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Full Length Article

Skin Cancer Detection using Convolutional Neural Network

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Abstract
Skin cancer is one of the most common and life-threatening forms of cancer worldwide, making early and accurate diagnosis essential for improving treatment success and reducing mortality rates. Conventional diagnostic methods, including visual examination by dermatologists and traditional image processing techniques, are often subjective, time-consuming, and dependent on clinical expertise, which may lead to delayed or inaccurate diagnosis, particularly during the early stages of the disease.Recent advancements in artificial intelligence (AI) and deep learning have significantly enhanced the field of medical image analysis. Among these technologies, Convolutional Neural Networks (CNNs) have demonstrated remarkable performance in automatically extracting complex image features and accurately classifying skin lesions without requiring manual feature engineering. This project presents a CNN-based automated skin cancer detection and classification system capable of distinguishing benign and malignant skin lesions from dermoscopic images.The proposed system utilizes a publicly available dermoscopic image dataset, where images undergo preprocessing techniques such as resizing, normalization, and data augmentation to improve model performance and generalization. The processed images are then fed into a CNN architecture consisting of convolutional, pooling, activation, and fully connected layers for feature extraction and classification. The trained model effectively identifies subtle visual patterns associated with different skin lesion types, thereby improving diagnostic accuracy while minimizing human error.
The proposed approach aims to provide a fast, reliable, and cost-effective computer-aided diagnostic system that can assist dermatologists in early skin cancer screening and clinical decision-making. By leveraging deep learning techniques, the system has the potential to enhance diagnostic efficiency, reduce workload, and improve patient outcomes through timely detection and treatment of skin cancer.

Keywords: *Skin Cancer Detection, Deep Learning, Convolutional Neural Network (CNN), Medical Image Analysis, Dermoscopic Images, Benign and Malignant Classification, Artificial Intelligence, Image Classification, Computer-Aided Diagnosis, Early Disease Detection.*

Introduction

Skin cancer is one of the most common and serious diseases affecting people across the world. It occurs when abnormal skin cells multiply uncontrollably due to factors such as prolonged exposure to ultraviolet (UV) radiation, genetic predisposition, and environmental influences. Detecting the disease at an early stage is essential for successful treatment and improved survival. Conventional diagnostic techniques, including visual examination and biopsy, are often time-consuming, expensive, and dependent on the experience of dermatologists. In addition, the differences in the size, color, shape, and texture of skin lesions make manual diagnosis difficult, particularly in areas where specialized medical professionals are not readily available.

To address these limitations, automated skin cancer detection systems based on image processing and deep learning have become increasingly important. Among the available techniques, Convolutional Neural Networks (CNNs) have achieved outstanding performance in medical image classification by automatically learning meaningful features from input images. Unlike conventional methods that require manual feature extraction, CNNs identify complex visual characteristics directly from the data. Image preprocessing techniques such as noise removal, contrast enhancement, resizing, and normalization further improve image quality and contribute to higher classification accuracy and robustness.

This project presents a CNN-based skin cancer detection system developed using MATLAB. The proposed system combines image preprocessing with deep learning to classify skin lesions as benign or malignant efficiently and accurately. It is designed to support healthcare professionals by providing reliable diagnostic assistance while reducing human effort and minimizing classification errors. The system also offers opportunities for remote screening and large-scale healthcare applications, contributing to improved patient care through timely and accurate skin cancer detection.

