applied to improve the training dataset's diversity artificially.
    - Use techniques like weighted loss functions, undersampling, and oversampling to address class imbalance.
- User Interface Development:
    - Provide a user-friendly interface so that medical professionals may submit and examine pictures of skin lesions.
    - Present data that are easy to understand and comprehend, as well as confidence scores and suggested diagnoses.

- Validation and Evaluation:
  - Verify the model's effectiveness using a variety of datasets, including actual clinical scenarios.
  - Analyze specificity, sensitivity, accuracy, and other pertinent parameters.
  - For robustness, apply cross-validation techniques.

3.3   OBJECTIVES

1) to conduct a survey and literature review on several AI-based techniques for diagnosing and categorizing skin cancer.
2) To conduct pre-processing on and search various skin cancer datasets that are accessible.
3) To design and verify deep learning models for skin cancer detection.
4) To design and verify deep learning models for skin cancer recognition.
5) To validate the proposed model and perform performance evaluation.

Ch. 4. SKIN LESION SEGMENTATION USING DEEP LEARNING ALGORITHM

The deep learning algorithm approach to skin lesion segmentation is presented in this chapter. This chapter thoroughly explains the methodology used to identify skin cancer. Fig.3.1. Depicts the brain tumor detection system using a deep learning algorithm called SegNet.
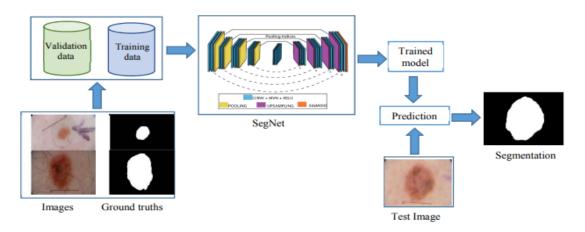

Fig.3.1.Block diagram of the Skin lesion segmentation using SegNet

4.1.Skin lesion Image Database

The label masks for the 200 dermoscopic images in the IPH2 dermoscopic collection. Every image has fixed dimensions of 572 x 765 pixels and is an RGB image. [14] The general public can use the dataset for study and experimentation. Before being put into the network, each image was initially reduced to 192×256 for training reasons. It reduces the training set-up, training time, and training complexity of the network without significantly altering the results.

4.2.SegNet

Convolutional neural networks like the SegNet architecture were created especially to handle pixel-by-pixel image segmentation tasks. It deals with segmenting distinct objects or features in the photographs, eschewing basic image attributes. In this instance, SegNet is used in the field of medical imaging. How it divides elements of photographs produced to resemble biological graphs serves as an example of how it

might be used. The structure of a human cell is one instance of a picture that resembles a graph. An additional one is a picture of a cell nucleus produced from the PH2 dataset.

Pixel-wise semantic segmentation is a skill that the University of Cambridge's Computer Vision and Robotics Group has demonstrated with their deep-learning architecture, SegNet. SegNet has three main components: an encoder network, a decoder network, and a pixel-wise classification layer. Each encoder consists of a max-pooling layer with a nonlinear activation function, a batch normalization layer, and convolutional layers with a ReLU layer at the top. The decoder upsamples the feature maps to the size of the input image. The max-pooling layer enters these up-sampling non-linear layers after performing down-sampling as its primary task. Restoring the feature map size to its initial input size across the majority of trainable parameters is the primary duty of the decoder. A softmax layer divides the ground truth into some classes and makes up the final layer.

Here is an overview of the key components and steps:

- Keras is used in the implementation of SegNet architecture. There are two stages to it: encoding and decoding.
- Convolutional layers with batch normalization and activation functions are a part of the encoding stage. Max-pooling layers are then added for downsampling.
- Upsampling is done at the decoding step, and then transposed convolutional layers with batch normalization and activation functions are applied.
- Skip connections help in accurate object localization by combining low-level and high-level characteristics.
- An output of the last layer is a binary segmentation mask.

The loss function that is utilized is the binary cross-entropy. The discrepancy between each class's forecast and the actual value is computed using the cross-entropy function. The classwise errors are averaged to determine the final loss. There are just two classes in this problem: depending on the mask, either black or white (0 or 1). Therefore, the loss function used in this study is binary cross-entropy, instead of the previously proposed categorical cross-entropy. The form of the binary cross-entropy is as follows:

$$L(y, \bar{y}) = -\frac{1}{N}\sum_{i=0}^{N}(y * \log(\bar{y}_1) + (1 - y) * (1 - \bar{y}_1)) \qquad (4.1)$$

The optimizer of the network is its stochastic gradient descent or SGD. The learning rate, a critical hyperparameter in the optimization, is set to 0.001, one of the values frequently used for the learning rate parameter.

Momentum also provides an improved rule inspired by physical optimization. Using momentum in conjunction with SGD has the advantage of greatly expediting learning from small modifications. Similarly, the velocities of all parameters are kept and used during the update procedure. A momentum value of 0.9 is used for optimization.

4.3. Performance Evaluation

We assessed the proposed method's effectiveness through several metrics, including Intersection over Union (IoU), Dice Coefficient (DI), Precision, Recall (Sensitivity), and Accuracy.

- Intersection over Union (IoU): This statistic, which is also called the Jaccard Index, measures how much two sets share in common. It computes the size of the intersection of the two sets and then divides that by the size of the union of the two sets. To calculate this, divide the union of the ground truth and predicted regions by the intersection of these regions.

$$IoU = \frac{Intersection\ of\ predicted\ and\ GT}{Union\ of\ predicted\ and\ GT} \qquad (4.2)$$

IoU values range from 0 to 1, with higher values indicating better overlap.

- Dice Coefficient (DI): This metric also assesses how comparable the segmentations from the ground truth and predictions are. It is obtained by dividing twice the total size of the intersections between the ground truth and predicted regions.

$$DI = \frac{2*Intersection}{Area\ of\ Predicted\ +\ Area\ of\ Ground\ Truth} \qquad (4.3)$$

The Dice Coefficient, like IoU, has a range of values from 0 to 1, with bigger values denoting more precise segmentation.

- Precision: The model's capacity to predict success is gauged in terms of successful outcomes. We can express this in ratio form. The model makes a certain number of successful forecasts (true positive predictions) and a certain number of unsuccessful forecasts (false positive predictions). To describe the model's forecast capacity, we can use the ratio of successful to total positive forecasts (true plus false).

$$\text{Precision} = \frac{\text{True Positive}}{\text{True positive} + \text{False Positive}} \qquad (4.4)$$

More precise levels indicate fewer false positives. The best precision values are near 1.