Literature Survey

Medical image analysis has become an important research area due to the increasing need for accurate and early diagnosis of diseases such as skin cancer. Initially, skin cancer diagnosis relied mainly on clinical examination and dermoscopy performed by experienced dermatologists. Although these methods are widely accepted, their effectiveness depends on clinical expertise and may result in inconsistent diagnoses because of subjective interpretation. As a result, researchers have focused on developing automated diagnostic techniques based on image processing and deep learning.Early automated skin cancer detection methods employed image preprocessing techniques to improve image quality through noise reduction, contrast enhancement, and lesion segmentation. After preprocessing, handcrafted features such as colour, texture, and shape were extracted and used for classification. While these methods improved diagnostic performance compared to manual analysis, they depended heavily on manually designed features and struggled to represent complex lesion characteristics effectively. Machine learning algorithms, including Support Vector Machines (SVM), K-Nearest Neighbours (KNN), and Decision Trees, were later introduced to classify skin lesions using extracted image features. These approaches achieved better accuracy than conventional image processing methods and reduced manual effort. However, they still required feature engineering and often showed limited performance when applied to diverse datasets containing different skin types and lesion variations. The introduction of Convolutional Neural Networks (CNNs) significantly advanced automated skin cancer detection by enabling automatic feature learning directly from images. CNN models eliminate the need for manual feature extraction and can recognize complex visual patterns with high accuracy. Studies conducted by Esteva et al. (2017) demonstrated that CNN-based systems could achieve diagnostic performance comparable to experienced dermatologists. Likewise, Codella et al. (2018) reported improved classification accuracy using deep learning models trained on large dermoscopic image datasets. Recent studies conducted between 2022 and 2024 have concentrated on improving CNN performance through transfer learning, data augmentation, and hybrid deep learning models. Researchers have utilized pretrained architectures such as ResNet and VGG to enhance classification accuracy while minimizing overfitting. Combining image preprocessing techniques with deep learning has further strengthened the capability of automated skin cancer detection systems. Although significant progress has been achieved, challenges such as limited labelled datasets, variations in skin colour, and differences in image quality continue to affect model performance. Despite these limitations, CNN-based approaches remain the most effective solution for automated skin cancer detection. Therefore, this project develops a MATLAB-based CNN model to provide accurate and efficient classification of skin lesions.

Skin Cancer Detection Using Convolutional Neural Network

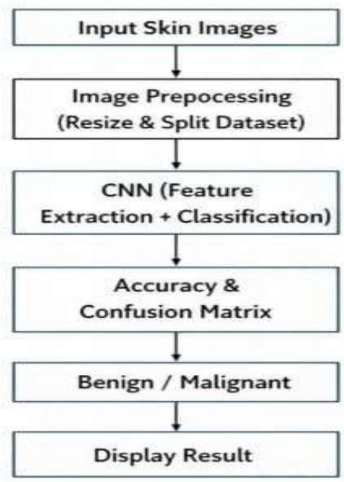

Figure 1 Block Diagram Skin Cancer detection using CNN

Skin cancer detection using Convolutional Neural Networks (CNNs) represents an effective deep learning approach for analyzing medical images of skin lesions. CNN models automatically learn important visual characteristics such as color, texture, shape, and structural patterns, allowing accurate classification of skin lesions without manual feature extraction. By learning from large image datasets, CNNs can effectively distinguish between benign and malignant lesions while improving diagnostic reliability and efficiency compared to traditional methods.

The objective of this chapter is to describe the design and implementation of a CNN-based skin cancer detection system developed in MATLAB. It explains the overall system architecture, processing stages, data flow, and classification procedure. The proposed framework follows a systematic approach in which preprocessing, feature extraction, and classification are organized into separate stages that can be independently analyzed and optimized to improve overall system performance.

This chapter also discusses the limitations of existing skin cancer detection methods, presents the architecture of the proposed CNN-based system, explains the block diagram and processing stages, and describes the preprocessing, feature extraction, and classification techniques used in the implementation.

Existing System

Several traditional methods have been employed for detecting skin cancer in clinical practice and medical research. These methods include manual examination by dermatologists, dermoscopic analysis, and conventional image processing techniques. Although these approaches are widely used, they have several limitations that reduce their effectiveness in automated and large-scale diagnostic applications.

Manual diagnosis depends entirely on the knowledge and experience of dermatologists, making the process time-consuming and susceptible to human error. Dermoscopy improves lesion visualization by providing magnified images of skin abnormalities, but it requires specialized equipment and expert interpretation, limiting its accessibility. Traditional image processing techniques rely on preprocessing, segmentation, and handcrafted feature extraction to identify lesion characteristics. However, these methods require manual feature selection and often fail to capture complex image patterns accurately.

Existing systems suffer from several drawbacks, including dependence on expert analysis, limited classification accuracy due to handcrafted features, difficulty in handling complex datasets, lengthy diagnostic procedures, and poor adaptability to new data. Convolutional Neural Networks overcome these limitations by automatically learning discriminative image features, improving classification accuracy, reducing human intervention, efficiently processing large datasets, and providing a scalable solution suitable for future real-time medical applications. MATLAB provides a convenient platform for implementing, training, and evaluating CNN-based models effectively.

Problem Statement

The primary objective of this project is to overcome the limitations associated with conventional skin cancer diagnosis by developing an automated detection system based on image processing and Convolutional Neural Networks. Traditional diagnosis depends heavily on dermatologists, increasing the possibility of human error and inconsistent clinical decisions. The proposed CNN model automatically analyzes skin lesion images and classifies them accurately, thereby reducing dependence on manual examination.

Conventional diagnostic procedures, including visual inspection and biopsy, require considerable time to complete. The proposed system accelerates the diagnosis process by automatically processing and classifying images using deep learning techniques. Early-stage skin cancer detection remains difficult because of subtle variations in lesion appearance. CNN models effectively learn detailed visual features such as texture, colour, and shape, resulting in improved classification accuracy. Skin lesions exhibit considerable variations in size, colour, shape, and texture, making manual classification challenging. The proposed CNN model is trained on a diverse dataset, enabling it to generalize effectively across different lesion characteristics. Furthermore, variations in image quality caused by lighting conditions and noise are addressed through image preprocessing techniques, improving the overall reliability of the detection system.

Methodology

The proposed methodology begins with collecting labelled dermoscopic images from publicly available datasets or other reliable sources. The images are organized into benign and malignant categories while maintaining diversity in lesion characteristics, including colour, texture, and size, to improve model learning and generalization. During preprocessing, all images are resized to a standard resolution of **224 × 224 pixels**, normalized to maintain consistent pixel values, and enhanced by removing noise when necessary. The prepared dataset is then divided into training and testing sets using a **70:30 ratio** to evaluate the model objectively.

The CNN architecture is designed using convolutional layers, batch normalization, ReLU activation functions, pooling layers, fully connected layers, and a Softmax output layer for binary classification. The network is trained using the training dataset with the Adam optimization algorithm, while appropriate values are selected for learning rate, batch size, and training epochs. Model performance is continuously monitored using training accuracy and loss curves. After training, the CNN model is evaluated using previously unseen test images. The network automatically classifies each image as either benign or malignant based on the learned features. The effectiveness of the proposed system is measured using classification accuracy and confusion matrix analysis, with additional evaluation metrics such as precision and recall used when required. Finally, the complete system is implemented in MATLAB, where the classification results and predicted images are displayed through a user-friendly interface for easy interpretation.

Software Requirements

The proposed skin cancer detection system is implemented using MATLAB along with its specialized toolboxes for image processing and deep learning. These software tools provide an efficient environment for developing, training, testing, and evaluating the CNN model while simplifying image preprocessing and performance analysis.

MATLAB:

MATLAB (Matrix Laboratory) is a high-level programming language and development platform widely used for numerical computation, image analysis, machine learning, and deep learning applications. It provides a comprehensive environment with built-in functions and visualization tools that simplify the implementation, training, and evaluation of convolutional neural network models for medical image classification.

ImageProcessingToolbox:

The Image Processing Toolbox is utilized to perform various preprocessing operations on dermoscopic images before they are provided to the CNN model. The preprocessing stage includes image resizing, normalization, filtering, noise removal, contrast enhancement, and other image enhancement techniques that improve image quality and ensure consistent input data for model training.

DeepLearningToolbox:

The Deep Learning Toolbox is used to design, train, validate, and evaluate the Convolutional Neural Network architecture. It provides predefined deep learning layers, optimization algorithms, training functions, visualization tools, and performance evaluation metrics that facilitate the development of

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an efficient and accurate skin cancer detection model.