- Recall (Sensitivity): Recall, often referred to as sensitivity or the true positive rate, gauges how effectively a model identifies all the positive instances in a dataset. It measures the proportion of the actual positive cases that the model predicts correctly, corresponding to the cases where the model projected a positive outcome.

$$Recall = \frac{\text{True Positive}}{\text{True positive} + \text{False Positive}} \qquad (4.5)$$

Higher recall numbers indicate fewer false negatives. Recall values range from 0 to 1.

- Accuracy is a broad indicator used to assess how accurate a forecast is overall. It is the proportion of accurately anticipated occurrences to all instances (true positives + true negatives).

$$Accuracy = \frac{\text{True Positive} + \text{True Negative}}{\text{Total Instances}} \qquad (4.6)$$

Ch. 5. SKIN CANCER RECOGNITION USING DEEP LEARNING ALGORITHM

This method was developed specifically for the different kinds of skin cancers. The various types of skin cancer are shown in the original image. From that image, the block diagram of the proposed system was derived.
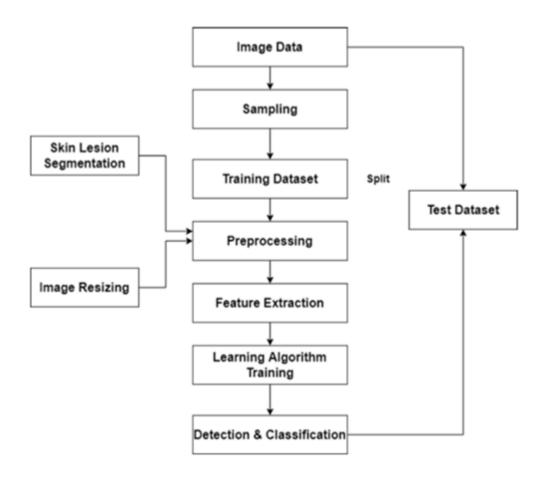

Fig. 5.1. Block diagram of Skin cancer recognition

5.1 Dataset Preparation

The following source provides the dataset upon which the suggested system is built. Segmentation and classification of ham1000 available at https://www.kaggle.com/datasets/surajghuwalewala

The comprehensive HAM10000 dataset substantially contributes to computer-aided skin cancer diagnosis research. It includes 10,000 excellent pictures of skin lesions. A dermatoscope was used to capture each image, with a 3000×2000 pixels

resolution. The photographs resemble histological sections because the dermatoscopes used to take them were calibrated to 100x, the same magnification as a light microscope. Thus, studies on deep learning for skin cancer can be trusted with diagnostic data. The skin lesions within the dataset are classified into multiple classifications, including basal cell carcinoma (BCC), nevus, and melanoma. Images of benign and malignant lesions are included in the examples, providing the dataset with the depth and breadth essential for accurately training AI.

5.2 Dataset preprocessing

The median filter is a popular method for image processing that reduces noise in skin lesion photos and improves the features' sharpness. In order to use it, first choose a pixel to work on and then calculate the neighborhood's median pixel values. That neighborhood is selected based on size and specific shape, typically square or circular. The pixel value is changed to the median value once determined. The neighborhood's size and shape are the only factors that can be changed for the median filter. Nonetheless, it works well on photos with edges and eliminates impulsive noise.

Noise reduction using a median filter in skin lesion photos can help increase the precision of later image analysis activities, such as feature extraction or machine learning-based categorization. During the image capture, noise of various kinds, such as speckles or random fluctuations in pixel intensity, can appear in skin lesion images.

Although median filtering is effective in some circumstances, the features of the picture noise and the objectives of the image processing must be considered when selecting a filtering method. Furthermore, any image processing method should be applied carefully since it could affect how medical images are interpreted.

5.3 Dataset Splitting

Splitting the dataset is a critical step in creating a machine-learning model. The dataset is split into two subsets in this method: training (80%) and validation (20%). The training set is a collection of examples with known labels used to build a model. While being trained, the model discovers the patterns and connections among the

labels in the training set. By evaluating the model on untested data, the validation set helps with hyperparameter adjustment and model evaluation during training, avoiding overfitting and guaranteeing optimal performance. Lastly, the testing set objectively gaits the model's performance in real-world situations by evaluating the model's generalization abilities on entirely new data. This thorough dataset separation technique makes it easier to build reliable machine-learning models to make precise predictions and perform well in generalization.

5.4 Classification of the skin lesion using deep learning algorithm

CNN, Densenet201, Xception, and hybrid CNN-SVM algorithms were employed in this method. This section presents the detailed architecture of all the algorithms.

A. CNN

Convolutional neural networks (CNNs) are applications focused on image recognition and classification. A multi-layered feed-forward neural network is what they are. In order to extract characteristics from images, a CNN is made up of some filters and filter banks. CNNs may identify specific features in a picture, such as edges or curves, by varying the filter weights. Convolutional and pooling layers alternate in a common CNN architecture, and one or more fully linked layers come after. In the convolutional layers, the rectified linear unit (ReLU) is frequently used as an activation function.
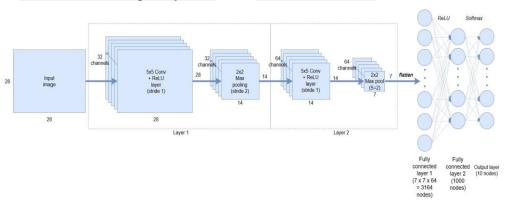

Fig.5.2. Block Diagram of CNN algorithm

- Convolutional Layer

One of the fundamental components of a convolutional network is the convolutional layer. In a convolutional network, most computations are carried out by the convolutional layer. Its primary goal is feature extraction,

or figuring out "what" is contained in the input data, which is a picture. When we describe an image as distorted, we indicate that its features have become unrecognizable. Convolutional processes often extract features at various degrees.
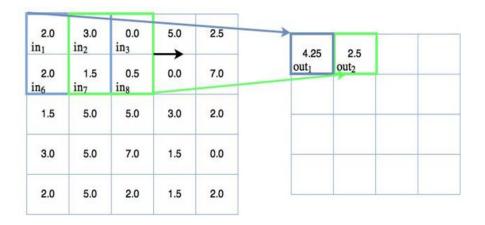

Fig.5.3. Moving 2X2 filter (all weights = 0.5)

As a result, the produced output image has an activation map or characteristic map that is used as input data by the subsequent convolutional layer. This computation can be mathematically represented by -

$$G[m,n] = (f * h)[m,n] = \sum j \sum j \, h[j,k][m - j, n - k] \quad (5.1)$$

The kernel is represented by h and the input picture by f. The row and column numbers of the output image are accordingly indicated by the selectors m and n.

The above figure only displays two outputs to make things easier to see. Every map is derived from a 2 by 2 input square. As previously mentioned, the mapping's weight for each input square is 0.5 for all four inputs.

This convolution stage reduces (lowers) the number of parameters and weights in several ways that benefit training:

- In a sparse connection scheme, not every node in the input layer connects with every node in the second layer. On the other hand, a fully connected neural network connects each node in the second layer to each node in the first layer.

- Consistent filter parameters: As the filter moves across the image, it applies a weighted sum of the filter with the two-by-two units of the image's nodes. This is known as constant filter parameters or unchanging filter parameters. Consequently, each filter works in tandem, but learns to perform a unique operation on the input data. Each filter has its own set of weights, which allows it to learn a particular feature of the input data over the course of training.
- Note: This does not mean every filter weight is always the same. In the case above, the weights were [0.5, 0.5, 0.5, 0.5], but they could have been [0.25, 0.1, 0.8, 0.001]. Everything depends on the method used to teach each filter.
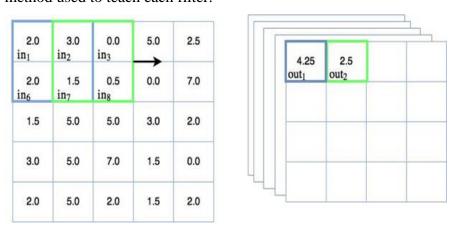

Fig.5.4. Multiple convolutional filters
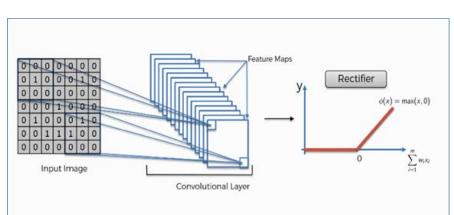
As individual filters are applied across the nodes of the input layer, with weights that are fixed during the training of the network, the weights of the filters can be adjusted to select for certain features in the input data. They could be made to select for typical geometric features in images—broadly speaking, edges, lines, and other simple figures that make up the contents of a picture.

One could also imagine the term "feature mapping" coming about because of the ability of the layers of filters to "map out" the features of the input data. Therefore, many filters trained to distinguish different attributes are necessary for any convolution layer. Therefore, the moving filter diagram that comes before must be adjusted such that it looks like this:

Several trained filters produce different two-dimensional outputs for the two-dimensional image, as seen in the image's output on the right side above. The word "channels" is frequently used in deep learning to refer to the various available filters. Ultimately, these channels will be trained to identify important visual spectrum components. The output from a convolution layer applied to a grayscale image (like those in the MNIST dataset) would yield three dimensions: the first two dimensions represent the height and width of the image, while the third dimension represents the different channels. For a grayscale image, there is only one channel. Thus, the output can be thought of as a volume with a height and width that are the same as the original image and a depth of 1.

- ReLU Layer

ReLU uses rectifier-type units and operates in a non-linear manner. It is an element-wise process; thus, every pixel is impacted similarly. Values less than or equal to zero in the feature map are changed to values greater than zero by ReLU. To put it another way, when we apply ReLU, we only emphasize the positive values of the feature map.

$$F(x) = max(0, x) \qquad (5.2)$$

Fig.5.5. ReLU

- Pooling Layer

The activation map's dimensions are reduced. Still, the most critical data are kept in the pooling layer. The images given serve to produce some non-

overlapping rectangles. What is pooling? Pooling is a sliding window approach, like many others, but instead of using tunable weights, it applies some statistical function to the contents of its window. The most commonly used form of pooling is max pooling; it uses the max() function on the contents of its window. Some other slight variations, including mean pooling (which takes the statistical mean of the contents), are also used sometimes. But in this chapter, we will be focusing on max pooling. A very standard diagram, shown next, illustrates the max pooling process.
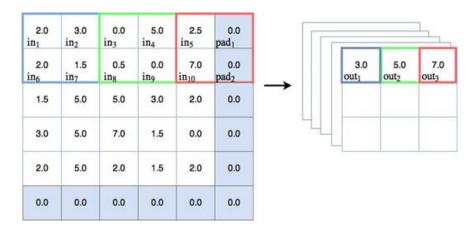

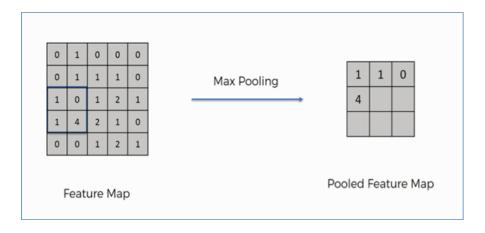Fig.5.6. ReLU Max pooling example (with padding)

Fig.5.7. Max pooling

The max-pooling layers do not learn anything independently and are simple to comprehend. With each kkkk block in the NxNNxN layer reduced to a single value, they take a NxNNxN layer as input and output a

NkxNkNkxNk layer. By all accounts, they do a fairly good job of minimizing the data that must be sent to the following layer.

- Flattening Layer

Convolutional neural networks are an effective way to create object representations from high-resolution data. Thus, although the network outputs information-rich results, to reach a true understanding of what the results mean—to achieve a final classification outcome—one must attach a traditional classifier to the network.

Additionally, the convolutional neural network output must first be flattened into a one-dimensional object before we can apply this classifier. Thus far, we have a pooled feature map via two procedures. Map of pooled features: It sounds like it belongs somewhere in the spill cleanup department. However, a pooled feature map should be used for more purposes than merely comprehending human-readable CNN output.
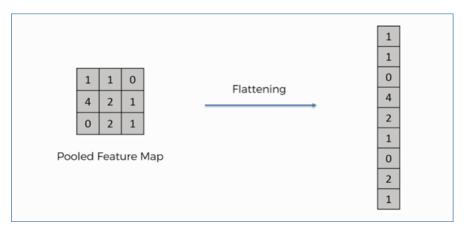
Fig.5.8. Flattening Layer

- Fully Connected Layer

We may use the features of the full connected layer (FCL) to categorize photos based on a training dataset. Images are mapped to classes by a Softmax activation function classifier, which receives signals from the FCL. The list of probabilities for each class label appears in the FCL's output. The probabilities represent the network's trust in a specific class label. They can be viewed as ratings for the class labels. Images can be

classified using the FCL layered on top of a convolutional neural network (CNN).
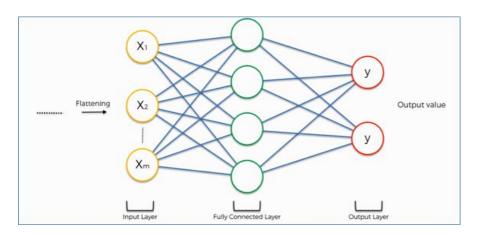
Fig.5.9. Fully Connected Layer