Results

The performance of the proposed CNN-based skin cancer detection system was evaluated using MATLAB. The experimental results demonstrate the effectiveness of the developed model in classifying dermoscopic images into benign and malignant categories. The evaluation focuses on model accuracy, prediction consistency, training performance, and overall classification capability. Various outputs generated during implementation, including the MATLAB code execution, training progress, dataset loading, and prediction results, are presented to validate the performance of the proposed system.

MATLAB Code Implementation Window

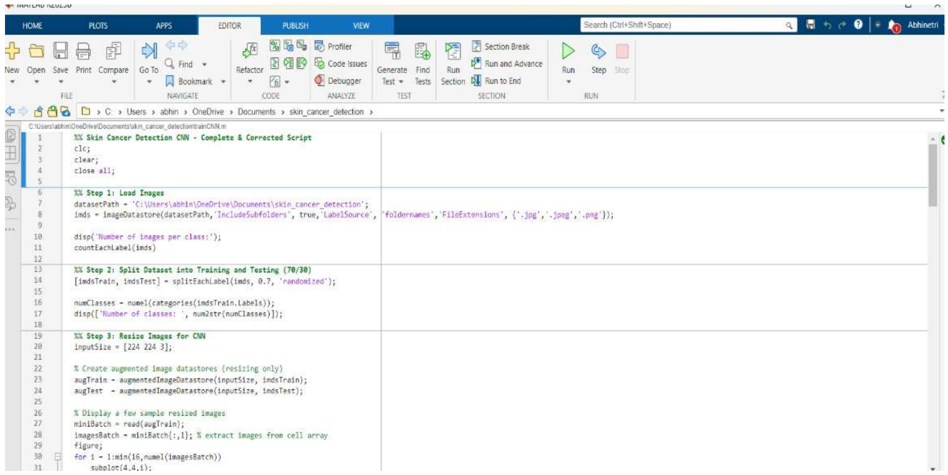

Figure: 1 Matlab Implementation window

The MATLAB implementation consists of a complete workflow for developing the skin cancer detection system. The program loads the image dataset, divides it into training and testing subsets, preprocesses the images by resizing and normalization, and defines the CNN architecture using convolutional, pooling, activation, and fully connected layers. The implementation also specifies the training parameters, performs model training using the selected optimization algorithm, evaluates classification accuracy, and generates the confusion matrix. This organized implementation ensures reliable execution of each processing stage and supports accurate classification of skin lesions.

Training Progress Graph (Accuracy and Loss)