B. Vgg16

Every year, ImageNet hosts the Large Scale Visual Recognition Challenge (ILSVRC), a computer vision competition. Numerous teams participate in this competition each year. By doing this, they address the challenge of localizing items in photos before taking on the more significant task of attempting to categorize elements in images. A couple of researchers at the University of Oxford in the UK submitted one of the entries for this contest, which created quite a stir.
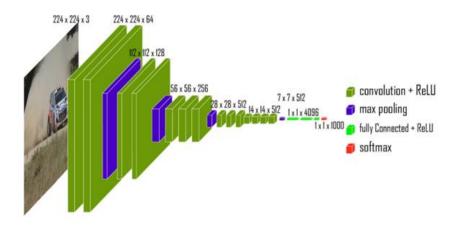
Fig.5.10. VGG-16 model architecture

With a startling 14 million images distributed across 1,000 classes in the ImageNet dataset, the model achieves an astounding top-5 test accuracy of

92.7%. The model gathers a good deal of evidence to support its accuracy. First, an input image with $224 \times 224 \times 3$ dimensions is sent to the network. There are 64 channels in the first two levels of the network, and the filter size is 3 x 3. The padding used by these two layers is the same (referred to as "SAME" in TensorFlow), a popular technique for maintaining an image's spatial dimensions from layer to layer.

The 256 filters in each of the next two convolutional layers have a size of 3 x 3. Next, two groups of three convolutional layers are arranged, each followed by a max-pooling layer. Each group consists of 512 filters, each of which is 3×3 in size. The filters are padded with the same values (3, 3). Next, a stack of two convolutional layers receives the picture from the final max-pooling layer. Instead of employing filters of size 7×7, ZF-11×11, and Alex Net filters in these convolutions and max-pooling layers, we utilize filters of size 3×3.

Moreover, several layers utilize 1x1 pixel operations to alter the number of input channels. Following a convolution layer, a 1-pixel padding layer ensures that the unique image retains its spatial configuration.

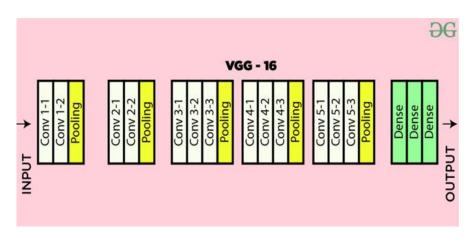Fig.5.11. VGG-16 architecture map

Through the means of a convolution and a max-pooling layer, we added a layer to the stack and achieved a (7, 7, 512) feature map. From there, we took this result and flattened it, yielding a number of values that's greater than 24000 (roughly, 25088 values). Following this, we had three layers that were fully connected. The first generated a vector of length (1, 4096),

where the input was the last feature vector, extracted using the method described earlier. The second layer also generated a vector of length (1, 4096) (although it is possible that dropout could be used between these two layers, it wasn't in our net), and the third layer produced a vector of length (1, 1000) that represented the 1,000 classes of the ILSVRC challenge. The third layer's output is sent to the softmax layer, which normalizes the classification vector; all hidden layers use ReLU as their activation function.

There has been some success in building a sizable library of labeled photos. Several large, practical, and meticulously documented image collections are available. Among them, "ImageNet," which has millions of photos organized into thousands of categories, is arguably the most well-known. Many significant pre-trained models have been developed thanks largely to the Imagenet database. The most well-known of these is presumably AlexNet, although the models "VGG" and "Inception" are a couple more that have elevated the Imagenet brand to even higher levels of achievement. Among the most popular computer vision models in the past ten years, these models are now well-known.

Figure 3.19 illustrates the exact architecture of the VGG-16 network.

- The initial two convolutional layers contain 64 feature kernel filters. These filters, 3 by 3 in size, take as input an RGB image with a depth of 3 and generate as output a feature map with dimensions 224 by 224 by 64. Following the feature map, the signal is sent to a max pooling layer with a stride of 2. The function of the max pooling layer is to reduce the "data quantity" (or the number of "features") that are carried forward while also increasing the "signals" of interest—in other words, making the bits that are useful more pronounced and the bits that are not useful less pronounced.
- The third and fourth convolutional layers contain the 124 filters for the feature kernels. Every filter is three by three in size. The following layer after the convolution is a max-pooling layer with a

stride of two. As a result, we are left with an output of 56x56x128.

- Each of the convolutional layers five, six, and seven consists of 256 feature maps, and the three layers together capture a rich representation of the input. They are followed by a max pooling layer with a stride of 2, which down-samples the 256 feature maps in such a way that it keeps the most important details of the feature maps from the three layers. The max pooling layer, therefore, keeps the best bits of the convolutional layers while reducing the amount of data that must be carried through to the next layer.

- The kernel size of the convolutional layers in the eighth through thirteenth sets is 3×3. With 512 kernel filters across all three sets, a significant portion of work is done in parallel.

- The max-pooling layer, which comes after these layers, likewise passes through the input with a stride of 1.

- The fourteenth and fifteenth hidden layers in this model are fully connected. Every layer contains 4096 units. A softmax output layer comes after these two layers. This sixteenth layer has 1000 units.

The goal of the research project ImageNet is to build a large database of photographs with annotations, such as labels. Various computer vision tasks have previously shown the efficacy of models like InceptionV1, InceptionV2, VGG-16, and VGG-19, which were pre-trained using ImageNet. They were created from the ground up and trained on an enormous dataset (over 14 million photos) with an enormous number of categories (about 20,000). The models are vast and deep due to the picture data volume, making them highly efficient in extracting features from images. The image annotation project's pre-trained models can "fine-tune" computer vision tasks assigned to various images (of various categories).

C. Xception

Proposed in 2016 by François Chollet, the Xception architecture represents a profound learning convolutional neural network (CNN). It is a

reengineered architecture of the Inception model, designed to fix the issues that basic CNNs have and to enhance the workings of such networks.

The term "Xception" is a portmanteau of "Extreme Inception" since it takes the Inception module's notion to an unprecedented depth. The fundamental concept of the Xception architecture is to use depthwise separable convolutions in place of the conventional convolutional layers seen in CNNs.

By breaking down the convolutional layer into two distinct operations— depthwise separable convolutions, the Xception architecture expands on this concept. Two phases make up depthwise separable convolutions:
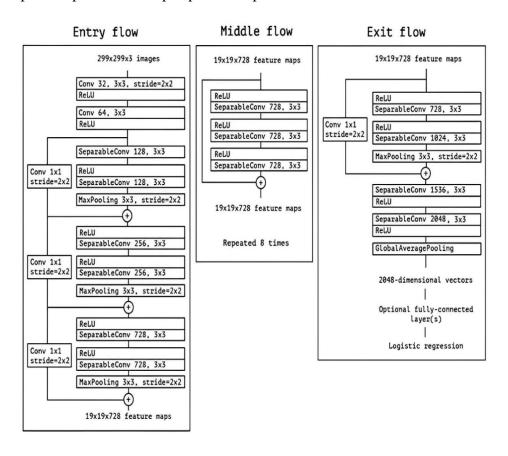

Fig.5.12. Overall Architecture of the Xception Model

The Xception module comprises three main parts, as shown in Figure 5.12: the entering flow, the middle flow (run eight times), and the exit flow. The diagram goes into further information about each of these elements, but a cursory glance tells you why this architecture is deemed "extreme." Two

"blocks" of depthwise separable convolutions precede ReLU activations and residual connections in the entering flow.

There are max pooling layers and several types of separable convolutional layers. The designers have meticulously documented the application of each layer's unique stride when one exists. Additionally, there are skip connections, in which the designers have opted to 'ADD' the two tensors together instead of concatenating them in the middle of the net using the 'cat' operation. The entrance flow displays the magnitude of the input tensor at each layer, which is a crucial feature. A 299x299x3 picture is the first in the entering flow, ending with a 19x19x728 image.

Similarly, this diagram clarifies the image dimensions, layer arrangement, number and shape of filters, type of pooling operation, number of times a specific layer is repeated, and the optional inclusion of a fully connected layer at the end for the Middle and Exit flows.

D. DenseNet201

With tiny datasets, transfer learning is a potent technique that yields significant results in classification problems. Furthermore, modifying the Deep Transfer Learning (DTL) model may further improve the results. This paper presents a deep transfer learning model based on DenseNet201. Using a convolutional neural network architecture with ImageNet as a weigh-learning base, the model extracts features.

The layers of a Dense Convolutional Network (DenseNet) are connected in a feed-forward fashion. Each layer in this design gets inputs from all layers that came before it. This means that the inputs of a layer are the outputs of every layer that came before it, which resolves the architecturally imposed vanishing gradient problem. From the standpoint of layer interconnectivity, each layer in a Densenet has a significantly larger input space and, logically, a much larger output space. Of course, the entire model would be unfeasibly large if every layer had a vast output size. This model can be viewed as a trivial inference step for all prior layers after a layer gets through to the end of a Densenet since

the input to a layer is (c.f. Equation 3.6) the concatenation of all preceding layers' outputs.
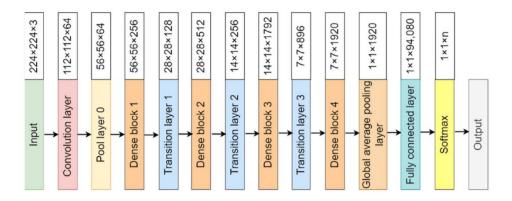

Fig.5.13. Architecture of Densenet201

A convolutional neural network architecture that belongs to the DenseNet model family is called DenseNet201. DenseNet, which stands for Dense Convolutional Network, is renowned for having a dense connection topology where every layer receives input directly from every level before it. This design helps solve the fading gradient problem, encourages feature reuse, and makes feature dissemination easier. An extensive overview of the DenseNet201 architecture may be found here.

- Dense Blocks: There are a lot of dense blocks in DenseNet. A thick block is made up of several closely spaced layers. All previous levels within a block are used to generate feature mappings for each layer in a dense block. The high degree of interconnection facilitates gradient movement and enhances feature reuse.

- Bottleneck Layers: DenseNet frequently employs bottleneck layers to lower computational complexity and parameter counts. A 1x1 convolution layer for dimension reduction and a 3x3 convolution layer form a bottleneck layer. With fewer parameters, this approach helps to capture complex patterns.

- Transition Blocks: The transition blocks reduce the number of channels and downsample feature maps' spatial dimensions between the dense blocks. Typically, a 1x1 convolution layer performs the dimension reduction, and then a 2x2 average pooling layer follows.

- Global Average Pooling (GAP): A global average pooling layer is frequently employed at the network's edge. The spatial dimensions are reduced to 1x1 by this

layer, which determines the mean value of each feature map. This helps to create a representation of a set size and serves as a technique for spatial compression.

- Fully linked Layer: The last layer has the right number of nodes for the particular task (classification, for example), making it fully linked. The final output, which shows the anticipated class probabilities, is produced.

- Details of DenseNet201: DenseNet201 is the name of a DenseNet version that has 201 layers. The number "201" denotes the total number of layers,

which includes activation, batch normalization, convolutional, and other layers. Broader datasets and more complicated activities frequently make use of this broader architecture.

- Pre-trained Weights: Before fine-tuning a particular job, DenseNet201, like many other deep learning models, is frequently trained on sizable datasets (such as ImageNet). The model can acquire helpful hierarchical features through pre-training that can apply to the intended job.

The architecture of DenseNet201 is a deep convolutional neural network with bottleneck layers, transition blocks, and dense connection patterns. It works well for applications like picture categorization because it can effectively capture complex patterns in data. Its capabilities are further enhanced across computer vision applications through pre-training and transfer learning.

5.5 Performance Evaluation

Several performance criteria are used to evaluate the proposed system, including accuracy, recall, F1-score, and precision. These are common metrics used to evaluate classifiers. What is good about them is that they offer contrasting perspectives on how well a classifier works. Additionally, they are simple to calculate from the confusion matrix, which is another useful feature. Let us examine each metric in turn:

- Accuracy: Accuracy evaluates the classifier's predictions for overall correctness. It does this by taking the ratio of correct predictions to total predictions and multiplying the result by 100 to get a percentage.It has the following definition:

$$Accuracy = \frac{(TP + TN)}{(TP + TN + FP + FN)} \tag{5.1}$$

This is where the counts of the predictions being true or false enter the picture. Numbers indicate how many predictions were correct and how many were incorrect: TP (true positive), TN (true negative), FP (false positive), and FN (false negative). We don't just look at accuracy, which is a good overall number to have, but isn't necessarily good when you're dealing with imbalanced datasets.

- Precision: The percentage of accurately anticipated positive cases among all positively predicted instances is the subject of precision. It is computed as follows:

$$Precision = \frac{TP}{(TP + FP)} \tag{5.2}$$

A classifier's precision tells us how well it avoids producing false positive results. A better precision shows a reduced rate of misclassifying negative cases as positive.