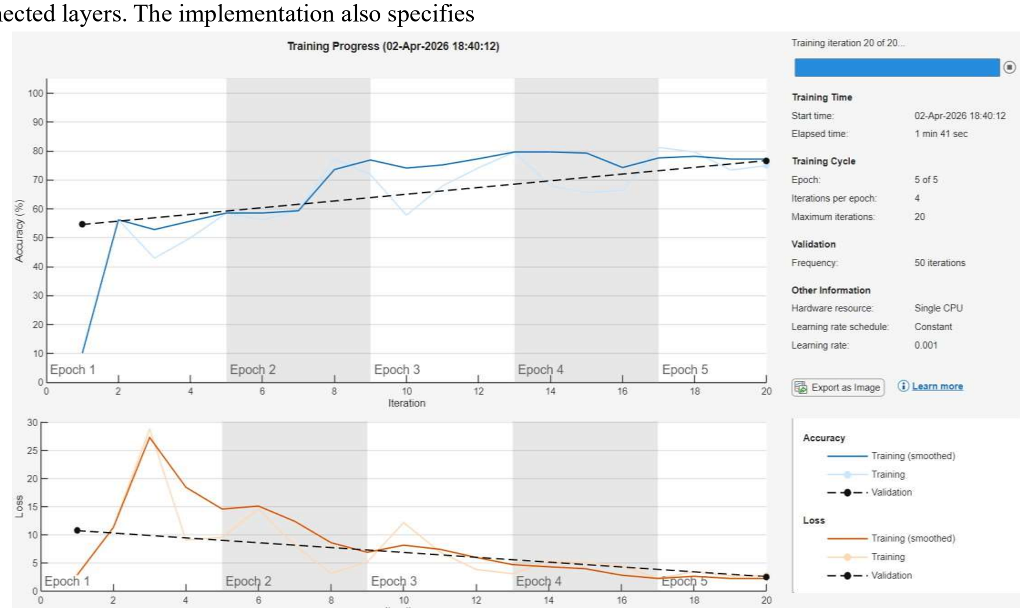

Figure: 2 CNN model Training performance Graph

The training performance graph illustrates the learning behavior of the Convolutional Neural

Network throughout the training process. The training accuracy increases steadily with each epoch, indicating that the network successfully learns discriminative features from the dermoscopic images. Simultaneously, the training loss decreases continuously, demonstrating a reduction in prediction errors during optimization. The validation accuracy closely follows the training accuracy while maintaining a similar trend, suggesting that the model generalizes well and does not suffer from significant overfitting. These observations confirm that the CNN training process is stable and converges effectively.

Dataset Directory Selection Window

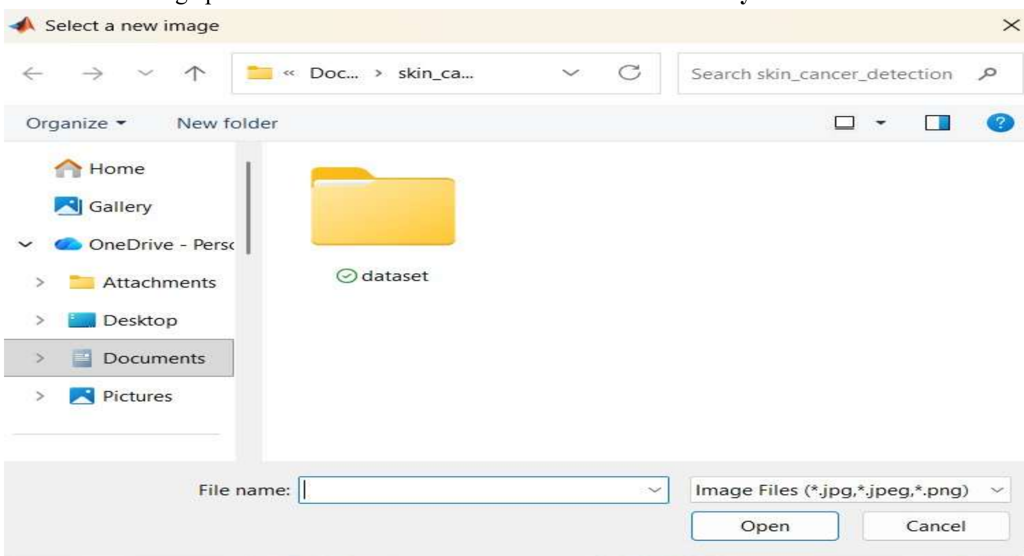

Figure: 3 Dataset Directory Selection Window

The dataset selection interface allows users to browse and select the folder containing dermoscopic skin lesion images. Once the directory is selected, MATLAB imports the dataset using the image datastore function, which automatically organizes the images according to their corresponding class labels. This approach enables efficient management of large image datasets and simplifies subsequent preprocessing, training, and testing operations. Proper dataset organization ensures that all images are correctly loaded before model development begins.

Predicted Benign

Figure: 4 Predicted Bengin

The prediction output demonstrates the successful classification of a dermoscopic skin lesion image as **Benign** by the trained CNN model. Before classification, the image undergoes preprocessing operations including resizing, normalization, and enhancement to improve image quality. The CNN then extracts important visual characteristics such as texture, color distribution, lesion boundaries, and structural features before generating the final prediction.

The classification of the lesion as benign indicates that the detected skin abnormality is non-cancerous and does not exhibit the aggressive characteristics associated with malignant lesions. The prediction confirms that the proposed model can effectively recognize the visual patterns commonly observed in benign skin lesions and accurately distinguish them from malignant cases.