- Recall, also known as True Positive Rate or Sensitivity, quantifies the percentage of accurately anticipated positive cases among all positive cases. It is computed as follows:

$$Recall = \frac{TP}{(TP + FN)} \tag{5.3}$$

Recall highlights the classifier's ability to identify positive instances correctly, and it is particularly useful when the goal is to minimize false negatives.

- F1 score: The F1 score is a metric that balances recall and precision by combining both into one. It is computed as follows and is the harmonic mean of recall and precision:

$$F1\ Score = \frac{2 * (Precision * Recall)}{(Precision + Recall)} \tag{5.4}$$

The F1 score balances precision and recall, and it does so by considering false positives and false negatives. The F1 score can be more informative than the simple accuracy calculation when you have an uneven class

distribution or when you really need to find a good balance between precision and recall.

These metrics are particularly important regarding binary classification tasks because there are two classes: positive and negative. By computing them independently for each class and then averaging them (e.g., micro-averaging, macro-averaging), they can also be applied to multi-class classification issues.

Prioritizing a set of metrics requires careful consideration of your classification task's unique demands and features. For instance, memory may be more significant in medical diagnosis to reduce false negatives, whereas precision may be more critical in spam email classification to prevent false positives.

Ch. 6. Results and Discussion

The outcomes of the deep learning algorithm-based skin lesion detection and skin cancer recognition system are covered in this chapter.

6.1. Results Of Skin Lesion Detection Using Deep Learning Algorithm

The training loss and accuracy obtained for the SegNet for 100 epochs are presented in Fig. 6.1.
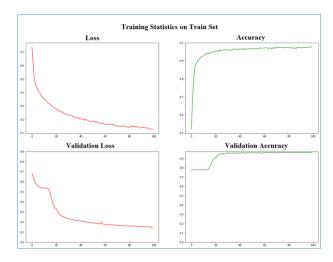

Fig.6.1. Training progress graph of SegNet for skin cancer segmentation

As the period grows, the algorithm's training loss lowers, and detection accuracy increases, as seen in Fig. 6.1. With little loss, the suggested method achieved good detection accuracy.

The performance of the SegNet algorithm on different testing images is tabulated in Table 6.1.
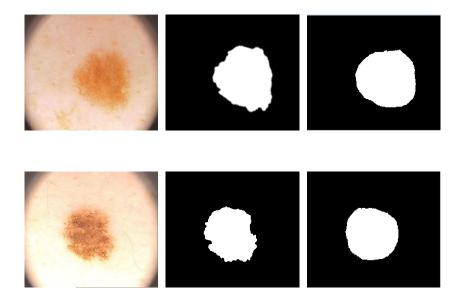
TABLE 6.1. Performance Of the Segnet for Skin Cancer Segmentation

Image Name	YOU	DI	Precision	Recall	Accuracy
IMD390	88.6487	93.6959	94.1563	93.3030	97.5891
IMD392	91.3809	93.10577	91.7550	94.4533	97.9594
IMD393	82.5091	91.7462	96.8662	87.0751	91.6137
IMD394	81.4715	88.3025	99.0446	79.4143	95.4935
IMD395	84.5796	93.0471	88.3356	98.1681	95.2107
IMD396	78.6634	89.8264	88.3665	91.2851	95.7885
IMD397	77.4382	90.6989	95.4223	86.3694	93.7947
IMD398	73.4582	85.7910	97.364	76.6427	80.8492
IMD399	83.2597	90.0542	83.1518	98.0891	95.8943
IMD400	70.5491	88.2608	99.5692	79.2122	90.3401
IMD402	86.0697	93.4688	96.6370	90.4492	96.8892
IMD403	86.0531	93.5515	98.5809	88.9933	91.0624
IMD404	72.8725	88.1839	80.7587	97.0557	87.9130
IMD405	81.5398	88.6892	83.671	94.1985	96.0306
IMD406	79.9282	91.7546	94.6498	88.9359	92.2932
IMD407	79.8268	90.9848	96.39	86.0291	93.4773
IMD408	92.1096	95.8868	97.3147	94.4909	92.8751
IMD409	85.8480	92.1197	96.4400	88.1463	90.1570
IMD410	74.6085	86.7594	97.7357	77.9552	86.9954
IMD411	96.4960	98.3061	99.3681	97.2624	96.7285
IMD413	80.7056	89.5501	100.0	81.0572	82.0800
IMD417	89.1924	94.4246	97.3593	91.6499	89.8010
IMD418	86.7094	93.0006	92.5390	93.4416	92.0043
IMD419	91.7258	96.3433	93.1384	99.7670	93.9066
IMD420	79.8968	88.3287	88.1336	88.4920	82.8938
IMD421	85.4635	92.8264	91.8733	93.7829	87.0442
IMD423	74.4015	89.6570	82.1417	98.6506	85.0484
IMD424	76.5431	86.9446	100.0	76.8805	77.2705

IMD425	50.2752	67.0301	100.0	50.3504	57.9203
IMD426	50.7592	70.3199	89.8994	57.6574	71.9563
IMD427	89.4674	95.4487	92.1210	98.9965	96.8892
IMD429	86.8115	91.9125	87.0902	97.2628	96.8404
IMD430	90.1406	94.4177	91.0153	98.2227	97.6155
IMD431	85.4778	94.7782	96.5293	93.0510	95.3369
IMD432	84.3751	91.3896	91.7192	91.0015	96.3277
IMD433	86.1530	84.3162	76.5241	93.6214	95.7946
IMD434	84.3383	89.3746	86.8090	91.9834	95.6685
IMD435	82.9337	91.1022	89.9630	92.2472	85.9456
IMD436	88.5409	94.9120	95.7019	94.0830	94.3074
IMD437	83.0516	94.5458	92.9558	96.1681	94.5271

The performance metrics of a SegNet model for skin cancer segmentation over several test photos are shown in Table 6.1. Intersection over Union (IoU), Precision, Recall, Accuracy, and Dice Coefficient (DI) are among the measures. Table I shows that the detection accuracy is achieved promisingly.

The qualitative analysis of the proposed system is presented in Fig. 3.

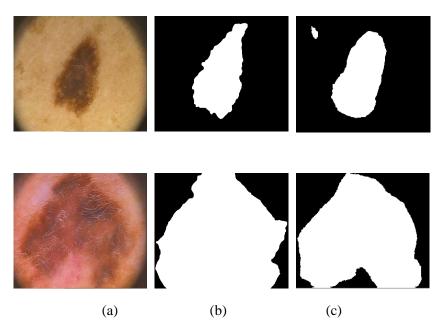(a)   (b)   (c)

Fig.6.2. Qualitative analysis of the proposed system (a) Input image, (b) Groundtruth, and (c) Output of the proposed system

Python is used in the development of the suggested system. The created system's accuracy in skin lesion segmentation is evaluated by a qualitative analysis, and the findings show a noteworthy reduction in false positives. In qualitative analysis, the segmentation results are visually examined in detail and are compared to reference or ground truth images to guarantee correctness. Focusing on fewer false positives in medical image analysis is important since it indicates a lower chance of misidentifying non-lesion areas as lesions.

6.2. Results of Skin Cancer Recognition Using Deep Learning Algorithm

The proposed system is developed to classify skin cancer into different types.

A. CNN

The CNN algorithm's results for classifying skin cancer into seven distinct types are shown in Fig. 6.3 below.
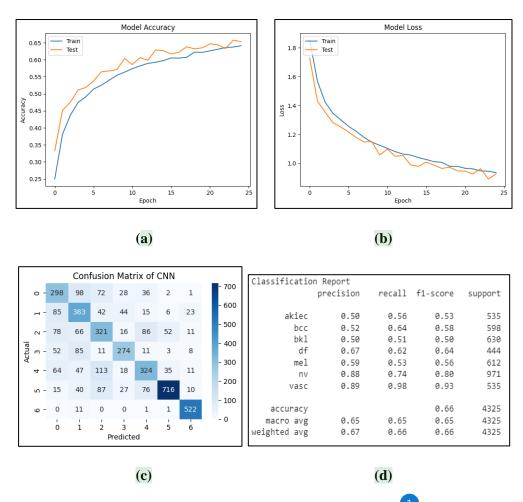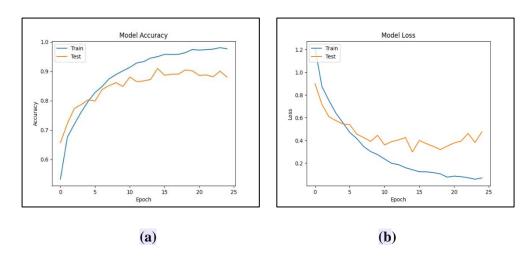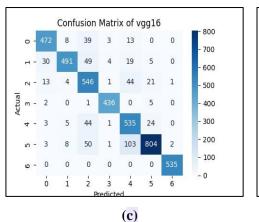
(a) (b)

(c) (d)

Fig. 6.3 Training performance of CNN on HAM10000 Dataset (a) Accuracy (b) Loss (c) Confusion Matrix (d) Classification report

B. Vgg16

The results of the Vgg16 algorithm for classifying skin cancer into 7 different types are presented below in Fig.6.4.

(a) (b)

Confusion Matrix of vgg16

	0	1	2	3	4	5	6
0	472	8	39	3	13	0	0
1	30	491	49	4	19	5	0
2	13	4	546	1	44	21	1
3	2	0	1	436	0	5	0
4	3	5	44	1	535	24	0
5	3	8	50	1	103	804	2
6	0	0	0	0	0	0	535

Classification Report

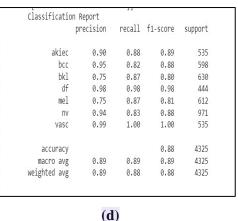|	precision	recall	f1-score	support
akiec	0.90	0.88	0.89	535
bcc	0.95	0.82	0.88	598
bkl	0.75	0.87	0.80	630
df	0.98	0.98	0.98	444
mel	0.75	0.87	0.81	612
nv	0.94	0.83	0.88	971
vasc	0.99	1.00	1.00	535
accuracy			0.88	4325
macro avg	0.89	0.89	0.89	4325
weighted avg	0.89	0.88	0.88	4325

(c)   (d)

Fig. 6.4 Training performance of Vgg16 on HAM10000 Dataset a) Accuracy (b) Loss (c) Confusion Matrix (d) Classification report

C. Xception

The Xception algorithm results for classifying skin cancer into 7 different types are presented below in Fig.6.5.
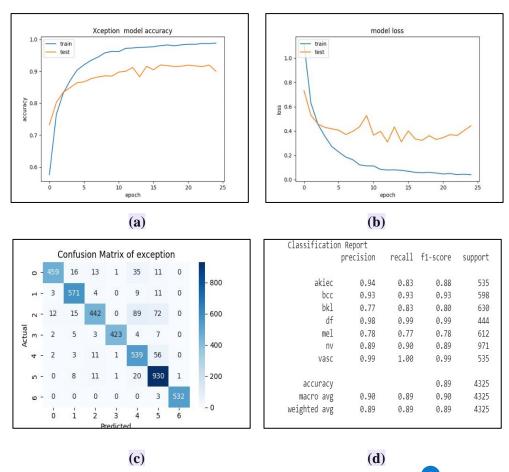

Xception model accuracy

model loss

(a)   (b)

Confusion Matrix of exception

	0	1	2	3	4	5	6
0	459	16	13	1	35	11	0
1	3	571	4	0	9	11	0
2	12	15	442	0	89	72	0
3	2	5	3	423	4	7	0
4	2	3	11	1	539	56	0
5	0	8	11	1	20	930	1
6	0	0	0	0	0	3	532

Classification Report

	precision	recall	f1-score	support
akiec	0.94	0.83	0.88	535
bcc	0.93	0.93	0.93	598
bkl	0.77	0.83	0.80	630
df	0.98	0.99	0.99	444
mel	0.78	0.77	0.78	612
nv	0.89	0.90	0.89	971
vasc	0.99	1.00	0.99	535
accuracy			0.89	4325
macro avg	0.90	0.89	0.90	4325
weighted avg	0.89	0.89	0.89	4325

(c)   (d)

Fig. 6.5 Training performance of Xception on HAM10000 Dataset a) Accuracy (b) Loss (c) Confusion Matrix (d) Classification report

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D. Densenet201

The results of the Densenet201 algorithm for classifying skin cancer into 7 different types are presented below in Fig.6.6.
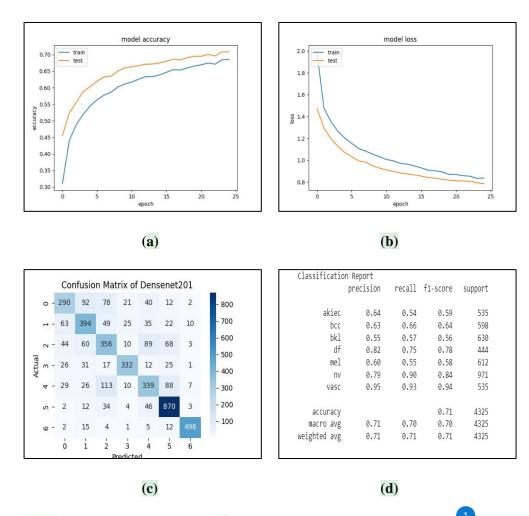

(a)

(b)

(c)

(d)

Fig. 6.6 Training performance of Densenet201 on HAM10000 Dataset (a) Accuracy (b) Loss (c) Confusion Matrix (d) Classification report

A comparative analysis of the three algorithms for classifying skin cancer into seven different types is presented in Table 6.2.