The effectiveness of benign lesion classification is evaluated by examining the number of correctly identified benign samples, the occurrence of false classifications, and the confusion matrix results. Sample prediction outputs further verify the correctness and consistency of the model across different testing images, demonstrating reliable performance for benign lesion detection.

Predicted Malignant

Figure 5: Predicted Malignant

The prediction output also demonstrates the capability of the proposed CNN model to classify dermoscopic images as **Malignant** when cancerous characteristics are detected. After preprocessing and feature extraction, the trained network analyzes lesion properties including irregular borders, pigmentation patterns, asymmetry, and texture variations before assigning the malignant class. Accurate identification of malignant lesions is particularly important because early diagnosis significantly improves treatment outcomes and patient survival. The proposed model effectively recognizes complex lesion characteristics associated with malignant skin cancer and correctly differentiates them from benign lesions. The performance of malignant lesion classification is evaluated by analyzing correctly classified malignant images, false negative cases, and confusion matrix statistics. Particular attention is given to minimizing malignant cases incorrectly classified as benign because such errors may delay medical treatment. The prediction results demonstrate the effectiveness and reliability of the CNN model in detecting malignant skin lesions.

Discussion

The experimental results demonstrate that the proposed Convolutional Neural Network provides an effective solution for automated skin cancer detection using dermoscopic images. The CNN successfully learns meaningful image features directly from the dataset without requiring handcrafted feature extraction, resulting in accurate classification of benign and malignant lesions. Image preprocessing techniques, including resizing, normalization, and enhancement, contribute significantly to improving input image quality and overall model performance. Analysis of the confusion matrix indicates that the proposed model achieves high classification accuracy while maintaining a low number of incorrect predictions. The close agreement between training and validation performance further suggests that the network has learned generalized features and exhibits minimal overfitting. Although the system performs effectively, factors such as dataset size, image resolution, class imbalance, and variations in lesion appearance continue to influence prediction accuracy. performance.

Conclusion

The proposed skin cancer detection system based on image processing and Convolutional Neural Networks provides an efficient and reliable approach for automated classification of dermoscopic skin lesion images. The developed model successfully preprocesses input images, automatically extracts significant visual features, and accurately classifies lesions into benign and malignant categories. The use of deep learning eliminates the requirement for manual feature extraction while improving classification accuracy and consistency.

The experimental results demonstrate that the proposed system is capable of supporting early diagnosis of skin cancer by providing rapid and dependable classification outcomes. The implementation in MATLAB offers a practical and cost-effective framework for computer-aided diagnosis that can assist healthcare professionals in making timely clinical decisions. Overall, the proposed system represents an effective application of artificial intelligence in dermatological image analysis and contributes to improving early skin cancer detection.

Future Scope

The proposed system offers several opportunities for future enhancement to improve its performance and expand its practical applications. Integration with cloud computing platforms would enable remote storage, processing, and access to medical images, supporting telemedicine and large-scale healthcare services. Advanced image preprocessing techniques can further improve lesion visibility and increase classification accuracy.

The system can also be extended to perform multiclass classification for detecting various skin diseases instead of limiting diagnosis to benign and malignant lesions. Incorporating transfer learning using pretrained deep learning models such as ResNet, EfficientNet, or DenseNet can improve classification performance, particularly when limited training data are available.

Future development may also include the integration of Explainable Artificial Intelligence (XAI) techniques to provide interpretable predictions that improve clinician confidence and trust in automated diagnosis. Computational efficiency can be optimized to reduce processing time and enable real-time deployment on portable devices.

The integration of Internet of Things (IoT)-based medical devices would facilitate continuous patient monitoring and remote healthcare applications. Furthermore, training the model using larger and more diverse datasets would improve generalization across different skin types and imaging conditions. Finally, developing mobile and web-based applications would make the proposed system more accessible, enabling users to perform preliminary skin cancer screening anytime and anywhere.

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