A comparison of different classifiers applied to the HAM10000 dataset is shown in Table 6.1, with performance measured in terms of precision, recall, F1 score, and total accuracy. Three algorithms—Xception, Densenet, and CNN—are evaluated. CNN's accuracy is 0.66, recall is 0.66, F1-score is 0.66, and precision is 0.65. This suggests that although CNN does quite well overall across various parameters, it is not particularly strong in any one area. Xception, on the other hand, performs better, with accuracy, recall, and F1-score all at 0.90 and precision

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at 0.90. This shows that Xception maintains a balanced performance in terms of precision and recall while achieving high levels of accuracy.

Table 6.2: Comparative analysis of different classifiers on the HAM10000 dataset

Algorithm	Precision	Recall	F1-Score	Accuracy
CNN	0.65	0.66	0.66	0.66
Vgg16	0.89	0.88	0.88	0.88
Xception	**0.89**	**0.89**	**0.89**	**0.89**
Densenet	0.71	0.71	0.71	0.71

Densenet201's precision, recall, F1-score, and accuracy are all 0.72, placing it in the middle of the other two classifiers. This suggests a consistent performance throughout the assessed measures; however, it is below Xception.

Concerning precision, recall, and F1-score metrics, Xception seems to be the most successful classifier for the HAM10000 dataset, according to this analysis, which also shows a high degree of accuracy.

Ch. 7. Conclusion

The performance of skin cancer detection and recognition is presented in the proposed system. The PH2 dataset of dermoscopic pictures is used to enhance the findings' clinical relevance. Augmentation techniques like rotation and flipping help the model perform better and allow for strong generalization under various circumstances. The encoding and decoding layers of the SegNet architecture show a careful approach to feature extraction and spatial information preservation. The suggested model is more effective overall because of the careful use of optimization techniques, such as Stochastic Gradient Descent (SGD), batch normalization, and activation functions. For future research projects, thoroughly explaining the training procedure, including the number of epochs, batch size, and validation set usage, offers transparency and reproducibility.

The accuracy of skin cancer detection and classification may be improved through the use of convolutional neural networks and certain established architectures, namely Vgg16, Xception, and Densenet201. This work explores those architectures in the context of dermoscopy images. This research highlights how successful deep learning can be in solving the problems tied to providing timely and early treatment for various forms of skin cancer. The authors accomplish this by using advanced digital image processing methods and a huge dataset namely, the HAM10000. Through a thorough evaluation and comparison of various CNN, Vgg16, Xception, and Densenet201, the work offers important insights into how architectural decisions affect the accuracy of skin cancer categorization.

Densenet201's rich connectivity patterns provide a nuanced investigation, underscoring the importance of architectural considerations in model construction, even while VGG16's simplicity and efficacy are appreciated. In addition to confirming the efficacy of these structures, the thorough evaluation procedure and careful testing methods point out possible areas for further development in automated skin cancer categorization systems.

The stage is now set for further advancements in the application of deep learning to medical image analysis, with the aim of enhancing diagnostic accuracy and, importantly, enabling the sort of early detection in dermatological health that can significantly affect patient outcomes. The Xception method performs better in the suggested system than the other algorithms regarding accuracy, precision, recall, and F1-score.

This research contributes substantially to developing improved diagnostic tools by addressing the growing health risks associated with skin cancer. This, in turn, promotes improved patient treatment and public health outcomes. The proactive strategy used in this study highlights the significance of ongoing research and innovation in medical image processing and has the potential to propel breakthroughs in dermatological health.

Ch. 8. Future Scope

The results and techniques of the study provide a strong framework for further investigation into automated skin cancer detection and categorization. Other directions could be investigated and improved in the future, providing fascinating chances to improve patient outcomes and diagnostic accuracy even more. Architectures designed especially for the classification of skin cancer. Although the study assesses the effectiveness of current architectures such as Xception and Densenet201, there exists a possibility of developing customized models that take advantage of domain-specific expertise and features of skin lesions. The state-of-the-art in dermatological image analysis could be further advanced by these custom architectures, which have the potential to achieve even greater levels of accuracy and precision.

Furthermore, including varied datasets and extra data sources may improve the generalizability and robustness of skin cancer classification algorithms. Incorporating photos from other populations, ethnicities, and clinical situations into the HAM10000 dataset could mitigate biases and enhance the model's precision in classifying skin lesions across various environmental circumstances and demographics.

Furthermore, skin cancer classification systems have the potential to achieve better performance by incorporating rich, diverse, and potentially relevant data in addition to the improved diagnostic capabilities expected from the previously described deep learning techniques. They include patient demographic information, histopathology data in image form and as numerical output from image analysis, and clinical data, such as results from dermatoscopic examinations—a significant improvement over depending solely on visual inspection. All of these have been shown to carry signals relevant for differentiating between non-cancerous and cancerous skin.

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AI-Driven Skin Cancer Detection for Early Intervention using Deep Learning

Submitted in partial fulfillment of the requirements of the degree of

(Master of Technology)

By

Abhishek Waghchaure

(Roll No: PA20   Exam Seat No: 1032221714)

Supervisor (s):

Prof. Dr. Deepali Javale

School of Computer Science and Engineering

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Appendix B

Approval Sheet

This thesis/dissertation/report entitled **"AI-Driven Skin Cancer Detection for Early Intervention using Deep Learning"** by Abhishek Waghchaure is approved for the degree of M.Tech (Data Science & Analytics).

Examiners

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Supervisor (s)

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Appendix C

Declaration

I hereby declare that this submission is representing my ideas in my words. The ideas and words included from other sources are adequately cited. I also declare that I have followed all principles of academic honesty and integrity of the University. I have not misrepresented or fabricated or falsified any fact/data/idea in this submission. I understand that any violation will cause for disciplinary action against me by the University as per UGC notification 2018. I also understand that there will be a penal action against me, from the sources, which have thus not been properly cited or from whom proper permission has not been taken wherever needed. I hereby give undertaking that the document is prepared by me and document is my original work and free of any plagiarism in the limit prescribed by UGC.

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